

# Flowering and Fruiting of Chinese Jujubes in Florida

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**Abstract.** Eighteen cultivars of the Chinese jujube (*Zizyphus jujuba* Mill.) grown in Florida comprised 2 flowering types based on the time of day when the flowers open. Flowers on 10 cultivars open each day between 0700 and 1000 HR and on the other 8 between 1400 and 1700 HR. Despite ample opportunity for cross-pollination and intense activity by pollinating insects, some cultivars set little or no fruit. Cultivars that fruit heavily and reliably are parthenocarpic. Supplemental light in the fall prolongs flowering and fruiting and could substantially increase yields.

The Chinese jujube is an ornamental fruit tree native to China (6, 10). It is deciduous and tolerates temperatures below  $-29^{\circ}\text{C}$  (8). In these and in many other ways it is distinct from the tropical Indian jujube, *Z. mauritiana* Lam., with which it has often been confused. This confusion arose because the Indian jujube was often referred to as *Zizyphus jujuba* Lam., in the older literature (9).

Seedling Chinese jujubes were introduced into the United States in 1837, but these produced small fruit of low quality. During his extensive botanical explorations of China in the early 1900s, USDA plant explorer Frank Meyer found jujubes widely cultivated in dry regions of China, both for fruit and as ornamental shade trees (7, 8). Meyer noted that jujubes had been cultivated for thousands of years and that more than 400 superior cultivars had been selected. Between 1908 and 1914, Meyer introduced 83 of the best cultivars into the United States (5). He reported that jujubes seemed to thrive best in those regions of China with dry climates and long hot summers. Based on these observations, he suggested that jujubes would probably be best suited to the semiarid southern and southwestern areas of the United States (7, 8).

The idea that Chinese jujubes require dry, hot summers for good growth and fruit production was repeated in much of the early U.S. literature (2, 4, 5, 9, 12). Most experimental jujube plantings in the United States were made in the arid southwest, where high and consistent yields were reported (4, 5). Although no systematic surveys have been made, jujubes are generally reported to fruit poorly in the humid southeastern United States. Causes for this low fruitfulness have not been explored, but rainy, humid summers have been implicated (4).

This report summarizes 5 years of obser-

vations on flowering and fruiting in an 18-cultivar, 60-tree jujube planting (Table 1) at Gainesville, Fla. (latitude  $29.7^{\circ}\text{N}$ ). The trees are all grafted onto a clonal rootstock obtained by digging suckers from an old tree in south Alabama. Scion wood was obtained from trees in Alabama, Georgia, California, Pennsylvania, and Florida. Eight cultivars were grafted in Jan. 1978; the others were added later.

In general, all cultivars have grown well in Gainesville and flowered the first year after grafting. They have shown no signs of insufficient chilling, even following winters with less than 400 accumulated hours below  $7^{\circ}\text{C}$ . Trees typically begin leafing out in mid-March and flower from April through July. April and May flowers produce few fruit, and the last half of the flowering season accounts for most of the fruit set. Flowers are visited by flies, wasps, bees, and other insects in great number and diversity, particularly during the warmest part of the day when the flowers become very fragrant. Most of the fruit ripens from mid-August through Oct. 1 with about a month difference between early

and late cultivars and also with much variation in the ripening time of the fruit on an individual tree.

The 8 cultivars observed for 5 fruiting seasons have shown large differences in yields. For example, 4 trees of 'Lang' have averaged less than one fruit per tree per year for the last 3 years, whereas 3 trees of 'Silverhill' averaged more than 200 fruit per tree per year for the same 3 years, with substantial crops on every tree every year. Although fruit was not weighed, yields were scored visually on 3 trees each of 8 cultivars for each of 3 years, and the cultivars were divided into high, medium, and low yielders on the basis of these observations (Table 1).

Ackerman (1) found that 6 jujube cultivars he tested in California were almost completely self-incompatible and failed to form viable seeds when selfed. He also found that some jujube clones developed fruit through self-fertilization, but few set appreciable crops by this means. Teatonia and Chauhan found that Indian jujubes were not only self-unfruitful, but that some cultivar pairs were cross-incompatible (11). The fertility relationships in both cultivated Chinese and Indian jujubes can probably be explained by observations made on a third species, *Z. spinachristi* (L.) Willd., which is native to North Africa and the Middle East. Galil and Zeroni (3) studied 200 wild plants in Israel and found that 49.5% were early flowering types and 50.5% were late-flowering types, the 2 types being defined by the time of day when anthesis occurred. They found that the opening of all flowers on a particular day on a given plant was synchronized. On seedlings of the early type, flowers began to open between midnight and 0400 HR. Flowers on late-type seedlings began to open from 1000 to 1200 HR. Flowers of both types were protandrous, the pollen being shed about 12 hr before the stigmas became receptive. Controlled self-pollinations gave less than 2% fruit set, whereas cross-pollinations between opposite flowering types gave 29%. More recently

Table 1. Fruitfulness and flowering type of jujube cultivars grown in Gainesville, Florida.

Cultivar	Budwood source	Yield in years 1 through 5	Flowering type <sup>y</sup>
So (PI 37484)	California	---	AM
Shui Men (PI 38245)	California	---	AM
Chico	California	low	AM
Thornless	California	---	AM
GI-7-62	California	---	AM
GI 1183	California	---	AM
Fitzgerald	Georgia	---	AM
Edhegard	Alabama	low	AM
Silverhill	Alabama	very high	AM
Rootstock	Alabama	high	AM
Lang (PI 22686)	California	low	PM
Tsao	Pennsylvania	---	PM
Li (PI 38249)	California	---	PM
Geant	Florida	medium	PM
GA 866	California	---	PM
Prine	Georgia	---	PM
Leon Burk	Georgia	high	PM
Swoboda	Alabama	medium	PM

<sup>z</sup>Trees too young to rate.

<sup>y</sup>Refer to text.

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Fig. 1. Fruit on the parthenocarpic 'Silverhill' Chinese jujube are 3.5 to 4.0 cm long.

Vashishtha and Pareek (13) reported that 7 cultivars of the Indian jujube constituted 2 flowering types. Anthesis occurred from 0730 to 0900 HR on 5 cultivars and from 1200 to 1330 HR on the other 2.

The 18 cultivars of Chinese jujube in the Florida planting also comprise 2 flowering types. Flowers on the 10 cultivars designated "AM" in Table 1 typically open between sunrise and 1000 HR. Flowers on the other 8 typically open between 1400 and 1700 HR. On days when the normal diurnal pattern of temperature change is altered by heavy clouds or by thunderstorms, the opening time of the flowers is changed, but cultivars in each group respond similarly. For example, if a rainy overcast morning gives way to clearing at 1500 HR, the morning-flowering cultivars will flower together shortly after 1500 HR as the temperature begins to rise, rather than at their normal opening time of 0700 to 1000 HR.

Flowering times for *Z. jujuba* in Florida do not correspond to those reported for *Z. spina-christi* in Israel. The AM type of *Z.*

*jujuba* in Florida flowers about 6 hr later than the early-flowering type of *Z. spina-christi* in Israel, and the PM type in Florida about 6 hr later than the late-flowering type in Israel. It is not clear whether this difference is environmental or genetic. Florida *Z. jujuba* and Indian *Z. mauritiana* are more nearly alike in flowering times.

The self-incompatibility of *Z. jujuba* (1) and the fact that clones of one flowering type shed most of their pollen at a time when their stigmas are not receptive indicates that effective cross-pollination and production of viable seeds requires trees of opposite flowering types. Inappropriate choice of cultivars for cross-pollination could explain some cases of poor fruiting in jujubes in the southeastern United States. Two lines of evidence, however, suggest that cross-pollination is not the entire answer to jujube fruit-set problems. First, some cultivars consistently set little fruit even when trees of both flowering types were closely interplanted. Second, isolated single trees of some cultivars (e.g. 'Silverhill', 'Swoboda', and 'Leon Burk') fruit heavily and consistently in Georgia and Alabama. Fruit of these isolated trees is largely parthenocarpic, in that the stones contain aborted kernels. Even in mixed cultivar plantings, 'Silverhill' produces few viable seeds in spite of its heavy fruiting. On the other hand, cross-pollination greatly increases fruit set on the morning-flowering clone that is used for rootstock. This cultivar produces little fruit when grown in isolation with 'Silverhill', another morning type, but fruits heavily and produces large numbers of viable seeds in the mixed planting at Gainesville.

Even in the arid southwestern United States, where Chinese jujubes have fruited well for 50 years, they have not been a commercial success, in part because of poor consumer acceptance. Home gardeners, however, have shown much interest in the species.

The best method to ensure good fruiting on Chinese jujubes in the southeastern United States, is to plant parthenocarpic cultivars. Based on observations and experience to date, 'Silverhill' (Fig. 1) and 'Leon Burk' seem to be good choices. Neither of these is available commercially.

Jujubes in Gainesville flower heavily in April and May, but these early-season flow-

ers almost all abort, and the crop is largely produced from flowers that open during the last half of the flowering season. Vegetative growth and flowering decline in late June and July and flowering largely ceases by Aug. 1. However, a 'Silverhill' tree growing within 3 m of a streetlight continues vegetative growth, flowering, and fruiting throughout August, September, and October, long after other 'Silverhill' trees of the same age and size have ceased growth and flowering. This tree produces much more fruit over a much longer season than 'Silverhill' trees that receive no supplemental light. The late-ripening fruit is of higher quality than that produced in the normal season, possibly because of drier weather and lower temperatures in September and October.

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