

Jujube as a Florida Fruit Crop¹

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Abstract

Despite being cultivated in China for millennia, the Chinese jujube is mostly unknown to Western consumers. The fruits are borne from vigorous trees that are tolerant to drought, disease, and other stresses. A number of cultivars have been demonstrated to produce well in Florida. This publication is a review of jujube genetics and management as this crop gains favor among small farms and homeowners.

Introduction

The Chinese jujube (Rhamnaceae; *Ziziphus jujuba* Mill.) (Figure 1) is a deciduous fruit-bearing tree that is among the oldest domesticated tree crops, with evidence of cultivation going back over 7000 years. While relatively unknown to most in the West, the jujube is a popular and nutritious fruit estimated to be enjoyed by over a billion people on a regular basis. In China, it is among the most popular fruits, consumed both fresh and dried (described as the “Chinese date”), and had a market value of over \$14 billion in 2017. Despite its limited cultivation in the United States, some cultivars of Chinese jujube have been shown to be well-adapted for production in Florida. Their rapid growth, prolific production, and resistance to abiotic stress suggest they may have at least some commercial potential, especially for small, local markets, including those that serve an Asian clientele. The Taiwan, sometimes referred to as Thai, jujube (*Zizyphus mauritiana*) does not share the

same growth characteristics, so this review applies only to the Chinese jujube.



Figure 1. Jujube tree and jujube fresh fruit.
Credits: Ali Sarkhosh, UF/IFAS

Jujube was brought to North Carolina from Europe in 1837, then to California from France in 1876. Jujube was cultivated at the USDA agricultural station in Chico, California, in 1908, where selections were identified and distributed throughout southern states.

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Previous controlled trials of jujube varieties in Gainesville, Florida, indicate that only several varieties of jujube are productive in that region. Newer varieties have been introduced since, and anecdotal reports of highly productive trees are abundant. It is unlikely that the jujube has commercial potential outside of local sales or farmers markets, but the jujube is an excellent choice for home growers, as it is attractive and low maintenance. With these caveats, it is of interest to understand the species and its potential as a fruit crop in Florida.

Cultivation

Approximately 99% of all Chinese jujubes are grown in mainland China. In the United States, most jujube cultivation is confined to the desert southwest and California.

Jujube trees may grow to a height of 15–30 feet (5–10 meters), yet size may be constrained by pruning. Some growers choose two to six of the strongest basal trunks and allow them to continue to grow. Fruit are borne on thorny branches, with fewer thorns produced as the tree ages. Some newer selections are thornless. Jujube typically produces suckers, new trees that may emerge several feet from the parent tree. While oftentimes densely suckering, jujube is not considered invasive by the UF/IFAS Center for Aquatic and Invasive Plants.

A central leader (Figure 2) and open center (Figure 3 and Figure 4) are the most common training and pruning systems in conventional orchards. They are characterized by upright trunks, short, angled shoots, and rough bark that loses its leaves in the winter (Figure 4 and Figure 5). Jujube trees have naturally drooping and thorny branches that grow in zigzag patterns (Figure 6 and 7).



Figure 2. Jujube tree trained as a central leader.
Credits: Ali Sarkhosh, UF/IFAS



Figure 3. Three-year-old jujube tree trained as an open center, mid-April, Gainesville, FL.
Credits: Dustin Huff, UF/IFAS



Figure 4. Four-year-old 'Shanxi Li' variety trained as an open center in early March, Gainesville, FL.
Credits: Dustin Huff, UF/IFAS



Figure 5. Bark pattern of 4-year-old 'Sugar Cane' variety, Gainesville, FL. Credits: Dustin Huff, UF/IFAS



Figure 6. Emerging vegetative buds, protected by adjacent thorn. Credits: Dustin Huff, UF/IFAS

Propagation

Jujube varieties are propagated by grafting dormant scions (Figure 8) to rootstocks derived from seed or to rooted suckers harvested from existing trees. It is well known that jujube trees produce many suckers from their lateral roots (Figure 9 and Figure 10). Suckers are commonly used for propagating jujubes. Propagation by seed requires

stratification (cold treatment) in moist peat moss for 90–120 days at 40°F (4°C). Seeds will germinate without stratification but at a much lower rate. Some sources recommend scarifying (to weaken the surface of) seeds manually or with boiling water, followed by cooling for 24 hours prior to sowing. The use of a germination heating pad has been suggested to increase the germination rate.



Figure 7. Thorniness with branches growing in a zig-zag pattern is apparent in many jujube varieties. Credits: Just Fruits and Exotics Nursery (<https://justfruitsandexotics.com/>); and Dustin Huff, UF/IFAS

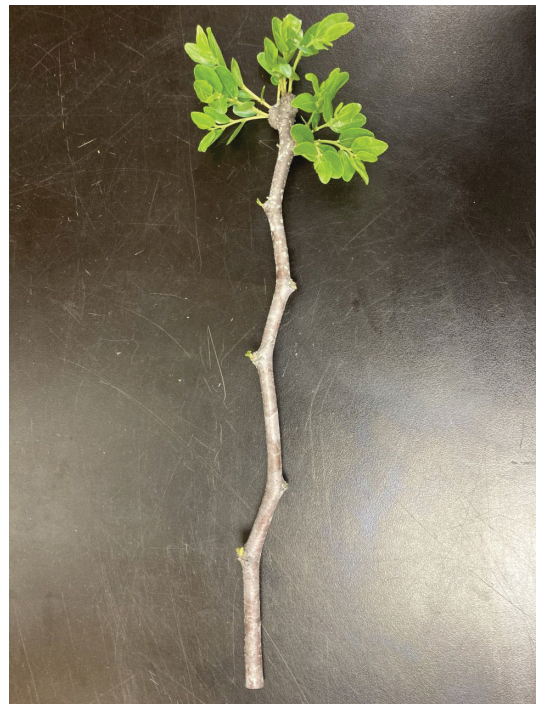


Figure 8. Cutting of 'Shanxi Li' for grafting. Credits: Dustin Huff, UF/IFAS



Figure 9. Suckering habit of jujube. Traditionally suckers have been used for propagation.
Credits: UF/IFAS



Figure 10. One-year-old jujube plant propagated by sucker.
Credits: Just Fruits and Exotics Nursery (<https://justfruitsandexotics.com/>)

Growing Conditions

Jujube is recognized for its adaptability to a vast range of conditions. This species is highly tolerant to drought and salinity. It maintains multiple mechanisms to stave off desiccation, including a long tap root and other mechanisms to retain water. It tolerates a broad range of soil types and has been successfully grown in pH extremes from 4.5–8.4. Established trees are cold tolerant to -20°F (-29°C), yet they grow well in hot, humid conditions. Varieties have been reported to perform well in USDA zones 5–10 yet perform best in zones 6–9. It has been reported that jujube requires

at least six hours of full sunlight a day to produce fruit. Jujube trees begin yielding three to five years after planting.

While these rules apply to jujube in general, fruit set has been reported to be problematic in Florida on some cultivars. The exact reason for this is unknown. While flowers and pollinators are abundant, few fruit form on many trees. It has been speculated to be due possibly to humidity, yet successful fruit set has been observed throughout humid regions of the United States, such as southeast Texas and Louisiana. The variation occurs differentially from year to year, so the cause may be attributable to the weather conditions during flowering.

Irrigation

Jujube is considered a drought tolerant tree. However, providing newly planted trees with adequate water is critical for establishment, especially in bare-root plantings, because transplanting shock can be quite a setback for young trees. Frequent irrigation (two to three times per week) is required after planting. The quantity of irrigation will be determined by several factors, including rainfall, soil type, and evapotranspiration levels. Microsprinklers and drip irrigation are effective means to supply water and can also be used for fertigation.

Fertilization

The fertilizer rates applied to jujubes have not been formally published. It is currently unknown what nutrient requirements and timing are specific to Florida. The use of proprietary NPK plus trace element fertilizers, such as 12.4.8 plus trace elements, provides a convenient approach to fertilizing. In general, they are formulated in ratios that are suitable for horticultural crops in most cases. The general guidance is to split the fertilization plan into three applications, with 50% applied in late dormancy (Feb/March) and 25% each in May/June and July/August. Magnesium deficiencies can occur if soil potassium or calcium levels are too high, and manganese and iron can be scarce in soils with a pH above 7. Heavy applications of quick-release nitrogen should be avoided because this can increase fruit drop. Monitoring for leaf nutrient levels is also a great way to fine tune a fertilizer program.

Flowering

The trees have been described as having a low chilling requirement (<400 hours) and perform well in protected cultivation. Moreover, they have a higher heat unit requirement to break dormancy, being one of the later fruit trees to leaf out in Florida. Jujube is a good choice for areas of

the state prone to late spring freezes. Flowering begins in early March from central Florida and can continue to late April in northern Florida, with the later flowers being more productive.

Jujube types may be characterized by the time of day that they flower (Figure 11 and Figure 12), which falls into one of two types. One type is open between 7 a.m. and 10 a.m., the other between 2 p.m. and 5 p.m., and flowering time is acutely affected by weather, especially ambient temperature. There are several reports that detail self-incompatibility in jujube varieties, indicating that several compatible trees must be planted to successfully produce fruit. Pollen is produced approximately 12 hours before the stigma is receptive to pollination, and successful fruit set has been observed between flowering-time types (Figure 13). The exceptions are the parthenocarpic varieties ('Silverhill' or 'Tigertooth', which are likely the same variety; 'Swoboda' or 'Leon Burk'), which are reliable producers albeit with few viable seeds.



Figure 11. Flowering habit of jujube.
Credits: Dustin Huff, UF/IFAS



Figure 12. Close-up of jujube flower.
Credits: Dustin Huff, UF/IFAS

Flowering occurs on fruiting spurs which give rise to a cyme inflorescence bearing numerous, small yellow perfect flowers (5–9 millimeters; Figure 12). Biennial bearing has not been described in jujube.

Fruit Quality

Fruits are borne on new growth (Figure 14) and expand through the summer months, typically ripening in August and September in Florida. The fruit is a drupe, containing a pit, with one or two seeds. Fruit size varies greatly among varieties, with 'Tigertooth' being ovate and 1–1.5 inches (2–3 centimeters) in length, to 'Thai Giant' being the size of an extra-large chicken egg. In most varieties, ripening is noted as a change in color from green to brown, yet fruits (peel and pulp) may be consumed fresh from the green to brown stage or dried. Different varieties are more amenable to drying.



Figure 13. Fruit set in jujube.
Credits: Just Fruits and Exotics Nursery (<https://justfruitsandexotics.com/>)



Figure 14. Fruit of jujube borne on new growth.
Credits: Ali Sarkhosh, UF/IFAS

The fresh jujube fruit is generally crisp like an apple, with similar texture, but generally not as juicy (Figure 15). The spongy flesh has a flavor reminiscent of apple or Asian pear with sweetness and a tangy aftertaste. The flavor and less-foamy texture improve as the tree ages. The sweetness varies significantly between genotypes (Table 1). Jujube flavor is significantly affected by environmental conditions and management practices, as fruit from any given cultivar have been described from “fruity and aromatic” to “crunchy and foamy” suggesting that genetics are necessary but not sufficient to produce a flavorful fruit.



Figure 15. Jujube fruit harvested for fresh market.
Credits: Ali Sarkhosh, UF/IFAS



Figure 16. Dried jujube fruit in supermarket.
Credits: Ali Sarkhosh, UF/IFAS

Jujubes may be dried, with some varieties being more amenable to dehydration than others. Dried fruit have a chewy consistency, with enhanced sweetness. Dried fruit (Figure 16) store well at room temperature and can be stored for several years at 40°F (4°C). Fresh fruit may be

stored for several months in sealed containers at 40°F. The fruits are rich in vitamin C, potassium, iron, and zinc, among the highest levels found in fruits.

Diseases and Pests

Disease has been noted as one of the primary limitations of jujube cultivation in China. Jujube is susceptible to several phytoplasmas that cause significant economic loss, namely “witch’s broom disease.” There are also multiple fungal and bacterial species that cause leaf rust, as well as numerous postharvest diseases.

Jujube pests have not been described in Florida specifically. Fruit may be damaged from birds or stinkbugs. Tree damage from insects or nematodes has not been reported. In the desert southwest United States, deer, gopher, and prairie dog issues have been observed, so protection of the main trunk may be advisable to protect from these animals as well as rabbits.

Cultivars

In China, there are 700–800 jujube varieties, specifically bred for drying or fresh consumption. Cultivars in the United States have expanded to the readily available genotypes on the following Table 1.

Genetic Improvement

The vast majority of germplasm improvement is happening in China, with sporadic breeding programs worldwide, including a program for genetic improvement at the University of New Mexico (United States). Over 930 cultivated varieties are said to exist in China. The central priority is introgression of disease resistance from wild accessions (i.e., introducing genes from disease resistant cultivars into less resistant types). Documentation of most breeding in China remains unpublished.

One of the challenges to jujube breeding is that flowers are extremely small, approximately $\frac{1}{4}$ – $\frac{3}{8}$ inch (5–7 millimeters) in diameter. While flowers are perfect, the small size makes emasculation (removal of pollen-producing parts) difficult, making it challenging to control pollination with any specific pollen variety. While flowers are abundant, fruit set is low in jujube, at about 1% of flowers producing fruit. Little is known about self-incompatibility and male sterility, complicating breeding efforts. Gametophytic self-incompatibility has been reported, with some varieties maintaining an S-RNase based incompatibility system. Hybrid seeds are extremely difficult to obtain from directed crosses. Some efforts have grafted varieties to be crossed

onto a single tree and then tented the tree in the presence of bees. Successful crosses were identified using molecular tools. Other varieties have been described as self-fruitful.

Conclusion

The jujube has some potential as a fresh or processed fruit in Florida. Its low chilling requirement, tolerance to disease, pests, and weather extremes make it an attractive candidate for targeted genetic improvement. Consumer acceptance is the central hurdle, as most are unfamiliar with the jujube, and those who are aware of this crop have not been impressed by the prematurely harvested, bland fruits that are sold in specialty markets. Small farm and dooryard production may be a promising gateway to broader jujube acceptance, coupled with importation of more varieties from China, conducting Florida trials with new cultivars from various breeding programs, and formal evaluation of varieties across Florida's varied soils and climate.

Acknowledgement

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Additional Reading

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Table 1. Jujube cultivars and some fruit characterizations.

Cultivar	Comments	Ripening [†]	Fruit Size*	Fresh	Dried
'Ant Admire'	Oval/elongated fruit.	E			
'Autumn Beauty'	(syn. 'Qi Yue Xian') Unlike other jujubes, they start in a dark-maroon color and turn green as they ripen. Small tree, early producer, excellent fresh fruit quality.	E	L	X	X
'Black Sea'	Produces well as a young tree. Does well in wet climates.	EM	S	X	
'Chico'	Round fruit with a flat bottom. Good flavor when green and acidic. Developed in California.	EM	S	X	X
'Coco'	Coconut flavor. Dark-brown fruit. Originating from Ukraine.	EM	S	X	
'GA866' (Figure 17)	High sugar content; up to 45°Brix. Trees are reported to not bear well until well-established in about 8–10 years. Developed in California.	ML	L	X	X
'Globe'	Large round fruit. Well suited for drying. Generally recognized as flavorless as fresh fruit.	L	L		X
'Honey Jar' (Figure 18)	Small, sweet fruit. Short-statured tree. >30°Brix	E	S	X	
'La Fleur'	Small, juicy fruits with vigorous growth.		S	X	
'Lang' (Figure 19)	Pear-shaped fruit. Best when fully red brown. Original trees imported by Meyer.	EM	L	X	X
'Li' (Figure 20)	Considered a high-quality fruit. Up to 85g per fruit. Brought to USA by Meyer.	E	L	X	X
'Norris #1'	A tree identified in eastern Tennessee from TVA plantings near Norris Dam. Abundant producer. Seems to thrive in warm, humid climates. Good quality fruit.	M	M	X	
'Redlands #4'	Very large and sweet.	M	L	X	
'Shangxi Li' (Figure 21)	Large fruit with sweet apple flavor. Precocious.	EM	L	X	X
'Sherwood'	Sweet fruit with erratic size. Generally poor yields. Thornless. Originated in Louisiana.	ML	varies	X	X
'Si-Hong' (Figure 22)	Considered by many to have the best flavor. Precocious.	M	L	X	X
'So' (Figure 23)	Contorted. Self-fertile. Good fruit quality. Developed by Meyer.	EM	M	X	X
'Sugar Cane' (Figure 24)	>32 °Brix. Good flavor. Round fruit. Recent import to US.	E	S	X	X
'Tigertooth' (Figure 25)	Small, abundant fruit. Suckers frequently. Trees grow well on their own roots. Noted for exceptionally abundant production in Florida.	L	S	X	X
'Winter Delight' (Figure 26)	Partially self-fertile. Produces egg-shaped fruits. Exhibits superior cold tolerance. Spicy-sweet flavor. Relatively new variety in the US. Originating in northern China.	L	L	X	
'Xu Zhou'	Chinese import that is reported to produce well at a young age and in wet climates.	L	S	X	
'Yazoo Li'	Believed to be a seedling of 'Li'. Exceptionally large fruit and better flavor. Originating in Mississippi.	E	L	X	

[†]Early (E) = June-July, Mid (M) August, Late (L) = October
X = history of use in this application
* Size: diameter at equator; small (S) = 1.5-2.5 cm, medium (M) =2.5-4.0 cm, large (L) = > 4 cm



Figure 17. 'GA866'.
Credits: Just Fruits and Exotics Nursery (<https://justfruitsandexotics.com/>)



Figure 20. 'Li'.
Credits: Just Fruits and Exotics Nursery (<https://justfruitsandexotics.com/>)



Figure 18. 'Honey Jar'.
Credits: Just Fruits and Exotics Nursery (<https://justfruitsandexotics.com/>)



Figure 21. 'Shanxi Li'.
Credits: Just Fruits and Exotics Nursery (<https://justfruitsandexotics.com/>)



Figure 19. 'Lang'.
Credits: Just Fruits and Exotics Nursery (<https://justfruitsandexotics.com/>)



Figure 22. 'Si-Hong'.
Credits: Just Fruits and Exotics Nursery (<https://justfruitsandexotics.com/>)



Figure 23. 'So'.
Credits: Just Fruits and Exotics Nursery (<https://justfruitsandexotics.com/>)



Figure 25. 'Tigertooth'.
Credits: Just Fruits and Exotics Nursery (<https://justfruitsandexotics.com/>)



Figure 24. 'Sugar Cane'.
Credits: Just Fruits and Exotics Nursery (<https://justfruitsandexotics.com/>)



Figure 26. 'Winter Delight'.
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