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Early Performance of Jujube Fresh Eating Cultivars in the Southwestern United States

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Abstract. **Jujube (*Ziziphus jujuba* Mill.), also called chinese date, cultivars have not been formally trialed in the United States after the 1950s. Currently, there are five to six commercially available jujube cultivars, with 'Li' as the dominant one. Both growers and consumers demand a wider range of cultivars to extend the maturation season and for different uses. We tested jujube cultivars at three locations in New Mexico [U.S. Department of Agriculture (USDA) hardiness zones 6a, 7a, and 8a] to assess their adaption and performance. These are early performance results for fresh eating cultivars. Jujubes were precocious; 50% to 95% of trees produced during their planting year, depending on cultivar and location. The average yield per tree for trees in their second to fourth year after planting were 409 g, 4795 g, and 5318 g at Alcalde; and 456 g, 3098 g, and 5926 g at Los Lunas, respectively. The yields varied by cultivar and location. 'Kongfucui' ('KFC') was the most productive cultivar at Alcalde and Los Lunas in both 2017 and 2018, followed by 'Daguazao', 'Gaga', 'Honeyjar', Maya', 'Redland', and 'Sugarcane'. 'GA866', 'Alcalde #1', 'Zaocuiwang', and 'Sandia' had the lowest yields among the 15 cultivars tested. 'Alcalde #1' was the earliest to mature with large fruit, suitable for marginal regions with short growing seasons, whereas 'Sandia' had the best fruit quality among all cultivars tested, suitable for commercial growers and home gardeners. 'Maya', 'Gaga', 'Honeyjar', and 'Russian 2' were very productive, early-midseason cultivars with small fruit but excellent fruit quality—a perfect fit for the home gardener market. 'Li', 'Daguazao', 'Redland', and 'Shanxi Li' were productive with large fruit. Cultivars grew faster and produced higher yields, larger fruit, and higher soluble solids at more southerly locations. This article discusses cultivars' early performance up to the fourth year after planting. This is the first jujube cultivar trial report in the United States since the 1950s.**

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Jujube cultivars (*Ziziphus jujuba* Mill.) were first imported from China into the United States from 1908 to 1918 by USDA agricultural explorer Frank N. Meyer (Meyer, 1911, 1916). During the 1920s, the USDA Chico Plant Introduction Station recommended four jujube cultivars: Li, Lang, Shuimen, and Mu Shing Hong (Thomas, 1927). The Chico Plant Introduction Station also distributed jujube plants to other research stations, including Dalhart, Big Spring, and Lubbock, TX; Woodard and Lawton, OK; Garden City, KS; and Tucumcari, NM (Locke, 1948). No records exist today regarding exactly how many cultivars were distributed, how they performed, how long the trees survived, or when they were ended at each station, except for Oklahoma (Locke, 1948, 1955). At Tucumcari, NM, the survivors from the 1930s trial became naturalized and survived for 90 years without irrigation (Yao, 2013). One hundred years later, of all Frank Meyer's importations—'Li', 'Lang', 'Shuimen', 'Mu', 'So' and 'Yu'—remained (Yao, 2013). After several years of observation in New Mexico, 'Yu' is a unique germplasm but not a cultivar, because it did not bloom normally or set fruit from 2012 to 2018 (Yao, 2018).

Jujube cultivars currently available commercially include 'Li', 'Lang', 'Sugarcane', 'Sherwood', 'GA866', 'Shanxi Li', and 'Honeyjar', with 'Li' as the dominant one in the United States. In Lucerne Valley, CA, there are several hundred acres of jujubes and more than 95% of them are 'Li'. Cultivar Li has large fruit, and is precocious and productive with reasonable fruit quality. But, 'Li' is not suitable for all climate conditions, soil types, and different end uses. Nevertheless, growers in the United States tend to harvest 'Li' relatively early in the green fruit stage or creamy stage for the fresh market (i.e., without any red/brown color), which, without proper packing, can contribute to fruit bruising and inadequate flavor. A wider variety of jujube cultivars is needed to extend the maturation season, expand marketing opportunities, and meet different end uses for consumers.

Commercial jujube production in the United States is mainly in California—from Fresno County in the Central Valley to Lucerne Valley in San Bernardino County—but there are scattered plantings in other states: from Pennsylvania to Florida and from Florida to California. Smaller scale and beginning growers are frustrated with limited cultivar choices and plant supply.

With jujube growers' and consumers' demands in mind, the New Mexico State University Sustainable Agriculture Science Center at Alcalde, NM (NMSU Alcalde Center) imported more than 30 cultivars directly from China and collected cultivars in the United States, amassing a total of ≈60 cultivars/selections at the NMSU Alcalde Center. After several years of preliminary observation, we established jujube cultivar trials at the NMSU Alcalde and Los Lunas Centers in 2015 and the Leyendecker Plant Science Research Center in 2017 with 35+ cultivars at each site. The objective of this study was to evaluate jujube cultivars in different hardiness zones in the southwestern United States and to recommend top-performing cultivars to growers in each region. Here we report the early performance of fresh eating cultivars; ornamental cultivars were reported in 2018 (Yao and Heyduck, 2018).

Material and Methods

Source of cultivars. Jujube cultivars were collected in the United States from 2011 to 2012 and imported as scionwood directly from China in 2011 (Yao et al., 2015). The directly imported scionwood was grafted to sour jujube rootstocks (*Z. spinosa* Hu) at NMSU Alcalde Center and quarantined for 2 years with inspections from the USDA

Animal and Plant Health Inspection Service. After several years of preliminary observations, these cultivars were grafted for further evaluation in Alcalde in 2014.

Cultivar trials. Jujube cultivar trials with 35+ cultivars per site were planted at the NMSU Alcalde and Los Lunas Centers in April 2015 using a completely randomized block design. There were two replicates (blocks) and two trees per cultivar in each block at each site. The planting density was 2.44×3.66 m at Alcalde and 3.05×4.57 m at Los Lunas. In April 2017, another cultivar trial with similar cultivars was planted at the NMSU Leyendecker Center with a 3.05×4.57-m planting density (Yao and Heyduck, 2018). Because of the large number of cultivars involved in these cultivar trials, we report cultivars for different uses separately, presenting results from fresh eating cultivars in this report (Table 1). Location and elevation of sites are as follows: Alcalde Center (lat. 36°05′27.94″N, long. 106°03′24.56″W; elevation, 1730 m) Los Lunas Center (lat. 34°46′04.7″N, long. 106°45′45.7″W; elevation, 1478 m) and Leyendecker Center (lat. 32°12′08.9″N, long. 106°44′41.4″W; elevation, 1176 m).

Field management. No specific training system was used and trees were allowed to follow their natural growing habits. Trees were pruned annually to control height and stimulate side branches if there were not enough scaffold branches during the first 1 to 3 years. For cultivars with excessive branches, competing and overcrowded branches were thinned out to avoid overshading. During the third year, and later after planting, we tried to top off the central leaders and main branches to slow down apical growth.

Trees were flood irrigated at all three sites once per week, with sandy loam soil at Alcalde; and once every 2 to 3 weeks at Los Lunas and Leyendecker Centers, with loam/clay soils, if there was no natural precipitation. Trees were fertilized once per year at a rate of 45 to 50 kg·ha^{-1} N, 15 to 20 kg·ha^{-1} P, and 25 to 30 kg·ha^{-1} K. Fertilizer and rate varied slightly from site to site according to fertilizer availability.

Tree performance, yield, and fruit characteristics. Trees were evaluated for fruiting status, and fruit number was counted in the first year. In the following years, fruit were handpicked by tree when a majority of fruit were full red or when a killing frost occurred. Total yield and weight of 30 fruit were collected. Pictures were taken annually at each site. Fruit dimensions (length and width) of 30 fruit per cultivar were measured with a caliper for most cultivars in 2017 at both the Alcalde and Los Lunas sites. Fruit soluble solids were juiced with a garlic press and measured with a digital refractometer (Atago U.S.A., Bellevue, WA) from a composite sample of 8 to 10 fruit per cultivar. Tree growing habits were evaluated, and tree height and width were measured in Mar. 2018. Tree growing habits were classified as four types: upright, more upright than bushy, bushier than upright, and bushy. Branch number directly from the trunk was determined for each tree, although the length and diameter varied depending on the cultivar.

No formal fruit tasting was carried out; rather, fruit-quality ranking was based on the corresponding author's fruit tasting during the past 7 to 8 years plus the responses of customers at our annual jujube fruit-tasting workshop in late September each year. Fruit fresh eating quality includes sweetness, flavor, juiciness, crispiness, and texture. Fruit size and color were not included in the fruit fresh eating quality part of this article.

Cultivar thorn rating was conducted in Mar. 2019 at Alcalde based on the straight thorn length on the branches of different ages.

Analysis of variance was conducted for yield and tree growth (height, width, growing habits, and number of branches) with Statistix 10 (Analytical Software, Tallahassee, FL).

Results

Precocity and yield. Jujube plants were more precocious than most temperate fruit species. At Alcalde, more than 90% of trees produced in 2015, the planting year. 'Daguazao', 'Alcalde #1', 'Redland', 'Li', 'KFC', 'Honeyjar', 'Maya', and 'Gaga' all had trees with 50 to 100 fruit. 'Sandia' and 'GA866' had no fruit for the planting year. In 2016, all trees produced, with an average yield of 409 g/tree (Table 2). 'Honeyjar', 'Daguazao', 'Shanxi Li', 'Maya', and 'Alcalde #1' were the top five performers at Alcalde. At Los Lunas, ≈50% of trees produced in 2015, the year of planting. In 2016, all trees produced, with an average yield of 456 g/tree (Table 2). 'Redland', 'Alcalde

Table 1. Fresh eating cultivar names, sources, and their planting locations. AL-Alcalde, LL-Los Lunas, and LK-Leyendecker.

Cultivar	Plant source	Planting locations
Alcalde #1 (Qiyuexian)[z]	China	AL, LL, and LK
Chico	California	AL,[y] LL,[y] and LK
Dabailing[z]	China	LK
Daguazao[z]	China	AL, LL, and LK
GA866	California	AL, LL, and LK
Gaga[z]	China	AL, LL, and LK
Honeyjar	California	AL, LL, and LK
Jing 39[z]	China	LK
Li	California	AL, LL, and LK
Kongfucui[z]	China	AL, LL, and LK
Maya[z]	China	AL, LL, and LK
Redland	California	AL, LL, and LK
Russian 2	California	AL,[y] LL,[y] and LK
Sandia[z]	China	AL and LL
Shanxi Li	China	AL, LL, and LK
Sugarcane	California	AL, LL, and LK
Zaocuiwang[z]	China	AL, LL, and LK

[z]Cultivars under trademark AmeriZao® series.
[y]Cultivars were tested as observation only, not in the replicated trials.
AL = Alcalde; LL = Los Lunas; LK = Leyendecker.

Table 2. Jujube cultivar yields (g/tree) from 2016 to 2018 at Alcalde (AL) and Los Lunas (LL), NM.

Cultivar	AL-2016	AL-2017	AL-2018	LL-2016	LL-2017	LL-2018
Alcalde #1	451	1,511	3,202	892	607	4,988
Daguazao	646	6,547	9,948	79	3,070	5,013
GA866	68	977	1,797	311	1,932	3,658
Gaga	238	5,953	6,321	456	1,835	5,707
Honeyjar	1,148	7,470	6,160	229	1,642	5,701
KFC	383	11,572	13,686	339	2,696	9,791
Li	80	4,267	3,756	210	6,681	8,377
Maya	538	5,995	6,432	643	2,623	6,446
Redland	431	6,387	3,985	1,015	8,265	8,999
Sandia	18	132	2,576	167	2,060	3,183
Shanxi Li	512	3,503	1,842	509	3,870	4,559
Sugarcane	423	6,366	8,500	868	2,852	3,882
Zaocuiwang	387	1,659	925	209	2,135	6,734
Mean	409	4,795	5,318	456	3,098	5,926
Critical value[z]		3,427	2,311		2,217	4,457
Chico[y]	32	859	2,127	681	1,892	4,195
Russian 2	1,700	4,066	1,160	1,620	—	—

[z]Critical values are used to compare significant differences in the same column. If the difference between any two cultivars in the same column is larger than the critical value, the difference is significant at $P \leq 0.05$ by Fisher's protected least significant difference procedure.
[y]'Chico' and 'Russian 2' were for reference only because we did not have enough plants for full replications.

#1', 'Sugarcane', 'Maya', and 'Shanxi Li' produced more than 500 g/tree.

At the Leyendecker site, 95% of trees fruited during the planting year in 2017. In 2018, early cultivars such as Alcalde #1 and Honeyjar were 100% lost to birds, but each tree had more than 100 fruit per tree for 'Alcalde #1' to several hundred for 'Honeyjar' when trees were estimated for crop yield in late Aug. 2018. The early cultivars and the late cultivars were damaged the most. When the late cultivars were harvested, we noticed the fruit left were those on the far end of the branchlets that could not be reached when birds stood on the side branches. Of the 36 trees harvested, the average yield was 2100 g/tree. One 'Dabailing' tree produced 6500 g. Comparing the tree performance at these three locations, cultivars grew and produced better at the southern Leyendecker location, with a longer growing season and warmer weather, than at Los Lunas and Alcalde.

Yield. At both Alcalde and Los Lunas from 2017 to 2018, 'KFC' had the highest yield among 13 cultivars tested, which was significantly higher than other cultivars (Fig. 1, Table 2). 'Redland', 'Daguazao', 'Li', 'Sugarcane', 'Maya', and 'Honeyjar' also had higher yields than 'Alcalde #1', 'GA866', and 'Sandia'. At Los Lunas, 'Redland' and 'Li' yields were significantly higher than the rest of the cultivars except 'KFC'. 'KFC' was higher than 'Honeyjar', 'Sugarcane', 'Alcalde #1', 'GA866', and 'Sandia'.

There was no significant difference in yield between 2017 and 2018 at Alcalde, but the 2 years were significantly different at Los Lunas. An irrigation pipe broke during fruit maturation in 2017, and much fruit was lost to wildlife, lowering yields for that year at Los Lunas. The low yield of 'Alcalde #1' was partially a result of its compact tree stature and early maturation season—fruit loss before the harvest season started. We had limited plants of 'Russian 2' when trials were established and it was not thoroughly replicated. The few 'Russian 2' trees at Alcalde, Los Lunas, and Leyendecker were all loaded with small fruit with excellent fruit quality each year.

Fruit traits. Table 3 lists the fruit dimensions, average fruit weight, and soluble solids content for both Alcalde and Los Lunas. Cultivars with large fruit weight (>20 g) were Redland, Alcalde #1, Li, Shanxi Li, Daguazao, and Zaocuiwang (Fig. 2). Cultivars with medium-size fruit (10–19 g) included GA866, Sandia, Chico, KFC, and Sugarcane (Fig. 2). Cultivars with small fruit (<10 g) were Maya, Gaga, Honeyjar, and Russian 2 (Fig. 2). Fruit weight depended on cultivar, location, crop load, and cultural management. In general, fruit weight was greater at Los Lunas than at Alcalde, likely a result of the longer growth season, but crop load and field management also affected fruit weight. 'KFC', 'Maya', 'Gaga', and 'Honeyjar' had much smaller fruit at Alcalde than those at Los Lunas, which could be a result, in part, of their heavy crop loads at Alcalde. 'Daguazao' in 2018 was smaller than in 2017 at Los Lunas as a result of the heavy crop load. Although the small fruit of 'Sugarcane' at Los Lunas in 2017 could be a result, in part, of its late fruit set, most fruit were on the current year's new growth. Figure 2 shows the fruit of 12 cultivars. Pictures of all cultivars tested can be found at https://aces.nmsu.edu/jujube/, which can be used to guide growers' cultivar selection and identification.

Tree growth. In general, trees were 3 m in height on average after 3 years in the field at both locations, but tree canopies at Alcalde were generally wider than those at Los Lunas (Table 4). Trees at Alcalde were bushier and had more branches than trees at Los Lunas. 'GA866', 'Gaga', and 'Maya' had very upright growing habits with fewer branches than other cultivars at both locations (Table 4). 'Maya' and 'Gaga' had similar growing habits and fruit shape, and strong secondary branches to carry the yields. 'Sandia' and 'Sugarcane' were the bushiest cultivars among those tested.

Tree growth varied by cultivar, location, soil conditions, and field management. Alcalde's growing season is 3 to 4 weeks shorter than Los Lunas. Alcalde has sandy loam soil whereas Los Lunas has heavier soil. Although the average tree height was

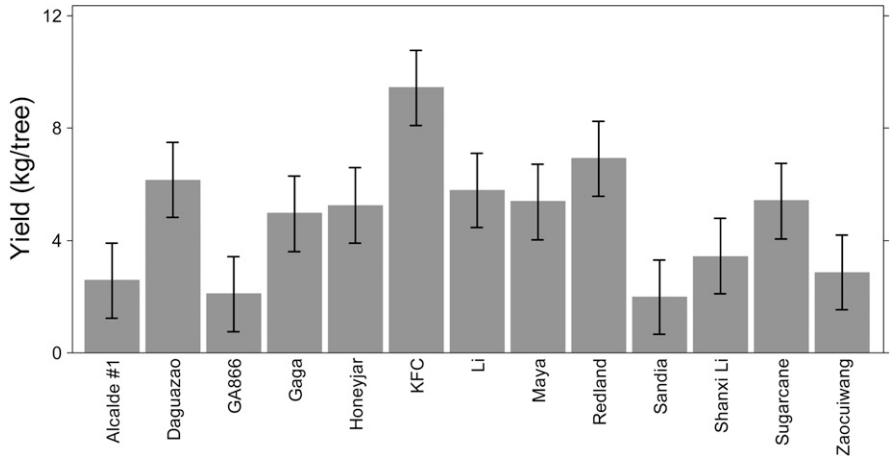

Fig. 1. Average yields of 13 fresh eating jujube cultivars at both Alcalde and Los Lunas across 2017 and 2018. The bars are 95% confident interval error bars and if they do not overlay, the different between two means are significant at $P \leq 0.05$. KFC, 'Kongfucui'.

Table 3. Fruit size, mean fruit weight, and soluble solids of different jujube cultivars at Alcalde (AL) and Los Lunas (LL) in 2017 (-17) and 2018 (-18; n = 30, some cultivars were an average of two trees at each location). The fruit diameter was measured for the biggest point for irregular-shaped cultivars. Fruit was picked at different times, depending on maturity, but fruit size was measured from stored fruit in cold storage within 1 week.

	Fruit dimension 2017 (length × width; mm)		Mean fruit wt (g)				Soluble solids (%)[z]			
Cultivar	AL	LL	AL-17	LL-17	AL-18	LL-18	AL-17	LL-17	AL-18	LL-18
Alcalde #1	51.8 × 36.6	48.8 × 38.1	29.8	31.2	26.3	25.8	30.9	32.8	32.8	28.9
Chico	27.8 × 33.1	29.7 × 34.6	13.4	14.3	—	—	22.7	24.2	—	—
Daguazao	39.3 × 38.0	39.5 × 41.9	22.9	27.1	21.1	17.1	27.6	28.7	27.0	25.4
GA866	43.9 × 24.5	47.3 × 27.9	10.7	14.8	12.9	14.1	27.9	29.2	35.2	32.9
Gaga	39.7 × 21.1	37.9 × 21.1	7.6	8.8	6.6	7.4	35.3	34.4	—	29.5
Honeyjar	24.1 × 25.0	24.7 × 24.9	7.3	7.6	6.9	7.2	24.4	33.6	27.9	32.3
KFC	39.7 × 26.2	39.0 × 28.0	11.5	12.6	10.1	14.2	29.0	32.7	25.2	31.3
Li	42.1 × 40.7	44.4 × 42.5	27.5	29.0	25.0	30.2	23.6	28.4	31.8	29.7
Maya	39.4 × 20.6	39.2 × 21.5	7.0	7.2	6.6	7.5	29.0	33.7	30.5	28.7
Redland	44.2 × 42.1	43.4 × 43.6	31.6	26.8	22.3	27.9	28.7	27.9	29.4	30.8
Sandia	31.7 × 31.7	29.3 × 30.8	14.8	14.3	9.5	16.4	33.0	34.6	36.5	34.3
Shanxi Li	43.8 × 39.6	42.1 × 41.4	27.3	21.3	17.1	17.0	25.2	29.9	28.7	32.1
Sugarcane	34.1 × 26.6	31.1 × 25.0	11.7	8.8	9.9	11.5	28.6	27.5	27.1	30.5
Zaocuiwang	37.8 × 30.5	42.4 × 37.7	18.4	20.8	19.83	25.4	30.1	34.3	29.5	32.3

[z]The soluble solids were extracted with a garlic press and measured with a digital refractometer from a composite sample of 8 to 10 fruit per cultivar with a wedge from each fruit.

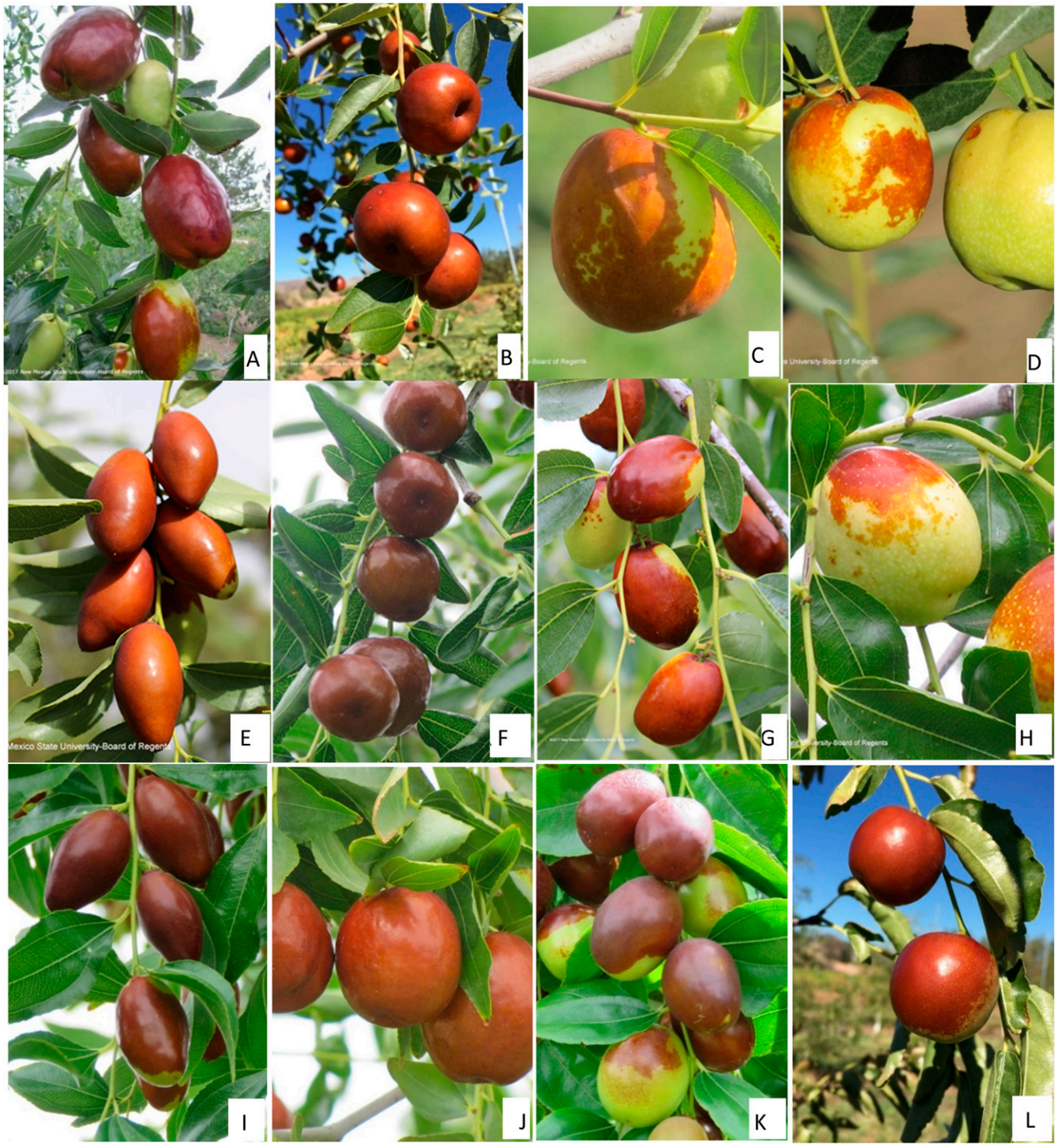

Fig. 2. Fruit pictures of different jujube cultivars in New Mexico. (**A**) 'Alcalde #1'. (**B**) 'Chico'. (**C**) 'Dabailing'. (**D**) 'Daguazao'. (**E**) 'Gaga'. (**F**) 'Honeyjar'. (**G**) 'Kongfucui'. (**H**) 'Li'. (**I**) 'Maya'. (**J**) 'Redland'. (**K**) 'Russian 2'. (**L**) 'Sandia'.

similar after 3 years of growth in the field, trees were more vigorous and upright at Los Lunas than at Alcalde 4 years after planting. Orchard management also affects tree growth, especially the frequency of irrigation. In general, trees are larger at more southern locations than in northern locations.

Fruit fresh eating quality. Each cultivar has a different flavor. Based on several years of tasting evaluation and customers' comments from the annual jujube fruit tasting workshops, 'Sandia' ranked highest in fresh eating quality, followed by 'Honeyjar', 'Maya', and 'Russian 2'. 'Alcalde #1', 'KFC', 'Sugarcane', 'Zaocuiwang', and 'GA866' also had better fresh eating quality than 'Li', 'Shanxi Li', 'Redland', and 'Daguazao'. 'Sandia' already had a reasonable flavor starting at the creamy stage, whereas the large-fruit cultivars ('Li', 'Shanxi Li', 'Daguazao', 'Dabailing', and 'Redland') had a better flavor when they were at the half creamy/half red stage. If they were picked before the creamy stage, the fruit were very mild, which is a common problem in the market now. Growers tend to pick the fruit early, which can make bruising more common and it compromises fruit quality and flavor.

Fruit maturation season. 'Alcalde #1' was the earliest cultivar among the 60 cultivars/selections tested at Alcalde and could become the dominant cultivar in short-season

Table 4. Tree growth (canopy height and width), uprightness, and branch number of different jujube cultivars after 3 years of growth at Alcalde (AL) and Los Lunas (LL) in Mar. 2018.

	Ht (cm)		Width (cm)		Uprightness (1–4)[z]		No. of branches	
Cultivar	AL	LL	AL	LL	AL	LL	AL	LL
Alcalde #1	285	291	195	148	3.5	2.3	8.3	4.0
Daguazao	305	294	241	130	3.3	1.5	8.3	2.5
GA866	343	367	176	186	2.0	1.8	2.3	2.4
Gaga	340	319	164	128	1.5	1.3	1.5	1.5
Honeyjar	305	241	156	123	2.5	2.0	4.3	5.7
KFC	339	308	245	155	3.3	2.3	5.3	4.5
Li	288	298	246	209	3.0	3.0	6.0	4.6
Maya	335	310	199	145	2.0	1.3	2.3	1.0
Redland	344	286	240	245	3.0	3.8	6.8	8.8
Sandia	224	268	204	141	4.0	2.8	11.8	6.0
Shanxi Li	288	290	219	160	3.1	2.0	5.0	2.8
Sugarcane	296	320	223	219	4.0	3.2	5.5	7.6
Zaocuiwang	230	275	214	184	3.3	2.5	5.0	4.3
Mean	302	297	209	167	3.0	2.3	5.5	4.3
Critical value[y]	65.4	17.5	51.6	44.0	0.9	0.9	3.8	3.0
Chico[x]	328	340	193	208	3.5	3.0	9.5	7.0
Russian 2	251	306	146	147	3.3	1.9	5.9	1.2

[z]Criteria for uprightness: 1 = upright; 2 = more upright than bushy; 3 = bushier than upright; 4 = bushy.
[y]Critical values are used to compare significant differences in the same column. If the difference between any two cultivars in the same column is larger than the critical value, the difference is significant at $P \leq 0.05$ by Fisher's protected least significant difference procedure.
[x]'Chico' and 'Russian 2' were for reference only because we did not have enough plants for full replications.

regions. 'Honeyjar', 'Maya', 'Gaga', and 'Sugarcane' were also relatively early cultivars. 'KFC', 'Li', 'Shanxi Li', 'Redland', and 'Daguazao' were midseason cultivars whereas 'Sandia' and 'Jing 39' were the latest to mature. Because 'Sandia' has reasonable flavor at the creamy to 20% red stage, it is—at best—marginal in northern New Mexico but ideal for central and southern New Mexico or similar areas.

'Honeyjar', 'Maya', and 'Russian 2' had excellent fruit quality but small fruit. They are a perfect fit for the home gardener market. For commercial production, the labor cost for picking has to be considered with small-fruit cultivars. 'Sandia' is not as precocious as other jujube cultivars, but the fruit quality compensates for its lateness. It is recommended for commercial production and home gardeners. 'KFC' was the most productive cultivar, with shiny fruit, very good fruit quality, and high potential for commercial production and home gardeners. Some large-fruit cultivars such as Li, Shanxi Li, Daguazao, and the midsize Sugarcane do have wrinkled fruit before they are fully colored or just fully colored.

Thorn length. In general, thorn length varied with cultivar, branch type, and age. Trees became less thorny as they aged. In the same cultivar, vigorous water sprouts had longer thorns than weak shoots. Most cultivars followed this pattern except for Daguazao and Gaga, which had more vigorous shoots in 2018. 'Alcalde #1', 'Li', and 'Chico' were thornier than other cultivars, whereas GA866, Honeyjar, Maya, and Sandia were less thorny than others when they were young trees; their 1-year-old branches were also thornless (Fig. 3). Although the cultivars were not evaluated for this study, trees of 'Lang' and 'Junzao' were almost thornless from 1- to 3-year old shoots (unpublished data).

Pests and diseases. From 2015 to 2018, we did not notice any insect or disease problems at Alcalde or Los Lunas, but we did notice raccoon damage at these locations. The Alcalde site was surrounded by an electrically wired fence that provided enough protection from raccoons and elk. At Los Lunas, the raccoons not only ate the fruit, but also broke large branches. One specimen of 'Russian 2' had no fruit harvested for either 2017 or 2018, but several hundred fruit were noted during the fruit estimation in late August. At the Leyendecker center, birds, not raccoons, caused the majority of fruit loss.

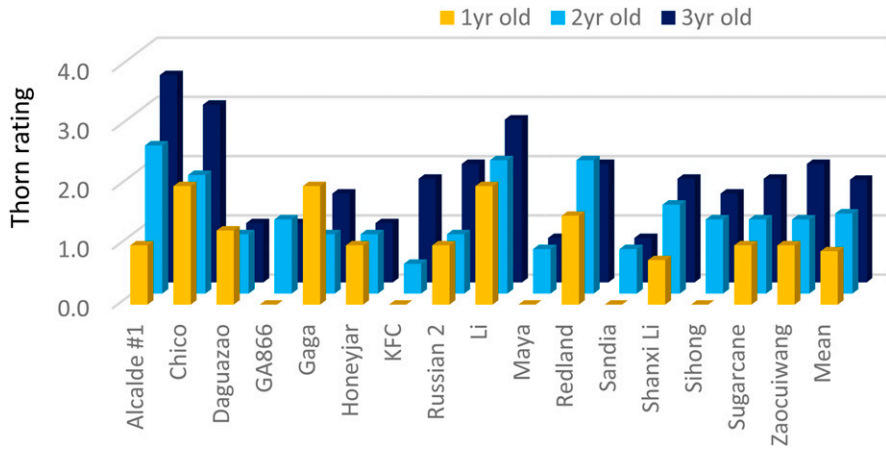

Fig. 3. Thorn lengths on branches of different ages of different jujube cultivars at Alcalde, NM. Evaluation criteria: 0, no thorns; 1, thorns 0 to 6 mm; 2, thorns 6 to 13 mm; 3, thorns, 13 to 25 mm; and 4, thorns >25 mm. KFC, 'Kongfucui'.

Discussion

Precocity. Jujube trees are more precocious than most temperate fruit tree species such as apple, apricot, peach, pear, cherry, persimmon, and so on. In China, there is a saying that it takes 3, 4, and 5 years for a peach, apricot, and pear tree to bear fruit, respectively, but you can have cash value on the planting year for jujube. Our trials showed that this is the case. With good field management, 90% of trees produced anywhere from a few to more than 100 fruit during the first year. We also noticed some cultivars such as 'Li' and 'Honeyjar' producing 30 to 50 fruit during the grafting year. During the second year after planting, all trees at all three locations produced from a few fruit to several kilograms per tree, depending on cultivar and location. Home gardeners would enjoy the precocity of jujubes for their quick and rewarding harvest.

Cultivar performance by location and fruit uses. From Alcalde to Las Cruces, jujube trees all grow and fruit well, but northern New Mexico has more limitations. Late cultivars such as 'Sandia' may or may not be fully mature when the early first frost arrives around Oct. 10 each year. Fortunately,

'Sandia' tastes sweet enough when the fruit is in the creamy stage. As a result, 'Sandia' is recommended for commercial production for central and southern areas of New Mexico or similar areas. Home gardeners can try it in northern New Mexico, but the higher elevation and colder temperatures of Santa Fe and Taos do not allow full maturation. 'Alcalde #1' has large fruit, early maturation, and good quality, and would be a good fit for Santa Fe and Taos or similar areas with a short growing season. 'Li', 'Redland', 'Shanxi Li', 'Daguazao', and 'Dabailing' do well in northern New Mexico but they fruit better in central and southern areas of New Mexico. The large-fruit cultivars Li, Redland, Shanxi Li, and Daguazao are very productive, but fruit quality is not as good as Sandia, Honeyjar, Maya, and Russian 2. Small-fruit cultivars Honeyjar, Maya, and Russian 2 are perfect for small growing operations and home gardeners because they have excellent fruit quality and are very productive and precocious. For commercial growers, the high labor cost associated with picking small fruit should be considered. 'KFC' ranks first for yield, even in northern New Mexico. With its high yield, shiny fruit, and very good fruit quality, it is a good choice for commercial growers. Growers from central and southern New Mexico can grow all fresh eating cultivars. 'Jing 39' is a potential late-maturing commercial cultivar for southern New Mexico or similar areas.

Fruit uses. Jujube cultivars have been traditionally classified as fresh eating, drying, multipurpose, processing, and ornamental. 'Li' is a typical fresh eating cultivar and is dominant in the jujube market in the United States now, but it was used as a drying cultivar in Lucerne Valley, CA. Cultivar classification for different uses is not clear, especially in the southwestern United States With a long growing season, fruit of 'Li' can reach soluble solids levels of 33% or higher and the quality of the dry products are reasonable in Lucerne Valley, CA. For most areas, cultivar Li is better used as a fresh eating cultivar. Any cultivar with a high soluble solids content can be used as a drying cultivar (e.g., Sugarcane, KFC, GA866, Sandia, and Alcalde #1), and can be classified as fresh eating or multipurpose cultivars.

Future report. This is an early performance summary of jujube cultivar trials in different USDA hardiness zones in the southwestern United States We will continue the trials and review their performance again when the trees are 8 to 10 years old. These trials involved little cultural intervention. For jujube trees, girdling and gibberellin application are common practices in China (Guo and Shan, 2010). The productivity of nonprecocious cultivars such as GA866 and Sandia may be improved through girdling or gibberellin application.

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