Project Title: **Jujube: a New Fruit Crop for Utah Production and Edible Low Water Landscapes 2012-14**

1. Project Summary: Jujube (*Ziziphus jujuba* Mill.; also known as a Chinese date) is a drought tolerant fruit tree unknown in Utah but is widely grown in Asia for fruit quality and health benefits, both fresh and dried. Jujube tolerance of cold and dry conditions in China ostensibly suggests that it should tolerate Utah's cold, dry and high pH conditions. Jujube's drought tolerance is partly due to small, glossy leaves and deep root system that are also attractive for low water landscaping, particularly edible landscaping, and possibly small fruit production in Utah. However, there has been no systematic evaluation of jujube in Utah to provide a basis for recommendations to producers and home owners. In particular there is no information on minimum water needs of jujube important for production under limited water supplies and in low water edible landscaping that is becoming increasingly important. USU was awarded two sequential Specialty Crop Block Grant, 2012-2014, to study jujube water use and performance in Utah.
   Jujube growth and water relations were studied in 2012, showing high rates of photosynthesis and transpiration, and indeterminate growth that continued partway into fall However, during the 2013 growing season trees showed iron deficiency symptoms of leaf yellowing and no response to nitrogen fertilization high water pH. Compounding iron deficiency, extreme cold in early December 2013 killed aboveground scion wood in 90% of the plants. Undamaged roots produced many undesirable suckers. Based on these results, these two jujube cultivars tested (Lang and Candy Cane) are not well adapted to northern Utah's high pH and risk of early, extreme cold. New Mexico State University is studying jujube in greater detail, where more information about more about jujube production in the U.S. Intermountain West is available:
   - General overview of jujube: http://aces.nmsu.edu/pubs/_h/H-330.pdf
   - Detailed overview of jujube: http://hos.ufl.edu/sites/default/files/faculty/gdliu/Jujubes.pdf
   - Jujube cultivar trial: https://newscenter.nmsu.edu/articles/view/10225/nmsu-studying-30-chinese-varieties-of-jujube-fruit-new-to-u-s

   Finally, this particular project at the overall level does have one research paper on jujube nutritional value that is a collaborative work with Chinese colleagues at Northwest Agriculture and Forestry University near Xi'an China: http://works.bepress.com/roger_kjelgren/146/

2. Project Approach. Jujube water use under different levels of water stress was the main data collected in this project.

   a. To measure water use and control water applications, we developed a hanging load-cell lysimeter system that consisted of 32 load cells attached to supported beams four meters above the ground, from which trees in containers were hung by chain. The load cells were connected to a data logger that measured and logged the change in daily weight of the hanging containers due to transpiration that we define as jujube volumetric water use. The amount of water used the previous day is then replaced at 110% to ensure the plants are not water stressed.

   b. Twelve plants each of the jujube cultivars 'Candy Cane' and 'Lang' were grown in 2012 in organic substrate in 10-gallon containers suspended from the load cells in an organic

media with slow-release fertilization at the USU Greenville farm. All plants were allowed to grow normally until July during which water use water measured.

c. During the entire 2012 season total tree leaf area was measured weekly by counting the number of unfolded leaves. The product of leaf count and average leaf area yields total transpiring leaf area; prior to autumn leaf fall all leaves were collected and measured with a leaf area meter to calculate final total leaf area. Daily tree water use in depth units is then calculated by dividing volumetric daily water use by leaf area estimated for that day. Depth of daily tree water use is then divided by local evapotranspiration rate (ETo; collected from the USU-Greenville weather station) for that day to calculate a jujube crop coefficient that can be applied to ETo to estimate jujube irrigation requirements.

d. In July water stress treatments were applied by replacing the previous day's water use at 75% for two weeks. Concurrently, leaf stomatal conductance and water potential are measured to assess jujube water stress level. After two weeks the trees were re-watered and allowed to recover for a week, then the procedure was repeated twice more during the season.

e. The study was not repeated in 2013 because the graduate student responsible for the project took a position in the private sector. In 2014 we had a Chinese student to work on the project, but all but two scions (specific jujube cultivar top) died from cold.

3. Project Achievements. The graduate student working on the project is determined to finish analysis and complete his MS degree he was able to process water use data from 2012 and calculate the ratio of jujube water use to reference evapotranspiration (crop coefficient Kc).

Figure 1. Top. Jujube tree at left survived early, extreme cold in December 2013. Tree at right shows the top (cultivar scion wood) is dead, with a vigorous shoot emerging from the rootstock. Bottom. Close up of root sprouts from damaged tree.

However, jujube showed a catastrophic response to environmental stress in Utah. As mentioned in the previous annual report, jujube appeared sensitive to iron deficiency. Jujube's drought tolerance ostensibly implies a certain degree of high pH tolerance that is associated with dry climates. However, this was not the case in Utah. While the trees were maintained well watered but no data collected in 2013, we observed leaves yellowing but not responding to nitrogen, strongly suggesting iron deficiency caused by high pH. This response is a major concern because most Utah soils are of sufficiently high pH that iron deficiency could be a pervasive and difficult correct problem. Correcting iron deficiency is possible with chelate iron, but iron chelate is very expensive and needs application every several years, adding cost and dimming economic and landscape potential and interest in jujube.

In addition to pH sensitivity/iron deficiency, jujube has shown itself intolerant of early season extreme cold temperatures. The first week of December, 2013, temperatures plunged from 40 F to 5 F for several days without temperatures cold enough to precondition the trees. Spring of 2014, the top (scion) wood of all but two trees was dead from the cold, while the root systems were still alive, and the rootstock sent out new but commercially useless shoots (Figure 1). Consequently there were too few healthy trees to conduct further research.

However, one paper has emerged from the larger jujube project that was conducted in China and looks at nutritional value of jujube: Wu, C., Q. Gao, R. Kjelgren, X. Guo, and M. Wang. 2013. Yields, phenolic profiles and antioxidant activities of Ziziphus jujube Mill. in response to different fertilization treatments. Molecules. 18:12029-12040.

4. Project Beneficiaries. Given jujube's sensitivity to both pH/iron deficiency and cold, these jujube cultivars have no future in northern Utah's climate. It has merit as a specialty tree for horticultural enthusiasts, but I cannot promote jujube for low water landscaping because of its pH and cold sensitivity. However, a jujube cultivar trial is underway at New Mexico State University where cultivars that could possibly perform better in Utah may be identified. A link to a description of this trial is at the end of the front page summary in this document.

5. Lessons Learned. Jujube does grow well in Utah, up to a point. In 2012 the trees grew nearly two feet of indeterminate branch elongation that did not stop until first frost. However, while the trees were maintained well watered but no data collected in 2013, other technical support observed the trees yellowing but not responding to nitrogen, strongly suggesting iron deficiency. This response is a major concern because most Utah soils are of sufficiently high pH that iron deficiency is a common problem in sensitive plants, of which jujube clearly is. Sensitivity to pH/iron deficiency could have made jujube more vulnerable to cold, but since northern Utah's is characterized by high pH soils and extreme cold temperatures, the **jujube cultivars trialed in this study are not suitable for growing in northern Utah** beyond being a horticultural curiosity for backyard enthusiasts. Again, cultivar trials by New Mexico State University at Alcalde NM, just north of Santa Fe, may identify cultivars that may be worth the investment to study in Utah, but there still may be limitations to growing jujube in northern Utah where winter temperatures are colder than northern New Mexico, and an even greater limitation is high pH sensitivity and resulting iron deficiency that is very common in northern Utah soil.

6. Dissemination. This report will be deposited in Utah State University's Digital Measures online file repository system

7. Project Contact: Roger Kjelgren, 435-797-2972, roger.kjelgren@usu.edu