Evaluation of Fruit Quality and Production of Cold-Hardy *Opuntia* Fruit Clones

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Due to the high water-use efficiency of cacti, the presence of high quality fruits in some *Opuntia*, and the need to increase economic returns for semi-arid regions in Texas, a major *Opuntia* germplasm collection was established at Texas A&M University-Kingsville. The collection was begun in 1984 with funding from the U.S. National Science Foundation. With the assistance of post-doctoral fellow, Charles Russell, and Research Scientist, Henri LeHouerou, fruit, forage, and vegetable *Opuntia* clones were obtained from Mexico, Chile, Argentina, Brazil, South Africa, and northern Africa.

Despite a minor freeze (–9°C) in the winter of 1984–1985 that damaged many clones, many cacti were 3 to 4 m tall in the summer of 1989 and produced excellent yields and fruit quality (Gregory et al., 1993). Spiny clones from Mexico (1288 and 1287) had particularly sweet fruit and high yields. In the summer of 1989, about 30 clones were being examined in a randomized complete block design with 3 replications. A severe freeze in December 1989 with minimum temperatures of –12°C and 60 consecutive hours below freezing killed all the clones described by Gregory et al. (1993) to ground level.

Since 1989, about 75 new clones with potential for increased cold hardiness were obtained and established in the field at Texas A&M University-Kingsville. In all cases, we have used the name for the species that was provided by the collector or source of origin. For *O. streptacantha*, *O. megacantha*, *O. amyclea*, *O. inermis* and *O. hypticantha*, there is uncertainty about the species identification.

These clones were obtained in three phases. The first 15 cold-hardy clones were obtained in a germplasm exchange with Ing. Fernando Borrego-Escalente in March 1991 (Borrego-Escalente et al., 1990). A second phase occurred in October 1991 when 10 clones (red, purple, orange, and green, with and without spines) were obtained at 2,200 m elevation in the mountains near Saltillo, Mexico (Barrientos et al., 1992). The third phase occurred in October 1993 when Dr. Avinoam Nerd and Peter Felker collected fruit-bearing *Opuntia*s in high elevation sites in the Chihuahuan desert (from Saltillo to Casas Grandes), which is Mexico's most northern desert. In August 1995, the cactus germplasm collection at Texas A&M University-Kingsville included about 130 clones. Seventy-five of these clones have been obtained since 1991 from locations that should experience severe freezing weather similar to Kingsville.

In the summer of 1995, many of the *Opuntia* fruit clones obtained from the University of Saltillo's cold-hardy fruit germplasm collection produced substantial numbers of fruit. Some of these clones originated from the breeding materials of Dr. Lorenzo Martinez Medina that survived the freeze (–18°C) of 1962 in Saltillo without damage.

While none of the clones collected with Dr. Nerd in October 1993 have fruited, many of the cold-hardy clones established in 1991 have fruited. Since there are about 130 clones in the field, we only provide here the top 10 fruit producers and the top 10 clones for fruit quality as evaluated by sugar content. The pH and sugar contents were measured on a homogenized filtrate with a portable refractometer that was calibrated with a glucose solution. Sugar contents of 12% are marginal in terms of quality. The fruits should be 13-14% to be top quality. The fruit yield was obtained by taking the mean fruit number and weight per plant and multiplying by 2500 plants/ha at the 1 × 4 m spacing.

Clearly, the Chilean clones (1319 and 1321) had the highest sugar content (Table 1). In a previous three-year study of fruit production and quality (Gregory et al., 1993), the Chilean clone 1321 had the highest sugar content (13.7%) and the greatest cold hardiness of all the spineless cacti. Of the six clones in Table 1 for which the cold hardiness is known, clone 1321 from Chile had the greatest cold hardiness. It is highly possible that clones 1383 and 1390 from the Borregos collection from Saltillo, Mexico may prove to have equal or greater cold hardiness.

All but two clones had a fruit pH of about 6.3. One of us (JP) thought the fruit flavor of clone 1383 was very agreeable due to a greater acidic taste in combination with the high sugar content. This is supported because clone 1383 had a pH of 5.8 while the other clones with a sugar content >13% had a pH of 6.3. Unfortunately, this clone also had a large number of spines. Clone 1287, with large orange fruits, has a fruity flavor and has always been a favorite of Felker.

This past year, production was excellent. The top 10 producers ranged from 10 to 45 ton/ha (Table 2). These yields may be an overestimate for commercial production because they were based on a row-plot of five plants. Nevertheless, yields for nonirrigated plantations as low as 10 to 15 ton/ha should be profitable at prices of $0.50/lb. Some of the clones are tall (3 to 4 m) and some pruning will be necessary to avoid using ladders when picking the fruit.

Fortunately, there were clones that had good fruit production and favorable sugar contents (marked with an asterisk in Table 1). The spineless *O. streptacantha* (1281) with the greatest overall fruit production (45 ton/ha) had the 9th greatest sugar content of 12.5%. The spiny green-fruited variety *O. megacantha* (1383), from the Universidad Autonoma Agraria Antonio Narro had the third highest sugar content (13.4%) and the 4th highest fruit production (22 ton/ha). The spineless yellow fruited variety 1278 had a very similar fruit sugar content (13.1%) and identical yield to 1383, but it probably has less cold tolerance than 1383. *O. ficus-indica* (1294) had only slightly less fruit production and sugar content than 1278 and 1383.

Unfortunately, one of the highest yielding fruit producers, 1277, which also had good cold tolerance, had a low fruit sugar content of 11.6%. It is also unfortunate that the spineless clone 1300, which had exceptionally beautiful large purple fruits, did not have a great enough sugar content to be among the top 10 sugar producers. Conversely, the Chilean clones with the very highest fruit sugar content of 13.7% (1321) and 14.6% (1319) had very low fruit yields of 1.2 ton/ha and 6.3 ton/ha, respectively. Despite the greater production and sugar content of clone 1319, it was less cold hardy (28% cold-hardiness score) than clone 1321 (88% cold-hardiness score).

However, our previous work (Karim et al., 1994) showed that fruit sugar concentration can be increased with fertilization. A cladode concentration of about 2.2% Mg was optimal for sugar concentration in cactus clones. This study also found that NPK fertilization significantly increased fruit sugar content. N fertilization has been shown to be very important in stimulating fruit production in some *Opuntia* (Nerd et al., 1993). Perhaps cultural practices can be identified that will increase the production of the high-sugar-content Chilean clones.

SUMMARY

With only five years growth and only two years fruit production, recommendations as to the most promising Opuntia fruit clones for south Texas must be considered very tentative. Nevertheless, some consistent trends are apparent. The clones with the greatest sugar concentrations are of Chilean origin, but these Chilean varieties have low production. The three most productive fruit-producing clones (production ranging from 34 to 45 ton/ha) had only marginal sugar concentrations. Trials should be conducted with Chilean clones 1319 and 1321 with the goal of improving their production. Trials should be conducted with clones 1277 and 1380 with the goal of improving their fruit sugar content. In the interim, it appears that the spiny clone *O. megacantha* (1383) with 22 tons of fruit/ha and 13.4% sugar holds the greatest potential as a commercial fruit cultivar.

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Table 1. Top 10 Sugar Producers Among Cactus Pears, Summer 1995

Species Access # and Origin	UAAAN #	Sugar %	Fresh Weight (g)	Color	pH	Frost score	Thorn (+/-)
O. ficus-indica 1319 CH		14.6	124	Green	6.3	28	-
O. ficus-indica 1321 CH		13.7	121	Green	6.3	88	-
*O. megacantha** 1383 MX	AN-T3	13.4	125	Green	5.8	n.a.	+
*O. ficus-indica** 1278 MX		13.1	121	Yellow	6.5	n.a.	-
*O. ficus-indica** 1294 MX		13.0	122	Yellow	6.2	64	-
O. ficus-indica 1279 MX		12.8	135	Red	6.3	n.a.	-
O. megacantha 1390 MX	AN-TV6	12.8	118	Yellow	6.3	n.a.	-
O. hyptiacantha 1287 MX		12.6	159	Orange	6.4	26	+
*O. streptacantha** 1281 MX		12.5	136	Red	6.3	47	-
*O. ficus-indica** 1320 CH		12.2	150	Orange	5.9	57	-

Abbreviations for origins are: MX=Mexico, CH=Chile
UAAAN # = code for Universidad Autonoma Agraria Antonio Narro
Frost score is estimated percentage of aboveground height remaining after the freeze of 1990.
* Species that were also the highest 10 species for production

Table 2. Top 10 Fruit Producers Among Cactus Pears, Summer 1995

Species Access. #	Origin	UAAAN #	Fruit Color	Thorn (+/-)	Yield tons/ha	Frost Score
*O. streptacantha** 1281	MX		Red	-	45	47 ±0
O. ficus-indica 1277	MX		Yellow	-	34	80 ±13
O.megacantha 1380	MX	AN-V5	Yellow	-	34	n.a.
O. ficus-indica 1300	MX		Purple	-	22	52 ±16
*O. megacantha** 1383	MX	AN-T3	Green	+	22	n.a.
*O. ficus-indica** 1278	MX		Yellow	-	22	n.a.
*O. ficus-indica** 1294	MX		Yellow	-	19	64 ±16
O. inermis 1270	BZ		Yellow	-	15	38 ±18
*O. ficus-indica** 1320	CH		Orange	-	15	57 ±23
O. megacantha 1297	MX		Green	+	10	n.a.

Abbreviations for origins are: MX=Mexico, BZ=Brazil, and CH=Chile
Frost score is estimated percentage of aboveground height remaining after the freeze of 1990.
UAAAN # = code of Universidad Agraria Autonoma Antonio Narro
* Species that were also in highest 10 species for sugar content