Sugarbeet Production in Puerto Rico

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INTRODUCTION

The potential of sugarbeets as a supplementary or alternative sugar crop for Puerto Rico has been explored.

Mechanization of sugar production is necessary for efficient operation. Machinery needed for the production of sugarbeets costs much less than that required by sugarcane. Sugarbeets have a higher content of sucrose than sugarcane and processing per ton of harvested product is cheaper. The by-products of sugarbeet production (leaves and crown) and of sugarbeet processing (pulp) are excellent feeds for ruminants.

No reports of previous attempts to cultivate sugarbeets in Puerto Rico have been found. However, some reports are available of trials with sugarbeets in areas which have a climate and geographical location comparable to Puerto Rico.

In Hawaii, sugarbeets were planted in 1910, 1911, 1917–18, 1948, 1959, and 1960 as reported by Younge and Butchart (*26*)[2], whose bulletin on sugarbeet trials during 1959 and 1960 by the Hawaiian Commercial and Sugar Co. is among the most complete accounts of sugarbeet production in the tropics. Root yields varied from 15 to 23 tons per acre. However, they recognized the potential sugarbeets might have as an interrow crop during the first 6 months of sugarcane growing and as a crop on land that would be idle at certain times. They concluded that beets could not compete with sugarcane in Hawaii unless sugar content could be increased to at least 18 percent vs. the 12 to 15 percent they were getting in two sugarbeet crops grown consecutively on the same land within a period of 12 months.

In Taiwan (Formosa), the Japanese experimented with sugarbeets during the second world war (*5,13*). The Chinese resumed experimentation in 1954 on a more extensive scale for the special purpose of studying the feasibility of interplanting sugarbeets with rice or sugarcane (*5,16,25*). Results were very promising, but it was concluded that beet culture was not feasible because of the prohibitive cost of adapting a sugarcane mill to beet processing. The value of beets for feed for cattle and hogs was em-

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[2] Numbers in parentheses refer to Literature Cited, p. 128–9.

phasized. Taiwan has a cool climate in the months of December to March, which prevents heavy infestation of *Cercospora* leaf spot. Yields of sugar averaged 1.4 T/A with a range of 1 to 3.5 T/A (*3,4,5,6,7,16,21,25*).

Sugarbeets also have been tried in South Florida (*15*), and West Kenya (*9*), but in these locations yields were inferior to those obtained in Hawaii or Taiwan. In the Rio Grande Valley, Texas, extensive tests showed that high root yields (40 tons/acre) with about 11.5 percent sugar could be obtained on certain soils when planted in early October and harvested in April–May (*18*).

MATERIALS AND METHODS

Because the evaluation of sugarbeets was initiated to test their potential as an alternative or supplementary crop to sugarcane, the test sites chosen were in sugarcane areas. Four of the six Substations of the Agricultural Experiment Station, University of Puerto Rico, were selected for this purpose:

1. Fortuna Substation is located on the south coast at an elevation of 68 feet, on level, well drained San Antón silty clay loam, a Fluventic Mollisol with pH 7.0. The highest yields of sugar per acre from sugarcane are obtained on the Island in this area.
2. Lajas Substation, with an elevation of 100 feet, is located on level, slowly permeable Fraternidad clay, a Vertisol with pH 7.0, also on the south coast in the Lajas valley, which is for the larger part in sugarcane.
3. Isabela Substation, with an elevation of 400 feet in the northwest corner of the Island, is located on nearly level Coto clay, a very well drained Oxysol with pH 6.5. Although sugarcane and dairy farms occupy most of the land, tobacco, pigeon peas, papaya, and vegetables also are grown.
4. Corozal Substation, with an elevation of 600 feet, is located in the foothills of the northern part of the Island, on slightly sloping somewhat poorly drained Corozal clay, an Ultisol with pH 5.0. Some sugarcane is planted there but most of the land is in pasture, root crops and bananas.

Puerto Rico lies at latitude 18° N. and longitude 67° W. A chain of mountains divides the Island over its entire length into a more humid northern area and a dry plain on the south coast. This is due mainly to the northeasterly trade winds which keep temperatures moderate and even through most of the year with rather small differences between north and south at comparable elevations.

Average climatic data for each of the sites are given in table 1.

Field testing was started on April 1, 1963 with the establishment of

an observational trial in Fortuna with 42 *Beta vulgaris* introductions from Turkey, Iran, Ethiopia, India, Afghanistan and Burma supplied by the USDA Plant Introduction Station at Ames, Iowa. Plot size was 6 X 25 feet. The trial was harvested in August 1963. On January 15, 1964 the same 42 introductions, plus sugarbeet varieties U.S. H-2, U.S. H-5, U.S. H-6 and U.S. 75, supplied from Salinas, Calif., by USDA, were planted in a similar observational trial at Fortuna.

Plot size for the 42 introductions was 6 X 25 feet and for the four California varieties 36 X 50 feet. These plots were harvested July 3, 1964. Larger scale tests, consisting of identical replicated trials with nine varieties, were established in Fortuna, Lajas, Isabela and Corozal in October 1964. Varieties included were SP 5822-0, SP 6322-0, (SL 126 MS x 128) MS x SP 6322-0 and (SL 129 MS x 133) MS x SP 6322-0, which are commercial *Cercospora* resistant lines from Michigan Also included in this planting were US 56-2, US H-2, US H-5, US H-6 and US 401, commercial

TABLE 1.—*Average rainfall and temperature at the four test sites*

Site	*Rainfall*	*Annual temperature*	*Minimum annual temperature*	*Maximum annual temperature*
	Inches	*Average*	*Average*	*Average*
Fortuna	37.5	79° F	69° F	87° F
Lajas	45.6	77	68	86
Isabela	66.8	77	67	85
Corozal	76.8	76	66	84

varieties developed by USDA, of which only US 401 has resistance to *Cercospora*. Plot size was 20 X 25 feet, with six replications.

A number of trials with the varieties named were repeated as follows:

Fortuna: planted 10/19/64—harvested 5/18/65
planted 1/02/65—harvested 6/15/65
Isabela: planted 11/18/64—harvested 6/07/65
planted 2/15/65—harvested 6/21/65
planted 3/30/65—harvested 9/27/65
Lajas: planted 10/28/64—harvested 6/01/65
planted 3/18/65—harvested 6/28/65
Corozal: planted 11/24/64—harvested 4/28/65

Seven of the nine varieties (excluding US 56-2 and US 401) were selected for a similar series of experiments in 1965–66 at Lajas, Isabela and Fortuna. No more seed of (126 x 128) MS x SP 6322-0 could be obtained, and at the suggestion of the supplier (126 x 128) MS x SP 5822-0 was substituted. For the first plantings at Fortuna and Isabela, plot size was 7 X 36 feet, with six replications. Each plot was duplicated; one was treated with 40

gallons of DD per acre 2 weeks before planting and the other received no nematocide. For the other 1965–66 trials, plot size was 14 X 36 feet, with six replications.

Planting and harvesting dates were:

Fortuna: planted 12/01/65—harvested 5/31/66
planted 1/12/66—harvested 7/14/66
Isabela: planted 11/10/65—harvested 5/16/66
planted 1/12/66—harvested 6/28/66
Lajas: planted 2/01/66—harvested 7/15/66

In addition to these replicated tests, observational trials were established in 1965 at the same sites involving the following varieties: S-102-H2, US H-7, US H-8, S-101-H7, S-301 H4, S-301-H6, S-201-H5 and S-202-H4 obtained from ARS, USDA Sugarbeet Experiment Station, at Salinas, Calif.; KWS Cercopoly from Germany; US 201 (SP 581001-0), US 401, SL 126 x SP 5460-0 and US H6 (Acc 2633) obtained from ARS, USDA at Beltsville, Maryland; Semarave, H-741, Cecerave, US-75 and Polyrave from The Netherlands. No fungicides were applied during these trials. Plot size was 7 X 36 feet. Planting and harvesting dates were as follows:

Isabela: planted 10/29/65—harvested 5/16/66
planted 1/12/66—harvested 6/28/66
Fortuna: planted 11/05/65—harvested 4/14/66

A planting was made at Lajas but it failed because of cutworm damage.

Only one replicated trial was established at Isabela during the 1966–67 season, planted on October 31, 1966 and harvested on June 15, 1967, and at Fortuna, planted on December 7, 1966 and harvested on June 15, 1967. The varieties tested were: Polyrave and Cecerave from the Netherlands; Maribo Resista-Poly and Maribo Magna-Poly from Denmark; (SL 126 MM x 128) MS x SP 5822-0 from Michigan; KWS Polybeet and KWS Cercopoly from Germany. Plot size was 14 X 36 feet, with six replications in a completely randomized block design.

Observational trials were conducted at each of these same sites in 1967; at Fortuna planting was made January 19, 1967 and harvested August 14, 1967; planted at Isabela December 29, 1966, and harvested August 17, 1967. The following commercial varieties were included: Polyrave and Cecerave from the Netherlands; KWS Polybeet and KWS Cercopoly from Germany; SP 5822-0, (SL 126 MM x 128) MS x SP 5822-0, SP 6322-0 and (SL 129 MS x 133) MS x SP 6322-0 from Michigan; US H-6, US H-5B, US H-2 and US 401 from USDA, Salinas, Calif.; and S-102-H2, an experimental variety from USDA. Plot size was 7 X 36 feet, replicated twice; one replication was treated with Brestan. The other received no fungicides to check on the effectiveness of this fungicide.

All tests had to be sprayed at 7-day intervals to control *Cercospora*

leaf spot and webworm (*Psaris bipunctalis*). In 1963, 1964 and 1965, Manzate was used at recommended rates for the control of *Cercospora beticola*, but this chemical was replaced in 1966 and 1967 by Brestan (triphenyl tin acetate) at the rate of 8 ounces of 60-percent wettable powder per acre. DDT was used at the rate of 2 pounds of 50-percent wettable powder per acre for the control of webworm. Overhead irrigation was applied at Fortuna. Lajas and Isabela until the plants were well established afterwards all plots were furrow-irrigated about every 10 days whenever necessary. No irrigation was employed at Corozal.

The land for all experiments was prepared by plowing, disking and the making of beds separated by furrows 2.5 feet apart on center. Seeds were planted by hand on top of the beds at a depth of about ¼ inch. In 1963, one row was planted on each bed but two rows were planted thereafter on beds 3.5 feet apart on center so that all rows were about 21 inches apart. The beets were prethinned as soon as the first pair of true leaves emerged by cutting across the row with a hoe leaving small groups of seedlings. When the seedlings in these groups had four leaves, they were thinned by hand to one plant every 12 inches.

Fertilizer was broadcast on top of the bed before emergence. In 1963 and 1964, the rate of application was 500 pounds of 10-10-10 fertilizer per acre. In 1965, 1966 and 1967, the rate of application was increased to 1,000 pounds per acre. In addition, in 1963 and 1964, ammonium sulphate was top-dressed at the rate of 500 pounds per acre before the plants covered the ground completely. In 1965–67, 250 pounds of ammonium sulphate were applied per acre after thinning. TCA and Endothal at 5 and 4 pounds active ingredient per acre, respectively, were applied together in 1966 the day after seeding as a preemergent spray. Weeds developing thereafter were eliminated by hoeing. Pyramin at 4 pounds active ingredient per acre was substituted in 1967 for Endothal.

Harvesting began when the beets were at least 6 months in the ground, but sometimes earlier because of *Cercospora* or webworm damage. In 1967 harvesting was started after 7 months.

The beets were harvested by lifting the entire plant out of the ground with a spade or fork and the head with leaves was separated from the root by cutting with a cane-knife about an inch below the lowest green petiole. In 1966 and 1967, plants at Isabela were lifted out of the ground with a double moldboard plow. The roots and tops in each plot were counted and weighed separately. A sample of six roots was taken from each plot and analyzed to determine degrees Brix and percent sucrose. However, of the first observational test conducted in 1963, only a refractometer reading was taken.

The results of 10 of the 14 replicated tests were analyzed statistically.

RESULTS AND DISCUSSION

Fourteen replicated trials and 7 observational trials were grown during the period from April 1, 1963 to August 17, 1967, at four different locations. These trials were extended over 5 crops; (1) summer 1963, (2) winter 1963–64, (3) winter 1964–65, (4) winter 1965–66, and (5) winter 1966–67. The trials with 42 *Beta vulgaris* introductions gave promising results and encouraged continued testing on a more extensive scale.

Yields at Corozal were low and of poor quality; this site thus was discarded after the first replicated crop of 1964–65. The low pH and a high incidence of leaf spot caused by *Cercospora beticola* were probably reasons for the low yields. The location in the Lajas Valley was abandoned as unsuitable in 1966. Soils in the valley are only slowly permeable and roots stood in water-logged soil for some time after each irrigation. As a result, a high percentage of them were damaged by root rot, caused mainly by *Sclerotium rolfsii.*

PLANTING DISTANCE

The spacing of 30 inches between rows proved too wide. Yields were low and the beet foliage did not cover the ground completely thus permitting weed competition during the entire growing period.

A distance of 21 inches between rows and 12 inches within the row was employed starting with the 1965–66 crop. This combination, which gives a perfect stand of about 20,700 plants per acre, is considered optimum in many beet growing areas (*14*).

WEED CONTROL

Of the two herbicide combinations tested, Endothal with TCA produced better weed control than Pyramin with TCA. These and other combinations were found effective elsewhere (*1,8,17,19,24*). The use of the first combination is expected to be equivalent to at least one hand-hoeing operation. The use of such an herbicide, while applying all the fertilizer at planting to make the beets cover the ground rapidly, could eliminate need for most hand cultivation.

USE OF MACHINERY

Blocking and thinning of the young beets, also harvesting, was by hand. However, machinery used with success for seeding, blocking, thinning, cultivation, spraying and harvesting in beet growing areas of the United States and Europe should work equally well in Puerto Rico. The beets were lifted out of the ground in 1966 and 1967 at Isabela with a double moldboard plow with excellent results. Use of machinery would be im-

perative for beet production in Puerto Rico because cost of hand labor would be prohibitive.

CLIMATE

The rainfall was normal at the different sites during the years 1963, 1964, and 1965 but was much less than normal in 1966 and 1967. Temperatures were normal at all locations for the entire period.

Ulrich (*22,23*) pointed out that optimum development of sugarbeets is favored by average day-temperatures of 23° C., a moderate but regular water supply during the first 3 or 4 months of growth, and night temperatures of 14° to 17° C., with relatively dry weather during the remaining part of the growing period. Temperatures are only slightly higher than 23° C. at Fortuna (table 1). The low rainfall during the 1966–67 experiment made it necessary to supply water only as needed to prevent wilting of the leaves before mid-day and to reduce the amount of water used for irrigation during the last two months of the growing period. It is presumed that this irrigation scheme was at least partly responsible for the 1966–67 superior yields of roots and sugar at that site.

INSECTS

Larvae of *Psaris bipunctalis*, a type of webworm, were a continuous menace, especially in the drier south coast climate. These pests required frequent spray applications containing DDT, which was effective (*20*).

Aphids and mites were observed occasionally but never caused serious problems.

DISEASES

Damage due to leafspot caused by *Cercospora beticola* is the major single problem in sugarbeet production in Puerto Rico. Varieties resistant to this disease have been developed in the more temperate climates of the beet growing areas of the United States and Europe, such as Michigan and Southern Germany. Beets are planted in those areas in the spring and conditions for the development of *Cercospora* usually occur only during July and August when the beets have become full grown. In Puerto Rico, *Cercospora* infections begin to occur as early as 6 weeks after planting, and they occur with even more intensity in areas of higher rainfall, such as Isabela, thus confirming the findings of Carlson (*2*).

The fungicide Manzate, used in the first two replicated crops (1964–65 and 1965–66), reduced the development of the fungus but did not control it. In 1966–67, Brestan (triphenyl tin acetate) was used and this fungicide proved to be much more effective, confirming results obtained elsewhere (*10,11,12*). It was noted, however, that preventive spraying was preferable

instead of delaying spraying until the disease first was observed, because once the inoculum became established it was impossible to eliminate.

Seedling diseases were a minor problem. When incomplete stands occurred, these were found to be caused by poor germination, too shallow planting, or unavailability of irrigation water to portions of the plot due to imperfect leveling. This type of stand loss can be reduced somewhat by the precision of mechanical planting. However, stand losses of 10 to 15 percent are normal in beet producing areas.

NEMATODES

The early experiments at Isabela and Fortuna in the 1965–66 crop to test the effect of DD nematocide did not show significant differences for either yield or percent of sugar (tables 5, 6, 7). The untreated plots showed more root knot than the treated plots, but this did not appear to affect the quality of the beets. Root knot nematodes therefore do not seem to be a limiting factor in sugarbeet production in Puerto Rico. No cyst-nematodes (*Heterodera schachtii*) were found.

YIELD

The results of the two observational trials conducted at Fortuna in 1963 and early 1964 were promising. Yields of the 42 *Beta vulgaris* introductions ranged from 3 to 16 tons of roots per acre in both plantings. Percent of sucrose was not determined but refractometer readings for total solids in solution ranged from 8 to 20 percent both years. More complete results are available for the four commercial varieties included in the second of these trials:

Variety	*Roots T/A*	*Percent sucrose*
US H2	17.1	14.4
US H5	18.4	12.2
US H6	13.2	12.8
US 75	10.9	13.9

On the basis of these yields, it was decided to start experiments on a more extensive scale. It was observed that the four US varieties tested in early 1964 were susceptible to *Cercospora* leaf spot; therefore, four resistant varieties were obtained from Michigan. To these were added US H2, US H6, US H5 B, US 56-2, and US 401. These nine varieties were included in a series of replicated trials, planting on different dates at four locations. Tables 2, 3, and 4 give the yield of beets in tons per acre, percent of sucrose, and yield of sugar in tons per acre, respectively, of these nine varieties of the 1964–65 crop. Tables 2, 3, and 4 show the best results were obtained at Isabela in the first planting harvested June 7, 1965, closely fol-

TABLE 2.—*Yield of sugarbeet roots in tons per acre in 1964–1965 trials*

Variety	Trial number[1]						
	1	2	3	4	5	6	7
US 56-2	3.5	8.69	6.86	9.24	4.60	1.66	1.63
SP 5822-0	6.2	13.08	7.06	15.34	6.30	1.70	3.87
SP 6322-0	5.6	9.98	6.02	16.06	5.29	1.26	2.81
H-6 Hybrid	3.2	12.01	8.72	15.95	6.13	1.88	3.38
H-2 Hybrid	3.7	9.74	9.46	15.20	6.66	1.54	2.12
H-5-B Hybrid	5.2	14.04	9.99	16.51	6.86	2.15	3.99
SL(129 MS x 133)MS x SP 6322-0	6.2	10.66	11.41	18.73	6.89	2.57	3.48
SL(126 MM x 128)MS x SP 6322-0	5.5	11.62	7.76	16.31	7.40	1.81	5.10
US 401	6.1	7.36	7.81	17.50	5.91	2.40	5.86
LSD .05	—	5.15	4.97	4.05	2.42	—	—
LSD .01	—	N.S.	N.S.	5.42	3.27	—	—

[1] 1 = Corozal 11/24/64–4/28/65
2 = Fortuna 10/19/64–5/18/65
3 = Lajas 10/28/64–6/1/65
4 = Isabela 11/18/64–6/7/65
5 = Fortuna 1/2/65–6/15/65
6 = Lajas 3/18/65–6/28/65
7 = Isabela 3/30/65–9/27/65

TABLE 3.—*Percent sucrose of sugarbeets in 1964–65 trials*

Variety	Trial number[1]						
	1	2	3	4	5	6	7
US 56-2	9.8	13.03	12.70	9.42	10.3	11.2	7.92
SP 5822-0	13.8	13.40	16.68	9.42	13.0	10.5	8.22
SP 6322-0	13.0	12.20	16.28	10.27	12.0	10.8	9.85
H-6 Hybrid	12.2	9.67	12.87	8.37	8.0	11.2	6.52
H-2 Hybrid	12.8	11.70	12.55	9.38	10.5	12.0	9.42
H-5-B Hybrid	12.2	11.68	12.37	8.10	9.2	10.7	8.30
SL(129 MS x 133)MS x SP 6322-0	12.4	13.70	15.33	9.72	11.4	11.4	8.60
SL(126 MM x 128)MS x SP 6322-0	—	12.47	16.18	10.50	11.9	11.6	9.35
US 401	14.0	12.07	15.33	9.80	10.9	10.4	9.25
LSD. 05	—	1.48	1.55	1.46	1.74	—	—
LSD .01	—	1.98	2.08	1.95	2.32	—	—

[1] 1 = Corozal 11/24/64–4/28/65
2 = Fortuna 10/19/64–5/18/65
3 = Lajas 10/28/64–6/1/65
4 = Isabela 11/18/64–6/7/65
5 = Fortuna 1/2/65–6/15/65
6 = Lajas 3/18/65–6/28/65
7 = Isabela 3/30/65–9/27/65

TABLE 4.—*Yield of sugar in tons per acre in 1964–1965 trials*

Variety	Trial number[1]						
	1	2	3	4	5	6	7
US 56-2	.34	1.10	.80	.88	.48	.19	.13
SP 5822-0	.86	1.75	1.18	1.48	.82	.18	.32
SP 6322-0	.73	1.31	.96	1.62	.64	.14	.28
H-6 Hybrid	.39	1.13	1.12	1.34	.49	.21	.22
H-2 Hybrid	.47	1.13	1.15	1.42	.70	.18	.20
H-5-B Hybrid	.63	1.62	1.23	1.32	.63	.23	.33
SL(129 MS x 133)MS x SP 6322-0	.77	1.49	1.74	1.81	.79	.29	.30
SL (126 MM x 128)MS x SP 6322-0	—	1.46	1.20	1.69	.88	.21	.48
US 401	.85	.92	1.18	1.71	.64	.25	.54
LSD .05	—	.68	.65	.36	.29	—	—
LSD .01	—	N.S.	.90	.49	.38	—	—

[1] 1 = Corozal 11/24/64–4/28/65
2 = Fortuna 10/19/64–5/18/65
3 = Lajas 10/28/64–6/1/65
4 = Isabela 11/18/64–6/7/65
5 = Fortuna 1/2/65–6/15/65
6 = Lajas 3/18/65–6/28/65
7 = Isabela 3/30/65–9/27/65

TABLE 5.—*Yield of beet roots in tons per acre in 1965–1966 trials*

Variety	Trial number[1]						
	1	2	3	4	5	6	7
SP 5822-0	14.06	12.89	12.27	13.05	14.39	16.57	4.86
(SL 126 MM x 128)MS x SP 5822-0	13.18	11.51	14.48	15.17	12.88	18.81	5.88
SP 6322-0	14.04	11.94	11.16	14.82	13.20	16.42	4.44
(SL 129 MS x 133)MS x SP 6322-0	12.48	11.55	14.35	15.60	13.78	14.85	5.28
US H-6	10.01	9.02	18.38	19.41	9.96	17.90	4.59
US H-5-B	10.62	8.57	19.43	18.28	10.39	18.05	3.71
US H-2	9.48	7.63	15.57	14.29	10.22	14.34	4.21
LSD[2] .05	1.62	1.62	2.77	2.77	2.28	3.89	—
LSD .01	2.15	2.15	3.69	3.69	3.06	N.S.	—

[1] 1 = Isabela 11/10/65–5/16/66, DD
2 = Isabela 11/10/65–5/16/66, no DD
3 = Fortuna 12/1/65–5/31/66, DD
4 = Fortuna 12/1/65–5/31/66, no DD
5 = Isabela 1/12/66–6/28/66
6 = Fortuna 1/12/66–7/14/66
7 = Lajas 2/2/66–7/15/66

[2] DD—no DD: no significant difference. LSD's of trials 1, 2, 3 and 4 are of average: DD + no DD.

lowed by the first planting at Fortuna, harvested May 18, 1965. Sugar percentage was higher at Fortuna. Yields of sugar per acre were quite similar at both locations. Later plantings at Fortuna and Isabela, and plantings at Lajas, show far lower yields. It thus appears that planting later than January 1 produced inferior results. Corozal proved unsuited for sugarbeet production. It was decided to modify the cultural practices for the 1965–66 season by closer planting, reducing the amount of nitrogen fertilizer, and by applying the fertilizer earlier in the growing season. The varieties selected for test were those of the previous crop, except US

TABLE 6.—*Percent sucrose of sugarbeets in trials, 1965–1966*

Variety	*Trial number*[1]						
	1	*2*	*3*	*4*	*5*	*6*	*7*
SP 5822-0	10.25	10.58	10.90	10.73	10.57	11.00	10.2
(SL 126 MM x 128)MS x SP 5822-0	10.67	11.73	11.68	11.73	9.23	11.00	10.7
SP 6322-0	11.80	11.25	10.33	9.60	11.37	10.70	9.6
(SL 129 MS x 133)MS x SP 6322-0	10.38	10.53	10.83	10.95	10.27	8.97	10.7
US H-6	8.65	9.27	8.67	9.67	9.53	9.00	8.5
US H-5-B	7.67	8.80	8.87	9.43	9.63	8.78	7.1
US H-2	8.67	8.78	9.87	10.13	9.17	9.03	9.9
LSD[2] .05	1.16	1.16	.92	.92	N.S.	1.22	—
LSD .01	1.54	1.54	1.22	1.22	N.S.	1.63	—

[1] 1 = Isabela 11/10/65–5/16/66
2 = Isabela 11/10/65–5/16/66
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4 = Fortuna 12/1/65–5/31/66
5 = Isabela 1/12/66–6/28/66
6 = Fortuna 1/12/66–7/14/66
7 = Lajas 2/2/66–7/15/66

[2] DD—no DD: no significant difference. LSD's of tests 1, 2, 3, and 4 are of average: DD + no DD

56-2 and US 401 which were dropped. Tables 5, 6, and 7 record the yields of beets, percent of sucrose, and yield of sugar per acre, respectively, of the seven varieties tested in the 1965–66 crop at three locations.

The results of the 1965–66 crop were conclusive in three respects: 1) root-knot nematodes attacked the beets, but apparently did not affect yield sufficiently to justify fumigation; 2) at Isabela, the three varieties susceptible to *Cercospora*, US H6, US H5 and US H2, consistently produced less than the resistant varieties from Michigan, indicating that *Cercospora* probably was a limiting factor, and 3) the yields of plantings made after January 1 were as high or higher than those planted earlier, indicating that resistant variety beets can be planted after January 1 under good

agronomic practices. At Fortuna, Manzate possibly was capable of compensating for the lack of resistance to *Cercospora* in the California varieties under less severe attacks that occurred there.

As a result of an observational trial run concurrently with the replicated trials during the 1965–66 crop, and following suggestions obtained through personal communication with European breeders, it was decided to establish a replicated test in the 1966–67 season mainly involving polyploid varieties. KWS Cercopoly was the best yielder in the observational trials of 1965–66 in which no fungicide was applied. Under severe *Cercospora*

TABLE 7.—*Yield of sugar in tons per acre, 1965–1966*

Variety	*Trial number*[1]						
	1	*2*	*3*	*4*	*5*	*6*	*7*
SP 5822-0	1.39	1.35	1.32	1.41	1.52	1.86	.50
(SL 126 MM x 128)MS x SP 5822-0	1.40	1.34	1.71	1.79	1.21	2.11	.63
SP 6322-0	1.62	1.32	1.17	1.39	1.51	1.76	.43
(SL 129 MS x 133)MS x SP 6322-0	1.27	1.19	1.52	1.68	1.41	1.39	.56
US H-6	.86	.81	1.59	1.87	.95	1.61	.39
US H-5-B	.81	.73	1.72	1.74	.97	1.57	.26
US H-2	.81	.65	1.54	1.42	.91	1.29	.42
LSD[2] .05	.19	.19	.34	.34	.30	.53	—
LSD .01	.26	.26	.45	.45	.41	.71	—

[1] 1 = Isabela 11/10/65–5/16/66
2 = Isabela 11/10/65–5/16/66
3 = Fortuna 12/1/65–5/31/66
4 = Fortuna 12/1/65–5/31/66
5 = Isabela 1/12/66–6/28/66
6 = Fortuna 1/12/66–7/14/66
7 = Lajas 2/2/66–7/15/66

[2] DD—no DD: no significant difference. LSD's of tests 1, 2, 3, and 4 are of average: DD + no DD

attack, this variety produced twice as much sugar per acre in Isabela as the best susceptible variety. Two other resistant varieties in the same test, US 401 and Cecerave, each produced about 85 percent of the KWS Cercopoly yield.

The 1966–67 crop (table 8), produced the highest yields of sugarbeets at Fortuna, but the yields at Isabela were about the same as in previous years. The high yields at Fortuna were probably not because a number of the varieties used were polyploid; two non-polyploids, Cecerave and (SL 126 MM x 128) MS x SP 5822-0, ranked fourth and first in yield of sugar per acre, respectively. At Fortuna, 4.93 inches of rainfall were recorded for the period December 7, 1966 to June 27, 1967, as compared to an

average precipitation of about 13 inches for that period during 25 years of measurement. This drought permitted careful management of water through irrigation, which may be the primary factor responsible for the high yields, as noted also in Hawaii (*26*). In addition, applying all fertilizer before foliage covers the field encourages early root development. This, in turn, allows a longer period for storage of sugar, if other conditions are favorable. Brestan was effective in controlling the degree of *Cercospora* infection and this minimized the losses caused by this disease, thus probably helped to raise the sugar content, highest for both sites. The yields obtained at Fortuna from the 1966–67 crop in about 7 months are of in-

TABLE 8.—*Yield of roots and sugar in tons per acre and percent sucrose in 1966–1967 trials*

Variety	Isabela[1]			Fortuna[2]		
	1			2		
	Roots/ Acre	Sucrose	Sugar/ Acre	Roots/ Acre	Sucrose	Sugar/ Acre
	Tons	Percent	Tons	Tons	Percent	Tons
Polyrave	15.09	11.9	1.80	24.6	11.96	2.94
Cecerave	12.58	11.5	1.45	23.0	12.98	2.99
Maribo Resista-Poly	15.51	11.3	1.75	26.1	13.58	3.54
Maribo Magna-Poly	12.18	12.0	1.46	21.8	10.63	2.32
(SL 126 MM x 128)MS x SP 5822-0	12.64	12.5	1.58	24.9	14.33	3.57
KWS Polybeet	14.28	13.3	1.90	20.9	12.83	2.68
KWS Cercopoly	11.10	12.9	1.43	21.6	14.8	3.20
LSD .05	N.S.	1.67	N.S.	2.90	1.22	.47
LSD. 01	N.S.	N.S.	N.S.	3.90	1.65	.63

[1] 10/21/66-6/15/67
[2] 12/07/66-6/27/67

terest because they are as high or higher than yields obtained commercially in the better U.S. beet growing areas such as Michigan, Colorado and California. These high yields compare favorably with yields of 5.5 tons per acre from a 12-month crop of cane on good land on the south coast of Puerto Rico. In both cases, yield of sugar per month per acre is about .45 tons. Although it might be agronomically feasible to produce sugarbeets, some major difficulties will have to be overcome before a profitable sugarbeet industry can be established in Puerto Rico.

Sugarbeets require intensive land preparation for each 6- or 7-month crop. Close daily attention and intensive care must be given to the crop throughout the entire growing period. It seems unlikely that cultivation of a crop such as sugarbeets can be attractive in Puerto Rico as long as

yields of sugar per acre per month obtained from beets under experimental conditions are comparable only to those of a good commercial cane crop, especially to farmers accustomed to growing cane requiring land preparation but once every 5 to 6 years and a crop requiring much less care.

Growing crops of sugarbeets would be a more attractive enterprise in Puerto Rico if (a) the sugar content of the beets was 18 percent or more and (b) yields of 30 tons or more of roots per acre could be achieved regularly on a commercial basis, the equivalent of 4 to 5 tons of sugar per acre in 7 months. Such yields are realized at times in the better sugarbeet growing areas. Sugarbeet varieties that give such a high yield of sugar in Puerto Rico are not available. An intensive and lengthy breeding effort probably would be required to produce these.

If commercial production of sugarbeets is to be attempted in Puerto Rico, the site should be on soils similar to those at Fortuna and with a similar climate. Further, as many operations as possible should be by machinery. Machines presently are available for seeding, thinning, spraying, cultivating, and harvesting, all of which reduces hand labor to a minimum. It would be expected that the *Cercospora* resistant varieties Maribo Resista-Poly, KWS Cercopoly, Cecerave and hybrid (SL 126 MM x 128) MS x SP 5822-0 or comparable varieties, under the cultural practices followed in the 1966–67 experiments, would give best results.

BY-PRODUCTS

The tops (leaves and crown) from healthy beets are a good cattle feed. They can be fed as such or as silage. The value of tops from our experiments was inferior because of damage by *Cercospora* leaf spot and webworm. These tops were readily accepted, however, by hogs and cattle. Beet pulp, the finely cut-up beets after juice extraction, also is used as cattle feed. Beets from our experiments were not processed thus no feeding trials were conducted. There seems no reason to believe that pulp produced from beets grown in Puerto Rico would not be equivalent to that grown elsewhere.

INTERPLANTING

Experiments were not conducted to evaluate the feasibility of interplanting sugarcane with sugarbeets, an objective of sugarbeet studies in Formosa (*3*). Such interplanting appears impossible from a commercial point of view in Puerto Rico because the practice requires too-expensive hand operations.

SUMMARY

Observational and replicated tests with a number of U.S. and European sugarbeet varieties were conducted from 1963 through 1967 at four sub-

stations of the Agricultural Experiment Station, University of Puerto Rico. The purpose of the tests was to determine the adaptability of this crop to Puerto Rico as a possible alternative or supplement to sugarcane for sugar production.

Best results were obtained with irrigation on the south coast where yields of 3 to 3.5 tons of sugar per acre were recorded. Such yields were considered insufficiently attractive to offset the disadvantages of sugarbeet cultivation with the advantages of sugarcane cultivation. Beets require intensive care, need close daily attention, and are highly sensitive to correct management.

RESUMEN

En cuatro Subestaciones de la Estación Experimental Agrícola del Recinto de Mayagüez de la Universidad de Puerto Rico, se llevaron a cabo pruebas de observación y también experimentos con algunas variedades europeas y de Estados Unidos de la remolacha azucarera. El propósito de este proyecto, llevado a cabo durante el quinquenio del 1963 al 1967, fue determinar la adaptabilidad de esta cosecha a las condiciones de Puerto Rico y de ser favorables usar su producción como una fuente de azúcar alterna o suplementaria a la de la caña de azúcar.

Los mejores resultados se obtuvieron en las siembras de regadío que se hicieron en la costa sur de la Isla, donde se lograron de 3 a 3.5 toneladas de azúcar por acre. Es obvio que estos rendimientos no fueron suficientemente satisfactorios debido a las desventajas que el cultivo de la remolacha azucarera presenta al compararse con el de la caña de azúcar, pues la primera requiere un cultivo intensivo, atención diaria y un manejo racional.

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