Preliminary Evaluation of Ten Sweet Sorghum Varieties for Sugar Production in Puerto Rico[1,2]

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ABSTRACT

Experiments were conducted to determine the influence of date of planting and maturity stages of sweet sorghum on yields as sugar per acre. A cyclical pattern of production was observed. Planting from January to July constituted the high yield season while from August to December constituted the low yielding one. Differences between yield at the milk, hard dough and dry stages of grain maturity were minimal. When comparing ratoon crop production with that of the plant crop, a marked yield decline was obtained.

INTRODUCTION

Sorghum (*Sorghum bicolor*, L.) (8) is one of the minor sugar producing crops. Members of this species may be grouped according to the different uses given to the crop, such as grain, forage, broom manufacturing, syrup, and sugar production. Sweet sorghums are characterized by sweet, juicy stalks, five to ten feet tall, that produce heads of different shapes and sizes with small to medium seeds (8). Some varieties are dual purpose, yielding both good grain and sucrose crops.

Sweet sorghums are best adapted to dry regions and may be grown in a large variety of soil types. The crop is propagated by sexually produced seed and is ready for harvest at 110 to 145 days, thus needing less mechanical or chemical cultivation (5) and fertilizers than sugarcane (1). Mechanization of the crop from planting to harvesting can be easily accomplished. Light mechanical equipment, which is readily available in the market, may be used with a minimum of adaptations. Sucrose loss is not significant in normal transit to the mill (3).

Experimental yields in the continental United States are around two tons of 96° sugar per acre in four months (7). Since, theoretically, more than one crop may be grown during the year in Puerto Rico, yields might possibly be similar to those of sugarcane.

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[2] This report covers research conducted cooperatively between the Sugarcane and Sweet Sorghum Investigations, Agricultural Research Service, U. S. Department of Agriculture, and the Agricultural Experiment Station, College of Agricultural Sciences, Mayagüez Campus, University of Puerto Rico, Río Piedras, P.R.

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The present studies were conducted to determine the feasibility of growing sorghum for sugar production in Puerto Rico by gathering information on the influence of planting date, performance of varieties with regard to sugar production and stage of seed maturity as criteria for harvesting the crop. The possibility and profitability of harvesting a plant and ratoon crops were also considered.

MATERIALS AND METHODS

This work was done at the Fortuna Substation Farm, Agricultural Experiment Station (lat. 66°32′ N., long. 18°07′ W.), which is located in the south coast, near Ponce, Puerto Rico. The mean maximum annual temperature is 84.6° F. and the minimum mean is 67.6° F. The mean rainfall is 32 inches and the soil type is a Paso Seco silty clay (6).

Twelve field trials were planted at monthly intervals in randomized field sites. Ten varieties were compared in split plot randomized block designs with three replications. The varieties tested were: 1) Meridian 56-15; 2) Meridian 63-3; 3) Meridian 64-3; 4) Meridian 64-4; 5) Meridian 64-7; 6) Meridian 66-1; 7) Meridian 67-1; 8) Meridian 67-15; 9) Brawley; and 10) Rio. Harvesting was performed at three seed maturity stages (milk, hard dough and dry). Plots consisted of three 14-foot rows spaced 3½ feet apart with a blank row between plots. Seeds were planted in hills, seven hills per row, spaced two feet apart, and seedlings were thinned to four per hill (2). The pre-emergent herbicide Propazine was applied at the rate of three lbs per acre. Hand hoeing was used when necessary. A 15-10-10 fertilizer was applied at the rate of 500 lbs per acre on the surface immediately after the hills were thinned. Water was supplied whenever necessary by both overhead and surface irrigation. Insect pests were kept under control with Sevin and Diazinon sprays.

Rows in each plot were harvested at a different stage of seed maturity: milk, hard dough and dry. The stalks were harvested, beheaded and detrashed manually. The diameter and length of stalks was measured in centimeters and the number of internodes counted. The stalks were also weighed, and the juice from samples was extracted in a roller mill at 2000-pound pressure with a juice extraction range of 68 to 70 percent. These samples were processed within 72 hours after harvest and the weight of the juice was recorded. Protein in the juice was precipitated using Horne's method (4). Celite was added to facilitate filtration. Filtration was performed by using special grade, rapid sugar filter paper. Some of the filtered juice was placed in a 200-millimeter long polarizing tube to determine polarization. Brix was determined directly in the crusher juice by the use of a Zeiss refractometer.

Available 96° sugar in sorghum was calculated by using the following

modification of the Winter Carp Formula:

$$AS\ 96° = \left(\frac{0.380239\ \text{Pol}}{1 + 0.003849B + 0.000015B^2} - 0.416667B\right) E,$$

where AS 96° = 96° available sugar in cane
Pol = polarization reading of the juice
B = Brix, solids in solution in the juice
E = Percentage extracted juice

Data was obtained for the plant crop and for the first ratoon.

TABLE 1.—*Mean stalk yield (tons per acre) of twelve plantings of sweet sorghum at the Fortuna Substation Farm, Puerto Rico*

Planting Time	Milk stage		Hard dough stage		Dry stage		Plant crop mean	Ratoon crop mean	Combined general mean
	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop			
1970									
February	8.6	3.6	9.3	9.0	9.2	10.8	9.0	7.8	8.4
March	11.9	10.4	11.0	8.2	10.1	10.4	11.0	9.6	10.3
June	15.3	3.5	14.5	4.3	13.8	3.3	14.5	3.7	9.1
July	17.0	6.3	16.1	5.6	13.9	3.7	15.6	5.2	10.4
August	12.0	3.8	11.6	3.8	11.0	4.5	11.5	4.0	7.8
October	4.4	4.5	4.1	4.4	3.4	5.8	3.9	4.9	4.4
November	5.6	5.9	5.5	5.2	5.0	4.9	5.3	5.3	5.3
December	4.9	5.4	4.8	5.0	4.4	6.8	4.7	5.7	5.2
1971									
January	9.2	10.9	8.1	11.4	7.7	9.4	8.3	10.5	9.4
February	10.9	10.6	11.3	10.3	10.6	6.3	10.9	9.0	10.0
March	13.2	8.5	12.2	8.4	12.0	7.0	12.4	7.9	10.2
April	17.0	8.2	16.4	6.7	16.3	7.7	16.5	7.5	12.0
Mean	13.0	8.2	12.5	8.2	10.3	8.0	10.3	6.7	10.3

RESULTS

INFLUENCE OF MONTHLY PLANTINGS ON PLANT CROP YIELDS

In the plant crop there was a cyclical tendency for high and low production as expressed in weight of stalks per acre (table 1). The plantings corresponding to the months from January to July constituted the high production season while those from August to December constituted the low season (fig. 1).

The cyclical tendency can be observed also with regard to sucrose percentage in stalks (fig. 2). In this case the high yield season began with the January planting, which with small variations continued until August,

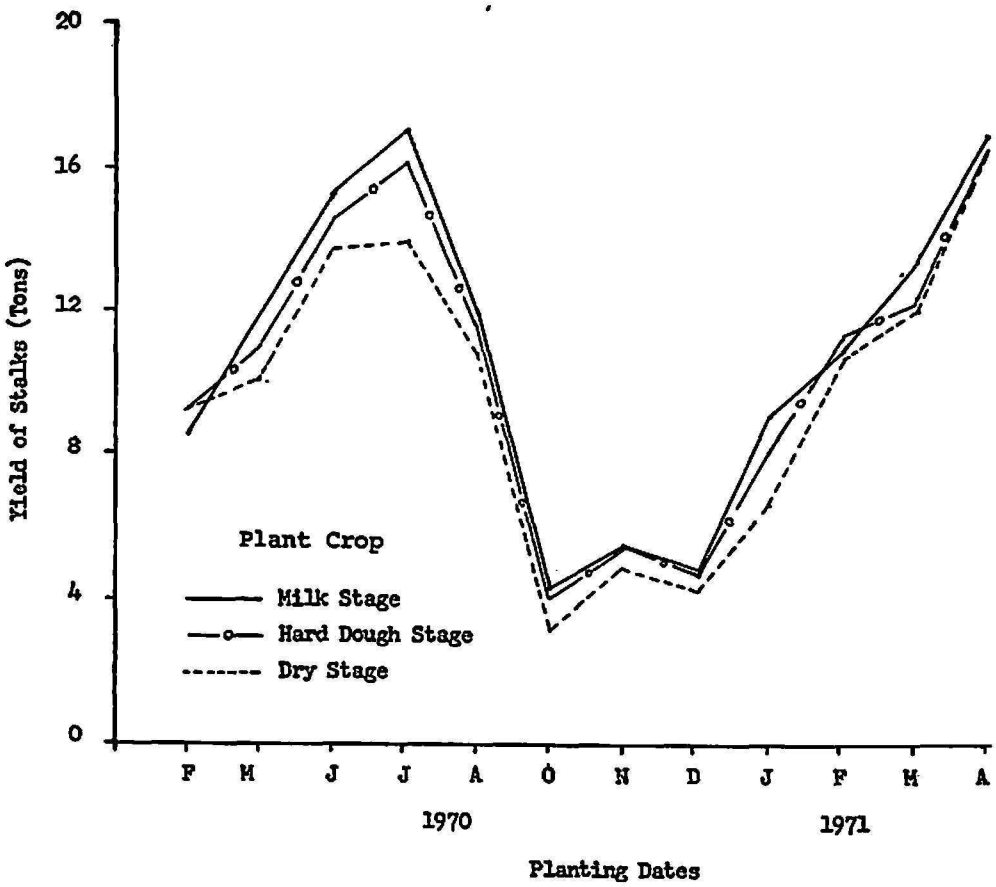

FIG. 1.—Mean stalk production (tons per acre) of twelve plantings of sweet sorghum at the Fortuna Substation Farm, Puerto Rico.

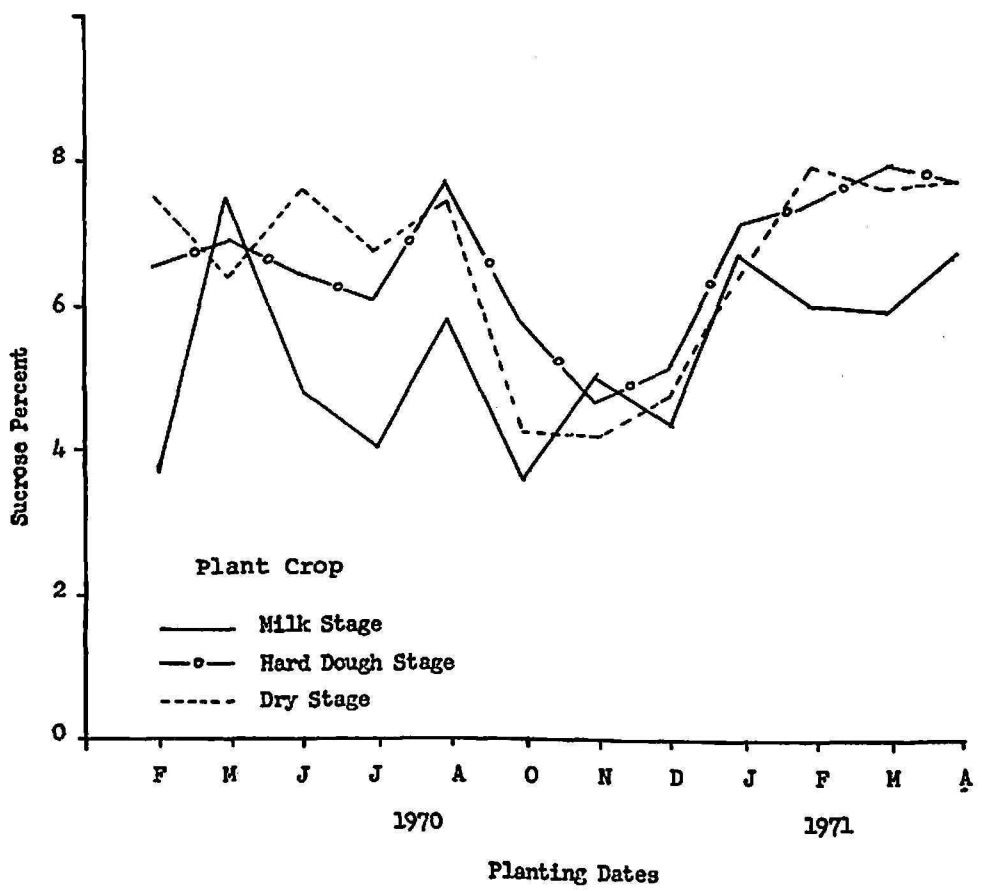

FIG. 2.—Mean sucrose percent in stalks of twelve plantings of sweet sorghum at the Fortuna Substation Farm, Puerto Rico.

with the exception of the July planting. Declination started progressively from the August planting until it reached the December planting, which constituted the low yield planting season (table 2).

The tendency of the plant crop to follow a cyclical pattern of high and low tonnage of sugar per acre production was more distinct. The highest yield was obtained from the January-July plantings and the lowest from August through December plantings (fig. 3). The highest yield was obtained from the April planting, while the lowest was the October planting (table 3).

TABLE 2.—*Mean sucrose percent in stalks of twelve plantings of sweet sorghum at the Fortuna Substation Farm, Puerto Rico*

Planting Time	Milk stage		Hard dough stage		Dry stage		Plant crop mean	Ratoon crop mean	Combined general mean
	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop			
1970									
February	3.7	2.2	6.6	4.1	7.5	7.5	5.9	4.6	5.3
March	7.5	5.8	6.9	6.9	6.4	6.8	6.9	6.5	6.7
June	4.8	5.2	6.4	6.0	7.6	5.9	6.2	5.7	6.0
July	4.0	5.6	6.0	6.4	6.7	4.7	5.5	5.5	5.6
August	5.8	4.8	7.7	4.8	7.4	5.3	6.9	4.9	5.9
October	3.5	3.6	5.7	7.9	4.2	7.1	4.4	6.2	5.3
November	4.9	4.2	4.6	7.5	4.1	7.1	4.5	6.2	5.4
December	4.3	5.0	5.0	6.8	4.6	7.5	5.2	6.4	5.5
1971									
January	7.1	7.3	7.0	8.0	6.4	6.9	6.8	7.4	7.1
February	5.9	6.5	7.3	7.1	7.8	5.4	7.0	6.3	6.7
March	5.8	3.8	7.8	6.6	7.5	6.4	7.0	5.6	6.3
April	6.6	5.3	7.6	6.7	7.6	7.0	7.2	6.3	6.8
Mean	5.3	4.9	6.5	6.5	6.4	6.4	6.1	5.9	6.0

The data shows that the best season for planting sweet sorghum at the Fortuna Substation Farm is from the months of January to July, with a peak in April.

INFLUENCE OF VARIETIES ON PLANT CROP YIELDS

The best performance as to tonnage of stripped, beheaded stalks per acre in the three stages of maturity, was that of Mer. 67-15, with a plant crop mean of 14.6 tons per acre. Mer. 64-7 and Rio ranked second and third with 12.1 and 11.4 tons, respectively (table 4).

The highest yield as to sucrose percentage content of stalks, combining the three stages of maturity of the plant crop, was obtained from Brawley, with 7.1 percent. Second highest was Mer. 67-15 with 7.0 percent, while Rio, with 6.8 percent, ranked third (table 5).

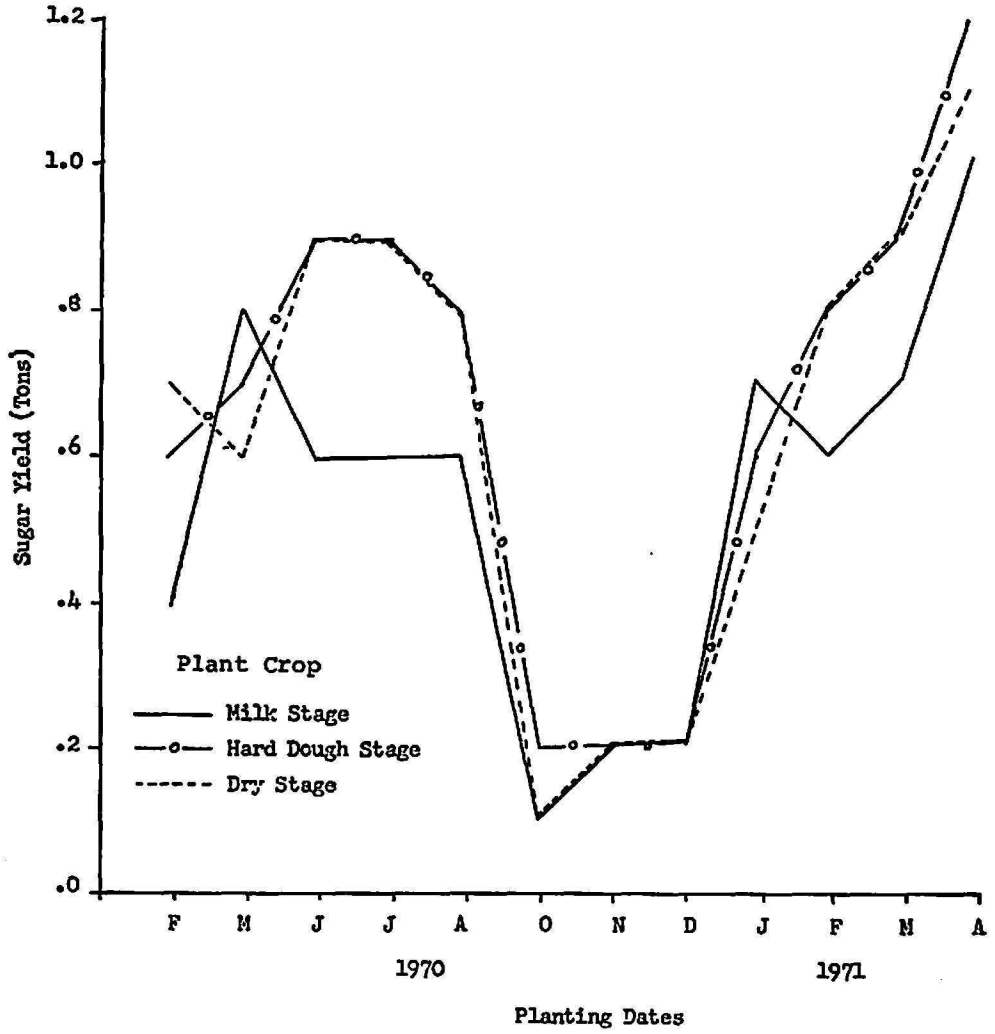

FIG. 3.—Mean sugar production (tons per acre) of twelve plantings of sweet sorghum at the Fortuna Substation Farm, Puerto Rico.

TABLE 3.—*Mean sugar production (tons per acre) of twelve plantings of sweet sorghum at the Fortuna Substation Farm, Puerto Rico*

Planting time	Milk stage		Hard dough stage		Dry stage		Plant crop mean	Ratoon crop mean	Combined general mean
	Plant crop	Rattoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop			
1970									
February	.4	.0	.6	.3	.7	.7	.5	.3	.5
March	.8	.5	.7	.5	.6	.6	.6	.5	.6
June	.6	.1	.9	.2	.9	.1	.8	.1	.5
July	.6	.3	.9	.3	.9	.1	.8	.2	.5
August	.6	.1	.8	.1	.8	.2	.7	.1	.4
October	.1	.1	.2	.3	.1	.4	.1	.2	.2
November	.2	.2	.2	.3	.2	.3	.2	.2	.2
December	.2	.2	.2	.3	.2	.5	.2	.3	.3
1971									
January	.7	.8	.6	.8	.5	.6	.6	.7	.7
February	.6	.6	.8	.6	.8	.3	.7	.5	.6
March	.7	.4	.9	.5	.9	.4	.8	.4	.6
April	1.0	.3	1.2	.4	1.1	.3	1.1	.3	.7
Mean	.6	.3	.7	.4	.6	.4	.5	.3	.5

Top performance in tonnage of sugar per acre in the plant crop, was obtained with Mer. 67-15, with 1.0 ton, followed by Mer. 63-3, with .8 ton of sugar. Mer. 64-7 and Rio held the third place (table 6).

From these results it is concluded that Mer. 67-15, Mer. 63-3, Mer. 64-7, and Rio show some potential for sugar production, and therefore merit further study.

TABLE 4.—*Mean stalk yield (tons per acre) of ten varieties of sweet sorghum planted at the Fortuna Substation Farm, Puerto Rico*

Variety	Milk stage		Hard dough stage		Dry stage		Plant crop mean	Ratoon crop mean	Combined general mean
	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop			
Mer. 56-15	9.5	6.1	8.7	6.3	8.2	6.0	8.8	6.1	7.4
Mer. 63-3	11.2	7.1	11.4	7.3	10.8	6.9	11.1	7.1	9.1
Mer. 64-3	10.6	6.0	10.7	7.4	10.2	7.7	10.5	7.0	8.8
Mer. 64-4	10.3	7.3	10.3	7.9	9.8	7.6	10.1	7.6	8.9
Mer. 64-7	13.1	10.1	11.9	10.0	11.5	9.2	12.1	9.7	11.0
Mer. 66-1	8.7	4.7	7.8	5.0	7.2	6.2	7.9	5.3	6.6
Mer. 67-1	8.7	3.4	7.8	3.3	7.2	3.5	7.9	3.4	5.7
Mer. 67-15	14.9	10.6	14.9	8.8	14.1	7.9	14.6	9.1	11.9
Brawley	9.3	5.6	8.7	5.2	8.0	4.3	8.6	5.0	6.8
Rio	12.0	7.1	11.7	7.4	10.7	6.1	11.4	6.8	9.2
Mean	10.8	6.8	10.4	6.9	9.8	6.5	10.3	6.7	8.5

TABLE 5.—*Mean sucrose percent in stalks of ten varieties of sweet sorghum planted at the Fortuna Substation Farm, Puerto Rico*

Variety	Milk stage		Hard dough stage		Dry stage		Plant crop mean	Ratoon crop mean	Combined general mean
	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop			
Mer. 56-15	5.4	5.5	5.8	7.0	6.3	7.3	5.8	6.6	6.2
Mer. 63-3	6.2	5.8	2.4	7.2	7.3	7.6	5.3	6.8	6.0
Mer. 64-3	3.3	3.5	5.2	5.5	4.3	4.5	4.2	4.5	4.4
Mer. 64-4	3.4	3.6	4.6	5.7	4.4	5.5	4.1	4.9	4.5
Mer. 64-7	4.8	4.3	6.1	5.3	6.6	5.9	5.8	5.1	4.7
Mer. 66-1	5.6	5.6	7.0	7.2	7.1	7.2	6.5	6.6	6.6
Mer. 67-1	5.6	5.0	7.2	6.2	7.0	6.2	6.6	5.8	6.2
Mer. 67-15	6.2	5.3	7.6	6.8	7.4	6.9	7.0	6.3	6.7
Brawley	6.5	5.6	7.5	7.4	7.3	6.7	7.1	6.5	6.7
Rio	6.3	5.2	7.0	7.1	7.2	6.8	6.8	6.3	6.6
Mean	5.3	4.9	6.6	6.5	6.5	6.5	5.9	5.9	6.0

GRAIN MATURITY STAGE AS A CRITERION FOR HARVEST TIME

In the plant crop, the highest mean yield in tons per acre of stripped, beheaded stalks was obtained in the milk stage—13.0 tons. Second highest in yield was the hard dough stage with 12.5 tons, while the dry stage was last with 10.3 tons. The maturity stage appears to have very little if any effect on the production of stalks per acre (table 1).

The hard dough stage showed the highest sucrose content (6.5 percent), followed closely by the dry stage (6.4 percent). The lowest was the milk stage (5.3 percent). Peak sucrose production was obtained in the hard dough stage; this yield was maintained throughout the dry stage (table 2).

TABLE 6.—*Mean sugar production (tons per acre) of ten varieties of sweet sorghum planted at the Fortuna Substation Farm, Puerto Rico*

Variety	Milk stage		Hard dough stage		Dry stage		Plant crop mean	Ratoon crop mean	Combined general mean
	Plant crop	Ratoon crop	Plant crop	Ratoon crop	Plant crop	Ratoon crop			
Mer. 56-15	.5	.4	.5	.4	.5	.4	.5	.4	.5
Mer. 63-3	.7	.4	.8	.6	.8	.5	.8	.5	.6
Mer. 64-3	.4	.2	.6	.4	.6	.4	.5	.3	.4
Mer. 64-4	.4	.3	.6	.4	.6	.4	.5	.4	.4
Mer. 64-7	.6	.5	.8	.6	.7	.6	.7	.6	.6
Mer. 66-1	.5	.3	.6	.4	.5	.3	.5	.3	.4
Mer. 67-1	.5	.2	.6	.2	.5	.2	.5	.2	.4
Mer. 67-15	.9	.6	1.1	.6	1.0	.6	1.0	.6	.8
Brawley	.6	.3	.7	.4	.6	.3	.6	.3	.5
Rio	.7	.4	.8	.5	.8	.4	.7	.4	.6
Mean	.6	.4	.7	.4	.7	.4	.6	.4	.5

The highest mean production in tons of sugar per acre (0.7 ton sugar) was obtained in the hard dough stage, whereas 0.6 ton was obtained in the milk and dry stages. As the differences in tonnage in the different stages are minimal, it is preferable to harvest in any stage of maturity (table 3).

PLANT CROP AS COMPARED TO RATOON CROP

There was a large decrease in production in tons of stalks and tons of sugar per acre in the ratoon crops of the February to August plantings, as compared with the plant crops, but the ratoon crops of the October to January plantings produced more than the plant crops. This might be due possibly to seasonal effect on the developing plants.

There was a 31 percent decrease in tons of stalks per acre, and the sucrose content was 0.2 percent higher in the ratoon crop. On the other hand, there

was a 40 percent decrease in tonnage of sugar per acre. The authors consider this excessively high.

DISCUSSION

The results indicate that the best planting season for sweet sorghum at this latitude, and under the climatic conditions at Fortuna, is from January to July. Although no planting was made during May, plantings during that month could perhaps be intermediate in production with reference to the April and June plantings. It is not advisable to plant sweet sorghum from August to December because of the low sucrose content. The data shows this crop cannot be used to complement sugarcane to prolong the grinding season as the optimum harvesting and milling dates for sweet sorghum coincide with those of sugarcane.

Sorghum being a three-month crop permits a more efficient land use in conjunction with other short cycle crops. A possibility exists for harvesting the grain thus adding extra income per acre. This aspect should be studied further in Puerto Rico where there is great demand for livestock feeds.

The field performance of the varieties tested was below those obtained in similar experiments in the United States (6). New varieties should be introduced and tested until yields comparable with those in the United States are obtained, or at least reach our maximum adaptability levels. These tests should also take into consideration the cost of sugar production per acre to evaluate the economical factors affecting this crop.

RESUMEN

En 1970 la Estación Experimental Agrícola de la Universidad de Puerto Rico inició unos experimentos para estudiar las posibilidades de producir económicamente azúcar de sorgo dulce.

En la Subestación de Fortuna se hicieron siembras mensuales, en las que diez variedades se probaron con respecto a tres estados de madurez (en leche, blando y seco). La posibilidad de obtener cosechas de los retoños también se observó. Se encontró que la mejor época de siembra es de enero a julio. La producción para las siembras de agosto a diciembre fue baja, siendo la de octubre la más baja.

De las diez variedades sembradas, cuatro acusaron posibilidades comerciales, a saber: Mer. 67-15, Mer. 63-3, Mer. 64-7 y Rio. Los mejores resultados se obtuvieron cuando el sorgo se cosechó en la etapa de semilla blanda, y ocupó el segundo lugar la cosecha en la etapa de semilla seca. Cuando la semilla estaba en leche el porcentaje de sacarosa fue muy bajo. La producción de azúcar por acre de la cosecha de los retoños fue solamente el 64 porciento de lo cosechado en las correspondientes siembras de plantilla.

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