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INTERCROPPING SUGARCANE WITH FOOD CROPS

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INTRODUCTION

Food production and supply have always been a matter of great importance to the inhabitants of Puerto Rico. More than half of the cereals consumed are imported. A great deal of the green and yellow vegetables and fruits are also imported, either as fresh or as canned products. Livestock products are also imported in large quantities for local consumption (4)[2]. In times of emergency, such as during World War II, food importations were reduced to critical levels. An increase in the total food produced in the Island would help substantially in assuring its food supply and in the amelioration of emergency shortages.

The Agricultural Experiment Station of the University of Puerto Rico has been engaged for a number of years in a program designed to increase the local production of food crops by making fertilizer and variety trials; by the introduction, selection, and breeding of food crops; and by seeking to devise improved soil- and crop-management techniques. The possibility of making a more intensive use of sugarcane lands by intercropping with food plants was given consideration during the past war emergency (1, 2, 3).

Generally speaking, the sugarcane plantings are located in the best lands of the Island. During the early stages (the first 2 or 3 months) of a sugarcane crop the slow germination and growth of the seedlings, especially from fall plantings, or ratoons provide an opportunity for using sugarcane lands more intensively by intercropping with food plants having a short growing period. Truck crops like tomatoes and cucumbers could be interplanted during the fall for shipping to continental United States during the winter season.

During World War II intercropping of sugarcane with beans, corn, cow-

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[2] Numbers in parentheses refer to Literature Cited, p. 182.

peas, soybeans, and other food crops was practiced to some extent by a considerable number of growers. The practice was then encouraged by the Agricultural Adjustment Administration (now Production and Marketing Administration) which required that some 20 percent of the productive farm area be in food crops in order to qualify for benefit payments. At present, the practice is virtually abandoned. Even at its peak, there seemed to be some reluctance among sugarcane growers to follow this practice, since claims were made that it yielded no profits. In fact, several growers and sugar companies reported heavy losses from intercropping.

The objective of the work herein reported was to provide information on the possibility of intercropping sugarcane with food crops, including crops suitable for the winter export market, under normal conditions. An effort was also made to determine which food crops are most suitable for intercropping with sugarcane. Incidental to the main objectives, a study was made of the best planting distances for sugarcane when interplanting with food crops.

EXPERIMENTAL PROCEDURE

Four field experiments were laid out, two at the Station's farm at Río Piedras in the north of the island, and two at the farm of the Isabela Substation in the northwest coastal area. The Río Piedras experiments were planted on a Vega Baja silty clay, a level alluvial soil, of the North humid coastal plains, normally requiring an extensive system of ditches to drain out excess waters. The plots were 33 feet long and 32 feet wide with a total area of 1,056 square feet, or 1/41.25 of an acre. Cane variety P.O.J. 2878, the most extensively grown in the Island, was planted both 4 feet and 8 feet apart, with 248 and 124 seedpieces per plot, respectively. There were eight furrows per plot at the 4-foot planting distance and four at the 8-foot planting distance. Cost accounts were kept for 3 crops at Río Piedras in terms of man-hours for all field operations performed on both the cane and food-plant crops.

Seminole soybeans and Mayorbela corn were interplanted with the plant cane in experiment No. 1, but native red beans were used instead of soybeans with the first ratoon crop. Cucumbers were used instead of corn in the second ratoon crop. For the second Río Piedras experiment, No. 3, native red beans and corn were interplanted with cane for the plant crop, while cucumbers were grown instead with the ratoon crop.

The Isabela experiments were planted on Coto clay, a rather friable, permeable, nearly level soil of the northwest coastal plains. One of the Isabela experiments, No. 2, was similar in design to the Río Piedras experiments except that sugarcane variety P.R. 903 was used instead of P.O.J. 2878. The following crops were interplanted with the plant cane of this

experiment: Cowpeas, cucumbers, melons, soybeans, and corn. In the first ratoon of this experiment the following crops were interplanted: Native red beans, corn, cucumber, native white beans, and tomatoes. The second ratoon crop of this cane had to be destroyed due to damage by white grubs.

In the second Isabela experiment, No. 4, sugarcane variety P.R. 902 was planted with 4-foot distance between rows and in $\frac{1}{70}$-acre plots. This plant cane was interplanted with native white beans, cucumbers, tomatoes, and melons, including check plots where sugarcane was grown alone. All treatments were replicated 12 times. In both Isabela experiments rainfall was supplemented with irrigation whenever necessary.

At all four experimental sites in both Río Piedras and Isabela, sugarcane was grown alone in plots randomized throughout the field. These were used as check plots in the statistical interpretation of the yield data. Each treatment was replicated 20, 15, 10, and 12 times at the Río Piedras, (experiments Nos. 1 and 3) and Isabela, (experiments Nos. 2 and 4), respectively.

The food crops interplanted with plant cane were set between each two sugarcane furrows; in ratoons they were planted only in the clean banks between sugarcane furrows. Two drills of seed were planted on each bank in the case of the legume crops. The cucurbits were planted on a single continuous drill in the center of each bank and were thinned out 10 days after germination. Corn was drilled along the banks in two rows with plants 2 feet apart in the row. Tomatoes were planted in rows with a 3-foot distance between plants. When cane was planted in rows 8 feet apart, there were twice as many food-crop plants as when it was planted only 4 feet apart.

The sugarcane plant crops received a 14-4-10 fertilizer at a rate of 1,000 pounds to the acre and a dressing of ammonium nitrate at a rate of 250 pounds to the acre. The ratoon crop received fertilizer at rates of 600 to 800 pounds to the acre, with dressings of ammonium nitrate ranging from 250 to 450 pounds to the acre.

The corn received a 10-10-5 fertilizer at a rate of 1,000 pounds to the acre. Cowpeas received 640 pounds to the acre of a 10-10-6 fertilizer. Other crops did not receive any special fertilizer applications, though they could share the fertilizer applied to the main crop.

Table 1 gives information as to planting and harvesting dates, age of cane at harvest, and rainfall during the growing period for the four crop cycles comprising the experiments. Eight sugarcane crops were harvested. The rainfall at Río Piedras was plentiful for both the sugarcane and food crops; however, at Isabela, supplemental irrigation was necessary to assure an adequate level of soil moisture during the growing period of the various crops.

The cane was harvested as in commercial practice. The cane from each

plot was weighed in the field by means of a portable crane and special weighing baskets. A sample of 10 canes was taken at random from each plot at harvesttime. The sample canes were then ground in the Station hydraulic mill at Río Piedras, and a juice sample was obtained for determination of the Brix and polarization values. The corn was all harvested at once, but the harvest of the other food crops was spread over a period of time. Legumes were picked at three different times during a 15-day period; cucurbits and tomatoes at various times for a short interval. In the second Isabela experiment, No. 4, cucumbers were harvested after the

TABLE 1.—*Location, crop cycles, planting and harvesting dates, age at harvest, and rainfall during the growing period for 4 intercropping experiments with sugarcane at Río Piedras and Isabela*

Location	Experiment No.	Crop	Date of planting	Date of harvest	Crop age	Rainfall during growing period
					Months	*Inches*
Río Piedras	1	Plant cane	May 10–11, 1944	Apr. 23–26, 1945	11½	67.7
		First ratoon		Mar. 21, 1946	11	60.0
		Second ratoon		Mar. 17–21, 1947	12	74.6
Isabela	2	Plant cane	May 10, 1944	Apr. 2–4, 1945	11	52.0
		First ratoon		Mar. 18, 1946	11	53.7
Río Piedras	3	Plant cane	Dec. 26–28, 1944	Feb. 11–14, 1946	13½	71.0
		First ratoon		Mar. 24–29, 1947	13	78.4
Isabela	4	Plant cane	Mar. 6–11, 1946	Mar. 17, 1947	11	52.0

fruits were mature as is done in seed production. The yields of food crops were weighed in the field. Statistical analyses were made of the yield data in terms of sugar produced per acre and also of the cost accounts data.

RESULTS

Table 2 shows the mean sugar production of a plant cane and two ratoon crops in the intercropping experiment at Río Piedras for the period 1944–47. Cost accounts are also given for the first two crops in the cycle.

As shown in Table 2, planting sugarcane with 4 feet between rows led to significantly higher available sugar yields than planting with 8 feet between rows, whether the cane was grown alone or intercropped with any one of the various food crops. (This is further corroborated by the data in tables

TABLE 2.—*Yields of and profits or losses on a plant cane and 2 ratoon crops in intercropping experiment No. 1, Río Piedras, 1944–47*

Treatment letter	Description of experiment No. 1				Available 96° sugar yields from—			Mean profit or loss per A. for[1]—	
	Crop interplanted with sugarcane in—			Distance between sugarcane rows	Plant crop	First ratoon	Second ratoon	Plant crop	First ratoon
	Plant crop	First ratoon	Second ratoon						
				Feet	*Cwt./A.*	*Cwt./A.*	*Cwt./A.*		
A1	None	None	None	4	65.7	73.8	113.5	$-52.2	$73.9
A2	do.	do.	do.	8	46.8	57.4	93.5	−65.6	30.8
B1	Soybeans	Native red beans	Native red beans	4	64.9	68.7	109.2	−44.3	24.2
B2	do.	do.	do.	8	42.6	53.1	94.7	−61.9	−17.0
C1	Corn	Corn	Cucumbers	4	54.1	65.4	109.2	−63.7	19.8
C2	do.	do.	do.	8	39.1	47.0	93.6	−69.9	−8.7
L. S. D. at the 5-percent level					5.2	5.7	6.2	13.2	17.0
L. S. D. at the 1-percent level					6.9	7.6	8.2	17.5	22.6

[1] Computed on the basis of 65 percent of the total sugar produced, the farm value of the food crops, and including all expenses in labor, fertilizer, and other materials.

TABLE 3.—*Mean sugar yields of 2 cane crops interplanted with food crops in intercropping experiment No. 2, Isabela, 1944–46*

Treatment letter	Description of experiment No. 2			Available 96° sugar yields for—	
	Crop interplanted with—		Distance between sugarcane rows	Plant cane	First ratoon crop
	Plant cane	First ratoon crop			
			Feet	*Cwt./A.*	*Cwt./A.*
A1	None	None	4	69.5	55.4
A2	do.	do.	8	51.1	43.1
B1	Soybeans	Native red beans	4	39.0	50.8
B2	do.	do.	8	40.8	32.3
C1	Corn	Corn	4	25.1	47.6
C2	do.	do.	8	33.5	29.2
D1	Cucumbers	Cucumbers	4	78.0	62.7
D2	do.	do.	8	52.4	45.7
E1	Cowpeas	Native white beans	4	65.3	59.5
E2	do.	do.	8	53.6	38.5
F1	Melons	Tomatoes	4	74.8	66.9
F2	do.	do.	8	54.5	47.9
L. S. D. at the 5-percent level				10.2	9.7
L. S. D. at the 1-percent level				13.6	12.8

3 and 4). Intercropping plant cane with the Seminole variety of soybeans had no significant effect on the available sugar yields. This conclusion is based on the respective comparisons of the sugar yields of treatments B1

TABLE 4.—*Mean sugar yields of 2 cane crops, and profits on the plant cane, when interplanted with food crops in intercropping experiment No. 3, at Río Piedras, 1944–47*

Treatment letter	Description of experiment No. 3			Available 96° sugar yields in—		Mean profits per acre for plant cane[1]
	Crop interplanted with—		Distance between sugarcane rows	Plant crop	First ratoon crop	
	Plant Crop	First ratoon crop				
			Feet	*Cwt./A.*	*Cwt./A.*	
A1	None	None	4	119.2	122.3	$151.9
A2	do.	do.	8	96.5	107.5	95.9
B1	Native red beans	Native red beans	4	118.2	135.2	206.6
B2	do.	do.	8	91.2	107.1	135.7
C1	Mayorbela corn	Cucumbers	4	108.4	139.1	139.7
C2	do.	do.	8	78.3	111.6	64.5
L. S. D. at the 5-percent level				9.0	9.3	24.4
L. S. D. at the 1-percent level				11.9	12.3	32.4

[1] Computed on the basis of 65 percent of the total sugar produced, the farm value of the food crops, and including all expenses in labor, fertilizer, and other materials.

TABLE 5.—*Mean sugar yields of a P.R. 902 plant-cane crop interplanted with food crops in intercropping experiment No. 4, Isabela, 1946–47*

Treatment letter	Crop interplanted with sugarcane	Distance between sugarcane rows	Available 96° sugar yields
		Feet	*Cwt./A.*
A	None	4	105
B	Native white beans	4	98
C	Cucumbers	4	99
D	Tomatoes	4	102
E	Melons	4	109
L. S. D. at the 5-percent level			12.6
L. S. D. at the 1-percent level			16.8

and B 2 with those of treatments A1 and A2. This lack of significance is further corroborated by the fact that there were no significant differences between the mean excess of expenditures over income for the corresponding treatments. Table 2 further shows that intercropping Mayorbela corn with sugarcane had a detrimental effect on sugar production when planting-distance effects are disregarded.

The intercropping of native red beans with sugarcane had no appreciable effect on sugar yields in the first ratoon crop, but intercropping with corn markedly reduced them. In the second ratoon crop, intercropping with

TABLE 6.—*Analysis of variance of the yield data obtained in 3 intercropping experiments at Río Piedras and Isabela, 1944–47*

Source of variation	Degrees of freedom	Sum of squares	Variance estimate	*f*
Río Piedras Experiment No. 1—plant cane				
Total	119	31,472		
Blocks	19	11,201		
Distance	1	10,435	10,435	83.48[1]
Error (a)	19	2,381	125	
Intercropping	2	1,943	971	14.11[1]
Intercropping × distance	2	278	139	2.02
Error (b)	76	5,234	69	
Río Piedras experiment No. 1—first ratoon				
Total	119	26,764		
Blocks	19	8,219		
Distance	1	8,484	8,484	80.36[1]
Error (a)	19	2,006	105	
Intercropping	2	1,796	898	10.98[1]
Intercropping × distance	2	41	20	.25
Error (b)	76	6,218	82	
Río Piedras experiment No. 1—second ratoon				
Total	119	27,110		
Blocks	19	8,820		
Distance	1	8,333	8,333	66.19[1]
Error (a)	19	2,392	126	
Intercropping	2	99	49	.52
Intercropping × distance	2	167	18	.19
Error (b)	76	7,299	96	
Isabela experiment No. 2—plant cane				
Total	116	48,268		
Blocks	9	5,806		
Distance	1	3,608	3,608	53.06[1]
Error (a)	9	616	68	
Intercropping	5	22,253	4,450	33.64[1]
Intercropping × distance	5	4,476	895	6.77[1]
Error (b)	87	11,509	132	

TABLE 6—*Continued*

Source of variation	Degree of freedom	Sum of squares	Variance estimate	
Isabela experiment No. 2—first ratoon				
Total	116	32,301		
Blocks	9	6,939		
Distance	1	9,399	9,399	128.75[1]
Error (a)	9	661	73	
Intercropping	5	5,252	1,050	9.29[1]
Intercropping × distance	5	216	43	.38
Error (b)	87	9,834	113	
Río Piedras experiment No. 3[2]—plant cane				
Total	88	35,555		
Blocks	14	5,364		
Intercropping	2	3,505	1,752	11.46[1]
Distances	1	15,920	15,920	104.07[1]
Intercropping × distance	2	211	105	.69
Error	69	10,555	153	

[1] Significant at the 1-percent level.

[2] Statistical data missing for ratoon crop.

native red beans and cucumbers produced no significant reduction in sugar yields.

The mean sugar yields of two cane crops interplanted with food crops in a field of Coto clay at Isabela (experiment No. 2) are shown in table 3. The results with the plant cane indicate that intercropping with soybeans or corn led to significant reductions in sugar yields at both planting distances, while intercropping with cucumbers, cowpeas, or melons had no effect on the sugar yields at either planting distance. The soybean crop was almost a complete failure because of a very severe insect attack. The melons were a complete failure. They were planted rather late and growth was slow, the partial shade of the young cane plants being very detrimental to their development.

Cucumbers, native white beans, and tomatoes interplanted with sugarcane ratoons had no significant effects on yields. In both the plant and ratoon crops the planting of corn between sugarcane rows resulted in lowered sugar yields.

Table 4 gives data on sugar yields of two crops grown at Río Piedras during the period 1944–47. In the plant crop, sugarcane was intercropped with native red beans and Mayorbela corn, while cucumbers instead of

corn were grown with the ratoon crop. Native red beans and cucumbers had no effect on the sugar yields, but corn reduced them.

Table 5 shows the results of the second Isabela experiment, No. 4. The yields of sugarcane were not affected by intercropping with native white beans, cucumbers, tomatoes, or melons. All the food crops were harvested successfully, except the melons. They could not keep pace with the rapid growth of the spring-planted cane seedlings.

TABLE 7.—*Yields of food crops interplanted with sugarcane in 4 experiments at the Isabela Substation and at the Río Piedras Main Station, 1944–45*

Crop No.	Crop[1]	Cane planting distance	Mean yields
		Feet	*Cwt./A.*
1	Cowpeas	4	3.3
2	do.	8	2.7
3	Soybeans	4	2.7
4	do.	8	3.2
5	Native white beans	4	3.6
6	do.	8	3.5
7	Native red beans	4	1.6
8	do.	8	2.0
9	Corn	4	22.4
10	do.	8	18.3
11	do.	4	12.0
12	do.	8	11.4
13	Cucumbers	4	16.1
14	do.	8	31.2
15	do.	4	40.4[2]
16	do.	8	21.1[2]
17	Tomatoes	4	16.1
18	do.	8	22.1

[1] Corn crops 11 and 12 were produced at Río Piedras, all others at Isabela.
[2] Harvested after fruits were mature, as used in seed production.

Data on the sum of squared deviations of the yields obtained in the various intercropping experiments conducted at both Río Piedras and Isabela, except for the ratoon of crop experiment No. 3, and the plant crop of experiment No. 4, are given in table 6.

Data on the mean yields of some food crops interplanted with sugarcane are presented in table 7. All yields were satisfactory considering the conditions under which the crops were grown. Corn, cowpea, native white bean, native red bean, tomato, and soybean yields did not seem to be affected by the planting distance of the sugarcane. However, P.R. 39 variety of cucumbers produced nearly 50 percent more fruits when the cane furrows were 8 feet apart than when they were only 4 feet apart.

DISCUSSION

An over-all examination of the data obtained from seven crops in three experiments indicates that a planting distance of 4 feet between rows of cane is much better from the standpoint of sugar yields than one of 8 feet. regardless of whether or not the cane is intercropped with these or some other food crops similar to those tested.

The experimental evidence further indicates that it is possible to intercrop cane with some food crops without affecting the sugar yields. It also shows that some crops like cucumbers, tomatoes, and melons, can be interplanted satisfactorily during the fall season with a possibility of shipping the produce to Continental United States during the winter season. These observations suggest the possibility of increasing the efficiency of utilizing sugarcane lands. This is of extreme importance in view of the limited amount of good arable land available in Puerto Rico for food-crop production. Furthermore, the sugarcane plantings are generally located on the more level and more fertile soils of the Island, where mechanization in field operations is practicable.

Legume crops, such as soybeans, native red beans, native white beans, and cowpeas, can be grown to advantage when intercropped with sugarcane. Field observations indicate that the soybeans and other legume crops do much better when grown in association with a plant cane than with a ratoon crop; this is true from the standpoint of both crops. It seems that the competition for nutrients and space is much stiffer with ratoon crops having well-established root systems than with young cane seedlings. The trash residues left after harvesting the sugarcane crops considerably reduces the planting area for the food crop.

Tomatoes and cucumbers, can also be grown profitably in association with a sugarcane crop. Melons could perhaps be intercropped to advantage, if planted early in the fall. However, it seems that melons are not suitable for intercropping in spring plantings because sugarcane grows more rapidly and the melon crop takes a rather long period of development. In general, crops which do not attain much height combine rather nicely with young sugarcane plants. Tall field crops of the grass family such as corn are not suitable for growing in association with young sugarcane plants. The results available from the five experiments in which corn was included consistently show a reduction in available 96° sugar yields from fields where corn was interplanted with sugarcane, as compared with no effects, or even beneficial effects, from interplanting sugarcane with legumes, tomatoes, cucumbers, and similar food crops.

The rather harmful effects of the association of corn plants with young cane may perhaps be caused by the heavy nutrient extraction from the soil by the rapidly growing corn plants, especially at the early critical stages

of cane growth. This competition for nutrients is probably more acute for nitrogen which is usually demanded in relatively large quantities by plants of the grass family such as sugarcane and corn. Moreover, field observations indicate that field mice are attracted by corn plantings and remain in the cane fields after the corn is harvested, doing great damage to the sugarcane crop.

The possibility of using the same land area for the production of a normal crop of sugarcane and another of food crops, other than corn, has no economic disadvantages. In some of the cases studied during the course of the experiments herein reported, significantly higher returns per acre were obtained when interplanting sugarcane with food crops than when planting sugarcane alone.

In a program geared to the most intensive utilization of the land as a means of increasing the agricultural output of the Island careful consideration should be given to the production of food crops in the sugarcane-producing areas. In this respect, the evidence reported here is rather encouraging and should receive careful consideration from growers and Government agencies alike.

SUMMARY

Data are presented here for two intercropping experiments, involving five sugarcane crops, conducted in an imperfectly drained alluvial soil at Río Piedras on the north coast, and for two intercropping experiments (three sugarcane crops) conducted at Isabela on a level lateritic soil of the northwest coastal plains. At both locations sugarcane was planted in rows 4 feet apart and 8 feet apart. Sugarcane was grown alone and intercropped with either soybeans, corn, native red beans, native white beans, cucumbers, cowpeas, melons, or tomatoes.

Statistical analysis of the results obtained indicate that, at a planting distance of 4 feet between rows of cane, higher sugar yields can be obtained than at an 8-foot planting distance, regardless of whether the cane is grown alone or intercropped. Legume crops such as soybeans, native red beans, native white beans, and cowpeas, can be grown advantageously with sugarcane. Cucumbers, melons, and tomatoes also can be grown in association with the young cane plants without reducing the sugar yields. Corn, however, is detrimental to the production of sugar when grown in association with the young cane plants. Such intercropping of sugarcane soils is feasible technically and economically and should receive careful consideration as a means of increasing Island food production on the same acreage.

RESUMEN

Se presentan aquí los datos de dos experimentos de campo, que incluyen cinco cosechas de caña, y los cuales fueron sembrados en un suelo de alu-

vión con desagüe imperfecto en Río Piedras, costa norte de Puerto Rico, y de dos experimentos con tres cosechas de caña en un suelo laterítico de la zona de Isabela, en las llanuras costaneras del noroeste. En ambos sitios, la caña se sembró en hileras a 4 y a 8 pies de distancia. En algunas parcelas la caña se sembró sola y en otras se intercaló con otros cultivos, tales como habichuelas soyas, habichuelas coloradas del país, habichuelas blancas del país, pepinillos, fríjoles, melones y tomates.

El estudio estadístico de los datos obtenidos revela que la caña sembrada en hileras a 4 pies de distancia rinde más azúcar que la que se siembra a 8 pies, no importa que esté sola o intercalada con otras cosechas. Las plantas leguminosas, tales como las soyas, fríjoles, habichuelas coloradas y habichuelas blancas del país pueden intercalarse ventajosamente con la caña. Los pepinillos, melones y tomates, también pueden sembrarse en asociación con las plantas jóvenes de caña sin temor a que ocurra una reducción en la producción del azúcar. El maíz, intercalado con la caña, no es recomendable, pues reduce la producción de azúcar de la caña. Tanto técnica como económicamente es posible usar los suelos que se dedican a la caña con cultivos intercalados, práctica esta que debería recibir mayor consideración como uno de los medios para aumentar la producción de alimentos en la Isla sin tener que utilizar terrenos adicionales.

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