Effect of Planting Distances on Shaded Coffee Yield in Puerto Rico[1]

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INTRODUCTION

Coffee is one of the main cash crops of Puerto Rico. In the coffee growing area, located in the West Central mountainous part of the Island at elevations varying from 500 feet to around 3,000 feet above sea level; highly leached latosols with slopes above 30 percent are predominant.

Statistics show an average production of 200 pounds of market coffee per *cuerda*[3], for an estimated area of 160,000 *cuerdas*. The yields are very low as compared with other coffee-producing countries such as Hawaii, El Salvador, and Brazil, and also with the few intensively managed coffee groves in Puerto Rico.

The results of field trials involving different planting distances in coffee-producing countries have been adequately covered by Wellman (*4*)[4]. Long-range experiments have shown favorable results of close planting distances at the beginning of the trials. In the long run, the close planting distances will require thinning to facilitate cultural practices. Factors such as soil fertility, elevation, slope, temperature, rainfall, and pruning system must be considered when deciding upon a suitable planting distance. Moreover, the incidence of diseases and insect pests must be taken into consideration when selecting a planting distance, not only because of difficulty in controlling the pests, but also to allow for the factors that might favor the spread of a disease or insect attack. A recent report by Beaumont and Fukunaga (*1*) of an experiment carried on at Kona, showed no statistical differences among three planting distances in rows 8 feet apart.

Medina (*3*), reported that a single Robusta coffee tree planted in a "cova" [5] with only one vertical produced as much coffee as a tree pruned to leave four verticals, or two and four trees per cova pruned to four verticals as a whole.

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[3] A *cuerda* is equivalent to 0.97 of an acre.

[4] Italic numbers in parentheses refer to Literature Cited, p. 86.

[5] "Cova" is a system of coffee planting in general use in Brazil and Angola in which 1 to 4 trees are planted per hole 1 foot apart.

This paper summarizes an experiment conducted at the Coffee Substation of the Agricultural Experiment Station, Adjuntas, at which different planting distances were tested as to coffee yield response.

PROCEDURE

The experiment was located at the Coffee Substation Farm, Adjuntas, in the heart of the coffee-growing area of the Island. At the site, at an elevation of around 2,000 feet above sea level, the soil was a highly leached latosol Alonso clay with fairly good structure.

Annual rainfall is approximately 70 to 80 inches with two peaks in the rainfall pattern during the months of April and May and August and September. Daily temperatures fluctuate from a minimum of 60°F. to a maximum of 85°F.

TABLE 1.—*Planting distances in the trial showing number of coffee trees per acre for each treatment*

Treatment	Planting distances in feet	System	Trees per acre
A	3 x 3 x 9	Double hedge	2,419
B	3 x 6	Single hedge	2,419
C	3 x 9	do.	1,613
D	3 x 12	do.	1,210
E	6 x 6	do.	1,210
F	6 x 9	do.	806
G	6 x 12	do.	605
H	9 x 9	do.	538
I	9 x 12	do.	403
J	12 x 12	do.	302

Uniform 1-year-old coffee seedlings of the Bourbon variety (*C. Arabica* L. var. Bourbon Rdz. and Choussy) were used. The seedlings were transplanted from the nursery to the field with an earth-ball to reduce root damage. The seedlings were planted at the same depth as they were in the nursery. The system followed as much as possible a square pattern for each plot. The population in a 36 x 36-foot plot varied from a maximum of 72 to a minimum of 12 trees per plot (table 1). The distribution followed a paired-plot design as recommended by Capó (*2*), with 9 replications.

The shade consisted of mixed leguminous trees and bananas. It was pruned annually to permit around 30 to 50 percent of sunlight. A 9-10-5 fertilizer was applied to each plot at the rate of 12 hundredweights per acre in two split applications.

Fertilizer was applied immediately after the picking season and the second application during the summer months. The fertilizer was broadcast around the trees and plot area.

Weeding was done as a general rule twice a year, although sometimes more than two weedings were performed in the year, depending on the weed growth. Leaf miner and other insects were controlled with a mixture of 1½ pound of 15-percent Parathion and 2 quarts of 15-percent Dieldrin per acre, as recommended by the Entomology Department.

Coffee was picked during the harvesting season regularly every 15 days. Berries were weighed immediately after picking in the field. During the last crop, data on the time required to pick each plot on each picking date were gathered. Data were changed to market coffee based on a 5:1 ratio.

The 7-year data were analyzed statistically by analysis of variance, and a correlation analysis on the time required for picking each plot was performed on the last-year crop.

TABLE 2.—*Unadjusted annual mean production of market coffee in hundredweights per acre, as related to planting distance, 1956–62*

Treatment	1956	1957	1958	1959	1960	1961	1962
A	1.33	14.40	12.84	12.42	12.50	10.18	10.71
B	1.47	16.07	19.26	17.36	16.03	12.05	13.30
C	1.32	10.96	10.03	12.20	11.58	10.48	10.70
D	.61	6.26	7.19	8.81	8.65	9.02	9.02
E	.75	10.72	11.08	13.14	12.32	12.70	13.01
F	.45	6.78	5.69	7.01	8.45	8.28	9.21
G	.56	3.04	4.75	4.71	7.09	6.48	8.78
H	.27	3.00	5.58	7.02	8.27	8.02	8.09
I	.08	2.50	3.54	4.84	6.18	7.35	8.17
J	.14	1.30	2.28	3.04	3.91	4.45	4.73

RESULTS AND DISCUSSION

The unadjusted annual mean yields are presented in table 2. As expected, trees under treatments A and B with a higher population per unit area reached their peak production, within the 7-year experimental period, sooner than the trees in all other treatments. This corroborates previous information summarized by Wellman (*3*). Nevertheless, the drop in yield was not as severe as expected. Even in treatment B, in which the maximum yield was observed in the third year, the drop was not sharp. The drop was steady until the sixth crop and then there was an increase in yield.

The overall effect of planting distances is presented in table 3. The results showed that a planting distance of 3 x 6 feet (treatment B) was the best suited for planting coffee in Puerto Rico. This treatment outyielded significantly the rest of the treatments. Treatments A (3 x 3 x 9 feet double hedge), C (3 x 9 feet) and E (6 x 6 feet) followed treatment B. The three

treatments significantly outyielded treatments D (3 x 12 feet), F (6 x 9 feet), G (6 x 12 feet), H (9 x 9 feet), I (9 x 12 feet), and J (12 x 12 feet). Treatments D and F were superior to treatment J; however, treatments G, H, and I did not significantly outyield treatment J. An increase in distance between trees in the lines brought about a decrease in yield. This fact can be clearly established in the comparison of treatments B, C, D and E, F, G. By comparing treatments B, E, and G; C, F, and H; and D, G, and I as separate groups, we can see that an increase in distances among lines, without a change in distances between trees reduced yields.

A clear explanation of the results cannot be traced to a simple increase of the population per unit-area. Treatments A and B had the same number

TABLE 3.—*Combined adjusted mean production of market coffee yields for 6 crops, as related to planting distance*

Treatment	Planting distance in feet	Trees per acre	Hundredweights per acre[1]
A	3 x 3 x 9	2,419	12.38 b
B	3 x 6	2,419	15.78 a
C	3 x 9	1,613	11.02 b
D	3 x 12	1,210	8.17 c
E	6 x 6	1,210	11.74 b
F	6 x 9	806	7.55 c
G	6 x 12	605	6.02 c d
H	9 x 9	538	7.05 c d
I	9 x 12	403	5.03 c d
J	12 x 12	302	3.40 d

[1] Differences between treatments with same letter or set of letters are not statistically significant at the 5-percent level.

of trees per unit-area, but B significantly outyielded treatment A. The same condition occurred in treatments D and E. Both treatments had the same number of trees per unit area, but treatment E significantly outyielded treatment D. Whether the differences can be attributed to competition for sunlight, efficiency in fertilizer absorption, or reduction of competition from weeds must be explored in future research along this line.

Correlation studies on the efficiency of coffee picking during the last crop did not show any detrimental effect of the different planting distances. Apparently, the increase in yield per unit-area in close-planted coffee compensates, to a certain degree, the difficulties inherent to the picking operation under such conditions. Moreover, the distances that the picker has to cover at close planting distances are reduced to a minimum.

From the practical point of view, the farmer should start his new plantings at a distance of 3 x 6 feet, specifically with Bourbon coffee. If

after two or three crops he finds that the trees are too close and interfere with farm practices, he can reduce the tree population to half its original. Still, the farmer will be able to obtain good yields without an increase in cost of production.

SUMMARY

An experiment was performed at the Coffee Substation Farm, Adjuntas, P.R., in an Alonso clay. The population per unit area varied from a maximum of 2,419 trees per acre a minimum of 302. Results after 7 years proved that the best planting distance was 3 x 6 feet. This treatment was followed in value by 3 x 3 x 9 feet (double hedge), and 3 x 9 and 6 x 6 feet. The reduction in yield of trees at farther planting distances cannot be attributed exclusively to a decrease in plant population, since treatments with the same number of trees per acre differed in their yields. Correlation studies during the seventh crop did not show any effect of planting distance on the efficiency of picking.

RESUMEN

En la Subestación de Café en Adjuntas, P.R., se llevó a cabo un experimento con café en un suelo Alonso. Se hicieron siembras de arbustos de café a distintas distancias sembrándose hasta un máximo de 2,419 arbustos y un mínimo de 302, por acre. Los resultados demostraron que la distancia más adecuada fue de 3 pies entre arbustos y 6 entre hileras. A esta prueba siguieron otras con las siguientes distancias: 3 x 3 x 9 pies (barrera doble), 3 x 9 y 6 x 6 pies.

Los estudios de correlación que se hicieron durante la séptima cosecha demostraron que las distintas distancias de siembra no dificultaron en modo alguno la recolección.

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