

Productivity of Nine Coffee Varieties Growing under Intensive Management in Full Sunlight and Partial Shade in the Coffee Region of Puerto Rico¹

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INTRODUCTION

Although there is little published information on the performance of improved varieties of coffee growing with intensive management in the Coffee Region of Puerto Rico, the Agricultural Experiment Station of the University of Puerto Rico is conducting studies on the performance of numerous varieties and selections of coffee at various locations in the Coffee Region.

This paper presents the results of studies carried out to determine the yields and quality of coffee produced by nine varieties growing under intensive management both in full sunlight and beneath shade trees under conditions typical of the Coffee Region of Puerto Rico.

MATERIALS AND METHODS

The trials were carried out at three locations near Adjuntas, Villalba, and Jayuya. At Jayuya the soil was steep Los Guineos clay, 2,500 feet above sea level, with a north-northeast exposure and about 90 inches of fairly well-distributed annual rainfall. At Villalba the soil was steep, Múcara clay at an elevation of 1,800 feet with a southern exposure and about 65 inches of annual rainfall, with a marked dry season from December through March. At Adjuntas the soil was sloping Cialitos clay on a site well protected from wind at an elevation of 2,000 feet with about 75 inches of annual rainfall.

¹ This paper reports the results of field trials carried out cooperatively by the Soil and Water Conservation Research Division, Agricultural Research Service, USDA, the Agricultural Experiment Station of the University of Puerto Rico, and the Soil Conservation Service, USDA. The authors express deep appreciation to Dr. Enrique Matta of Villalba, Mr. Jaime Rullán Mayol of Adjuntas, and Mr. Luis A. Becerra of Jayuya, on whose farms these trials were conducted. These distinguished farmers gave valuable advice and bore the full cost of the trials.

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All the coffee varieties were planted during 1957. The trees were planted 4 feet apart in rows 10 feet apart with individual plots consisting of eight trees in a row. A randomized block design was used with four replications of all varieties both in full sunlight and under shade at Jayuya, three replications in full sunlight and under shade at Villalba, and four replications in full sunlight at Adjuntas.

The rows of coffee trees were kept weed-free, but grass, mowed periodically, was allowed to grow between rows to control erosion. Shade trees were pruned so that they provided about 30 percent of shade. The coffee trees were sprayed periodically with a mixture of parathion and dieldrin to control leaf miners. Zinc sulfate was added to the spray as required to correct symptoms of a deficiency of zinc. After each crop, old, broken, weak or diseased branches and excess suckers were removed from the trees. The soil was limed to about pH 5.5 at the start of the experiments, and 1 ton of 12-6-16 fertilizer containing 300 pounds of magnesium sulfate was applied per acre yearly in three equal applications in April, August, and December.

Yields were taken for 3 consecutive years starting 4 years after planting when a good stand of well-developed trees had been obtained. Coffee berries were picked as they ripened and yields of market coffee produced by each plot determined.

During the last year, 1 *almud*³ of berries from each plot of the different varieties growing in full sunlight and under shade trees at Jayuya was weighed, depulped, demucilaged, the beans dried in the sun to a moisture content of 12 to 14 percent, and the parchment removed. Weight of market coffee produced per *almud* was then determined.

The beans were then passed through a series of sieves used to grade coffee commercially⁴ and the proportion of beans in each size group determined. Average volume of beans produced by each plot was determined by measuring the water displaced by 100 randomly selected beans. The number of abnormal beans of various types in each sample was determined visually.

RESULTS AND DISCUSSION

Table 1 shows that all nine varieties of coffee yielded much more heavily when grown in full sunlight than under partial shade provided by trees. The Mundo Nuevo and Puerto Rico 401 varieties were the highest yielders in full sunlight, producing over 1 ton of market coffee per acre yearly. All

³ Unit used for measuring coffee in Puerto Rico—equal to 20 liters or 28 pounds of berries. Pickers are paid and coffee berries purchased on this basis.

⁴ Deep appreciation is expressed to Mr. Pablo Velázquez, Executive of Cooperativa Cafeteros de Puerto Rico, for his advice and wholehearted cooperation in conducting these studies.

the other varieties except for lowest yielding Columnaris produced similar yields, averaging 1,590 pounds per acre. Under shade trees, yields were about 40 percent lower and there was no significant difference in the productivity of the Mundo Nuevo, Yellow and Red Bourbon, Puerto Rico

TABLE 1.—Yields (pounds) of 9 varieties of coffee growing with intensive management in full sunlight and in partial shade provided by trees under typical conditions in the Coffee Region of Puerto Rico¹

Yields ² of market coffee produced per acre yearly			
Variety	Full sunlight ³	Variety	Partial shade ⁴
Mundo Nuevo	2,340 a	Mundo Nuevo	1,400 a
Puerto Rico 401 ⁵	2,110 a	Yellow Bourbon	1,400 a
Red Bourbon	1,680 b	Red Bourbon	1,350 a
Kent	1,650 b	Puerto Rico 401	1,170 ab
Villalobos	1,610 b	Pacas	1,120 ab
Yellow Bourbon	1,610 b	Villalobos	1,110 ab
Caturra	1,550 b	Kent	1,110 ab
Pacas	1,420 b	Caturra	990 b
Columnaris	990 c	Columnaris	950 b
Average	1,661		1,178
L.S.D. ⁰⁵	420		330

¹ All values are averages of 3 heavy crops.

² Varieties having 1 or more letters in common do not differ significantly.

³ Averages of 11 replications at 3 locations—Jayuya, Villalba, and Adjuntas.

⁴ Average of 7 replications at 2 locations—Jayuya and Villalba.

⁵ Selection from a high-yielding tree on the farm of Mr. Antonio Soto Matías, Bo. La Torre of Lares, by Dr. Tara Singh Dhaliwal, Plant Breeder, Agricultural Experiment Station, University of Puerto Rico, and identified as Puerto Rico 401. See Desarrollo de Estirpes de Biotipos Superiores de Café Mediante la Selección, la Hibridación, y la Propagación Asexual para su Cultivo en Puerto Rico, Tara Singh Dhaliwal, *Rev. de Agr. de P.R.* 44(2): 59-77, 1957.

401, Pacas, Villalobos, or Kent varieties, which yielded an average of 1,240 pounds of market coffee per acre.

Table 2 shows that considerably larger beans were produced by all varieties under shade than in full sunlight. In full sunlight, an average of 16.8 percent of the beans were larger than $1\frac{3}{64}$ of an inch in width and 48.6 percent were larger than $1\frac{7}{64}$ of an inch, compared to 31.0 and 59.8 percent, respectively, under shade. These sizes are considered of top export grade. Average volume of the beans for all varieties was 129 mm.³ in full sunlight compared to 141 mm.³ under shade. On the other hand, shade had no

TABLE 2.—Size of coffee beans produced by 8 varieties of coffee growing in full sunlight and under shade trees at Jayuya, P. R.

Beans retained on sieve with $\frac{1}{4}$ -in. diam. perforation ¹				Beans retained on sieve with $\frac{1}{8}$ -in. diam. perforation ²				Average volume of coffee beans			
Variety	Full sunlight ³	Variety	Partial shade ³	Variety	Full sunlight ³	Variety	Partial shade ³	Variety	Full sunlight	Variety	Partial shade
	<i>Percent</i>		<i>Percent</i>		<i>Percent</i>		<i>Percent</i>		<i>Mm.</i> ³		<i>Mm.</i> ³
Mundo	(26.0)*	Villalobos	(48.2)	Puerto Rico 401	90.1	Villalobos	90.7	Kent	143 a	Puerto Rico 401	151 a
Nuevo	63.8 a		75.6 a	Villalobos	89.4	Puerto Rico 401	89.8	Puerto Rico 401	137 ab	Villalobos	150 a
Puerto Rico 401	(21.8)	Puerto Rico 401	(50.3)	Mundo	89.3	Kent	89.7	Mundo	134 abc	Mundo	145 a
Kent	(23.6)	Mundo	(38.4)	Nuevo				Nuevo		Nuevo	
	55.6 b	Nuevo	65.8 b	Kent	89.2	Caturra	88.6	Villalobos	128 bcd	Kent	143 abc
Villalobos	(13.3)	Kent	(33.7)	Red Bourbon	86.9	Mundo	88.2	Yellow Bourbon	127 cd	Caturra	140 abcd
Caturra	(13.4)	Yellow	(22.9)	Bourbon		Nuevo		Bourbon			
	43.0 cd	Bourbon	59.0 bc	Caturra	85.4	Yellow Bourbon	88.0	Caturra	125 cd	Pacas	133 bcd
Red Bourbon	(13.3)	Caturra	(26.6)	Yellow Bourbon	84.5	Pacas	87.7	Red Bourbon	124 de	Yellow Bourbon	132 cd
	41.8 cd		57.9 c	Pacas	83.4	Red Bourbon	83.7	Pacas	115 e	Red Bourbon	130 d
Yellow Bourbon	(11.2)	Pacas	(14.8)								
	38.7 d	Red Bourbon	45.9 d								
Pacas	(11.5)		(13.5)								
	37.7 d		39.9 d								
Average	(16.8)		(31.0)		87.3		88.3		129		141
	48.6		59.8								
L.S.D. ⁰⁵	7.6		7.4		N.S.		N.S.		9.0		11.0

¹ Top export grade.

² Good commercial-grade coffee.

³ Percentage by weight of air-dry (12- to 14-percent moisture) market coffee, parchment removed. Sieving as performed commercially separates beans on basis of their width. Numbers in parentheses show percentage of beans larger than $1\frac{3}{64}$ inch in width. Varieties having one or more letter in common do not differ significantly.

appreciable effect on the proportion of beans exceeding $15/64$ of an inch in width, which is considered a good commercial grade.

In full sunlight the Kent, Mundo Nuevo, and Puerto Rico 401 varieties produced beans with the largest average volume and the Mundo Nuevo and Puerto Rico 401 varieties the largest proportion (about 60 percent) of beans exceeding $17/64$ of an inch in width, considered top export grade. Under shade, the Villalobos and Puerto Rico 401 varieties produced the

TABLE 3.—*Abnormal beans produced by 8 varieties of coffee growing in full sunlight and under shade trees at Jayuya, P.R.*

Variety	Type of bean (percent)									
	Caracolillo ¹		Triangular ²		Giant ³		Inferior ⁴		Normal	
	Full sunlight	Partial shade	Full sunlight	Partial shade	Full sunlight	Partial shade	Full sunlight	Partial shade	Full sunlight	Partial shade
Caturra	4.9	10.1	8.6	8.7	0.1	0.4	1.7	0.5	84.7	80.3
Villalobos	4.8	6.9	3.3	.2	0	.2	3.3	2.2	88.6	90.5
Mundo Nuevo	6.8	9.8	1.7	2.5	.1	.2	2.3	1.1	89.1	86.4
Red Bourbon	4.6	7.7	8.4	8.1	.2	0	1.5	1.2	85.3	83.0
Puerto Rico 401	5.1	10.2	1.3	1.7	0	.2	1.5	.7	92.1	87.2
Yellow Bourbon	9.5	7.3	3.0	4.4	.1	.1	.9	.5	86.5	87.7
Kent	5.3	9.7	4.3	7.7	.1	.1	1.6	1.1	88.7	81.4
Pacas	7.0	8.5	9.8	9.3	0	.1	1.0	.7	82.2	81.4
Average	6.0	8.8	5.1	5.3	0.08	0.16	1.7	1.0	87.2	84.7

¹ Rounded beans resulting from development of only 1 bean in a berry. Not a commercial defect.

² Triangular-shaped beans resulting from development of more than 2 beans in a berry. Not a commercial defect.

³ Oversized beans with 2 endosperms. Sometimes the 2 endosperms become separated, giving the appearance of broken beans which are considered a commercial defect.

⁴ Beans of poor appearance, etc.

highest proportion of beans of this size, about 75 percent. There were no significant varietal differences in the proportion of berries exceeding $15/64$ of an inch in width, produced either in shade or in full sunlight. Coffee-bean size is a major component of quality in the European market, but is of small importance in the United States where flavor as determined by cup-testing is the main criterion.

Table 3 shows that a higher proportion of *caracolillo* beans was produced under shade than in full sunlight, but there were no sharp varietal differences. The Caturra, Pacas, and Red Bourbon varieties produced more triangular beans than the other varieties, both under shade and in full sun-

light. All varieties produced negligible quantities of Giant and inferior beans both in shade and full sunlight.

Figure 1,A shows that shading considerably delays ripening of the coffee berries; only 10 percent of the shaded crop was harvested in October compared to 38 percent of the sun-grown crop. Figure 1,B shows that the Caturra variety ripens somewhat later than the others; only 20 percent of the berries of this variety were harvested in October compared to an average of 43 percent for the others. These data suggest two ways of making coffee-picking more uniform, to make better use of labor and reduce losses

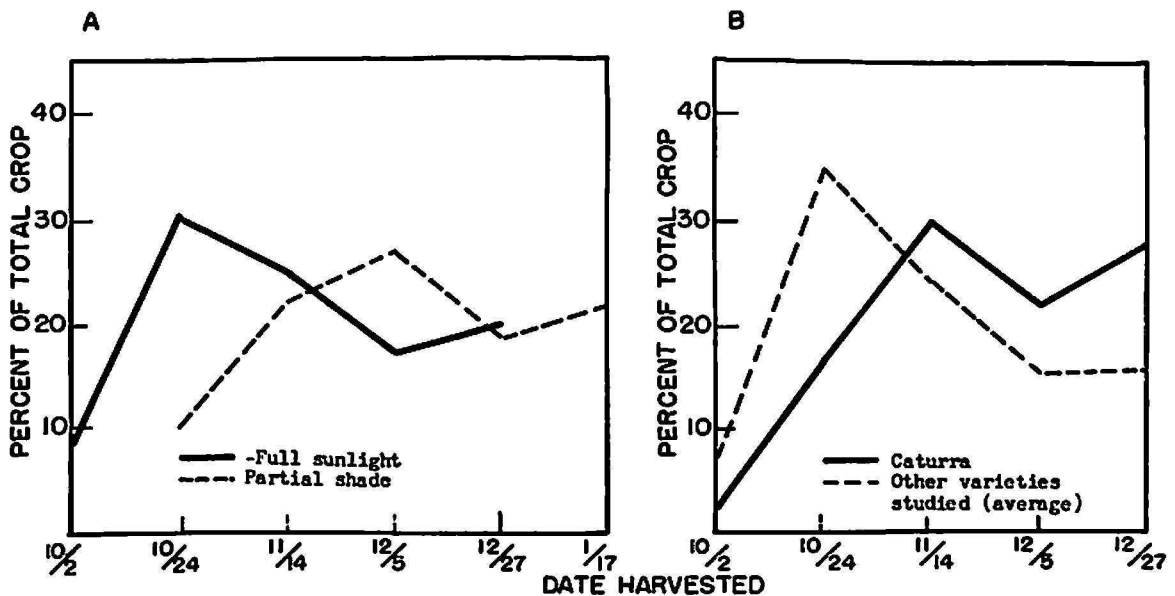


FIG. 1.—Effect of shade and of variety on ripening rate of coffee berries at Jayuya: A, Effect of shade when all varieties studied are averaged; B, Caturra in full sunlight as compared with other varieties.

from berry drop occurring when much of the crop ripens over a short period of time.

Table 4 shows that shading had no appreciable effect on yields of market coffee obtained per *almud* of berries, but that there were marked varietal differences. In both full sunlight and under shade trees the Mundo Nuevo and Puerto Rico 401 varieties produced an average of about 5 pounds of market coffee per *almud*, followed by the Red and Yellow Bourbon and Kent varieties which averaged 4.61 pounds per *almud* and, finally, by Pacas and Caturra which averaged only 4.32 pounds per *almud*.

Neither shading nor varieties had any appreciable effect on weight of an *almud* (20 liters) of ripe berries which averaged about 28 pounds, or on the percentage of parchment which averaged about 19 percent of the weight of dry parchment coffee. The ratio of market coffee to ripe berries is of obvious importance to buyers of unprocessed coffee berries and to farmers.

The data presented in this paper show that intensively managed coffee growing under typical conditions in the Coffee Region of Puerto Rico produces much higher yields when grown in full sunlight than under partial shade provided by trees. Although shading had no effect on the proportion of commercial-sized coffee, a somewhat higher proportion of the beans produced in partial shade were of the largest sizes. There is no evidence in the literature to indicate that shading affects the cup quality of coffee.

The data also indicate that the Mundo Nuevo and Puerto Rico 401 varieties (fig. 2) were the most productive. The Mundo Nuevo variety produced the highest average yields of market coffee both in full sunlight

TABLE 4.—*Relation of ripe berries to market coffee with 7 varieties growing in full sunlight and under shade trees at Jayuya¹, P.R.*

Variety	Weight of 1 almud (20 liters) of ripe coffee berries	Market coffee produced per almud of ripe coffee berries ²	
		Full sunlight	Partial shade
	<i>Pounds</i>		
Puerto Rico 401	28.2	5.07 a	5.04 a
Mundo Nuevo	27.8	4.96 a	4.89 a
Red Bourbon	27.8	4.69 b	4.57 b
Yellow Bourbon	28.0	4.65 b	4.66 b
Kent	27.8	4.56 b	4.55 bc
Caturra	28.0	4.31 c	4.41 bc
Pacas	27.5	4.23 c	4.33 c
Average	27.9	4.64	4.64
L.S.D. ⁰⁵	N.S.	0.24	0.22

¹ All values are averages of 4 replicated plots.

² Varieties having 1 or more letters in common do not differ significantly.

and under shade trees, but was not statistically superior to Puerto Rico 401. Both varieties produced a similar high proportion of large-sized beans, had the lowest berry to market coffee ratios, and a similar insignificant proportion of abnormal beans. The semidwarf Caturra (fig. 3), Pacas, and Villalobos varieties are easy to pick since they rarely exceed 8 feet in height. However, it has been observed that these varieties are particularly susceptible to attacks by scale insects which are hard to control and often attack the berries, causing fruit drop. These varieties are also very susceptible to dieback during the first heavy crops, particularly during dry years and if leaf miners are not kept under control. Obviously, further studies including block plantings of the numerous promising varieties of coffee under different conditions in the Coffee Region are required.



FIG. 2.—Highest yielding Mundo Nuevo coffee variety growing in full sunlight under intensive management consistently produced well over a ton per acre of market coffee of excellent quality.



FIG. 3.—The semidwarf Caturra coffee variety is easy to pick but is prone to dieback during the first years of heavy bearing and is susceptible to attacks by scale insects.

SUMMARY

The productivity of nine varieties of coffee, grown with intensive management in full sunlight and beneath shade trees under typical conditions in the Coffee Region of Puerto Rico, were determined.

Much higher yields were produced by all varieties when grown in full sunlight than in about a 30-percent shade provided by trees. The Mundo Nuevo and Puerto Rico 401 varieties were the highest yielders in full sunlight, averaging well over 2,000 pounds of market coffee per acre yearly. Columnaris was lowest. There was little difference in yields of the Red and Yellow Bourbon, Kent, Caturra, Pacas, and Villalobos varieties under these conditions. There was little difference in the productivity of the various varieties when grown under shade trees. Somewhat larger beans were produced by all varieties when grown under shade than in full sunlight. The Mundo Nuevo and Puerto Rico 401 varieties yielded a high proportion of large-sized beans. There was no sharp difference in the proportion of commercial-grade beans, $> 1\frac{5}{64}$ inch in width, produced by the different varieties either in full sunlight or under shade trees.

Shading had no appreciable effect on the ratio of berries to market coffee, but there were marked varietal differences. The Mundo Nuevo and Puerto Rico 401 varieties had the narrowest ratios, producing about 5 pounds of market coffee for every 28 pounds (20 liters or 1 *almud*) of berries. Neither shading nor varieties had any important effect on the proportion of abnormal beans.

Shading considerably delayed ripening of the coffee berries and berries of the Caturra variety ripened considerably later than those of the other varieties studied.

RESUMEN

Se determinó la productividad de nueve variedades de café con un sistema intensivo de cultivo, tanto a pleno sol como bajo árboles de sombra, bajo condiciones típicas de la Zona Cafetalera de Puerto Rico.

La producción fue mayor cuando los cafetos se cultivaron a pleno sol que cuando se les proveyó alrededor de un 30 por ciento de sombra. Las variedades Mundo Nuevo y Puerto Rico 401 fueron las de más alto rendimiento cuando se cultivaron sin sombra, promediando más de 2,000 libras de café pilado por acre, por año. La variedad Columnaris fué la de menor producción, mientras que las variedades Borbón Rojo, Borbón Amarillo, Kent, Caturra, Pacas y Villalobos produjeron rendimientos similares. Hubo muy poca diferencia en la producción entre todas las variedades cuando éstas se cultivaron bajo sombra.

Todas la variedades produjeron una mayor proporción de granos grandes cuando se cultivaron bajo sombra que cuando se sembraron a pleno sol,

pero las variedades Mundo Nuevo y Puerto Rico 401 produjeron la más alta proporción de éstos. No hubo diferencias de importancia entre las variedades, tanto al sol como a la sombra, en cuanto a la producción de granos de tamaño comercial (un ancho superior a $1\frac{5}{64}$ de pulgada).

La sombra no afectó la proporción de café uva a café pilado, aunque sí hubo diferencias notables en este aspecto entre las variedades estudiadas. Las variedades Mundo Nuevo y Puerto Rico 401 produjeron el rendimiento mayor, o sea alrededor de 5 libras de café pilado por cada 28 libras de café uva (20 litros o un almud). La sombra y la variedad no afectaron la proporción de granos anormales.

La sombra retardó considerablemente la madurez del grano. De las variedades estudiadas, la Caturra fue la más tardía en madurar.