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Effects on Coffee of Two Levels of Fertilizer and Frequency of Their Application[1]

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INTRODUCTION

Numerous fertilizer experiments have been conducted during the past 60 years on the most important soils of the Coffee Region regarding levels of the major elements required for high coffee yields. Little research has been conducted, however, on the effect of frequency of application.

Most coffee farmers in Puerto Rico fertilize immediately after the harvesting season is over. The few farmers growing unshaded coffee often fertilize two or more times a year. There is insufficient experimental data available to support this second procedure.

This report presents results on yields of shaded and unshaded coffee by two levels of fertilization and four frequencies of their application.

REVIEW OF LITERATURE

Abruña et al. (1,2) reported that intensively managed unshaded coffee grown on Alonso clay at Castañer, P.R., responded strongly to yearly applications of 150 pounds of nitrogen and potassium per acre with strong evidence of a response to heavier applications during years of abundant rainfall. They also found that similarly managed but much higher yielding coffee grown on Los Guineos clay at Jayuya responded strongly to yearly applications of 300 pounds each of nitrogen and potassium per acre. They reported no significant response to phosphorus applications. Anstead (3) in India found that split applications of fertilizer gave best results. McClel-

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land (4) found that shaded coffee growing on alluvial-fan soil, not typical of the Coffee Region, responded in yield to applications of potassium particularly if accompanied by nitrogen, but did not respond to phosphorus. Rodríguez et al. (5) reported a response in yields of shaded coffee to nitrogen application on a Catalina clay at Maricao with the variety Puerto Rico, but not with Columnaris. No response to nitrogen was obtained on Alonso clay. Rodríguez et al. (6) found that the variety Columnaris grown on Los Guineos clay at Jayuya did not respond to fertilization but that the Puerto Rico cultivar responded to the application of all the major nutrients. Sanders and Wakefield (7) in Tanganyika reported that nitrogen applied during bud formation encouraged vegetative growth thus reducing yields. Vicente-Chandler et al. (8,9) recommend the use of 200 to 300 pounds of nitrogen, 80 pounds of phosphorus and 200 to 300 pounds of potassium per acre yearly, in two to three equal applications, on mature high-yielding, intensively managed coffee, depending on the yields.

EXPERIMENTAL PROCEDURE

Two experiments were conducted to determine the effect of frequency of fertilizer application on yields of the variety Red Bourbon growing on Morado clay at the Adjuntas Substation. The experimental sites are at an elevation of 1,850 feet. The mean monthly temperatures varied from 59° to 82° F. during the years in which the treatments were under evaluation. The mean monthly rainfall was 5.83 inches, ranging from 0.49 in February 1965 to 13.66 in September 1966. The annual rainfall varied from 50.34 to 75.99 inches.

The coffee seedlings were planted during September 1963 at 6 feet × 6 feet intervals for a total of 1,210 trees per acre. In one experiment, the seedlings were planted in full sunlight. In the other, they were planted under approximately 40-percent shade provided by trees of *Inga vera* Wild., which were planted at 24-foot intervals and pruned annually to obtain the desired intensity of light.

A partially balanced block design was used with eight treatments replicated 10 times. Each experimental plot had six coffee trees. The treatments were applied starting 1 year after the coffee trees were planted in the field. No fertilizer was applied to the coffee plantation before the treatments were started. Yields of ripe berries were determined for all the trees for 5 consecutive years.

Two levels each of nitrogen and potassium (100 and 200 and 200 and 400 pounds per acre, respectively) and one of phosphorus (75 pounds per acre) were tested in one, two, four, and six applications yearly.

The one-application treatment was given in July; the two-application treatment, in January and July; the four-application treatment, in January,

April, July, and October; and the six-application treatment, in January, March, May, July, September, and November. The fertilizer was applied on or about the 24th of the month.

RESULTS AND DISCUSSION

PARTIALLY SHADED COFFEE

Table 1 presents the results obtained from the experiment in which the coffee was grown under approximately 40-percent shade. It shows the fertilizer levels evaluated, the frequency of application, and the different yields expressed in terms of hundredweights of market coffee per acre.

TABLE 1.—*Effects of two levels of fertilization and four application frequencies on yields of coffee grown under partial shade*

Fertility levels— N	P	K	Number of applications	Production— 1965	1966	1967	1968	1969	Statistical mean[1]
Lbs./acre/year				*Hundredweights of market coffee per acre*					
200	75	400	4	14.34	28.09	11.73	18.71	7.96	17.04 a
100	75	200	2	13.14	25.51	8.69	14.99	6.83	15.19 ab
200	75	400	1	14.65	25.22	13.51	15.68	6.69	14.82 ab
100	75	200	4	12.63	23.87	8.16	17.73	5.13	14.21 ab
200	75	400	6	18.22	24.31	11.66	9.83	7.07	14.15 ab
100	75	200	6	15.65	25.69	11.01	14.32	5.64	14.14 ab
200	75	400	2	15.86	25.07	11.42	12.42	7.21	13.66 ab
100	75	200	1	15.33	22.06	12.99	11.69	8.77	12.68 b

[1] The mean production was calculated considering the statistical correction for soil fertility differences of the experimental sites. Treatments having one or more letters in common do not differ significantly.

The corrected statistical mean production and the statistical differences observed from the combined analysis of five crops are indicated.

The only statistical difference recorded among the treatments was the higher yields obtained when the 200-75-400-pound formulation was applied in four applications as compared to those obtained when the 100-75-200-pound formulation was given in one application only. Yields obtained when the lower level was applied at the end of January and July were not significantly different from those obtained with the higher level, when this was applied in one, two, four, or six applications.

Similar yields were obtained from the higher levels, regardless of whether the treatments consisted of one, two, four, or six applications yearly. A possible explanation is that the level of fertilizer applied provided an excess of the amount of nutrient required by the plant, irrespective of the number of applications. However, when the lower fertilizer levels were

applied in two or four applications, higher yields were obtained than when applied in either one or six. A possible explanation may be that a greater fertilizer loss from lexiviation resulted when all of the fertilizer was given in one application, and when given in six applications the individual portions were too small and did not permit the coffee trees to use the fertilizer efficiently during the periods in which the tree requirements were critical.

The differences in yields attributed to the number of applications made were more apparent in the case of the lower fertilization levels because the quantity of the nutrients applied was a limiting factor and the effects were

TABLE 2.—*Effects of two levels of fertilization and four application frequencies on yields of coffee grown in full sunlight*

Fertility levels— N	P	K	Number of applications	Production— 1965	1966	1967	1968	1969	Statistical mean[1]
Lbs./acre/year				*Hundredweights of market coffee per acre*					
200	75	400	6	15.09	36.12	10.51	47.55	11.85	25.42 a
200	75	400	1	12.61	33.28	9.34	41.54	11.27	22.63 a
100	75	200	2	11.98	29.23	6.93	40.05	13.24	21.95 a
200	75	400	2	14.69	33.73	6.16	44.85	8.98	21.89 a
200	75	400	4	13.44	31.28	7.01	40.01	8.70	19.22 ab
100	75	200	4	11.17	27.15	7.03	35.76	12.52	18.89 ab
100	75	200	6	12.94	25.10	5.84	26.23	9.48	14.35 b
100	75	200	1	12.30	24.67	3.47	26.80	7.77	13.19 b

[1] The mean production was calculated considering the statistical correction for soil fertility differences of the experimental site. Treatments having one or more letters in common do not differ significantly.

more marked than with the higher levels, which provided higher amounts of the nutrients.

UNSHADED COFFEE

Table 2 shows the fertilizer levels evaluated, the frequency of application, and the different annual yields of market coffee per acre. The corrected statistical mean production and the differences observed from the combined statistical analysis of five crops are also shown.

The application of a 200-75-400-pound formulation of nitrogen, phosphorus, and potassium per acre, respectively, in one, two, and six applications yearly produced significantly higher yields of coffee than did the 100-75-200-pound formulation per acre of the same elements when applied in one or six applications yearly. The two-application treatment with the

100-75-200-pound formulation resulted in higher yields than the one-application treatment. No significant differences were found among the other treatments compared.

Yields obtained when the 100-75-200-pound formulation was applied at the end of January and July were not significantly different from those obtained from the 200-75-400-pound formulation applied at the end of July.

Similar yields were obtained from the two levels of fertilizer when both were applied in one, two, four, or six applications yearly. Furthermore, no significant difference was found between the production resulting from both levels under comparison even without considering the number of applications. This suggests that under the conditions prevailing at Castañer, it was more desirable to apply the 100-75-200-pound formulation

TABLE 3.—*Overall effects of a high vs. low fertility level on coffee yields*[1]

Number of applications	Unshaded coffee—Fertilizer levels		Shaded coffee—Fertilizer levels	
	High	*Low*	*High*	*Low*
1	22.63	13.19	14.82	12.68
2	21.89	21.95	13.66	15.19
4	19.22	18.89	17.04	14.21
6	25.42	14.35	14.15	14.14
Total	89.16	68.38	59.67	56.22

[1] Mean yields of five crops expressed in hundredweights of market coffee.

of nitrogen, phosphorus and potassium in one application yearly in the case of shaded coffee. It also suggests that similar yields may be obtained at approximately half the cost by using this rather low fertilizer level. Nevertheless, in zones of heavy rainfall, as in certain parts of the Coffee Region, it is recommended that the fertilizer be given in two applications a year approximately during January and July. The cost of application is not too high and excessive fertilizer leaching during the heavy rainy season is thus reduced.

The overall effects of applying 100 and 200 and 200 and 400 pounds of nitrogen and potassium per acre, respectively, are presented in table 3. It may be observed that the differences between the low and the high levels were greater in the unshaded or sun-grown coffee. This points out to a better utilization of the higher fertilizer levels when the coffee is sun-grown and, consequently, produces higher yields. The application of the higher levels resulted in an average production of 5 hundredweights more of market coffee per acre yearly than when the lower levels were used.

SUMMARY

Experimental work was conducted at the Adjuntas Substation to determine the effect of frequency of application of two fertilizer levels on coffee grown both in full sunlight (unshaded) and under partial shade, the latter provided by trees of *Inga vera* Wild., planted 24 feet apart. The partial shade was estimated at 40 percent. The two formulations, 100-75-200 and 200-75-400 pounds per acre of nitrogen, phosphorus and potassium, respectively, were applied in one, two, four, and six applications per acre per year, and later evaluated.

The combined statistical analysis of five experimental crops of coffee grown in full sunlight revealed that higher yields were obtained from the 200-75-400-pound formulation when applied in one, two, and six applications per acre per year than from the 100-75-200-pound formulation when applied in one or six applications. Higher yields were obtained from the 100-75-200-pound formulation when applied in two applications instead of one. No significant differences were found among the other treatments tested.

The combined statistical analysis of five experimental crops of coffee grown under partial shade showed that higher yields were obtained from the 200-75-400-pound formulation when applied in four applications per acre per year than when the 100-75-200 formulation was applied in one application only. There were no significant differences among the other treatments tested.

The results make it advisable to use the 200-75-400-pound formulation of nitrogen, phosphorus and potassium, respectively, per acre per year, applied in two applications, when the coffee is grown in full sunlight under conditions typical of the Coffee Region. The 100-75-200-pound formulation applied to shaded coffee in two applications per acre per year apparently gives similar good results.

RESUMEN

En experimentos que se llevaron a cabo en la Subestación de Adjuntas se determinó el efecto de la frecuencia del abonamiento en la producción del café sembrado a pleno sol y bajo sombra parcial.

Se probaron los niveles de 100-75-200 y 200-75-400 libras por acre de nitrógeno, fósforo y potasio, respectivamente, aplicando la totalidad del abono en una, dos, cuatro y seis aplicaciones durante el año. La distancia de siembra usada fue de 6 pies entre los arbustos de café, y los árboles de guaba, *Inga vera* Wild., para sombra se sembraron a intervalos de 24 pies lográndose una sombra aproximada de un 40 por ciento.

El análisis estadístico combinando los datos de cinco cosechas experimentales de café cultivado sin sombra demostró diferencias positivas en cuanto a producción de café cuando se compararon los resultados obtenidos con el tratamiento en que la totalidad del abono de la fórmula 200-75-400 libras se aplicó en una, dos y seis aplica-

ciones, con los obtenidos cuando la totalidad del abono de la fórmula 100-75-200 libras se aplicó en una o seis aplicaciones. Las diferencias en producción obtenidas cuando se dividió el total de la fórmula 100-75-200 libras en dos aplicaciones fueron estadísticamente significativas al compararse con la producción lograda cuando se aplicó el mismo nivel de abono en una sola aplicación. No se encontraron diferencias estadísticas significativas entre los otros tratamientos bajo comparación.

El análisis estadístico combinando la producción de cinco cosechas del experimento en que el café se cultivó bajo sombra parcial, reveló que la producción lograda cuando se aplicó la fórmula 200-75-400 libras por acre de nitrógeno, fósforo y potasio, dividido el total en cuatro aplicaciones, fue superior a la obtenida cuando se aplicó la formula 100-75-200 una sola vez.

Parece deseable usar el nivel de 200-75-400 libras de nitrógeno, fósforo y potasio, respectivamente, en dos aplicaciones al año para café al sol, y el de 100-75-200 libras en dos aplicaciones al año para café a la sombra.

LITERATURE CITED

1. Abruña, F., Vicente-Chandler, J., Becerra, L. A., and Bosque-Lugo, R., Effects of liming and fertilization on yields and foliar composition of high-yielding sungrown coffee in Puerto Rico, J. Agr. Univ. P. R. 49(4): 413–28, 1965.
2. ——, Vicente-Chandler, J., and Silva, S., The effect of different fertility levels on yields of intensively managed coffee in Puerto Rico, J. Agr. Univ. P. R. 43(3): 141–6, 1959.
3. Anstead, R. D., Coffee. Its cultivation and manuring in South India, Mysore State Dept. Agr. Bull. 6, 1915.
4. McClelland, T. B., Experiments with Fertilization for Coffee in Puerto Rico, Fed. Exp. Sta. Mayagüez, P. R. Bull. 31, 1926.
5. Rodríguez, Saulo J., Bosque-Lugo, R., Pérez-Pérez, R., and Rodríguez Cabrera A., Yield response of the Puerto Rico and Columnaris coffee cultivars in two Latosols of Puerto Rico as affected by different levels of nitrogen, phosphorus, potassium, and lime, J. Agr. Univ. P. R. 48(3): 255–62, 1964.
6. ——, Bosque-Lugo, R., Boneta-García, E. G., and Morales-Muñoz, A., Effects of different levels of the major nutrients and lime on coffee yield in Puerto Rico, J. Agr. Univ. P. R. 52(3): 195–203, 1968.
7. Sanders, F. R., and Wakefield, A. J., Some factors in arabica coffee growing with special reference to the Northern Province Tanganyika Territory. Dept. Agr. Tanganyika Territory, Pamphlet 7. (Abstract in Hort. A. B., Vol. 3, No. 2, ABS 237).
8. Vicente-Chandler, J., Abruña, F., and Silva, S., A Guide to Intensive Coffee Culture, USDA Prod. Res. Report No. 31, October 1959.
9. ——, Abruña, F., Bosque-Lugo, R., and Silva, S., Intensive Coffee Culture in Puerto Rico, Agr. Exp. Sta. Univ. of P. R. Bull. 211, 28–37, 1968.