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COFFEE YIELDS IN A PLANTATION OF *Coffea arabica* *var. caturra* SHADED BY *Erythrina poeppigiana* WITH AND WITHOUT *Cordia alliodora*

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Program of Natural Renewable Resources
Turrialba, Costa Rica, 1981

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ABSTRACT

In order to quantify the effect of Cordia alliodora on coffee yields, a study was initiated in a plantation of Coffea arabica var. caturra, shaded by Erythrina poeppigiana with and without Cordia alliodora. During the 2 year study period coffee yields of individual bushes were measured. First year results showed a 47 percent higher coffee yield in the association with C. alliodora. However, second year yields were 22 percent lower with C. alliodora

Considering the annual volume increment of C. alliodora, the estimated potential gross income was higher from the association with Cordia alliodora.

RESUMEN

Con el objeto de cuantificar el efecto de Cordia alliodora en el rendimiento del café, se inició un estudio en una plantación de Coffea arabica var. caturra con sombra de Erythrina poeppigiana, con y sin Cordia alliodora. Durante los 2 años que duró el estudio se midió el rendimiento de los arbustos de café en forma individual. Los resultados del primer año mostraron un rendimiento mayor en un 47% en la asociación de C. alliodora. Sin embargo, en el segundo año el rendimiento fue menor en un 22% en la asociación de Cordia alliodora.

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Nancy Glover

INTRODUCTION

Coffee is Costa Rica's leading commercial crop with some 85,000 hectares in production (17). The typical coffee farm is a small, owner-operated unit of less than 10 hectares. Coffee is grown at elevations of 150-1800 meters, covering a wide range of ecological conditions. Levels of production are equally as wide with experimental levels reaching 65 fanegas per hectare, equivalent to 3000 kilograms of processed coffee per hectare (17). International coffee prices fluctuate considerably and have been dropping steadily since 1976. For example, between 1977 and 1979, the volume of coffee exported increased by 34.5 percent while revenues decreased 10.3 percent (1). Thus the need is obvious for crop diversification to reduce risks of market fluctuations, especially in areas of low production and poor quality. The advantage of diversifying production in the coffee growing areas is that the network of access roads can be used. Moreover, the management done in connection with coffee growing may directly or indirectly favor the other crops.

In spite of current recommendations for high intensity management of unshaded coffee, in Costa Rica it is nearly always grown under shade. Shade trees are predominantly of the family Leguminosae, the most common being *Inga* spp, *Erythrina* spp and *Gliricidia sepium* (9). In addition to shade trees, fruit trees and timber producing species are often found growing within the coffee. Such systems are structurally more complex than monocultures, produce diverse yields and have the potential to augment income. A distinct advantage of timber is that it is more tolerant of delays in processing than agricultural export cash crops. Trees can be harvested when market conditions are favorable or when needed, unlike agricultural crops which must be harvested when ready, irrespective of market conditions. Examples of coffee grown in association with timber producing trees, a type of agroforestry, exist throughout the country.

Ford (7) estimated the yield of *Cedrella odorata* grown in association with coffee in San Carlos, Province of Alajuela and Tabarcia of Puriscal, Provence of San José. Rockenbach (18) describes coffee in association with *Eucalyptus deglupta* in Turrialba, Province of Cartago *Pinus caribaea* is also found growing in the Turrialba area with coffee (2). In San Antonio de Coronado, Province of San José, Fournier (8) planted *Alnus acuminata* along the access roads of his coffee plantation. Growth rates and production values of *Cordia alliodora* in a coffee plantation are reported from CATIE,

Turrialba (6). The performance of Terminalia ivorensis when associated with recently planted coffee in Turrialba was studied by Castañeda (5). Juglans spp. and Casuarina equisetifolia are also intercropped among coffee (pers. observation).

The Natural Renewable Resources Program at CATIE, in collaboration with the United Nations University and Peace Corps initiated a case study of traditional agroforestry practices in a wet tropical zone: The "La Suiza" project in 1979 (3,4). The emphasis of research is aimed at understanding the interaction of one crop with another and with the environment as a whole. Farming systems being both an ecosystem and a unit of economic activity.

Prominent among the systems being studied is the traditional practice of growing coffee in association with Erythrina poeppigiana, a leguminous low storey shade tree, together with the naturally regenerating timber species Cordia alliodora. E. poeppigiana, ("poró gigante"), native in Panama and southward to Bolivia but naturalized in Costa Rica, is a tall tree armed with stout spines, broad trifoliar leaflets reaching 20 cm in length and beautiful orange flowers (19). Some 20 years ago, under the direction of the Ministry of Agriculture, E. poeppigiana was planted in the Turrialba area for shade in coffee plantations, removing the previously used Inga spp. Although Inga spp. provide excellent firewood, they grow slowly and are difficult and more expensive to manage. (Carlos Delgado, pers. communication). The excellent resprouting ability of E. poeppigiana facilitates its management while producing large quantities of biomass rich in nutrients. Molleapaza* reports between 41 and 46 kilograms of nitrogen per hectare released through each pruning of E. poeppigiana; pruning being every 6 months with the densities between 225-275 per hectare./ Cordia alliodora, ("laurel") is a rapidly growing timber species partly self-pruning and naturally forms a relatively straight trunk with a narrow, open crown. It is thus not heavily shading and is generally deciduous during the dry season although the dead leaves may remain on the tree until the new flush (14), occurring at the beginning of the wet season. Being a pioneer species, it regenerates plentifully and can reach a height of 30 meters. Although C. alliodora grows best at lower elevations average diameters and heights in Turrialba, 600 m, are from 12 to 21 cm. and 10 to 14 m., respectively, for 10 year old trees (13).

Coffea arabica varieties in the Turrialba area include Criollo Hibrido, Tico, Caturra, Villalobos and Mundo Novo. Densities are variable, between 1000 and 6000 plants per hectare. Yields vary between 5 and 50 fanegas per hectare, equivalent to 1250-12500 kilograms of coffee berries (information based on conversations with local farmers). The E. poeppigiana shade is planted between 150 and 300 trees per hectare and are pollarded to a height of 3-7 meters, 2-4 times a year depending on the individual farmer. Cordia alliodora, occurring as self-sown trees, are found at varying densities.

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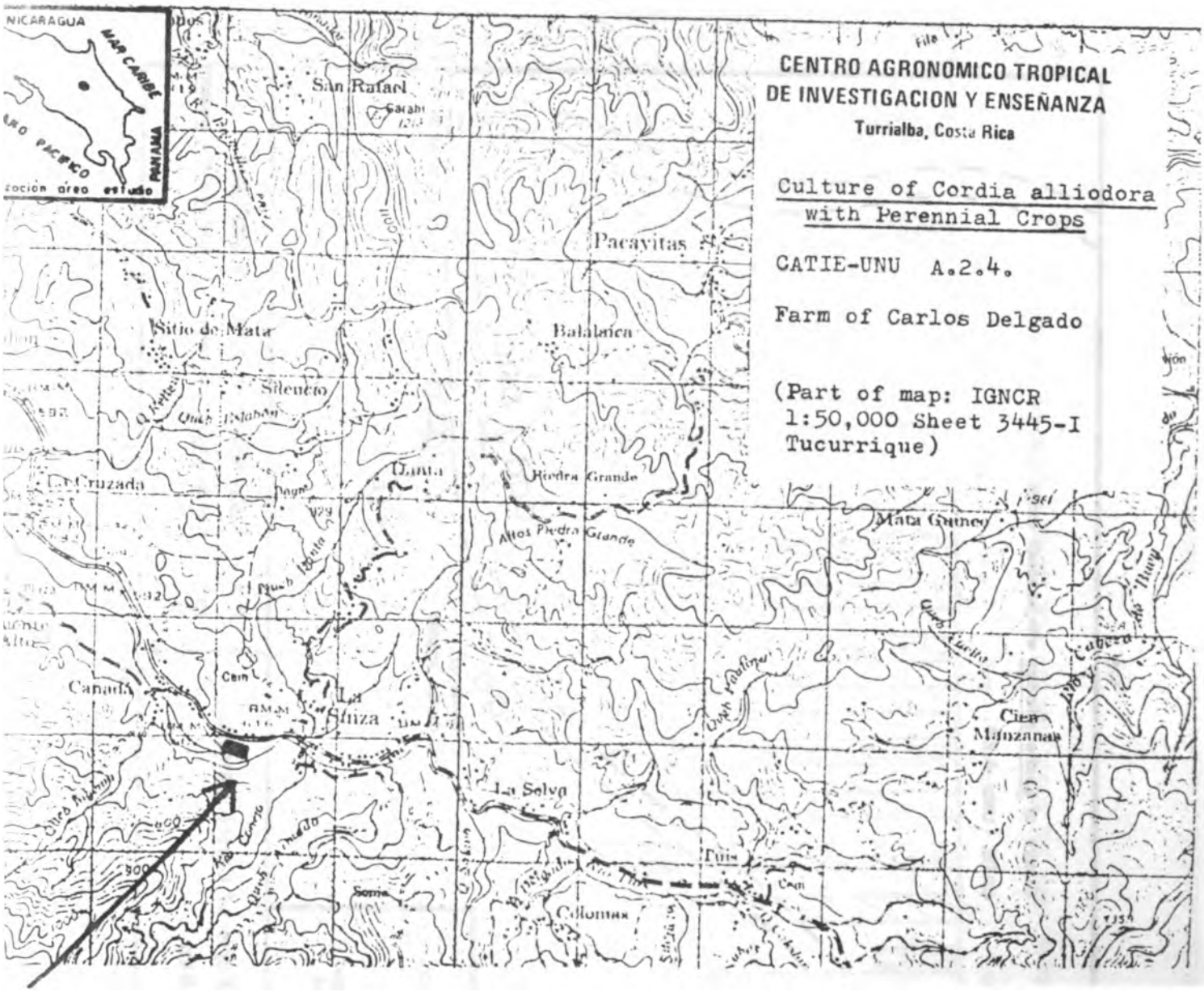
* MOLLEAPAZA, A., Producción de biomasa de Poró (Erythrina poeppigiana (Walpers) O.F. Cook) y del laurel (Cordia alliodora (Ruiz y Pav.) Oken), asociados con café. (No publicado).



ig. 1. Location of the Farm of Carlos Delgado, Canada, Costa Rica.

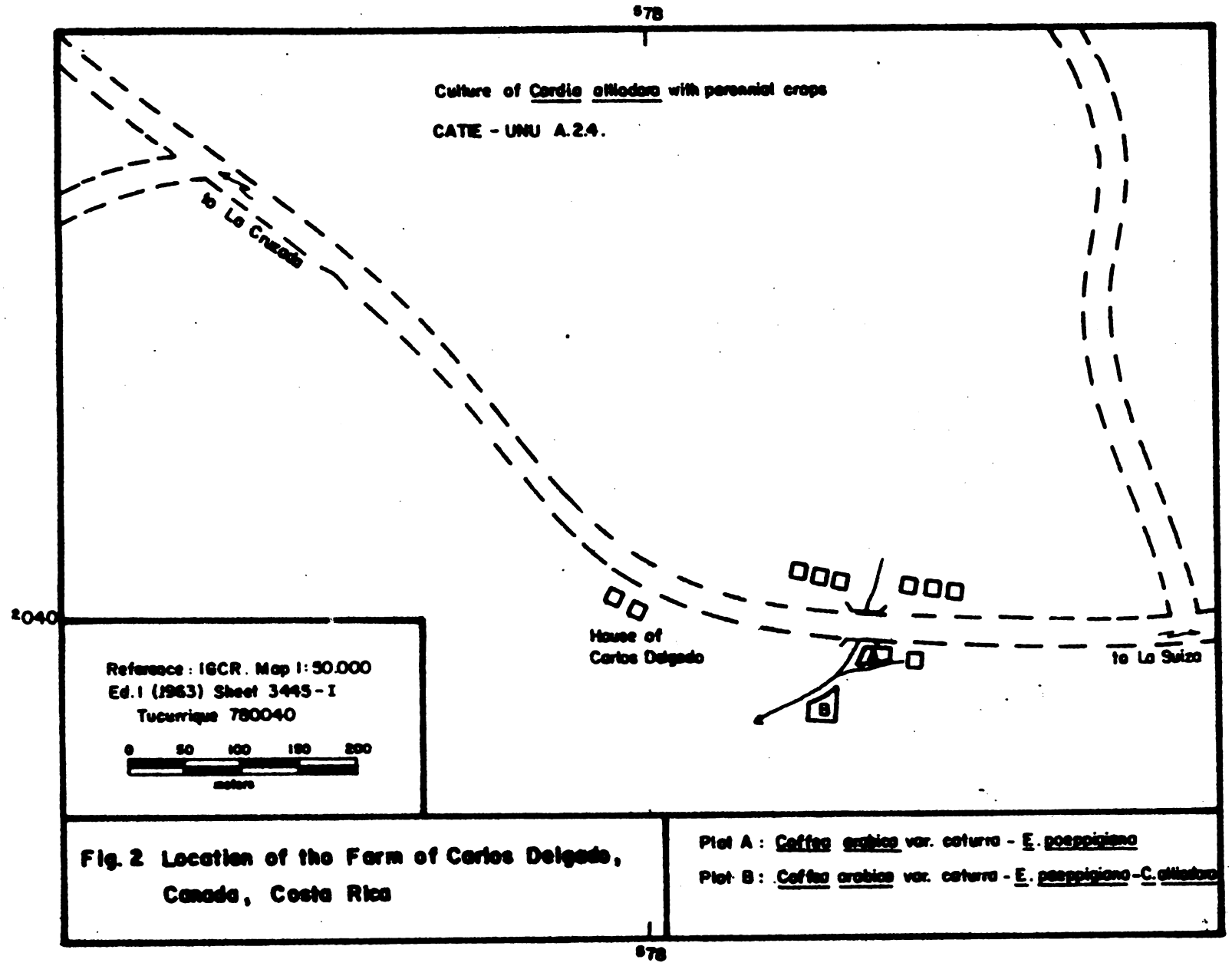


Fig. 2 Location of the Farm of Carlos Delgado, Canada, Costa Rica

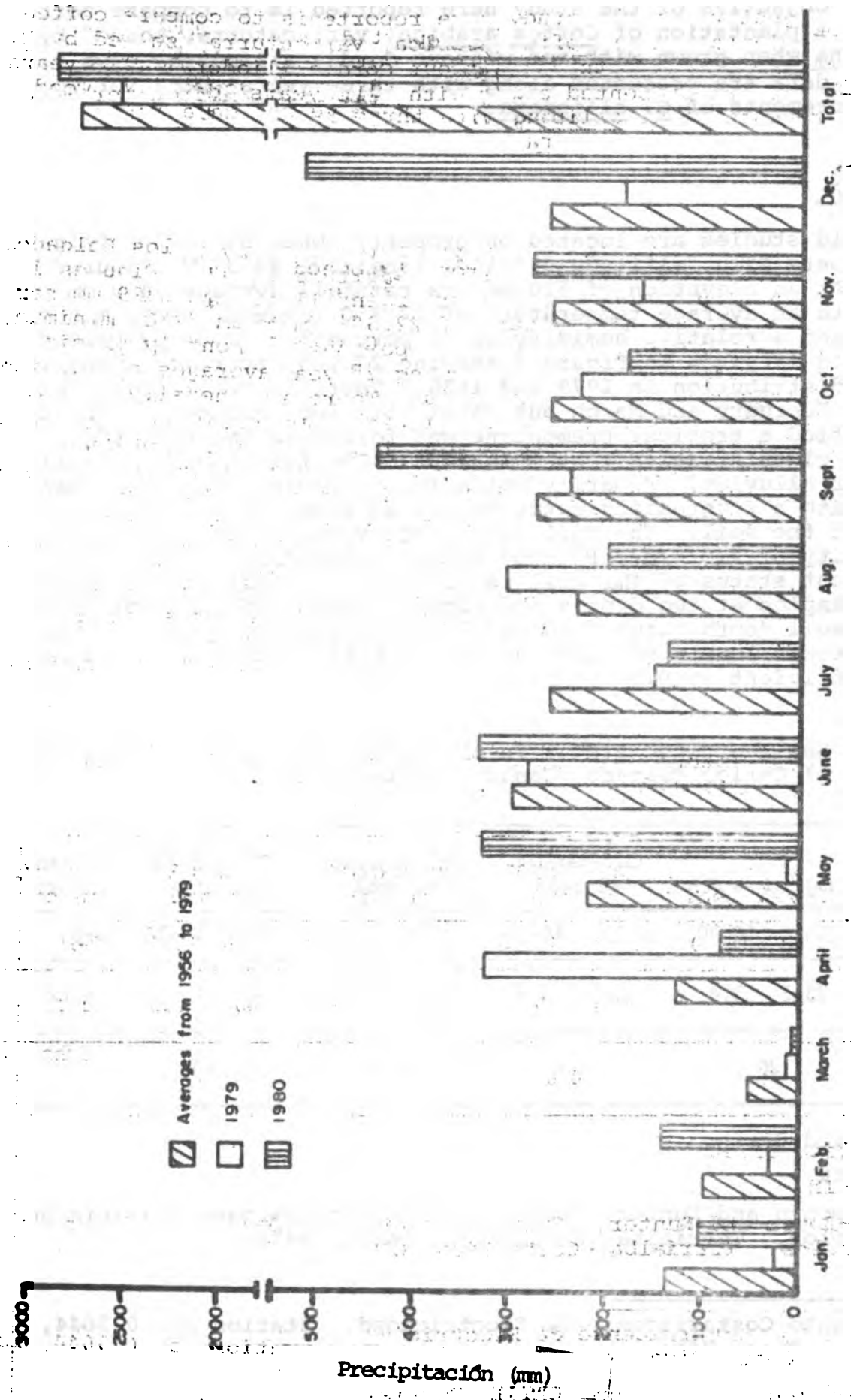


Fig. 3 Precipitation data : averages, 1979 and 1980. Source : ICE Station #073044, La Suiza

The objective of the study here reported is to compare coffee yields in a plantation of Coffea arabica, var. caturra, shaded by E. poeppigiana when grown with and without Cordia alliodora. Two years of coffee data are presented along with three years' data for wood volume increments of C. alliodora.

STUDY AREA

Field studies are located on property owned by Carlos Delgado, Canada, Costa Rica, altitude 09°51'N, longitude 83°37'W (Figures 1 and 2). At an elevation of 610 meters rainfall average 2499 mm per year * with an average temperature of 22.3°C (maximum 27°C, minimum 17.6°C), and a relative humidity of 87 percent**. Monthly precipitation data is given in Figure 3 showing 23 year averages along with rainfall distribution in 1979 and 1980. There is generally a drier period in February and March but still with some rainfall. The area is classified a tropical premontane wet forest in the Holdridge life zone classification system (12,20). The farm lies on stratified Tuis river alluvium, primarily volcanic in origin. The land surface is flat with a fluctuating water table, at times 50 cm below the surface of the soil. The soil is a gravely clay loam with an average bulk density of 1.0 g/m^3; pH(H_2O) values range from 4.4 to 5.5. The nutrient status of the soil is presented in Table 1, averages from 12 samples at two depths are given. Levels of phosphorous are low at a soil depth between 10 and 30 cm, potassium levels are borderline and toxic levels of aluminum are present. Calcium and magnesium are in sufficient supply.

Table 1. Soil nutrient status in the coffee plantation of the Farm of Carlos Delgado, Canada, Costa Rica.

	P[1] mg/ml soil		Ca[2] meq/100 ml soil		Mg[2] meq/100 ml soil		K[1] meq/100 ml soil		Al meq/100 ml soil	
Soil depth (cm)	0-10	10-30	0-10	10-30	0-10	10-30	0-10	10-30	0-10	10-30
	73.3	12.4	5.8	8.4	2.2	2.9	.48	.40	1.12	.27
Optimum levels[3]	20		4.0		2.0		.40		less than .3	

1/ Modified Olsen.

2/ KCl IN

3/ Díaz-Romeu and Hunter. Guía de interpretación para análisis de suelos. Turrialba, Costa Rica, CATIE, 1978.

* Instituto Costarricense de Electricidad. Station No. 073044, La Suiza, Costa Rica.

** Meteorological station, CATIE, Turrialba, Costa Rica.

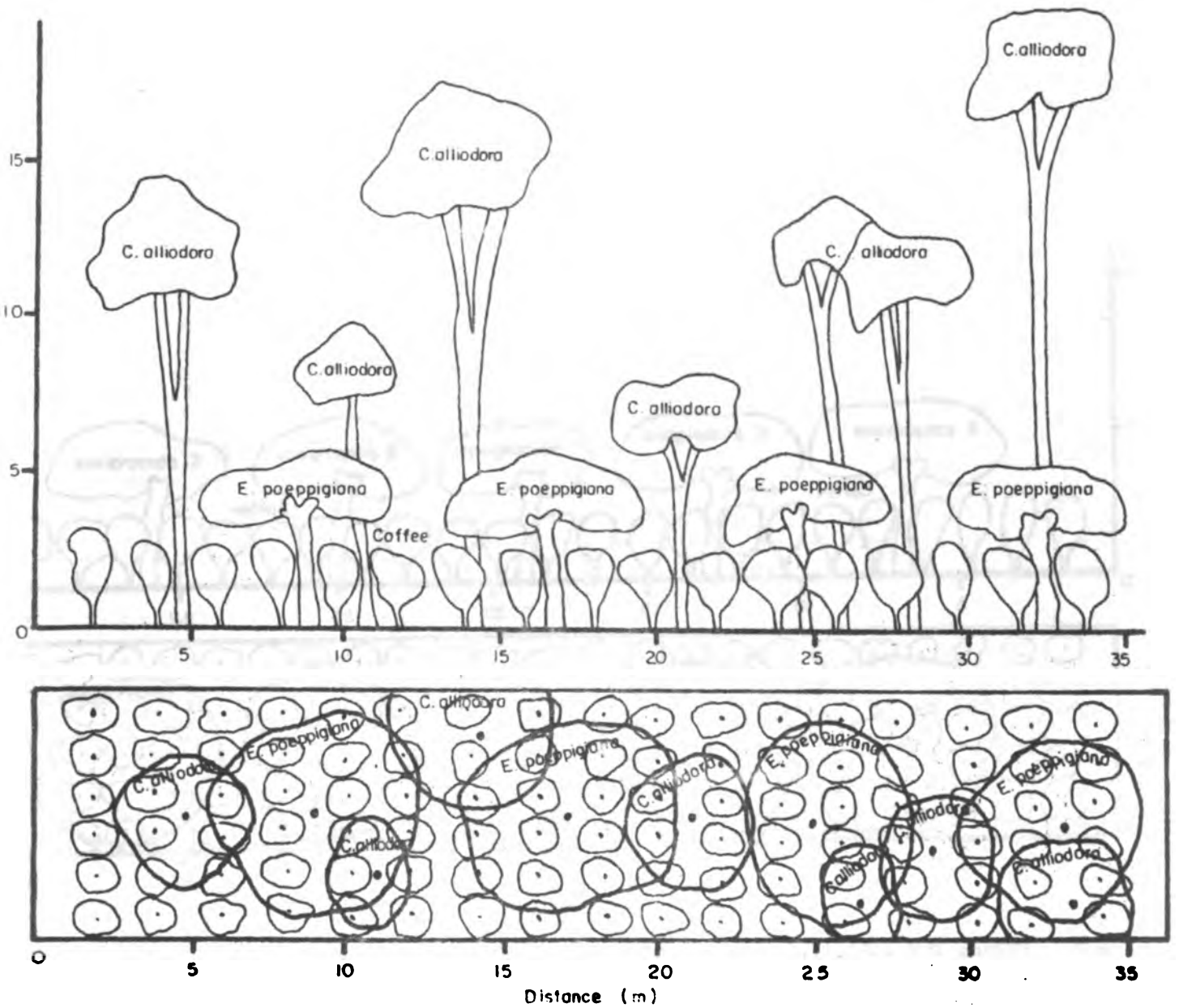


Fig. 4 Profile and canopy diagram of Coffea arabica var. caturra - Erythrina poeppigiana - Cordia alliodora at full canopy

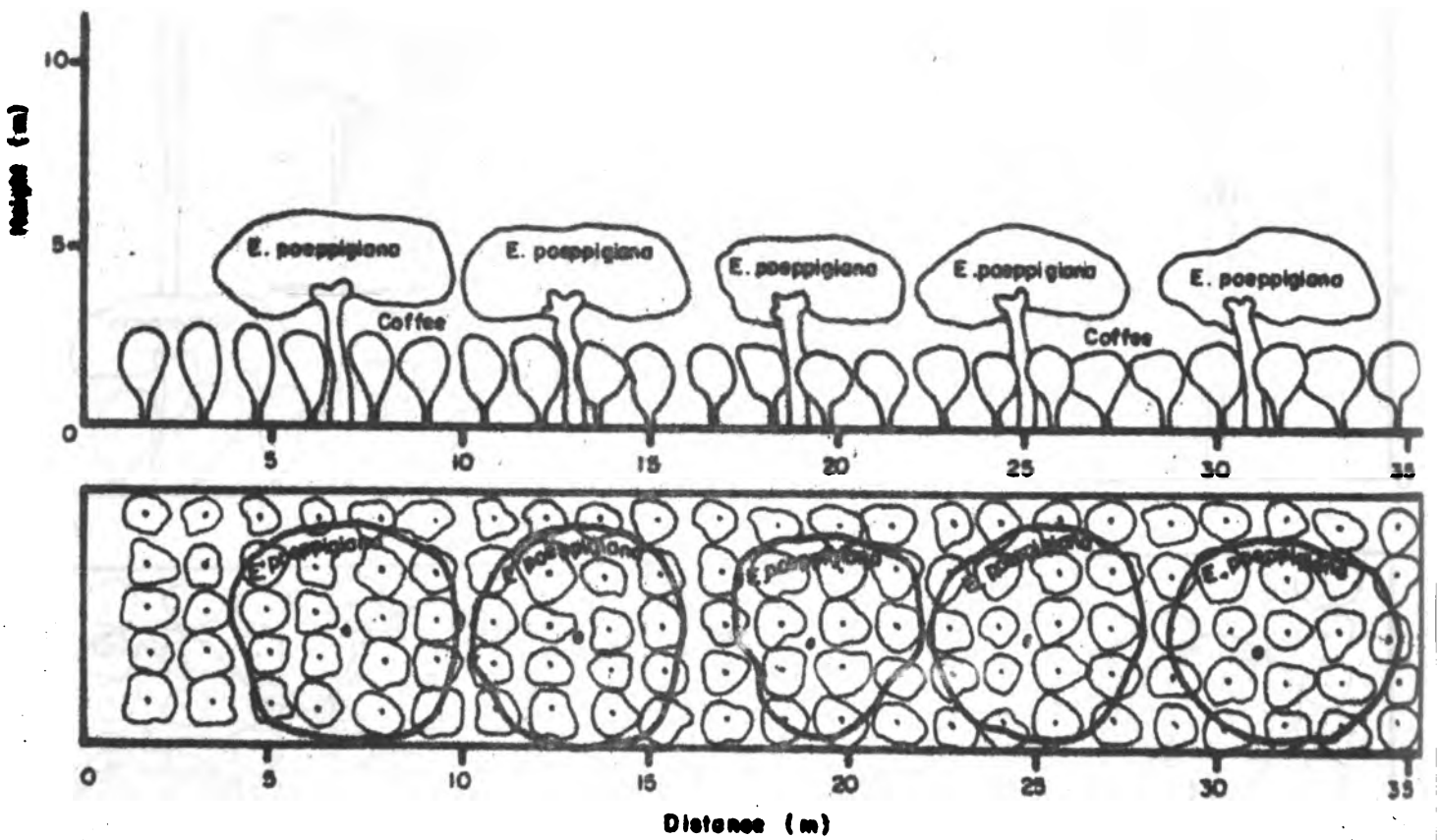


Fig. 5 Profile and canopy diagram of Coffea arabica var catura Erythrina poeppigiana at full canopy

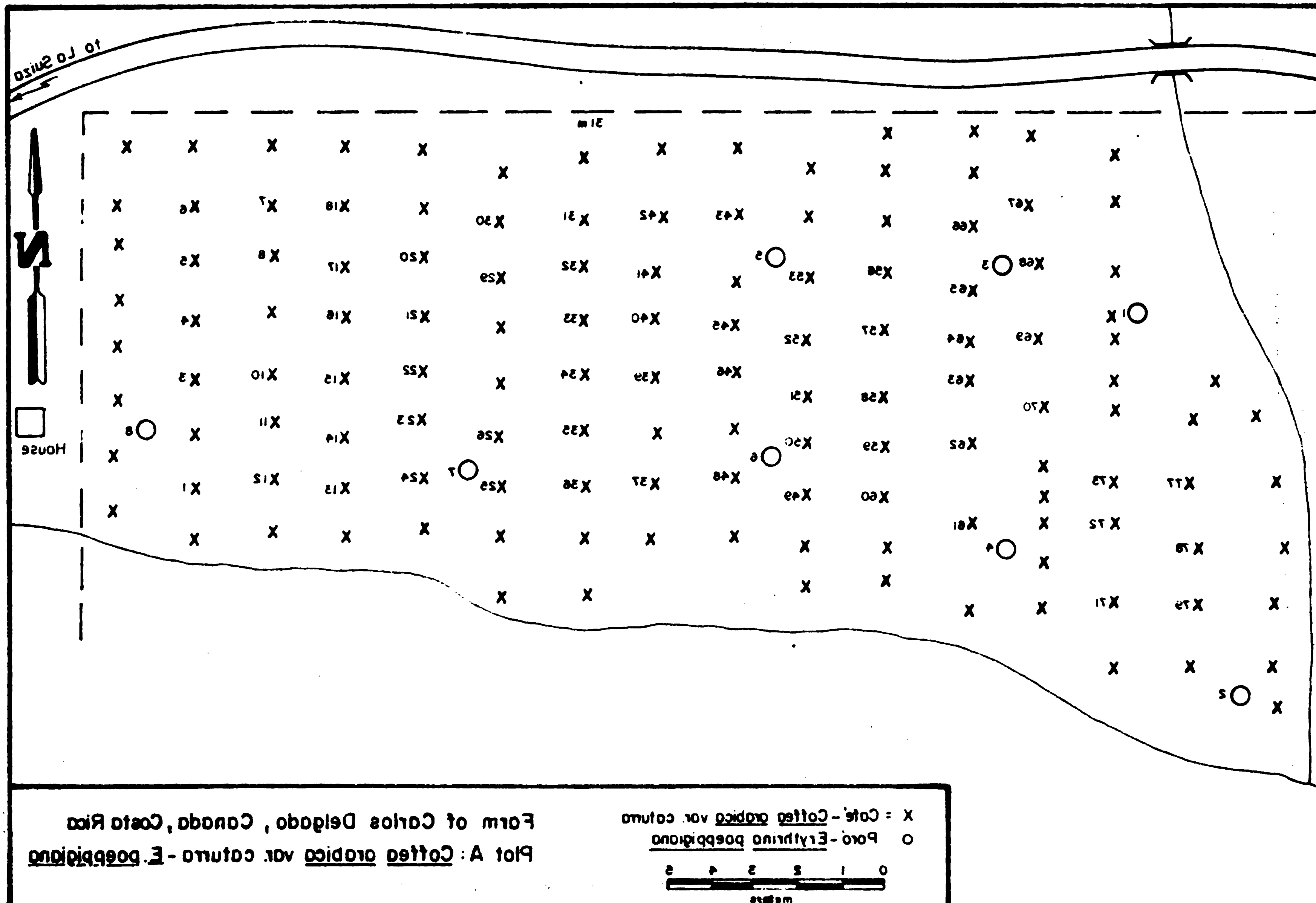


Fig. 6 Map of Plot A

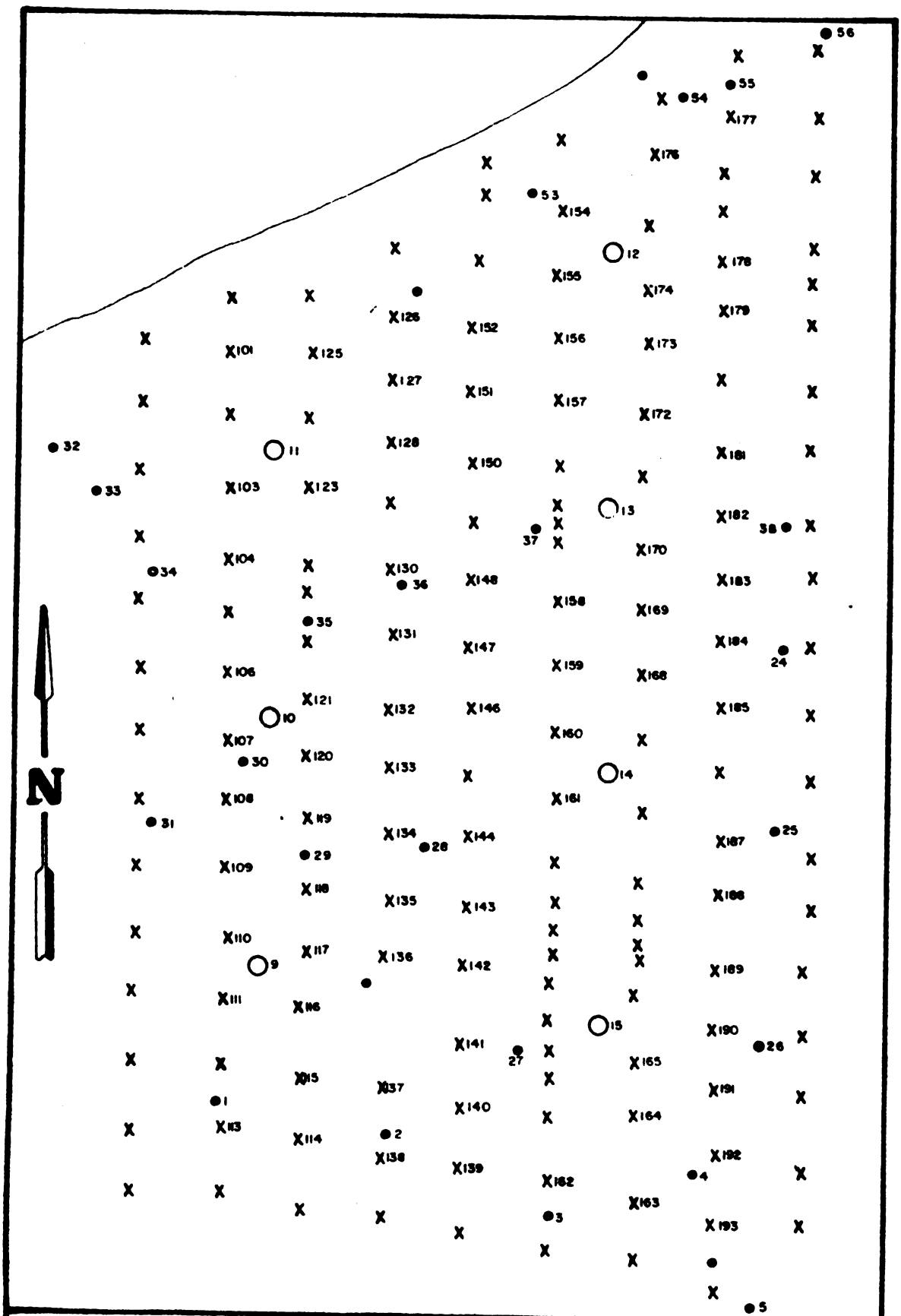


FIG. 7 MAP OF PLOT B

The most suitable climatic conditions for growing arabica coffee are found in high-altitude areas with average annual temperatures between 15 and 25°C and a rainfull of 1700-2000 mm per year (10). Rainfall distribution is a more important factor than total rainfall. Definite wet and dry seasons are regarded as most desirable for the coffee cycle of vegetative growth, flowering, maturing of fruit and a rest period for the bush. Rain induces flowering only when preceded by a period of water shortage. With uniform distribution of rainfall, a certain amount of flowering and fruiting occurs throughout the year.

It is therefore concluded that the study area is not optimum for coffee growing being situated at an elevation of only 610 meters with no definite dry season.

ESTABLISHMENT AND MANAGEMENT OF THE COFFEE PLANTATION

The land, previously used as pasture, was planted with Coffea arabica var. caturra seedlings in May 1967. E. poeppigiana was planted for shade, at the same time, throughout the plantation from 2 meter stakes cut from neighboring trees. In three-fourths of the plantation Cordia alliodora regenerated naturally. General profile diagrams of both associations are given in Figures 4 and 5.

Two trial plots were established, Plot A, 188 m^2, of C. arabica var. caturra- E. poeppigiana and Plot B, 295 m^2, of C. arabica var. caturra - E. poeppigiana - Cordia alliodora (Figures 6 and 7). The experiment was only established on this farm because it is one of the rare examples of a fairly uniform, even aged coffee plantation in the area with an adjacent section containing C. alliodora. Large plots of each association were chosen with the intention of eventually relating individual bush yields to the proximity of the shade trees. There is a slight variation in spacing of coffee plants and shade trees within the plantation. Densities of all components are given in Table 2.

Table 2. Densities of all components.

PLOT	Coffea arabica var. caturra		Erythrina poeppigiana		Cordia alliodora
	spacing	plants/ha	spacing	trees/ha	trees/ha
A	1.7 x 1.5 m	3922	6.8 x 6.0m	245	-
B	1.9 x 1.5 m	3509	7.5 x 6.0m	222	475

It is important to note that 10 Cordia alliodora trees are within a 2 meter band surrounding Plot B. Thus the measured plot density is an underestimate of the number of trees which may influence the plot. A few coffee bushes of the varieties Hibrido and Villalobos are mixed in with the Caturra due to a bad seed supply.

A calendar of all management practices is presented in Figure 8.

Fertilization

Fertilizers are applied twice a year, in June of July, before the harvest, and in December or January, after the harvest. One-fourth of a pound (0.11 Kg.), is broadcast around each coffee bush within a radius of 5 meters. Before the harvest an application of 20(N) - 7(P_2O_5) - 12(K_2O) - 3(MgO) - 1.2(B_2O_3) is used; (values by percentage weight). After the harvest 18(N) - 5(P_2O_5) - 15(K_2O) - 6(MgO) - 2(B_2O_3) is applied. Because of the difference in coffee densities, 863 kilograms per hectare per year is applied to Plot A while Plot B receives 772 kilograms per hectare per year. Table 3 gives quantities of all elements applied.

Table 3. Quantities of all elements applied during fertilization.

PLOT	Date	Amount Kg/ha	N	P(P_2O_5)	K(K_2O)	Mg(MgO)	B(B_2O_3)
A	June-July	431	86	13 (30)	43 (52)	8 (13)	2 (5)
A	Dec-Jan	431	78	9 (22)	54 (65)	15 (26)	3 (9)
Total Kg/ha,yr		862	164	22 (52)	97 (117)	23 (39)	5 (14)
B	June-July	386	77	12 (27)	38 (46)	7 (11)	1 (5)
B	Dec-Jan	386	69	8 (19)	48 (58)	14 (23)	2 (8)
Total Kg/ha/yr		772	146	20 (46)	86 (104)	21 (34)	3 (13)

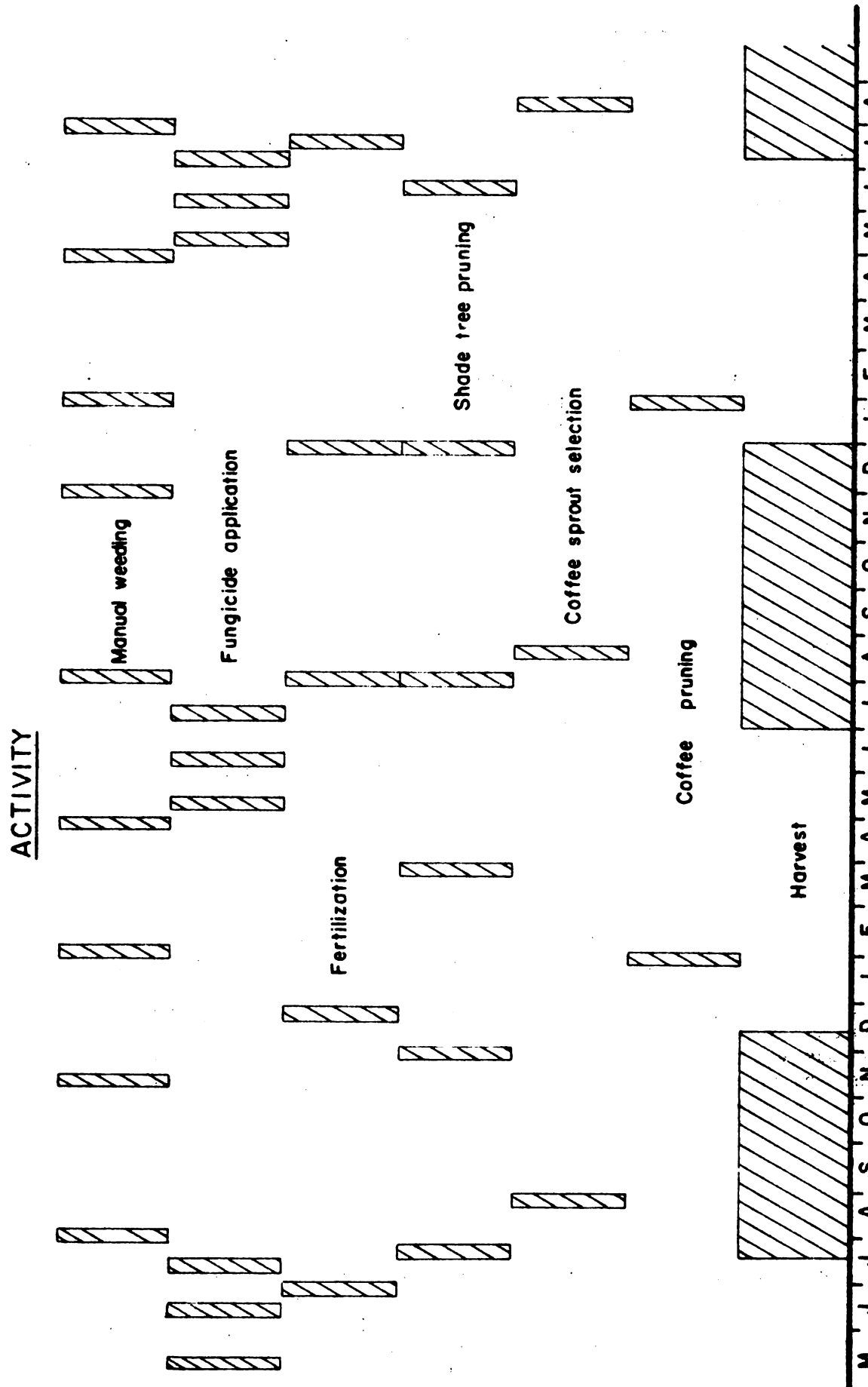


Fig. 8 Calendar of management in coffee plantation on the Farm of Carlos Delgado, May 1979 - Aug. 1981

Fertica, a fertilizaer company, recommends two applications of 400 kilograms per hectare of 20-7-12-3-1.2 or 18-5-15-6-2 in May or April and August or September. Also recommended is an application of 250 kilograms per hectare of nitrogen in November. The Ministry of Agriculture recommends an application of 660-1320 kilograms per hectare per year of 18-5-15 or 18-6-12 in two applications, January and May. In June or August an application of 200-400 kilograms per hectare of nitrogen is recommended (15).

Weed control

The coffee plantation is cleaned of weeds with a spade every three months. The residues are piled in the middle of the coffee row. The owner of the farm believes that herbicides have a detrimental effect on the coffee plants and the regeneration of *Cordia alliodora* and therefore never uses them.

Disease control

Fungal diseases such as "mal de hilachas" (*Pericularia koleroga*), "ojo de gallo" (*Mycena citricolor*), and "rosada" (*Corticum solmonicolor*), are controlled by three applications per year of fungicides. In May $CuSO_4$ (1 Kg), PbA_5O_3 (1 Kg), $ZnSO_4$ (.5 Kg), and Pega-fix (.25 Kg a sticker) is mixed with water (190 l) and sprayed at a rate of 1080 liters per hectare. In early June and July the same mixture with the exception of lead arsenate is applied at the same rate. The use of lead arsenate is prohibited during the harvest.

Coffee pruning

Coffee plants are pruned every year in January after the harvest. Pruning is done per plant eliminating old branches (usually four years old), diseased branches and branches damaged by pickers. The severity of pruning can vary markedly within the plantation which varies the production within the plantation from year to year. Coffee stems with diameters approximately 1 cm and greater are sometimes harvested for firewood. Selection of coffee sprouts take place in August when two or three shoots per stem are left to develop.

Shade tree pruning

Generally in June or July, just before the harvest, and in November or December, after the harvest, all shade trees are pollarded. All foliage and branches are cut and the residues chopped and used as mulch. Another common practice in the area is to leave two

to four major branches. This practice varies considerably depending on individual farmers. The owner has only left branches once during the study, in July, 1979. In March, 1980, he pollarded the shade trees because of unusual heavy rains in February. Every few years the trunks are cut back, about 1 meter, to maintain a low storey. A low storey is desired because of the belief that large raindrops falling a long distance from the shade trees increase the spread of "ojo de gallo". The owner cut back the trunks in December, 1980. Another common belief among the farmers in the area is that if shade pruning after the harvest is delayed so will the subsequent harvest. Shade, having an influence on flowering, can be a means of regulating the time of ripening.

Cordia alliodora

Cordia alliodora trees are usually not managed but in 1981 the owner decided to prune and cut some trees because of the high incidence of fungal diseases on the coffee. His intention was to reduce humidity by eliminating shade and thus fungal diseases. A few trees spaced too close and badly formed were removed.

Harvesting

The harvest season starts in early July and continues until the second or third week in December. Mature berries are hand picked approximately every 15 days during this period. The height of the harvest usually occurs in October. At the end of the season all remaining green berries are picked and sold for half price. Coffee berries are sold by fanegas, a volume measurement. One fanega is equivalent to 250 kilograms of coffee berries (measured during the study).

METHODS

Coffee yield:

Selection of individual coffee bushes to be measured was based on the criteria of variety and spacing. Coffee bushes of the variety caturra spaced greater than 1 meter apart were used in the yield study.

Coffee bushes to be harvested were numbered at the base of the bush, 5 cm from the soil surface, and a corresponding numbered plastic bag was placed beside each bush before each picking. Mature berries were hand picked and weighed on a triple beam balance to the nearest gram. Mature berries which had fallen to the ground around each plant were included. At the end of the harvest the green berries were picked and weighed separately.

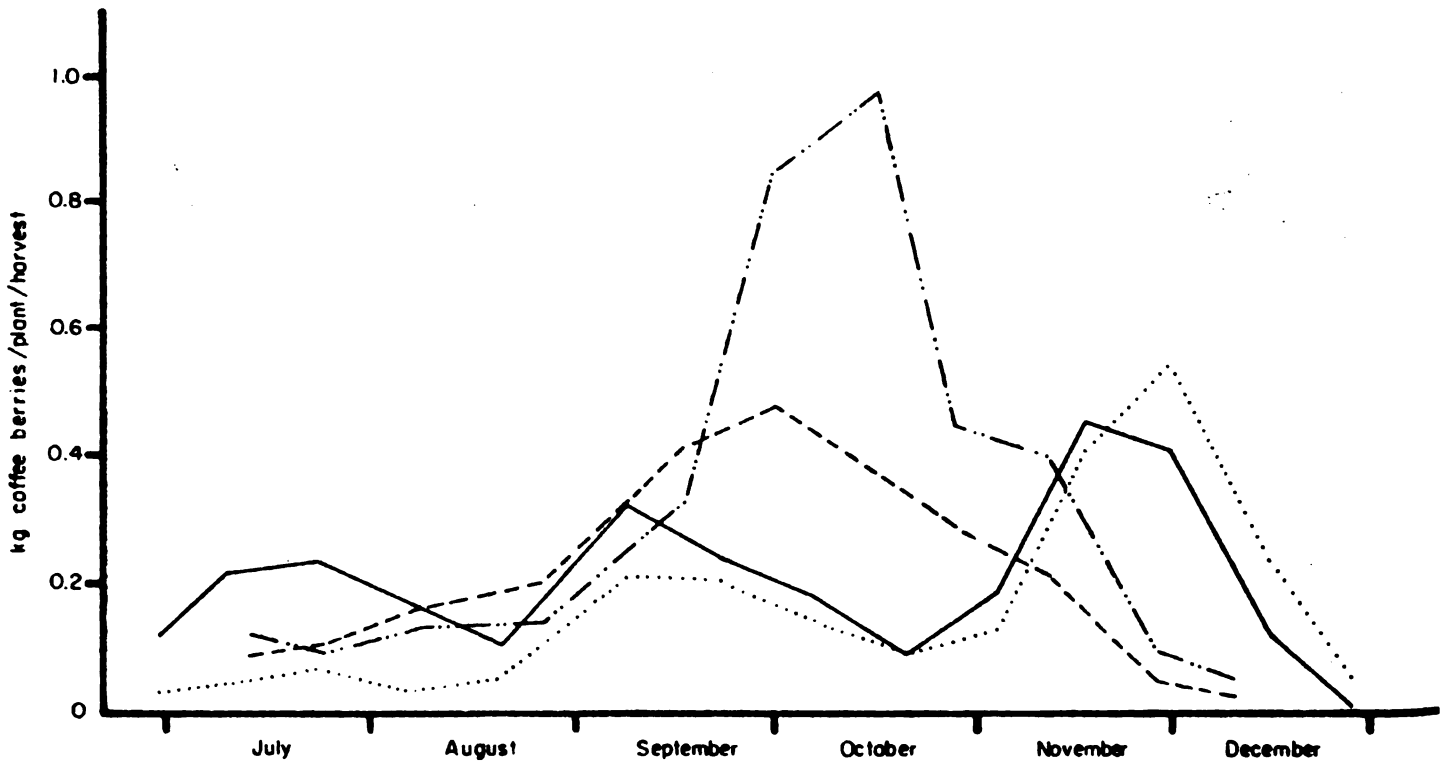


Fig. 9 Average coffee yield in berries (kg) per coffee bush per picking. Data from 1979 and 1980 in associations of Coffea arabica var. caturra - Erythrina poeppigiana and Coffea arabica var. caturra-E. poeppigiana - Cordia alliodora on the Farm of Carlos Delgado, Canada, Costa Rica

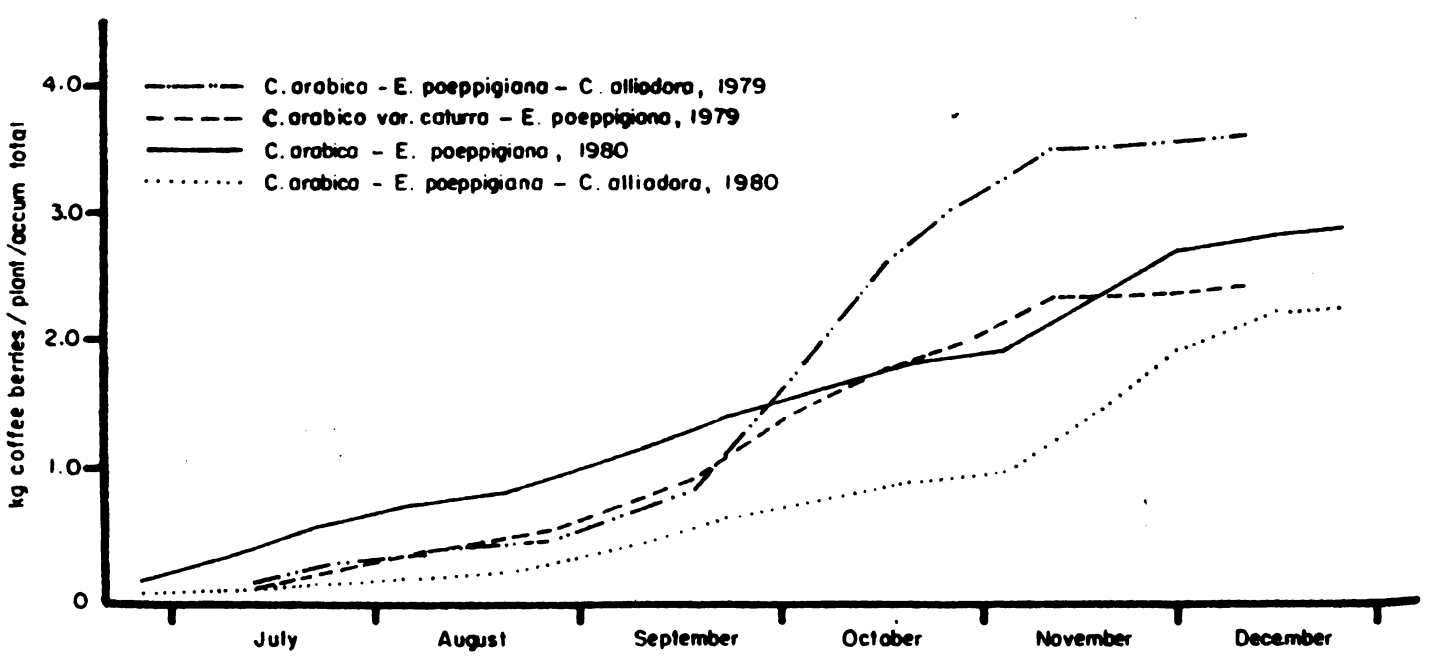


Fig. 10 Cumulative average coffee yields in berries (kg) per coffee bush. Data from 1979 and 1980 in associations of Coffea arabica var. caturra - Erythrina poeppigiana and Coffea arabica var. caturra-E. poeppigiana - Cordia alliodora on the Farm of Carlos Delgado, Canada, Costa Rica

Growth measurement of Cordia alliodora

In January, 1979, mensurational plots for C. alliodora associated with sugar cane, pasture and coffee were established on farms in La Suiza, in order to compare the growth in the different associations. Diameters and heights were measured annually using a diameter tape and a Sunnto inclinometer. The data reported here was taken from this study.

RESULTS

After each picking the average yield per bush was calculated, Kg coffee berries/bush/picking. Data on coffee yields are given in Figure 9 and Table 4. In 1979 the peak of the harvest in plot A, without C. alliodora, occurred between September 17th and October 1st. The peak of the harvest in Plot B, with C. alliodora, occurred two and a half weeks later, between October 1st. and 16th. This difference occurred again in 1980, the peak of the harvest being two and a half weeks later in Plot B.

Cumulative averages of coffee yields in Kg of berries per coffee bush are presented in Figure 10 and Table 4. In 1979 coffee bushes in Plot A yielded 2.479 kilograms per bush compared to 3.646 kilograms per bush in Plot B. Individual bushes in Plot B yielding 47.0 percent higher than Plot A. However in 1980, Plot A yielded 2.895 kilograms per bush while Plot B yielded 2.269 kilograms per bush; Plot B yielding 21.6 percent lower than Plot A. An average of the 2 years results show values in Plot A to be 2.687 kilograms per bush and 2.958 kilograms per bush in Plot B; Plot B yielding 10.1 percent higher than Plot A.

Calculating coffee yields on a kilogram per hectare basis gives slightly different results because of the difference in coffee densities. Results are presented in Table 5. In 1979 Plot A yielded 9,723 kilograms of coffee berries per hectare while Plot B yielded 12,794 kilograms per hectare. Plot B yielding 31.6 percent more than Plot A. In 1980 Plot B yielded 29.9 percent less than Plot A. An average of the two years shows a 1.5 percent lower yield in Plot B than in Plot A.

Table 4. Coffee yields from the Farm of Carlos Delgado, Canada, Costa Rica.

	Plot A *Coffea arabica* var. caturra-*Erythrina poeppigiana*		Plot B *C. arabica* var. caturra-*E. poeppigiana*-*Cordia alliodora*	
Date of harvest	Kg/plant/picking	Kg/plant/acc.total	Kg/plant/picking	Kg/plant/acc.total
7-13-79	.093		.123	
7-24-79	.109	.202	.102	.225
8-8-79	.164	.366	.136	.361
8-27-79	.209	.575	.144	.505
9-17-79	.418	.993	.326	.831
10-1-79	.474	1.467	.841	1.672
10-16-79	.378	1.845	.968	2.640
10-29-79	.288	2.133	.450	3.090
11-12-79	.268	2.401	.403	3.493
11-27-79	.049	2.450	.100	3.593
12-10-79	.029	2.479	.053	3.646
6-24-80	.124		.026	
7-8-80	.212	.336	.042	.068
7-22-80	.238	.574	.069	.137
8-5-80	.162	.736	.038	.175
8-20-80	.117	.853	.052	.227
9-8-80	.338	1.191	.218	.445
9-22-80	.248	1.439	.204	.649
10-6-80	.182	1.621	.149	.798
10-20-80	.088	1.709	.089	.887
11-3-80	.184	1.893	.139	1.026
11-17-80	.453	2.346	.412	1.438
12-1-80	.411	2.757	.538	1.976
12-15-80	.121	2.878	.237	2.213
12-29-80	.017	2.895	.056	2.269

Table 5. Coffee yields per hectare presented in berries, processed coffee and fanegas

Plot	Year	Kg coffee berries/bush	density/ha	fanegas/ha[1]	Kg coffee berries/ha	Kg processed coffee/ha[2]
A	1979	2.479	3922	39	9,723	1,768
	1980	2.895	3922	45	11,354	2,064
	Average	2.687	3922	42	10,538	1,916
B	1979	3.646	3509	51	12,794	2,326
	1980	2.269	3509	32	7,962	1,448
	Average	2.958	3509	42	10,378	1,887

1/ 1 fanega = 250 kg coffee berries
2/ 5.5 kg coffee berries = 1 kg processed coffee

According to Perez and Gutierrez (16) a decrease of .5 meters between coffee plants should result in a 16 percent increase in yield per hectare, a linear response for coffee densities between 2500 and 5000 plants per hectare. Considering coffee densities only, Plot B should yield 6.4 percent lower than Plot A since the average interbush distance is less by .20 meters.

Cordia alliodora yield

Diameters, heights and basal areas for individual trees within Plot B are given in Annex 1. Averages and total volumes are given in Table 6. Annual volume increment from 1979 to 1980 measured 22.0 m^3 per hectare and 20.0 m^3 per hectare between 1980 and 1981. According to the owner the trees are between 4 and 9 years old. This was confirmed by annual ring counts, from basal discs of 17 trees which were thinned from the coffee plantation (John Beer, pers. comm.). An annual volume increment of 11.12 m^3 per year per hectare for 19 year old trees of *Cordia alliodora* in combination with coffee at Bajo Chino, Turrialba, 228 trees per hectare was reported from CATIE (6).

Table 6. Measurement of Cordia alliodora in combination with coffee, Farm of Carlos Delgado, Canada, Costa Rica (Unpublished data from John Beer, CATIE).

Date	N Trees/ha	$\bar{G}$ m^2/ha	$\bar{h}$ m	Total Volume[1] m^3/ha
24/1/79	475	10.0	13.1	64.8
26/2/80	475	12.1	14.1	86.8
Annual increment		2.1	1.0	22.0
26/1/81	475	14.0	15.3	107.8
Annual increment		1.9	1.2	21.0

1/ Total volume = G x h x f, f = 0.46 (overbark) (11)

Economic data

Estimated potential gross income from coffee and C. alliodora is presented in Table 7. The potential value of coffee for 1979 and 1980 based on the liquidation price for 1979 since the liquidation price for 1980 has not yet been set.

The potential value for Cordia alliodora is reported twice, assuming that total volume increment is equal to commercial volume increment and secondly that one half of the total volume increment is equal to commercial volume increment.

Assuming total volume increment is equal to commercial volume increment the potential estimated gross income in 1979 from Plot B was 72 percent higher than Plot A and in 1980 8 percent higher. For the two years together Plot B gave a 47 percent higher gross income than Plot A. Results from the second assumption, one-half of the total volume increment is equal to commercial volume increment, show a 52 percent higher gross income from Plot B than from Plot A in 1979, however, in 1980 gross income from Plot B is 11 percent lower. For the 2 years together Plot B gave a 27 percent higher gross income than Plot A. These results confirm conclusions made by González (11) that the dollar value from coffee and Cordia alliodora trees is superior to coffee not associated with Cordia alliodora.

Table 7. Estimated potential gross income

Plot	Year	Value of coffee $/ha[1]	Value of coffee ¢/ha[2]	Value of laurel $/ha	Value of laurel ¢/ha[3,4]	Total $/ha	Total ¢/ha
A	1979	3,461	29,558			3,461	29,558
A	1980	2,301	34,516			2,301	34,516
Total		5,762	64,074			5,762	64,074
B	1979	4,554	38,894	1,406	12,012	5,960	50,906
B	1980	1,614	24,204	874	13,104	2,488	37,308
Total		6,168	63,098	2,280	25,116	8,448	88,214
				1/2 TV = CV Values of laurel[5]			
1979				703	6,006	5,257	44,900
1980				437	6,552	2,051	30.756
Total				1,140	12,558	7,308	75,656

1/ 1 U.S.$ = ¢ 8.54 in 1979
1 U.S.$ = ¢15.00 in 1980

2/ 1 Kg coffee berries - ¢3.04; 1979, 1980

3/ 1979 - ¢1.75 PMT
1980 - ¢2.00 PMT

4/ Value of commercial volume increment = Total volume increment x 312* x ¢/PMT

5/ Value of commercial volume increment=0.5 Total volume increment x312* x ¢/PMT

* 1 m^3 = 312 PMT (Costa Rican inches)

DISCUSSION

The delayed peak of the coffee harvest in Plot B could be due to the fact that the coffee berries ripen slower with the additional shade of C. alliodora, possibly resulting in better quality, or due to the effect of C. alliodora shade delaying time of flowering; the latter confirming the beliefs of the local farmer.

An explanation for the difference in coffee yields between plots cannot be attempted without further studies. As mentioned before, coffee pruning greatly affects yields within a plantation and is possibly the greatest factor affecting yields between plots. Farmers in the area have expressed concern that the large raindrops, falling from the high C. alliodora leaves, cause coffee flowers to drop off resulting in a lower yield. The low 1980 coffee yield in Plot B could be explained by this phenomenon since high rainfall was recorded in February and May. Also in March, 1980, the E. poeppigiana shade was pollarded, eliminating the protection against large raindrops to the coffee flowers.

The annual volume increment for C. alliodora is high because the trees are young. This results in a high estimate of potential gross income.

CONCLUSIONS

1. Two years data on coffee yields is not sufficient to conclude what effect C. alliodora has on coffee yields because of differences in coffee pruning between plots.

2. From 2 years data the estimated potential gross income is high when coffee is associated with C. alliodora.

RECOMMENDATIONS

1. The coffee yield study should be continued for at least 2 more years.

2. The relationship between rainfall and yield should be analized for each association.

3 The time of coffee flowering should be observed and compared between associations.

4. The quality of coffee between associations should be compared.

5. Quantification of microclimate differences between associations.

6. Nutrient cycling studies.

7. Root studies and nitrogen-fixation studies of E. poeppigiana

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ANNEX 1

ANNEX 1
MEASUREMENTS OF CORDIA ALLIODORA IN PLOT B

No. of tree	Diameter (cm)			Height (m)			Basal Area (m^2)		
	24/1/79	26/2/80	26/1/81	24/1/79	26/2/80	26/1/81	24/1/79	26/2/80	26/1/81
26	23.4	25.2	26.5	16.8	17.4	19.1	.043	.050	.055
4	10.7	12.6	13.7	11.0	11.6	12.7	.009	.012	.015
27	10.1	11.9	12.8	11.8	10.2	10.9	.008	.011	.013
37	18.2	20.2	21.5	14.0	14.2	15.1	.026	.032	.036
53	15.0	17.5	19.4	12.2	14.6	16.1	.018	.024	.030
36	20.4	23.1	25.5	14.6	17.5	17.7	.033	.042	.051
35	12.9	14.8	16.1	10.6	12.4	14.7	.013	.017	.020
30	11.8	13.3	14.4	12.0	13.8	14.7	.011	.014	.016
29	22.5	24.6	26.0	14.6	16.1	17.3	.040	.048	.053
2	23.8	26.6	28.2	20.2	20.2	21.1	.044	.056	.062
1	15.2	16.8	18.2	11.8	12.2	13.1	.018	.022	.026
3	10.7	12.2	13.1	9.8	10.5	12.2	.009	.012	.014
28	12.5	14.5	15.8	11.0	12.4	14.7	.012	.016	.020
$\bar{x}$				13.1	14.1	15.3			
S.D.				2.9	3.0	2.9			
CV %				22.1	21.3	18.9			
Σ							.295	.357	.412