Research Note

EFFECT OF PLANTING DATES AND FREQUENCIES OF INTERCROPPING ON YIELD AND INCOME OF BEAN AND BANANA[1,2]

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J. Agric. Univ. P.R. 83(3-4):209-215 (1999)

Intercropping has not been widely practiced in the highly mechanized U.S. agriculture, except for certain tree crops, grass-legume pasture systems and nursery crops for establishing seedlings (American Soc. Agronomy, 1976). However, intercropping is a common practice in the tropics (Okigbo and Greenland, 1976). The intercropping of either banana or plantain with bean is practiced both in South America and Africa (Wortmann et al., 1992; Wortmann and Sengooba, 1993). Rao and Edmund (1984) found that banana yield was not significantly reduced when intercropped with other crops such as cowpea, maize (*Zea mays* L.), or sweet potato (*Ipomoea batatas* L.). In Puerto Rico, Beaver and Román (1994) demonstrated that the highest green-shelled yields were produced when beans were planted from October to December. However, the effect of planting date and frequency of planting beans has not been studied for a bean and banana intercropping. This study gathered information related to yield and economic benefits of this cropping system.

Banana is one of the most important crops in Puerto Rico. In 1995-96, some 318 million fruits were produced for a gross income of $6.1 million (Anonymous, 1996). This crop was largely produced by 1,000 small-scale farmers. Banana has a relatively long growing cycle, requiring 12 to14 months to harvest a crop, a long wait for banana farmers to recover their investment. Any additional income that could be earned during the wait for

[1]Manuscript submitted to Editorial Board 10 February 1999.

[2]We are grateful to Agro. Pedro A. Santo-Grillo for providing the land and other needed assistance in this study and to the Sustainable Agriculture Research and Education Program, Southern Region, for the financial assistance in conducting this field experiment. Bean cultivars used in this experiment were supplied by Dr. James Beaver, Plant Breeder of the Agricultural Experiment Station, University of Puerto Rico, Mayagüez Campus.

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the banana harvest would be financially attractive. The intercropping of bean with banana could provide an additional source of income. Each year approximately 4,900 metric tons of bean having a cash value of $15 million is imported into Puerto Rico (Beaver et al., 1992). More beans might be produced locally if bean intercropping with banana could be shown to be economically viable. The objectives of this study were to determine the effects of planting date and frequency of bean on yield of banana and bean, and to determine the economic benefits of the different planting dates and frequencies of a bean/banana intercropping.

The experiment was established on a Múcara clay loam (montmorillonitic, isohyperthermic Vertic Eutropepts). The pH and organic matter of the soil were 5.9 and 3.1%, respectively. The N, P, K contents were 0.19%, 16.4 mg/kg and 49 cmol/kg, respectively. A randomized complete block design with four replications was used. Two bean cultivars (Arroyo Loro and Rosada Nativa) were intercropped either once (at the banana planting time) or twice (at the banana planting time and immediately after the first bean harvest), with the banana cultivar Gran Naine. The experiment was conducted on a private farm located in the Cagüitas precinct, Aguas Buenas, Puerto Rico, approximately 150 m above sea level.

A pasture field was treated with glyphosate at 1% to eliminate the existing vegetation. Drainage ditches were designed with a self-level apparatus and constructed at 6-m intervals by a plow pulled by paired oxen. The slope of the land at the experimental site was between 30 to 40%. Under no-till conditions, six corms of banana were planted in a 5.5 × 5.5-m plot along the contour lines. Four 5.5-m rows of beans were intercropped between the two rows of banana plants in the center portion of the plot. Two border rows of bean plants were planted on each side of the banana rows. The bean cultivars were intercropped at four planting dates (November, January, March and May). All agronomic and pesticide management practices were in accordance with recommended practices (Beaver et al., 1992; Estación Experimental Agrícola, 1995). Despite the fact that the pesticides used for each crop were registered, it is not legal for farmers to use them in an intercrop unless each pesticide has been registered for both crops. It is permissible to use them only under experimental conditions. Whole pod yields were measured for the bean crop. The yield of bananas was measured as the weight of fruit production. The yield data of both crops were analyzed by using the Analysis of Variance, and their means were separated by Duncan Multiple Range Tests.

A partial budget analysis (Perrin et al., 1981) was used to determine incomes derived from different treatments. The gross income of banana was calculated on the basis of the weight of fruits. A farm gate value of $0.33 per kg of banana fruit was assumed. Gross income of bean was based on whole pod yield. A farm gate value of $2.20/kg of whole pod beans was assumed. Variable production costs of bean consisted of wages and materials. Wage costs were calculated on the basis of $4.25/h for land preparation, planting, fertilizing, applying pesticides, harvesting, and removal of pods. The material input costs include seed, fertilizer, pesticides and bags for shipment.

There were no significant differences ($P < 0.05$) between yield from banana monoculture and yield from banana intercropped with beans within each individual planting date except for March (Table 1). These results indicated that banana yields were not significantly affected by bean intercropping provided that all banana plants were planted on the same date. The apparent low yield of banana from March and May plantings was partially attributed to the fact that the owner's loose cattle entered the fenced experimental area and caused damage to banana plants. Another explanation for poor banana yields is that bananas were planted during the months with relatively low rainfall. Consequently, our banana yields from the March and May plantings were lower than those of November and January plantings.

TABLE 1.—*Fruit production of a banana experiment intercropped with bean at an Aguas Buenas farm under different planting dates (1997).*

Treatment	Banana and bean planting dates			
	November	January	March	May
	kg/ha			
Banana with one intercropping of Arroyo Loro	44,251 a[1]	43,719 a	32,158 ab	34,151 a
Banana with two intercroppings of Arroyo Loro	43,603 a	41,128 a	34,151 a	34,550 a
Banana with one intercropping of Rosada Nativa	45,148 a	41,460 a	31,494 ab	33,188 a
Banana with two intercroppings of Rosada Nativa	41,360 a	40,530 a	33,387 ab	37,540 a
Banana monoculture	44,649 a	40,529 a	30,397 b	33,653 a

[1]Means within the same column followed by the same letter or letters do not differ significantly at $P < 0.05$.

The highest bean yield was obtained from two intercroppings of Arroyo Loro at the November planting date (4,425 kg/ha). This yield was significantly greater than that of the single crop of either Arroyo Loro or Rosada Nativa but did not differ from that of two intercroppings of Rosada Nativa (Table 2). The bean yield obtained in November, higher than from other planting dates, coincides with that of Beaver and Román (1994), who reported that bean yields were higher from October to December. Poor bean yields obtained

TABLE 2.—*Whole pod yields of bean plants harvested from a banana-bean intercropping experiment at Aguas Buenas farm (1996).*

Treatment	Banana and bean planting dates			
	November	January	March	May
	kg/ha			
Banana with one intercropping of Arroyo Loro	2,777 b[1]	2,185 bc	581 a	566 bc[1]
Banana with two intercroppings of Arroyo Loro	4,426 a	3,519 a	604 a	1,090 a
Banana with one intercropping of Rosada Nativa	2,725 b	1,783 c	640 a	393 c
Banana with two intercroppings of Rosada Nativa	4,343 a	2,545 b	670 a	818 ab

[1]Means followed by the same letter or letters do not differ significantly at $P < 0.05$.

TABLE 3.—*Gross income ($US / ha) derived from a bean and banana intercropping experiment at Aguas Buenas farm, P.R.*

Treatment	Gross income according to planting dates							
	November		January		March		May	
	Bean	Banana	Bean	Banana	Bean	Banana	Bean	Banana
	$US/ha							
Banana with one intercropping of Arroyo Loro	6,122	14,638	4,878	14,462	1,282	10,638	1,247	11,297
Banana with two intercroppings of Arroyo Loro	9,759	14,424	7,760	13,605	1,332	11,297	2,404	11,429
Banana with one intercropping of Rosada Nativa	6,009	14,935	3,931	13,714	1,411	10,418	868	10,979
Banana with two intercroppings of Rosada Nativa	9,577	13,682	5,612	13,408	1,478	11,045	1,805	12,418
Banana monoculture	0	14,770	0	13,407	0	10,056	0	11,133

TABLE 4.—*Production costs ($US / ha) for a bean and banana intercropping experiment at Aguas Buenas farm, P.R.*

	Production costs according to planting dates							
	November		January		March		May	
Treatment	Bean	Banana	Bean	Banana	Bean	Banana	Bean	Banana
	$US/ha							
Banana with one intercropping of Arroyo Loro	4,202	11,074	3,928	11,074	3,188	11,074	3,180	11,074
Banana with two intercroppings of Arroyo Loro	6,676	11,074	6,257	11,074	4,909	11,074	5,096	11,074
Banana with one intercropping of Rosada Nativa	4,179	11,074	3,743	11,074	3,215	11,074	3,101	11,074
Banana with two intercroppings of Rosada Nativa	6,540	11,074	5,807	11,074	3,106	11,074	3,106	11,074
Banana monoculture	0	11,074	0	11,074	0	11,074	0	11,704

from March and May plantings may be attributed to damage by cattle. Unlike the banana plants, the beans had no way to recover; therefore, we are concerned about the quality of data from the March and May plantings. Another explanation for poor bean yield might be that our experiment depended solely on rainfall (March and May were months with relatively low rainfall). Consequently, our bean yields from the March and May plantings were low compared to the yields of Beaver and Roman's experiments, which were provided with supplementary irrigation at the Isabela and Fortuna Substations during the drier months of the year. Of the two bean cultivars, Arroyo Loro yielded only slightly higher than Rosada Nativa.

The highest gross income of bean ($9,758/ha) was obtained from two consecutive intercroppings of the bean cultivar Arroyo Loro at the November planting date (Table 3). The highest gross income of banana ($14,935/ha) was also obtained from the November planting date, and the lowest gross income of bean ($868/ha) was derived from the single intercropping of Rosada Nativa at the May planting date. Table 4 shows production costs of bean and banana. The highest bean production cost ($6,676/ha) was from the two intercroppings of Arroyo Loro with banana at the November planting date, and the lowest production cost ($3,101/ha) was from the one intercropping of Rosada Nativa with banana at the May planting date. However, production costs for banana remained constant at $11,074/ha throughout the course of this experiment. The highest combined net income ($6,433/ha) was obtained from two intercroppings of Arroyo Loro at the November planting date (Table 5). We did not attempt to make any combined net income analyses of March and May planting dates because of the low and atypical bean yields. According

TABLE 5.—*Net income ($US/ha) derived from a bean and banana intercropping experiment at Aguas Buenas farm, P.R.*

Treatment	Net income according to the planting dates[1]					
	November			January		
	Bean	Banana	Total	Bean	Banana	Total
	$US/ha					
Banana with one intercrop of Arroyo Loro	1,920	3,564	5,484	950	3,388	4,338
Banana with two intercrops of Arroyo Loro	3,083	3,350	6,433	1,503	2,531	4,034
Banana with one intercrop of Rosada Nativa	1,830	3,861	5,691	188	2,640	2,828
Banana with two intercrops of Rosada Nativa	3,037	2,608	5,645	-195	2,334	2,139
Banana monoculture	0	3,696	3,696	0	2,333	2,333

[1]No economic analysis was performed for the March and May planting dates.

to our economic analysis data, we suggest that the most profitable treatment is the two consecutive intercroppings of bean cultivar Arroyo Loro with banana at the November planting date. This treatment earned an additional net income of $2,737/ha over that of banana monoculture.

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