Economic analysis of potential intercropping systems in Jamaica[1] /

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Resumen

*El proyecto "Allsides" constituye un intento para aumentar la producción agrícola de Jamaica. Una mayor provisión de alimentos para la población es el objetivo que se trata de alcanzar mediante una explotación intensiva de los limitados recursos naturales. Se requiere investigación adicional en Jamaica, sin embargo los sistemas de cultivos intercalados que han sido examinados muestran su fácil adopción por parte de los pequeños agricultores. Aún cuando sólo un pequeño porcentaje de las 220 000 pequeñas fincas adoptara el sistema de cultivos intercalados, se podría esperar un aumento considerable en producción alimenticia, ingreso y empleo en Jamaica. Además, el productor individual se beneficiará con los siguientes dos sistemas de cultivos intercalados, por ejemplo 1) papas irlandesas y rábanos, cuando son intercalados con ñame (*Dioscorea cayenensis*) y, 2) maíz dulce y frijoles cuando son intercalados con ñame, produjeron un incremento del 67 y 51 por ciento sobre el ingreso neto del agricultor, respectivamente, con relación al sistema del monocultivo del ñame. Cuando se comparan los sistemas de cultivos intercalados mencionados (1) y (2) con el sistema tradicional más productivo, el primero produce un ingreso de 300 por ciento y el segundo de 400 por ciento sobre el sistema tradicional.*

Todavía existen muchas dudas de carácter económico y biológico respecto al sistema de cultivos intercalados, el cual representa un campo propicio para efectuar investigación multidisciplinaria. El presente trabajo muestra los resultados del primer año del proyecto piloto para el desarrollo del sistema "Allsides" de cultivos intercalados. Se recomienda tener cautela al interpretar y tomar decisiones con base en éstos resultados.

Introduction

Recent world food shortages and prospects for inadequate supplies in the future have prompted growing interest in new or improved cropping methods in developing countries. In many of these nations a significant part of domestic staple foods are produced by very small farms which have been by-passed by the well-known Green Revolution (3, 6, 9, 10). For the most part, the gains in productivity and income of these rural people will require the development for and use by many farmers of new high-yielding, science-based crop and animal production systems tailored to the unique combination of soil, climate, biological, economic and cultural conditions of every locality and region in every nation. For this reason, increasing scientific attention is being directed to the study and improvement of the centuries-old practice of multiple cropping used on many of the small farms in developing nations (1, 4, 11, 13, 16).

Multiple cropping describes forms of cropping practices where total production from a land unit in a farming year is achieved through growing crops simultaneously, sole crops in sequence or a combination of mixed and sole crops sequentially. A more specifically defined system-intercropping-refers to two or more component crops grown simultaneously on the same land, although not necessarily sown or harvested at the same time. Intercropping implies some pre-planned spatial arrangement of plants in contrast to mixed cropping which may be nothing more than a random plant combination or arrangement.

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Advantages of the variants of multiple cropping may include improved utilization of solar radiation, soil moisture and nutrients, reduced soil erosion and pest control as well as provide the small farmer improved nutrition, lower risks of crop failure and efficient use of available land and labor over time (2, 5, 12, 14, 15, 18). Only quite recently have agricultural researchers recognized these advantages and the potential for improving traditional small-farm multiple cropping systems. To date, research has focused primarily on the biological aspects of multiple cropping with very limited attention being given to economic analysis of traditional and improved systems.

This paper reports an economic analysis of the first-year results of intercropping research carried out in Allsides, Jamaica. Nine intercropping systems are evaluated against a base yellow yam (*Dioscorea cayenensis*) treatment with similar levels of technologies and management. In addition the alternative croppings systems are compared to a low and high yield traditional monoculture system of yellow yams. The traditional farm system represents the low and high yield range of small-hillside farmers in the Allsides Project Area Jamaica, with high rural and urban unemployment, a population density of 440 people per square kilometer of arable land, an estimated 220 000 farms of less than two hectares, alarming rates of annual soil loss from the mountainous farmlands [131 metric tons per hectare (54 tons/acre) on slopes of 17 degrees (17] and declining food output, presents a set of conditions highly conducive to the introduction of new and/or improved intercropping systems.

The Allsides Pilot Development Project

The Allsides Pilot Development Project, started in February of 1977, is the second phase of a national program aimed at utilizing the low productive sloping land through the development of efficient commercial farming systems. There are approximately 400 farmers living inside the project area with an average farm income of J$850.00 per family (8).

The area is characterized by deep rugged cut valleys enclosed by steep hills with 90 percent of the 252 hectares being over 15 degrees slope. The traditional crop cultivated, as well as the main source of family income, is the yam (*Dioscorea* spp). The traditional cultivation practices consist of burning the vegetation and manually preparing the steep hillsides by bushing, clearing and forking the land into one meter square mounds for the planting of the yams. These practices, together with the maintenance of weed-free plots result in serious deterioration and depletion of soil resources, sediment pollution, and inefficient use of production inputs.

The Inter-American Institute of Agricultural Sciences (IICA) and the Conservation Unit, Ministry of Agriculture are providing technical assistance and training personnel in the field of intercropping. The project's main objectives are to increase rural farm incomes, improve family nutritional levels and expand domestic production through better cropping systems, and improve conservation treatments.

The design of the agronomic research involved one monoculture and nine intercropping treatments replicated five times on fifty, thirty square meter plots on bench terraces eight feet wide with a five degree backward slope. The terrace ridges were seeded to 'Napier' grass (*Pennisetum purpurum*) to reduce deterioration. All treatments were grown on the same soil type, wirefence clay loam. Each system experienced the same yam staking pattern, and received 6.7 ton per hectare each of chicken manure and lime.

Nine of the ten cropping systems studied had two to three component crops intercropped with the yam crop which was common to all treatments. Each intercropping system was designed to meet dietary acceptance, climate conditions and cultural preference within the Allsides Project area. Fertilizer and lime rates were calculated according to the results from the microplot and lime experiments conducted previously by IICA (7). The type of component crop, date of planting and harvesting, plant density, amount of fertilizer applied and labor used per system are summarized in Table 1 for both the intercropping systems and the traditional farming systems.

Methodology and Hypotheses

Enterprise budget analysis was used to compute return values to gross margin, net farm income (a return to family labor, equity and management), farm labor, risk and management, and farm investment capital. Although these intercropping budgets are not specific to any particular farm they do relate to a specific soil type and technology level.

The yield per hectare was the calculated average yield of the five replicated treatments per crop at harvest time. Systems total gross income was computed by summing the individual values of component crops and the yam crop. Data collected from unterraced farms in the Project Area were used to develop low and high yield budgets which represented the range of the traditional monoculture (yam) system. The traditional farm system had a lower level of technologies and management applied than did the experimental plots.

Table 1: Type of Cropping System, Date of Planting and Harvesting, Plant Density, Fertilizer Amount and Labor Required Per System, Per Hectare. Allsides Pilot Development Project, Jamaica.

	System	Date				Plant Density	Fertilizer (kg/hectare)			Labor Requirements Mandays/ hectare
		Planted		Harvested			N	P_2O_5	K_2O	
I	Yellow Yam	April	1 977	March	1 978	10 000	125	150	75	321.2[2]
II	Yellow Yam	April	1977	March	1978	10 000	50	50	25	531.3
	Red Pea	April	1977	July	1977	89 000	50	50	25	–
	Onion	August	1977	March	1978	88 888	80	50	50	–
III	Yellow Yam	April	1977	March	1978	10 000	50	50	25	454 6
	Sweet Corn	April	1977	August	1977	30 000	75	50	50	–
	Red Pea	September	1977	November	1977	89 000	50	50	25	–
IV	Yellow Yam	April	1977	March	1978	10 000	50	50	25	464 5
	Grain Corn	April	1977	August	1977	30 000	50	50	25	–
	Irish Potato	October	1977	January	1978	16 666	75	50	25	–
V	Yellow Yam	April	1977	March	1978	10 000	50	50	25	617 7
	Irish Potato	April	1977	June	1977	25 000	50	50	25	–
	Radish	July	1977	August	1977	133 333	30	20	25	–
	African Red Pea	October	1977	February	1978	44 444	50	30	25	–
VI	Yellow Yam	April	1977	March	1978	10 000	50	50	25	427 5
	Pumpkin	May	1977	–[1]	–	10 000	40	50	25	–
	Sweet Corn	September	1977	December	1977	30 000	90	50	50	–
VII	Yellow Yam	April	1977	March	1978	10 000	50	50	25	548 6
	Cabbage	April	1977	August	1977	30 000	40	50	25	–
	Carrot	August	1977	December	1977	66 666	40	50	25	–
	Red Pea	December	1977	March	1978	89 000	50	50	25	–
VIII	Yellow Yam	April	1977	March	1978	10 000	50	50	25	474 43
	Sweet Potato	April	–	October	1977	10 000	50	50	25	–
	Red Pea	September	1977	December	1977	89 000	80	50	50	–
IX	Yellow Yam	April	1977	March	1978	10 000	55	–	25	491 73
	Cassava	April	1977	–	–	10 000	100	100	50	–
	Red Pea	April	1977	July	1977	89 000	–	–	–	–
X	Yellow Yam	April	1977	March	1978	10 000	62 5	75	37 5	454 66
	Ginger	April	1977	–	–	–	–	–	–	–
	Sweet Potato	August	1977	March	1978	10 000	55	–	25	–
Traditional Farm System										
Low Yield		April	1977	March	1978	10 000	44	133	200	145
High Yield		April	1977	March	1978	10 000	44	133	200	145

1 Crop not harvested

2 One manday equals 8 hr

Information concerning prices of production and technical inputs were obtained from private dealers in Christiana and Kingston. Product prices used were based on guaranteed market prices offered by the Agricultural Marketing Corporation.

Five specific hypotheses are examined in this paper with respect to land, labor, capital and management. The potential intercropping systems were evaluated against the monoculture system grown under similar soil, environmental and technology levels. The hypotheses tested are as follows:

1. Labor productivity is greater in the intercropping systems than for the yam monoculture system.

2. Land productivity for the intercropping systems is higher than for the yam monoculture system.

3. Gross Margin (income above variable cost) is greater for the intercropping systems than for the yam monoculture system.

4. Returns to Management and Risk are greater for intercropping systems than for the yam monoculture system.

5 Capital requirements are greater for the intercropping systems than for the yam monoculture system.

Results

The hypotheses that land and labor resources are more productive and capital requirements are higher for the intercropping systems than for the monoculture system are summarized in Table 2. Land productivity is measured by summing total kilograms of economic bio-mass produced per system, per hectare. Economic bio-mass refers to the portion of plant material with economic value. Eight of the intercropping systems gave at least a 9 percent increase of economic bio-mass above the monoculture system. System V yielded the highest amount of economic bio-mass per hectare, 44 and 188 percent higher than system I and the high-yield traditional farm system, respectively. Only system VIII had a lower yield of economic bio-mass than did the monoculture system.

Labor productivity, measured by returns to farm labor showed that three of the intercropping systems provided higher labor returns than the yam monoculture system. However, all nine intercropping systems showed higher farm labor returns than two traditional farming systems (Table 2). System III provided 10 and 265 percent respective increases above the yam monoculture system and the high-yield traditional farm systems.

Table 2: Summary of Land and Labor Productivity, and Capital Requirements for the Intercropping Systems and Traditional Farm System, Allsides Pilot Development Project, Jamaica.

System	Tonne/ hectare of Economic Bio-Mass[1]	Labor Productivity[2] JS/manday	Capital Requirement: Total Variable Cost/ hectare (JS)[4]	Capital Requirement: Percent Return to Farm Investment Capital/ hectare JS
I	31.48	19.12	4 573.45	83
II	37.44	15.95	5 028.76	98
III	41.84	21.01	4 770.66	127
IV	36.74	14.79	5 860.47	73
V	45.29	17.01	6 594.30	109
VI	39.84	19.79	4 641.82	112
VII	34.25	12.63	4 911.48	71
VIII	29.09	10.79	4 795.51	48
IX	37.69	17.51	4 920.74	106
X	41.93	19.81	5 114.67	114
Traditional Farm System				
Low Yield	11.23	3.96	3 894.94	0[3]
High Yield	15.72	5.76	3 894.94	4

1 Assumes that a kg of associated crop material is equal to a kg of yam material.

2 Labor productivity is measured as labor income per manday. Labor is a residual claimant. A charge for management and capital has been subtracted from net farm income. Also labor refers only to the expended and does not represent the potential labor of the family.

3 A zero was recorded since the low yield traditional farm system had a negative return.

4 All values are reported in Jamaican dollars. In 1978 one U.S. dollar = 2.55 Jamaican dollars.

Labor requirements increased 92 percent from the yam monoculture system to a four-crop system of yam intercropped with 'Irish Potatoes' (*Solanum tuberosum* L.) sequentially followed by 'Radish' (*Raphanus sativus*), and then 'Red Pea' (*Phaseolus* spp)*. Yam intercropped with 'Sweet Corn' (*Zea mays* L.) sequentially followed by 'Red Peas' gave the highest return to farm labor of JS21.01 per manday which represented a 250 percent increase above the current average market wage rate of JS6 per manday. The two traditional farming systems returned about J$3.96 and JS5.76 per manday for the low and high yield budgets, respectively.

* The red pea is a local name used for the traditional field bean

Capital requirements, measured by total variable costs, showed that all nine of the intercropping systems had higher capital requirements than the monoculture system or the traditional farm system. System VI had the smallest increase of 5 percent above the monoculture system. At 44 percent above the monoculture, system V had the largest capital requirements of the nine intercropping systems. Fixed capital requirements were the same for all ten alternative cropping systems.

Another measure of capital productivity is the return to total farm investment capital. System III provided the highest return to total farm investment capital, 127 percent, which was a 53 percent increase above the improved monoculture system. Six of the intercropping systems provided higher returns to total farm investment capital than the monoculture system. The average return to total farm investment capital of the intercropping systems was 227 percent higher than that for the high yield traditional farm system. The high yield traditional farm system gave a return of 4 percent to total farm investment capital.

Results for the hypotheses with respect to farm income are summarized in Table 3. For eight of the intercropping systems, gross margin was at least 11 percent higher than the monoculture system. Only System VIII was lower (15 percent) than the monoculture system. The average gross margin for the nine intercropping systems was 30 percent higher than the monoculture system and 300 percent higher than the high yield traditional farm system. Farm income increased J$1 138 on the average, for the intercropping systems when compared to the monoculture system. Net additional income represents the additional reward for the additional time and energy spent managing two or three crops intercropped with the yam crop.

Six of the intercropping systems provided higher returns to management and risk than the monoculture system. For the nine intercropping systems average returns to management and risk were 26 percent higher than the monoculture system and 110 percent above that for the high-yield traditional farm systems.

Table 3: Summary of Gross Margin, Net Farm Income, and Returns to Management and Risk for the Intercropping Systems and Traditional Farm System, per hectare, Allsides Pilot Development Project, Jamaica[1].

System	Gross Margin	Net Farm Income	Return to Management and Risk
I	9 304.67	8 919.79	6 381.63
II	12 440.20	12 055.32	8 231.49
III	13 862.28	13 477.40	10 124.65
IV	10 344.92	9 960.03	6 475.03
V	15 234.65	14 849.79	10 394.04
VI	13 046.00	12 167.00	8 991.72
VII	10 375.31	9 990.42	6 075.67
VIII	7 952.42	7 577.53	4 094.96
IX	12 614.75	12 229.86	8 648.00
X	13 155.85	12 770.97	9 392.74
Traditional Farm System			
Low Yield	2 354.46	1 994.89	−317.02
High Yield	3 023.86	2 983.29	671.37

1 All values are reported in Jamaican dollars. In 1978 one U.S. dollar = 2.55 Jamaican dollars.

show current potential for adoption by small farms in Jamaica. If adopted by even a relatively small percentage of the 220 000 small farms, a considerable increase could be expected in aggregate food production, income and employment. Several advantages could also accrue to the individual producer. For example, two intercropping systems, Irish potatoes and radish intercropped with yellow yams, and sweet corn and red peas intercropped with yellow yam, provided a 67 and 51 percent increase in net farm income, respectively above the monoculture system. When these two systems are compared to the high yield traditional farm system the income increase was approximately 300 to 400 percent, respectively.

Much remains unknown about the economic as well as the biological relationship of intercropping. Economics and Agronomy are inseparable in researching intercropping systems. Intercropping provides an excellent framework within which to undertake multidisciplinary research and development. This paper presented only the first year's results of the Allsides Pilot Development Project intercropping systems. Care must be taken when interpreting and making decisions on the basis of these results.

Summary

The Allsides Project is one effort to increase Jamaica's capacity to feed its expanding population from its limited land resources. Much additional multiple-cropping research is required in the country, yet several of the intercropping systems examined

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