# An economic analysis of banana intercropping in the Windward Islands.

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ASPECT ECONOMIQUE DES CULTURES INTERCALAIRES EN BANANERAIE DANS LES WINDWARD ISLANDS.

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RESUME - La documentation disponible sur l'intérêt des cultures intercalaires semble montrer que ces cultures rapportent un bénéfice plus important et plus sûr que dans le cas d'une culture unique. Les principaux avantages économiques des cultures intercalaires sont une minimisation des risques, une meilleure répartition des périodes optimales de travail et une exploitation plus complète de l'environnement à travers l'implantation de cultures ayant des périodes de maturité différentes.
Une condition nécessaire de maximisation des profits passe par un meilleur rendement des facteurs les plus limitants comme la marge brute à l'hectare ou le rendement brut d'une journée de main-d'oeuvre. Ce critère permet d'estimer l'adaptation du système de culture aux grandes variations des facteurs entrant en jeu.
Le système de cultures intercalaires est plutôt adopté par les petits planteurs et en tant que tel toute amélioration dans la technologie bénéficiera vraisemblablement aux planteurs les moins dotés. C'est une notion d'équité qu'il est important de considérer pour toute stratégie de recherche agricole.

## INTRODUCTION

Most of the documented evidence on intercropping tends to suggest that intercropping gives higher and more dependable gross returns per hectare than sole crops in India (MATHUR, 1963) and Northern Nigeria (NORMAN, 1974). Intercropping also gave higher returns per unit of labour during labour scarce periods in Northern Nigeria (NORMAN, o.p. c.t.).

Crops requiring high input costs may not fit well into the small farmer's intercropping systems as he may not want to divert costly inputs meant for bananas to other crops.

The actual cropping decisions are most likely to be influenced by farm characteristics. A farmer's choice of any particular system is most likely to be determined largely by his resource base (e.g. size of farm, soil type, family labour, etc) as well as the relative product prices.

The fact that intercropping is most popular with smaller farmers is a good indication of the risk-minimising rationale behind it. Unlike bigger farmers, small farmers tend not to have enough risk bearing capacity not enough land to viably diversify cropping by planting different pure stand crops on several plots.

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There are other non-risk factors that may make intercropping economically attractive to the small farmer :

a) Intercropping tends to be labour-intensive as such smaller farmers with a supply of family labour tend to be at a comparative economic advantage ;

b) Depending on the nature of the component crops and the spatial arrangements of planting and field operations, particularly weeding and harvesting. Intercropping calls for care and a sense of responsability by labour. Family workers are more likely to display this attitude to farm work than hired labour.

c) The staggered or phased operations that occur in an intercropping system may work well in the context of the small farmers' ressource base. Weeding and harvesting operations may tend to require labour on a staggered and uneven pattern which may not allow for the efficient use of hired labour. In this context, family labour can be employed on a part-time and even odd-hourly (i.e. during «non-working» hours) basis without much difficulty.

As banana intercropping is largely the smaller farmers' system, any improvement in the technology is likely to benefit the less endowed farmers relatively more than the better-endowed ones. This is an equity consideration which has in recent years been important in Agricultural research strategies in many parts of the tropics.

In the Windward Islands the crops interplanted with bananas tend to range from tree crops, aroids, fruit crops, cereals, legumes and vegetables. With the exception of bananas, the crops are generally grown in a random fashion (GEORGE, 1981). The most common food crops in banana intercropping are dasheen. tannia, eddoe, corn and pigeonpea ...

If bananas are the key crop in the system, intercropping may not viably extend beyond the first or perhaps second ratoon, provided there is sufficient light under the banana canopy to allow for the adequate growth and development of the lower component crops.

On the other hand intercropping if it is positively associated with higher cash income to farmers, may make replanting (which is a major investment) more economically attractive as the returns would be higher.

## BIO-ECONOMIC RELATIONSHIPS IN MULTIPLE CROPPING : COMPETITION AND PRINCIPLE OF MARGINALITY

In a multiple cropping environment with a given level of inputs and overlapping growth cycles, production of the crops will be related in one of three basic ways. If two crops are grown on the same piece of land, the relationship between them may be :

a) **Competitive** : where the output of one crop can only be increased at the expense of the other.

b) **Complementary** : where an increase in the output of one crop will also bring about an increase in the production of the other.

c) **Supplementary** : where the output of one crop tends to be independent of the output of another.

It may appear that in many banana-based intercropping systems the yields the two or more crops tend to be biologically independent over «normal» ranges of plant populations. This is most likely to be the case where the maximum demands made on the environment by the two crops occur at different times.

In most cases however, increasing the product of one of the component crops, at the limit, is only achieved at the expense of the other.

Although there might be a degree of biological independence between banana yield and the yield of the intercrop under usual management practices, the farmer still has to make the decision as to :

a) which crop is it best to grow in association with bananas ?
b) what are the optimum planting densities for both crops ?
c) what are the optimum combinations of other inputs (e.g. labour, fertilizer, insecticide) to apply to the intercrop ?

The optimum combination of crops to grow and the inputs to use will depend on the objectives of the farmer in growing the crops, the ressources available and the prevailing constraints.

Under normal circumstances, the optimum combination of inputs is that which maximises net economic benefit, subject to the prevailing production constraints. For a meaningful estimate of net benefit to be made, it is essential that both output (gains, returns) and inputs (cost, losses) are measured in the same units, namely monetary units or market prices.

A weakness in the use of market prices is that they may not always reflect the true values to the decision-maker (the farmer), of products and scarce resources. This problem can partly be solved through the use of opportunity costs or values. Another weakness in the use of market prices is that prices differ both spatially and temporally thus making comparisons of cropping systems a lot more complicated. However, this may in part be a strength in the use of market prices in that it enables the economic combinations of inputs used and crops produced to be tailored to specific and changing economic conditions.

Conceptually for an economically efficient level of input use in an intercropping system, the farmer or decision-maker should add additional units of the productive input as long as each additional unit of the input earns or saves more money than it costs. This is to say that it pays to increase the level of input use so long as

$$P_y \; Y_y \; P_X \; x \; \ldots\ldots\ldots\ldots\ldots\ldots \; (1)$$

where $Y_y$ is the incremental change in the output of the Yth crop component of the system brought about by an increase in the level of input use X, $P_y$ is the field price per unit of crop $Y_y$ ; and $P_x$ is the field price of the input X.

The optimum level of input use is where the above inequality, (1) becomes the equation :

$$P_y \; Y_y = P_x \; X \; \ldots\ldots\ldots\ldots\ldots\ldots \; (2)$$

The equation in (2) can be rearranged as :

$$\frac{P_y \; Y_y}{X} = P_x \; \ldots\ldots\ldots\ldots\ldots\ldots \; (3)$$

where $\frac{Y}{X}$ is the marginal product of X.

Multiplying the marginal product of an input by the product price (i.e. the left hand side of the equation yields the marginal value product).

Although intuitively, the concept of marginality can be logically useful in designing efficient combinations input levels to apply, the direct budgeting approach may be more practically useful in ranking the economic profitability of different systems and associated cultural practices (FLINN, 1978). In this way, the net economic benefits of alternative technologies can be ranked according to a number of choice criteria, where the appropriate criterion is that which maximises the productivity of the system in relation to the most limiting factor(s) in the system.

In most small farmer situations in the Windward Islands, labour costs dominate in terms of both money and opportunity costs. There are many problems involved in attempting to estimate the opportunity costs of family labour. It may vary for different members of the household depending on work alternatives available to them. Extra labour may be required at a time when family labour is fully occupied. If the need for extra labour occurs during a relatively slack period, it may be reasonable to use (50-75% of the going farm wage rate (PERRIN et al., 1977). The indication from WINBAN farm management studies is that at around 1.22 hectares, it becomes necessary to take on an extra fulltime labour unit, which gives a boost to per hectare productivity at the margin, which is followed by a further decline, presumably until the next labour unit is employed. Budgeting techniques, supplemented by returns to the most limiting resources and by measures of variability in most cases provide a detailed system of economic analyses and comparisons of new innovations within cropping systems-oriented programmes.

Results from WINBAN Research trials have shown that intercropping does not significantly affect banana yields does affect the days taken to shooting and harvesting of bananas (RAO and EDMUNDS, 1981).

The effect of intercropping on the number of days to harvest depends on :

a) **the type of intercrop** : a short growing legume such as cowpea cannot shade the bananas. It therefore has a very minimal effect on banana bunch maturation (three to four days in most cases).

b) **the duration of the intercrop** : the longer the duration of the intercrop the greater the effect on banana bunch maturation. Cowpea for instance, which has a relatively short period of growth has the least effect on the banana maturation period compared to sweetpotato and cassava.

c) **time of planting** : competition for water is considerably reduced if the intercrop is planted during the rains.

Table 1 illustrates the effect of intercropping on the marketable yield of bananas.

## PERFORMANCE CRITERIA FOR THE ECONOMIC ANALYSIS OF CROPPING SYSTEMS

**Gross margin :**

This is the gross returns from an enterprise or cropping system less the variable costs attributable to it.

**Returns to factors of production :**

A good insight to the attractiveness of any new technology is given by looking at the rate of return to a factor or a group of factors. This factor may be considered throughout the production cycle or over a limited time, usually the time at which it is most scarce in relation to demand (JAYASURIYA, 1980).

For example, the appropriate cropping system in an area with a marked shortage of labour at a certain time of year will be one that increases the return per unit of labour at that time (NORMAN and PALMER-JONES, 1977). This may be a completely different system from that appropriate where land is the most limiting factor.

The general formula for the rate of return to a factor A is :

**TABLE 1 - Effect of intercropping on marketable yield of banana.**

| Treatments | Yield (t/ha) | Ratio of yield to sole banana (%) | Bunch weight |
|---|---|---|---|
| B | 30.93 a* | - | 20.66 a |
| B + 4C | 29.75 a | 96.1 | 19.71 a |
| B + 4M | 31.47 a | 101.7 | 20.87 a |
| B + 4S | 31.14 a | 100.6 | 20.53 a |
| B + 3C + 2M | 29.82 a | 96.4 | 19.83 a |
| B + 3C + 2S | 31.38 a | 101.4 | 20.32 a |
| B + 2C + 3S | 31.64 a | 102.2 | 20.69 a |
| B + 2M + 3S | 31.89 a | 103.1 | 20.87 a |
| C.V. (%) | 3.5 | - | 3.5 |

* Means within each column not followed by letters in common are significantly different by 't' test at $p = 0.05$

Source : RAO (M.M.). Second annual Report : Banana cropping systems. Windward Islands Banana Growers Association. June 1980.

**TABLE 2 - Effect of intercropping on days taken to shooting and harvest of bananas.**

| Treatments | Days taken from planting to | |
|---|---|---|
| | Shooting | Maturity |
| B * | 229 a | 318 a |
| B + 4C | 241 b | 323 a |
| B + 4M | 266 a | 355 c |
| B + 4S | 284 f | 379 e |
| B + 3C + 2M | 255 c | 344 b |
| B + 3C + 2S | 277 e | 372 d |
| B + 2C + 3S | 287 f | 380 e |
| B + 2M + 3S | 286 f | 383 e |
| C.V. (%) | 1.7 | 1.9 |

Source : RAO (1980, op. cit).

B : banana  C : cowpeas  M : maize  S : sweetpotato

$$\text{Rate of returns} = \frac{\text{Gross returns - all costs other than costs of A}}{\text{Amount of A}}$$

Examples of performance criteria that evaluate returns to a group of factors are :

- returns to farm resources : gross returns - costs of all non-farm resources
- returns to labour costs : $\frac{\text{gross returns - all material costs}}{\text{cost of labour}}$
- returns to material costs : $\frac{\text{gross returns - labour costs}}{\text{material costs}}$
- returns to all variable costs : $\frac{\text{gross returns}}{\text{variable costs}}$

Other criteria may be returns to a subset of labour input, such as family labour during certains periods.

The analysis in this paper uses a partial approach to the testing and evaluation of cropping systems. In other words, a field using the system is planted, and the inputs and outputs recorded together with other important data such as prices. It has, however, not been attempted to look at the whole farming system because :

a) such an approach would demand very many more research resources particularly skilled personnel ;

b) the trials themselves constitute an intervention in the farming system and a fermer's adaptation strategy on a whole-farm basis would probably not accurately reflect what he would do in more normal circumstances ;

c) studies carried out by the Caribbean Agricultural Research and Development Institute (CARDI) have provided the necessary data on the general farming systems (GEORGE, 1981, op. lit.).

A summary of the costs and returns per hectare of the various cropping systems is presented in Tables 3 a and 3 b.

TABLE 3 a - A summary of costs and returns per hectare (EC$) of the various cropping systems.

| | B | B + 4C | B + 4M | B + 4S | B + 3C + 2M | B + 3C + 2S | B + 2C + 3S | B+2M + 3S |
|---|---|---|---|---|---|---|---|---|
| Yield (t/ha) | 30.93 | 30.96 | 35.50 | 42.30 | 32.94 | 39.02 | 41.82 | 45.23 |
| Gross returns * | 12,734 | 15,877 | 16,945 | 20,333 | 17,120 | 19,811 | 21,259 | 22,343 |
| Labour cost | 1,834 | 2,460 | 2,374 | 2,445 | 2,579 | 2,615 | 2,611 | 2,568 |
| Material cost | 4,876 | 4,510 | 4,600 | 4,856 | 4,650 | 4,779 | 4,865 | 4,910 |
| Total variable cost (TVC) | 6,710 | 6,970 | 6,974 | 7,301 | 7,229 | 7,394 | 7,476 | 7,478 |
| Gross margin | 6,024 | 8,907 | 9,971 | 13,032 | 9,891 | 12,417 | 13,783 | 14,865 |
| Returns to labour | 4.28 | 4.31 | 5.20 | 6.33 | 4.84 | 5.75 | 6.28 | 6.79 |
| Returns to material costs | 2.24 | 2.97 | 3.17 | 3.68 | 3.13 | 3.60 | 3.83 | 4.03 |
| Rate of return to variable costs | 1.90 | 2.28 | 2.43 | 2.78 | 2.37 | 2.68 | 2.84 | 2.99 |

* Returns were calculated at the following prices :
Cowpeas EC$ 2,860/metric tonne Maize (grain) : EC$ 669/metric tonne
Sweetpotato : EC$ 550/metric tonne and Banana : EC$ 418/metric tonne
EC$ 2.70 = US $ 1.00

TABLE 3 b - Summary of costs and returns per hectare (EC$) of the various cropping systems.

| | B | B + C | B + M | B + G | B + S |
|---|---|---|---|---|---|
| Yield (t/ha) | 36.60 | 40.95 | 42.26 | 41.60 | 42.50 |
| Gross Return | 15,301 | 20,306 | 19,219 | 21,944 | 21,465 |
| Labour costs | 1,673 | 2,126 | 2,018 | 2,403 | 2,155 |
| Material costs | 5,617 | 5,131 | 5,234 | 5,232 | 5,413 |
| Total variable costs (TVC) | 7,290 | 7,257 | 7,252 | 7,635 | 7,568 |
| Gross margin | 8,011 | 13,049 | 11,961 | 14,309 | 13,897 |
| Returns to labour | 5.79 | 7.14 | 6.93 | 6.95 | 7.45 |
| Returns to material costs | 2.43 | 3.54 | 3.29 | 3.73 | 3.57 |
| Rate of return to variable costs | 2.10 | 2.80 | 2.65 | 2.87 | 2.84 |

The figures in Table 3 have been converted from a plot to a per hectare basis. From an economic point of view, this presents certain problems, particularly :

a) deciding on how much yields should be discounted to reflect the fact that they are still «experimental» rather than «farmers» yields ;

b) deciding on the correct labour coefficients to use. Labour estimates from trials tend to over estimate labour availability and use under normal farm conditions (i.e. the farmer's own practice).

c) deciding on the probable level of use of other inputs based on the availability and costs to the farmer.

There can be no hard and fast rules to the considerations and sensible intuitive judgements based on experience can be considered adequate.

As shown in Table 3 a, the system B + 2M + 3S yielded the highest gross margin per hectare and returns to the factors labour and material costs. Sole banana yielded the lowest gross margin and returns to factors. In all cases, intercropping yielded a higher gross margin than sole banana and the returns to labour were higher than the returns to material costs. This suggests that intercropping may be a good means of maximising returns to labour which is often a constraint in banana production.

As shown in Table 3 b in the trial at Forestierre, the treatments B + C and B + M had lower variable costs compared to sole banana. This was mainly because the costs of weedicides and pesticides were substantially reduced. The costs of weedicides and pesticides for sole banana totalled $ 2,301 per hectare. The costs totalled $1,640 in both of the treatments B + C and B + M.

The costs of weedicides and pesticides and consequently total material cost were also considerably reduced in the other treatments B + G and B + S. These treatments however recorded substantial increases in labour costs (mainly for harvesting). As such the total variable costs for these treatments were higher than those for sole bananas. The percentage increase in the labour requirement over sole banana was 27.3, 19.6, 43.4 and 29.7 in banana + cowpea, banana + maize, banana + groundnuts and banana + sweetpotatoes, respectively. The returns to labour were higher in all the intercropped systems compared to sole banana.

**TABLE 4 a - Marginal rates of return of various cropping systems (compared to pure stand bananas)**

| System | Marginal rate of return (%) |
|---|---|
| B | - |
| B + 4C | 12.09 |
| B + 4M | 15.95 |
| B + 4S | 28.78 |
| B + 3C + 2M | 8.45 |
| B + 3C + 2S | 10.35 |
| B + 2C + 3S | 11.13 |
| B + 2M + 3S | 12.51 |

**TABLE 4 b - Marginal rates of return of various cropping systems (compared to pure stand bananas)**

| System | Marginal rate of return (%) |
|---|---|
| B | - |
| B + C | 152.67 |
| B + M | 103.95 |
| B + G | 18.26 |
| B + S | 21.17 |

A key indicator of the economic attractiveness of any new technology is the marginal rate of return. This is the marginal net benefit divided by the marginal cost. The marginal rates of returns presented in Tables 4 a and 4 b are in relation to pure stand bananas.

The system with the highest marginal rate of return is B + 4S (28.78%). All the other system generally have low rates of return over sole bananas.

Table 4 b shows that in the on-farm trial at Forestierre the treatments B + C and B + M yielded marginal rates of return above 100 % (152.67% and 103.95% respectively). This was mainly due to the substantial reduction in variable costs particularly herbicides and pesticides. The other treatments, B + G and B + S had much lower marginal rates of return, 18.26% and 21.17% respectively.

It has been suggested that a figure of 20% above the effective lending rate for investments with average risk be considered the minimum rate of return that would encourage farmers to adopt a new technology (PERRIN et al., 1977). This is the case where loans are widely available for financing investments on farms (e.g. a new technology). Where farmers will be financing the investments themselves, a minimum opportunity rate of returns of 40 % is suggested.

## FARMERS' CHOICE OF CROPPING SYSTEMS

A farmer's choice of cropping system is influenced by yields, prices, and variable costs (BARNARD and NIX, 1979). In this respect, there are four main alternatives open to the farmer :

a) to retain the same cropping policy but reduce combined labour and capital costs ;
b) to substitute some high for low gross margin crops, with the same complement of regular labour and machinery where applied ;
c) to substitute high for low gross margin crops with added labour and/or capital costs. The objective here is to raise total gross margin (TGM) more than fixed costs are increased.
d) to substitute low for high gross margin crops with reduced labour and/or capital costs. The object here is to save more in fixed costs than the reduction in TGM.

The best choice of cropping would therefore depend on a) the farmers' objectives, b) his financial circumstances and c) relative crop margins.

This brings us to the problem of marketing and the price farmers would receive if the intercrops were sold on the market. It is evident that, at present, most intercrops in banana production are for the farmers own home use. However, marketing would become an important issue if more farmers were to adopt intercropping bananas with food crops on a major scale. A strategy or policy for banana intercropping has been suggested (EDMUNDS and RAO, 1981) but much of this will depend on governmental action.

A substantial increase in the number of intercrops and their sale on the domestic market would tend to push prices down. This effect on prices beyond a certain extent, could be enough to deter marketing and thus further production. On the other hand, a reduction in domestic food prices as a consequence of marketing of more locally procuded crops could be beneficial to consumers in terms of a situation of consumers' surplus.

The extent to which new cropping systems can be adopted by farmers will be largely determined by domestic and/or external market accessibility for farmers. A final point of issue is whether research can generate a new intercropping technology for the benefit of small farmers. JODHA (1979) argues that the best strategy in intercropping research lies in generating more and better options in terms of variables that constitute the intercropping system and leaving their selection to the individual farmer. These variables are adopted crops or varieties, crop combinations, spatial arrangements or crop geometry and also the level and timings of different inputs used.

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