Seminar on CROPPING SYSTEMS

- YAM
- VEGETABLES
- GINGER
- IRISH POTATO
- PULSES

Research & Development Department,
MINISTRY OF AGRICULTURE.

Sponsored in collaboration with IICA & CARDI

on Thursday, Dec., 4, 1980 at the J.S.A. Auditorium

FOREWORD

In order to ensure that a desirable level of agricultural development will take place in the Caribbean including Jamaica, it is necessary to provide relevant information on research and development, and to formulate appropriate extension methods that will accommodate the development as expeditiously and effectively as possible. There are adequate indications to support the conviction that this development can be achieved. In this context we are encouraged by the fact that the interval between the conception of scientific ideas and the time these ideas are put to practical use is steadily getting shorter. It took 112 years to develop photography, 35 years for steam locomotion and radio, 10 years to develop the atomic reactor and 3 years to commercialize the transistor.

We art not exactly starting from scratch where agriculture is concerned, and so our rate of transfer of technology can move faster. It depends largely on the expertise of the technologists and the receptivity of the adopters. At seminars like these, it is very satisfying to present summary reports on research findings on a particular crop or production system. It is very exciting to give previews of research projects in the pipeline. It is most beneficial to state positive recommendations that can lead to increased production and productivity.

These seminars bring together people with common interests, and the benefits gained should be increased by the fact that whereas individuals can be creative, groups of individuals should be more creative. We will not be dealing with policy matters that need approval and support at the political level, but will be evaluating existing cropping systems and closely-related practices, in seeking ways of adopting and improving them where feasible and efficient. It is our hope that we can thereby add another strong link in the chain of agricultural success in our region.

J.R.R. Suah
Head of Unit
CARDI, Jamaica

Percy Aitken-Soux
Director
IICA, Jamaica

R. J. Baker
Acting Director
Crops and Soils Dept.
MINAG, Jamaica.

******** A G E N D A ********

OPENING SESSION

9.00 -, 9.30 a.m.	**Slide Show**	-	
9.30 - 10.15 a.m.	Introduction	-	Dr. Wellington
	Welcome to JSA	-	The Principal, JSA
	Opening Address	-	Dr. the Hon. Percy Broderick, Min. of Agric.

FIRST PAPER SESSION

Chairman - Dr. Percy Aitken-Soux (IICA, Jamaica)

10.15 - 10.50 a.m.	Development Potentials of Cropping Systems for Hillside Agriculture - A. Wahab, P. Aitken-Soux, I.E. Johnson and H. Murray (IICA - JAMAICA).
10.50 - 11.15 a.m	CARDI'S Small Farms Systems Research Project in Jamaica - L. Daisley (CARDI - JAMAICA).
11.15 - 11.25 a.m.	C O F F E E B R E A K

SECOND PAPER SESSION

Chairman - Mr. R. Burghess (SIRI)

11.25 a.m. -12.15 p.m.	Cropping Systems Involving Banana - Allan Jones (Banana Co.)
12.15 - 12.40 p.m.	Cropping Systems Involving Coconut in Wet Tropics - D.H. Romney (Coconut Industry Board)
12.40 - 2.00 p.m.	L U N C H

THIRD PAPER SESSION

Chairman - Mr. D.H. Romney (Coconut Industry Bd.)

2.00 - 2.25 p.m.	Cropping Systems as they Affect Pest Population Dynamics and Control - J.R.R. Suah (CARDI, JA.)

2..25 - 2. 50 p. m.	Cropping Systems Approach to Crop Production in the Pindars River and Two Meetings Watershed - S. H Dacanay and H. Aikman (IRDP)
2. 50 - 3. 15 p. m.	Role of Livestock in Cropping Systems - Dr. D. S. McLeod (MINAG).
3. 15 - 3. 25 p. m.	C O F F E E B R E A K

FOURTH PAPER SESSION   Chairman - Mr. K. Hall (FIDCo.)

3. 25 - 3. 50 p. m.	Coffee /Forestry Intercropping - Miss M. Headley (Forestry Dept.)
3. 50 p. m.	PANNEL DISCUSSION AND RECOMMENDATIONS (Rapporteur - Mrs. G. H. Barker, CARDI)

CLOSING SESSION

REFRESHMENTS

MODERATOR - Mr. R. J. Baker

****

SPONSORS:

- Instituto International de Ciencias Agricolas (IICA)
- Caribbean Agricultural Research and Development Institute (CARDI)
- Ministry of Agriculture, Jamaica.

CONTENTS

COFFEE/FORESTRY INTERCROPPING

by
Marilyn Headley, Forest Department

Introduction

During the 19th Century, the Blue Mountain region of Jamaica was a major coffee producing area. This continued throughout the century until the early 20th Century when production declined rapidly, and resulted in large areas becoming eroded. A re-afforestation programme was implemented by the Forest Department to prevent further deterioration of these lands. In this programme *Pinus patula*, and *Juniperus* spp were planted in Clydesdale, Silver Hill, Wallenford and Chestervale, all primarily coffee areas.

In 1969, the Coffee Industry Board launched a Coffee Resuscitation and Expansion Programme to increase the acreage of coffee producing lands, and also to improve cultural practices to increase yields significantly. In its drive to obtain lands, the Board met with a number of problems in the Blue Mountain viz. -

i) the lack of participation of large landowners, this has now changed;

ii) small holdings in the Blue Mountains are used to produce high priced vegetables, which can be marketed throughout the year;

iii) the Coffee Industry Board had to compete with the Forest Department for lands which were planted out in *Pinus patula* and *P. caribaea*.

Agri-Silviculture

An agreement was drawn up between the Forest Department and the Coffee Industry Board in 1973, that coffee be planted under the pines. This meant that one would not have to remove all the valuable pines which are important for the watershed areas and in reducing the import bill of J$50M for Forest Products.

This form of agri-silviculture was introduced on only 7,3 acres (2.95 ha) of land. Presently there are 103 acres (41.7 ha) of coffee under pine; 63 acres (25.5 ha) at Clydesdale,

30 acres (12. 1 ha) at Moneague, 10 acres (4. 0 ha) at Mt. Airy. Initially, the Pinus caribaea is planted at 9' x 9' (2. 7 x 2. 7m) i. e. 530 trees/acre. Between ages 8 to 10 years the stand is thinned to 50% leaving approximately 270 trees per acre. The coffee is then planted between the pine in rows, with distances of 10 feet (3m) between rows and 5 feet (1. 5m) within rows, giving 870 coffee plants/acre. The coffee plants are given the general treatments recommended by the Coffee Industry Board, and all the cultural practices adhered to for producing healthy, insect and pest free plants.

Pinus caribaea has a crop rotation of 20 years in Jamaica. At the end of the 20 years the final crop is cleared, felled and the area replanted. At the time of harvesting pine, the coffee trees are approximately 10 years and are ready to be cut back. These two practices can be undertaken simultaneously with minimal damage to coffee plants. Then the questions arise:

i) what will be used to provide shade for the coffee during regrowth, at which time the pines are at the seedling stage?

ii) How can damage to coffee plants be lessened when the logs are being removed?

Recently it was decided by the Forest Department to plant the coffee under pines grown in seed stands. A seed stand is an area designated for the production of seeds. It is thinned to a much lesser density than the regular stands, to encourage high productivity of each tree; this is also a permanent stand. Coffee planted in seed stands get much less shading and is not likely to be damaged by felling. There are at present 10 acres (4 ha) of this type of production at Mt. Airy.

Yield

The coffee under pine cropping system was not operated on an experimental basis, therefore data on yield (except for 79/80) and rate of growth of coffee and pines, were not recorded. However, yield data from the Coffee Industry Board's coffee under pine project at Wallenford were obtained for 1978/79 and 1979/80.

Table 1. Yields of coffee planted under pine at Wallenford

Year	Quantity of Coffee berries/acre
1978/79	98 boxes*
1979/80	68 boxes*

*A box of cherry coffee weighs approx. 60 lbs with an average output of 10 lbs clean market coffee.

The yield from a stand of coffee not planted with pine is approximately 150 boxes/acre. One problem in obtaining reliable yield figures from the coffee plots belonging to the Forest Department, is the high rate of pilfering.

Sample plots

In order that data can be obtained from the Forest Department's coffee under pine plantations, five sample plots have been established in these areas, three (3) at Clydesdale, one (1) at Moneague. and one (1) at Mt. Airy. Two more will be established on Coffee Board's lands, one in the Wallenford plot and one in a pure stand of coffee. The objective of the sample plots is to assess the performance of Coffea arabica and Pinus caribaea and P. patula when grown in the same stand by measuring:

i) the yield of coffee beans in the sample plot, under pine and in pure stands;

ii) the growth rate of the overstorey pine.

The size of the sample plots are 66' x 66' (20m x 20m). All yields from coffee and the height increments of each tree in the plot will be recorded.

Plots were established in coffee stands of different ages and with varying degrees of shade. Results from these plots will be very useful in determining the future of this form of Agri-Silviculture.

Practices in other Tropical Countries

Intercropping of coffee and forestry is very important in Costa Rican Forestry. Coffee is underplanted in stands of Cordia allidora; in some areas coffee is grown with Erythrina spp - plantains, gungo, and cordia. Cordia allidora is planted on a very small scale in Jamaica, but there is much scope for increasing production. The farmers in Costa Rica receive a tax exemption when they practice this form of intercropping. Over in the Far East, in Malaysia coffee is under planted in stands of Eucalyptus spp and Gmelina arborea. This has been a very successful project and is now practised on a large scale. Cocoa is also interplanted in the forest.

Discussion and Conclusions

A great deal of information is needed to assess the real value of the coffee interforestry cropping system. There still remain many questions to be answered. The most important is whether the right mixture of crops is being used? Is pine suitable for growing with coffee, should preference be given to a crop with a longer rotation? For answers we can probably examine the work done in Costa Rica and Malaysia and see how their results can be utilized here. On the question of collection of coffee beans, maybe we could adapt the system used in Puerto Rico where a net or saran is placed under the trees to ensure the collection of all the seeds. Finally, there is the question of shading the coffee throughout its rotation by forest trees. Should this be reduced and how will this affect the final crop of forest trees?

Even with all these questions still to be answered, the fact is that the land which used to yield one crop of timber after 20 years is now also producing coffee which is sold at approximately $50/box and is an important foreign exchange earner.

CROPPING SYSTEMS AS THEY AFFECT PEST POPULATION DYNAMICS AND CONTROL

by
J. R. R. Suah
Caribbean Agricultural Research and
Development Institute

Introduction

Pests destroy a large proportion of agricultural production at all stages of crop growth, and in storage. In Jamaica, these losses have been estimated at between ten and forty percent, ranging from negligible to complete destruction. Most vegetable and pulses are considered high risk crops mainly because of pests.

Plant life is essential for all animal life, as only they are autotrophic - can use chlorophyll and light energy to convert carbon dioxide into carbohydrates. Herbivorous animals such as insects and mites feed on plants to provide food for themselves and in turn carnivores. If they feed on plants that are sources of food to us, they are in direct competition with us hence are regarded as pests (Heddergot 1969).

Present shortage of food, and the need to feed ourselves and export surplus to earn foreign exchange, require that losses from pests be minimized or eliminated. We need to increase crop production and productivity together with quality, at practical economical rates and to this end within the last three decades much emphasis and research has been directed to systems of pest management. At first the stress was on chemical control methods encouraged by the successes of the synthetic pesticides, but when faced with the problems of insect resistance to pesticides, poisoning, pollution of the environment, severe reduction in the species and populations of beneficial organisms, high costs, and the shortage of foreign exchange to purchase pesticides, one is now forced to re-examine the role of non-chemical methods such as biological and cultural control. This paper examines the effect of cropping systems on pest populations and their control.

Cropping Systems

Holdridge (1959) and Janzen (1973) have defined tropical agro-systems as diversified systems with assemblage of crops in polycultural patterns. Cropping systems in Jamaica and the Caribbean vary from classical monoculture such as sugar cane or cotton production through permanent intercropping for example, pasture under coconut or pimento, mixed annuals and perennials such as corn, peas or potato planted through citrus, or cocoyam through banana, mixed annuals for example corn and dried beans planted together, to multiple tiered systems as breadfruit over coffee over yam. Each system is evolved and adopted to suit specific needs, and in most cases are highly successful.

Monoculture and its effect on pests

The term is used here to include sole, double and triple cropping etc. and ratoon cropping. It is regarded as an extreme example of environmental simplification and specialized management. Although undoubtedly very productive and efficient, because of its pure genetic and horticultural uniformity, it is very susceptible to changes in conditions such as the weather, soil fertility and pest attack (Pimental 1961, Southwood and Way 1970, Nickel 1973, Van Embden and William 1974).

Since most pests depend on particular plants as their source of food, it follows that the greater the number of species in a community or biocoenosis the greater the number of pests that can live there. However, in a community that has many species there will be fewer individuals of each plant or animal as each species is subject to stiff competition from other species. In extreme conditions the fewer the number of plant species, the fewer the number of pest species, but the greater the number of a particular species will be present. This principle is amply demonstrated in communities that have been drastically altered by agriculture, for example where monoculture is practiced in sugar cane and cotton production. Here a single plant species is present supporting only those insects that can survive on the crop. The ecosystem becomes ideal and in the presence of abundant food and in the absence of competition mostly from natural enemies, the organisms soon become pests.

However, where only a few species exist, control becomes simpler, since most of the beneficial species (natural enemies) will also thrive and proliferate in a favourable ecosystem and in the presence of abundant food as would be provided by the pest species. Many of the pests of perennial crops grown in monoculture have been studied, and there are several cases of successful biological control in Jamaica. The most outstanding is that of the citrus blackfly Aleurocanthus woglumi by the larval wasp parasite Prospaltella opulenta. Cultural control methods have been less dramatic but equally valuable. By manipulating the water level in rice fields effective control of the fall armyworm Spodoptera frugiperda has been obtained. In the case of chemical control it is simpler to select the most effective pesticide and decide on the best dosage rate for the proper time and method of application at the desired frequency and number of application to effect adequate control.

Polyculture and its effect on pests

The term has been proposed by some writers to include all other cropping systems than monoculture (Kass 1978) and is achieved by growing two or more crops simultaneously. It should not be confused with multiple cropping in which a piece of land is farmed under monoculture in sequence, or a combination of monoculture and mixed cropping in sequence (Andrews and Kassam 1976).

Based on the discussion under monoculture, it would seem that in polyculture where there are several plant species in a community or biocoenosis, there should be more insect species but less individuals of each species hence less chance of pest outbreak. This is generally so, but occasionally the hypothesis is negated.

The various cropping systems or cropping patterns present different spatial arrangements of plants, and plant populations. In row intercropping where two or more crops are grown simultaneously in rows, depending on the mix, each might provide conditions ideal for a pest or complex of pests to result in a pest outbreak. The same applies to strip cropping where two or more crops are grown simultaneously in different strips wide enough for different treatments but narrow enough for the species to interact. In relay intercropping where two or more crops are grown simultaneously during the life of each (a second crop is planted after the first is established) each may at some time present conditions experienced with monoculture.

Mixed intercropping where two or more crops are grown simultaneously with no distinct row arrangement, is a popular practice among local small farmers. The factors that influence biotypes and population dynamics in these sometimes complex communities, have never been systematically studied. However, experience has shown that except for epidemic outbreaks of polyphageous pests such as cutworms, fall armyworm, mites and stink bugs, many of the crops in the mix escape serious damage.

Other such systems have been studied and are still being studied. Nickel (1973) has examined pest situations in changing agricultural systems. Lessinger and Moody (1976) have reviewed the role and effect of integrated pest management in multiple cropping systems, and Hart (1974) evaluated bean, corn and cassava polyculture cropping systems for the humid tropics. They have all found some benefits in mixed cropping. In a study of corn and dry bean polycultural systems by Altieri et al (1978) at the Centre for International Tropical Agriculture (CIAT) in Columbia, it was shown that corn and bean grown together had 26% less bean leaf hopper Empoasca kraemeri than bean in monoculture, 45% less striped cucumber beetle Diabrotica balteata, 15% less fall armyworm Spodoptera frugiperda as cutworm and 23% less S. frugiperda as armyworm.

Some problems with Polyculture

In spite of the pest control advantages shown in many studies of polyculture, great care has to be exercised in selecting the mix of crops to obtain adequate pest control. The common practice of growing potatoes through citrus, pimento or avocado orchards can result in serious damage to both crops from fiddler beetle Exophthalmus and Pachnaeus spp, and control by pesticides is hampered. Corn and pigeon pea share Heliothis spp as major pests. Cocoa Xanthosoma sp. is the favoured host of slug Veronicella sp. which severely damage bananas in many areas. Attempts at the control of some pest species under mix intercropping systems by chemical means have occasionally led to disaster. A good example of this was where banana was sprayed with DDT to control a leaf hopper Metascarta histrio. This led to a severe outbreak of mites Tetranychus sp. on several crops growing under the banana.

Conclusion

This paper was not intended to recommend any one cropping system over another as far as their pest control benefits but rather to present a discussion on the systems, highlighting their merits and demerits. It should be recognised that much more study is needed before definite recommendations can be made. Many individuals and Institutions are presently engaged in these studies and it is hoped that our farmers will be kept appraised of the developments, and will be willing and ready to apply the recommended findings when they are made. The future in this aspect of research is indeed bright.

REFERENCES

1. **Altieri**, M.A., C.A. Francis, A. V. Schoonhovan and J.D. Doll, 1978. A review of insect prevalence in maize (*Zea mays* L.) and bean (*Phaseolus vulgaris* L.) polycultural systems. Field Crops Research 1. (1978) pp33-49.

2. **Andrews**, D.J. and A.H. Kassam, 1976. The importance of multiple cropping A.S.A. Special Publication No. 27 pp1-10. Madison, Wisc.

3. Hart, K.D., 1974. The Design and Evaluation of a bean, corn and manioc polyculture cropping systems for the humid tropics, Ph.D. Thesis, Univ. of Fla., Gainsville, U.S.A. 158pp.

4. Heddergott, H. 1969. The principles of Integrated Pest Control A working paper. In Recent Development in the field of Plant Protection and Pest Control. A German Foundation for Developing Countries Publication pp2-24.

5. **Holdridge**, J.R., 1959. Ecological Indications of the need for a new Approach to Tropical Land Use. Econ. Botany 13 (4):271-280.

6. Janzen, D.H., 1973. Tropical Agrosystems. Science 182: 1212-1219.

7. Kass, D. C. L., 1978. Polyculture Cropping Systems: Review and Analysis. In: Cornel International Agri. Bull. 32:1-5 Ithaca, N. Y.

8. Litsinger, J.A., and K. Moody, 1976. Integrated Pest Management in Multiple Cropping Systems. In: Multiple Cropping. ASA Special Publication No. 27 pp293-316.

9. Nickel, J. L., 1973. Pest Situation in Changing Agricultural System: A Review. Bull. Ent. Soc. AM. 19: 136-142.

10. Pimental, D. 1961. Species Diversity and Insect Population Outbreaks. Ann. Ent. Soc. AM. 19:136-142.

11 Southwell J. R. E., and M. J. Way, 1970. Ecological Background to Pest Management. In: Concepts of Pest Management. N. C. State Univ. Raleigh pp6-28.

12.. Van Embden, H. F. and G. F. Williams, 1974. Insect Diversity and Stability in Agroecosystems. Ann. Rev. Ent. Vol. 19:455-475.

DEVELOPMENT POTENTIALS OF CROPPING SYSTEMS FOR HILLSIDE AGRICULTURE

- Based on the Allsides Project Experiences 1/

Abdul H. Wahab, Percy Aitken-Soux,
Irving E. Johnson 2/ and Howard Murray 3/

Introduction

1.1 Jamaica is the largest of the British Commonwealth islands within the Caribbean. It is located 18° North of latitude and longitude 77°W. At the most distant points it is 146 miles long and 51 miles wide. The area is 4,411 square miles (11,400 km^2), 80% of which is hilly to mountainous. Over 50% of the island is characterized by slopes of 20° (36%) and greater and as a conseqnence only 30% of the total area lends itself to mechanized agriculture. The flat lands are dedicated mainly to the cultivation of export crops such as sugar cane and banana, while the hilly lands supply most of the domestically consumed foodstuffs and substantial quantities of animal protein.

1.2 Population as estimated in 1978 was 2,106,000, with approximately 60% living in rural areas. In 1978 population density based on arable land was 434 persons per km^2 and population was increasing at 1.5% per year.

1/ Development Potentials of Cropping Systems for Hillside Agriculture in Jamaica, - Based on the Allsides Project Experiences. Paper presented at Seminar on Cropping Systems under the aegis of the Ministry of Agriculture, the Caribbean Agricultural Research and Development Institute (CARDI), and the Inter-American Institute of Agricultural Sciences (IICA-OAS), held at the Jamaica School of Agriculture December 4, 1980.

2/ Agricultural Research Specialist and F. S. B. Project Director, Mission Director, and Agricultural Economist, respectively, IICA/Jamaica.

3/ Project Agronomist, Ministry of Agriculture, Jamaica.

Mortality in 1976 was 20.4 per 1,000 live births and life expectancy at birth was 70.6 years. In 1960 literacy was estimated to be 60%.

1.3 Distribution of arable land among farmers is characterised by a great imbalance as can be seen in Table 1. Data obtained during the Agricultural Census for 1968/69 revealed that there was a total of 190,582 farms of which 149,703 were less than five acres (2.02 ha), had an average size of 1.5 acres and represented 15% of all farm lands in Jamaica[1/]. Many programmes suggested for the improvement of land distribution and the rationalization of tenancy have been implemented begining 1969, so it is likely that changes in distribution of land by size of farms will have occurred since then.

1.4 Demographically, small farmers constitute the most important group of producers of domestically consumed foods. These small producers are:

i) located on the hills;
ii) cultivate lands that are highly erodible and inherently infertile;
iii) practice low technology agriculture; and
iv) depend entirely on rainfall for crop production.

1.5 The heavy population density, the scarcity of land of good quality and the continuing high dependence of many persons on agriculture render it imperative to devise ways and means for utilizing hillside lands more effectively for agricultural purposes.

1.6 The present socio-economic reality of Jamaica makes it imperative that *inter alia*, food imports be substituted by domestically produced foods, and that farm production and productivity be increased. In cognizance of this the Government of Jamaica has identified food production and rural employment as areas of high priority as means for redressing problems such as:

i) inadequacy of supplies of domestically grown crops for home consumption;

ii) high concentration of small farmers ($<$ 5 acres) on the hillsides (80% of all farmers);

iii) serious erosion of hillside lands;

iv) disparity in income distribution between the rural and urban populations (J$600 vs J$2,500 ([1] per capita per annum); and

v) high unemployment (Over 30% of the labour force) in the rural areas, and as a direct consequence a high rate of migration of rural youths into the cities.

1.7 One of the first actions of the Government of Jamaica towards promoting sound land use and increased food production on steep lands was to quantify the extent of soil erosion on these lands resulting from improper cultural practices. In this context a series of studies over the period 1969 - 1973 resulted in the following principal conclusions:

(a) There was an average soil loss of 136 t/ha/yr (54 t/ac/yr) from unprotected yam plots having a 17° slope, and as a consequence a reduction in soil fertility and productivity;

(b) when hillsides are bench-terraced soil loss is reduced to 18 t/ha/yr (7.3 t/ac/yr), and soils can be cropped on a sustained basis. [2]

1.8 On the basis of these findings the Government of Jamaica embarked on an ambitious programme of soil conservation throughout the island. By 1976, in recognition the fact that:

i) soil conservation measures <u>ipso facto</u> were not enough to solve the problems of low food production on the hillsides; and

ii) bench terracing is a very costly capital investment, (J$7,000 ha presently), it became a <u>sine qua non</u> that viable production practices be developed and implemented for their effective utilization. Consequently, the Government of Jamaica requested IICA's assistance in developing viable systems of production for newly terraced soils.

1.9 On hillside farms in general, farmers only use about one-third of the land under their control even on small farms. Thus there is an additional factor which contributes to the reduction

of agricultural production. The reasons are that farming on these steep lands is rather irksome, returns are low and additionally it is difficult to obtain capital and labour for farming these lands. Again, leaving land idle deliberately (fallowing) enables the land to be restored. This latter reason, however, ignores the fact that judicious fertiliaer usage can achieve such a goal.

2. THE ALLSIDES PROJECT

2.1.1 The project encompasses 251 ha (622 ac.) and consists of 233 farm families totalling 1,398 individuals.[3/] A detailed topographic survey of the project sire indicates that over 55% of the area is characterized by slopes 15° and greater.[4/]

2.1.2 The predominant soil type of the area is an Utisol locally classified as Wirefence Clay Loam, Map No. 32. This soil is very highly acidic (pH 4.9) and contains high levels of exchangeable aluminium and is relatively infertile as evidenced by medium, low and very low levels of N, P and K respectively. Annual precipitation over a three year period averaged 1980 mm (78 inches) and is characterized by a bimodal distribution pattern with wettest months occurring in May and October. Yam (Dioscorea spp) a root crop and an important staple in Jamaica is grown by almost every hillside farmer in the project area who generally cultivates the crop on individual mounds with little or no regard to soil erosion control measures.

2.1.3 The overall objective of the project is to develop a body of knowledge for intensive hillside farming (on protected or soil-conserved land) using cropping systems conducive to changing the traditional pattern of hilly land farming.[4/] Specifically, it is expected that the project would develop production systems for bench terraces which could result in:

(a) increased levels of production and productivity;
(b) increased farm income;
(c) enhanced nutritional profiles of farm families; and
(d) increased opportunities for rural employment.[4/]

Additionally, the high costs of bench terracing implied that the cropping systems would need to include high valued crops and that early steps would have to be taken to find alternative and cheaper measures for controlling erosion.

2.2 Strategy for Achieving the Project Objectives

2.2.1 Following construction of bench terraces, the farmers' hillside plots are rendered flat and thus can be cultivated with more ease and greater intensity than before terracing. For instance, terraced land can be used to great advantages in cropping systems in which yam grown on continuous mounds is intercropped with other row crops such as potatoes, ginger, peanuts and red peas. Such a multiple cropping system has the added advantage of:

i) substantially reducing splash erosion because of the continuous crop cover resulting from the crops selected for the system; and

ii) mitigating the hazards of farming under completely rainfed agriculture. 5/

2.2.2 More importantly however, a system of intercropping in the context of Jamaica hillsides ensures optimal exploitation of:

(a) space;
(b) available soil moisture;
(c) available soil nutrients and applied fertilizers;
(d) incoming solar radiation; and
(e) available farm labour.

Thus the strategy employed in achieving the project objectives was to:

i) test and identify farming systems which are suited to the edaphic and climatic conditions of Allsides, Trelawny where farming is done entirely under rainfed conditions;

ii) determine the financial feasibility of those systems of production which have been identified as being agronomically and nutritionally suitable for the area;

iii) ascertain the feasibility of maintaining a combination of small (goats) and large (cattle) livestock from the forage produced on the risers of the terraces;

iv) conduct rapid adaptive research aimed at solving problems related to soil and crop management e. g. fertility, liming, crop density and crop variety trials;

v) produce acceptable seed material for distribution to adoptors of the improved technology; and

vi) provide training opportunities for national technicians in the areas of watershed management and research techniques with special emphasis on farming systems for hillsides.

Concomitantly, a vigourous programme of on-farm soil and water conservation works cum crop development is conducted on plots operated by the target group.

2. 3 Experimental Approach and Methodology

2. 3. 1 Consistent with the strategy spelled out above, research and developmental work was conducted *inter alia* on a total of 20 systems of production during the crop years 1977/78 and 1978/79. Beginning in October 1978 and again in March 1979 and 1980 respectively, work commenced on the further refinement and economic viability of eight of the more promising cropping systems. For each cropping system the dates of planting and harvest of the respective component crops are plotted on scale. For example, the planting and harvest dates of System 2, are as follows:

Yams	- March 3, 1979, and February 13, 1980;
Irish potato	- April 20, 1979 and July 11, 1979;
Radish	- July 17, 1979 and August 27, 1979; and
Peanut	- September 20, 1979 and January 23, 1 1980.

2.3.2 Following construction of terraces in early 1977 and prior to crop establishment, lime in the form of marl and poultry manure each at the rate of 3 t/ha (1.2 t/ac) were applied to ameliorate soil acidity and low soil organic matter content respectively. Irrespective of the cropping pattern, rates of fertilizer application for the first two crop years remained constant as follows:

N	-	200 kg/ha as urea or ammonium sulphate
P_2O_5	-	300 kg/ha as triple super phosphate; and
K_2O	-	150 kg/ha as muriate of potash.

Commencing in 1980, the fertilizer dosage was altered to conform to a commercially available blend which the farmers are accustomed to using. Presently, 1,440 kg of 12:24:12 is administered per hectare per crop year.

2.3.4 Irrespective of whether yellow yam (Dioscorea caynensis), the principal crop of the area is grown as a sole crop or in association with other crops, the density is kept constant at 10,000 plants/ha (4,050/ac). Yams are planted on continuous mounds with rows spaced 1.5m apart and at 0.67m within the row. This requires approximately 8,000 kg of yam "heads" and 2,500 wooden stakes per hectare for sowing and staking of yam vines. Irish potato planted with yam at the beginning of the crop cycle is sown in rows spaced 0.75m apart and 0.25m within the row. This results in a crop density of 53,000 plants/ha (21,500/ac) and requires approximately 2 t/ha of seed material.

Peanut when grown as an intercrop with yam at the commencement of the crop cycle and thereafter at six months is seeded in consecutive and peripheral (with respect to yam) rows respectively, spaced 0.4m apart and 0.15m within the row. This results in a crop density of 166,000 and 83,000 plants/ha during the first and latter halves respectively of the crop cycle.

The spatial arrangement used for red pea (Phaseolus sp.) and Vigna sp.) at the beginning of the crop cycle, is rows 0.4m apart and 0.15m within the row. This results in a population of 166,000 plants/ha. Cropped with yam during the latter half of the crop year, sowing is done in rows peripheral to two consecutive yam rows at a density of 83,000 plants/ha.

Ginger when grown with yam for most of the crop year is sown in rows 0.4m apart and 0.21m within the row, giving a crop density of 125,000 plants/ha. Field observations included:

(a) Crop adaptability;
(b) total and marketable crop yields;
(c) crop performance as affected by various planting dates;
(d) response of crops to varying rates of N. P. K. and lime;
(e) time-motion data on discrete operational variables involved in the production of each of the eight promising cropping systems inclusive of land preparation; and
(f) variable costs of materials required for production of the crops.

Additionally, Napier grass (Pennisetum purpureum) was established on the risers of bench terraces to stabilize these structures thus rendering them less susceptible to erosion from heavy rains. As a spin-off, the forage was harvested at regular intervals and fed to four goats and two heads of cattle on a year round basis, observations were taken of forage yield and weight gains.

2.4 Principal Results and Accomplishments

2.4.1 Presented in Table 2 are yields of each crop component and cropping system tested during the 1977/1978 crop year. Yam yields were excellent when compared with those obtained by farmers in the project area (10-15 t/ha) of marketable tubers); yields ranged from a low of 26.565 t/ha in the cropping system where sweet potato and red pea were grown in association with yam.

Except for cropping system number 8 (yams grown in association with sweet potato followed by red pea) there was an appreciable increase in total yam output by every other treatment compared to the check treatment (system No. 1). Further, Irish potato of the red pontiac variety sown together with yam and harvested 85 days thereafter produced a yield of over 9 t/ha of good quality tubers.

2.4.2 It was significant that other component crops such as onion, corn, pumpkin, cabbage, carrot, cassava, ginger and sweet potato performed poorly. This was attributed to several factors viz.:

i) poor seed quality which resulted in extremely poor crop stand in the case of onion and ginger;

ii) inability of the soil to supply adequate quantities of magnesium for acceptable corn growth and yield;

iii) inability of the cassava and sweet potato crops to accumulate carbohydrates despite excellent top growth;

iv) a high population of cabbage looper which rendered a high percentage of the heads unmarketable; and

v) significant loss in carrot stand due to seed loss from yam mounds consequent to heavy rains and prior to seedling emergence.

2.4.3 The encouraging yam, Irish potato and red pea yields coupled with the direct soil conservation benefits to be gained from yam cultivation on mounds and the demonstration of an improved farm cash flow situation which could accrue to the small hillside farmer stimulated further work in identifying viable systems of production.

2.4.4 During the 1978/79 crop year, corn was again tested and new crops such as the 'dwarf determinate' variety of pigeon pea (UWI - 17), bodie bean (Vigna spp), peanut and lettuce were included in the crop mixes.

2.4.5 The yield data for each cropping system are presented in Table 4. Except for System 6 in which yams were grown with peanut and sweet potato an increase in saleable yam tuber yield over the yam monoculture was recorded for each of the other systems tested.

Further, systems in which yam was intercropped with Irish potato, ginger and peanut produced saleable yields of 7.15, 3.06 and 2.13 t/ha respectively of these crops during the first half of the cropping cycle.

2.4.6 Again, as was observed in the 1977/1978 crop, corn, onion, sweet potato and carrot performed poorly as intercrops. The pigeon pea crop yielded poorly whereas lettuce seeds failed to germinate. Overall, the legume mixes resulted in a fair level of performance.

2.4.7 To ascertain yield response of yams and other crop mixes when established during the September - October rainy season, four production systems were tested on semi-commercial sized plots. The crop mixes consisted of:

i) yam as a sole crop;
ii) yam grown together with peanut followed in sequence by Irish potato and radish;
iii) yam grown together with peanuts followed by Irish potato; and
iv) yam grown together with African red pea and followed by peanut.

The yield data of yams and each component crop are shown in Table 3. Yam tuber yield was highest (27 t/ha) when this crop was grown as a monoculture and production declined by an average of 23% as other crops were intercropped with yam.

Notwithstanding periods of sustained drought conditions which could have led to the overall lowering of yam yields, peanut performed well on both terraces which had been planted to this crop together with yam in the first half of the cropping year. Yields of whole sound kernels expressed at a moisture content of 10% averaged 1.45 t/ha and 0.78 t/ha during the first and latter halves respectively of the yam crop cycle.

The Irish potato crops were severely affected by early and late blight. This resulted in immature ripening of the crop and as a consequence, tuber size was small. The radish crop performed well and when viewed in the context of its short maturity period (4-5 weeks) appears promising.

2.4.8 Following a detailed review of the results obtained from April 1977 to February 1979, eight crop mixes were established on whole terraces thereby simulating in size, farmers terraced plots. These terraces varied in hectarage from 0.02 to 0.07 ha (0.05 to 0.17 ac). The mixes were selected on the basis of their:

i) demonstrated high yielding potential;
ii) nutritional values;
iii) ability to establish a good crop canopy at an early stage of the yam growth cycle;
iv) ability to enhance farm income; and
v) labour intensive requirements.

2.4.9 Notwithstanding the fact that yam yields were greater than those of the project farmers, available information indicates that several factors might have militated against higher yields. These are:

i) inter-crop competition particularly when yam is cropped with sweet potato;

ii) sustained periods of unseasonably heavy rains which resulted inter alia in leaching and thus decreased effectiveness of applied fertilizers and other available soil nutrients;

iii) a build-up in the levels of yam specific nematodes in the yam tubers which resulted in a high loss of marketable tuber material; and

iv) late staking of yam vines (12-14 weeks after planting) due to unavailability of yam stakes at time of sprouting.

These are important aspects which must be taken into consideration in divising crop mixes, improving the performance of polycultures and providing a satisfactory basis for projecting revenue.

2.5 Economic Assessment

2.5.1 Summarized in Table 7, are the input costs incurred in producing each system, the outputs derived from each crop component and the returns per hectare exclusive of costs for terracing. In three of the eight systems viz., 2,4 and 5 net farm income increased over the yam mono-culture system by 111%, 15% and 90%, respectively. Total output realized from the sale of crops exceeded those of the sole yam crop in six of the seven crop mixes.

2.5.2 Relatively high production costs were associated with a number of investigatory and improvement aspects. Adjustments must be made to ensure that they do not imappropriately negate the economic benefits which could have been obtained. **These increased production costs are being reduced through:**

i) improved efficiency in field tillage, crop sowing and harvesting operations;

ii) rationalization of the disease and pest control programme; and

iii) rationalization of the soil - crop management programmes.

2.5.3 The results presented in Table 4 further indicate that on the hillsides of Jamaica farm family incomes could be increased several fold, provided that the farmer adopts the practice of polyculture together with improved technology.

2.5.4 However, the high costs of production of the intercrops would require the establishment of a closely supervised farm credit scheme to ensure that inputs are acquired and used on a timely schedule.

Also, a strong Extension input is a sine qua non for transferring the research information to the farmer - who is an individualist and manifests a behaviour which depicts the motto "Every Man for Himself". 6/

2.5.5 Another distinct advantage of polyculture at Allsides and other hilly areas in Jamaica is that the entire holding can be cultivated continuously versus the present traditional practice in which areas are allowed to go into fallow or "ruinate" for one year following three years of continuous yam cultivation. Farmers claim that this practice "enable the land to recover its strength". 6/

2.6 Nutritional Evaluation

2.6.1 One of the major problems of the developing countries today is inadequate food production. In Jamaica, the critical shortage of foreign exchange requires a greater dependence on

domestically produced foods. As in other islands of the Caribbean the small farmers will continue to play the dominant role in food production. They will require assistance to enable them to use those crop mixes which can provide a balanced food intake. A nutritional survey was conducted using farm families of the project area as the source for ascertaining levels of consumption patterns of farm families. 7/

2. 6. 2 The survey results indicate that polyculture is a far more efficient producer of calories than monoculture when the same principal crop is included in both systems. Also, the multiple cropping systems performed nutritionally superior to the yam monoculture. It is gratifying to observe that within the project area of Allsides, a significant number of producers who previously grew root crops continuously are now including peanuts, cowpea, red pea and Irish potato in their cropping mixes. This will result eventually in a more balanced dietary intake, by the target group.

2. 7 Employment Evaluation

2. 7. 1 Jamaica as well as many other developing nations are experiencing rising unemployment. The rural areas are worst affected. Consequently, there is a tendency for rural youths to migrate to the large cities. This trend has led to severe pressures on existing social and health facilities in the urban centres and as one direct consequence crime rates in the cities have increased considerably. In cognizance of this, deliberate efforts are made to create projects which have a favourable employment generation potential. Indeed, one of the objectives of the project was to demonstrate the employment potential by the adoption of a rational system of crop and soil management for the Allsides area.

2. 7. 2 Presented in Tables 5 and 6 are the observed monthly labour inputs required for the establishment and maintenance through to crop maturity of the eight cropping systems, evaluated on whole terraces during the 1979/1980 crop year. When contrasted with the traditional practices of the farmers there is little difference in the total labour required for yam monoculture produced on continuous mounds on the terraces, although there is variation on a monthly basis.

2. 7. 3 Although farmers claim that they use more labour than that required by the project, for every cropping system used the labour requirements have been much greater than for the traditional farming practices. Another important consideration is related to the direct soil conservation benefits which will accrue from the use of continuous mounds on terraced land in such a system, i. e. a recorded soil loss of 18 t/ha/yr compared to 136 t/ha/yr sustained by farmers on plots having a 17° gradient. 2/

Systems 2 and 5 which produced the highest farm gate revenues and quantities of energy and protein were also shown to have high employment potentials. These findings are even more meaningful when cognizance is taken of the labour distribution patterns over the 12-month cropping cycle.

2. 8 Livestock

2. 8. 1 The possibility of converting forage produced on the risers of terraces into animal protein was examined. It has been successfully demonstrated over the period 1977/1980 that two heads of large livestock (cattle) and four heads of small livestock (goats) can be maintained by zero grazing from the Napier grass produced on a total riser area of 0. 07 ha (. 18 ac).

2. 8. 2 In addition to serving principally to stabilize risers, Napier grass could be used to significant advantage in enhancing farm income and increasing the availability of animal protein to the population of Jamaica. It is most important that the grass be zero-grazed to protect the risers from destruction by the animals.

2. 8. 3 The agro-socio-economic data reported herein that under rainfed conditions intensive farming of hilly lands in Jamaica could result in:

i) increased food production;
ii) increased farm income;
iii) decreased rural unemployment;
iv) improved standard of living;
v) improvement in the Government's import substitution efforts;

vi) an increase in G. N. P. ; and
vii) positively influencing the rate of national economic growth.

2.8.4 It is extremely encouraging that the improved technology is being adopted by a significant number of producers within the area and elsewhere. However, to achieve greater success it is necessary that a strong Extension Unit be set up together with a Farmers' Credit Unit, charged specifically with serving the credit needs of the small hillside producer.

2.9 Costs of Production of Crops Produced in the Allsides Project.

i) Detailed costs for every operation, and all inputs were recorded for each and every activity of the project. Where labour operations are concerned time and motion studies were undertaken. These were subsequently synthesized.

ii) Metric units have been used but these were converted into British measures for ease of comparison.

iii) (a) The assumption is made that all farmers plant yams, and for this reason land preparation in every instance is charged to the yam crop.

(b) Operations which are specific to the intercrops are charged against each such crop.

iv) The data involved is voluminous and accordingly is presented in summary form.

Other Considerations

The data does not include the following:

i) land rental
ii) management
iii) interest costs

iv) soil conservation costs, which vary with slope categories and which are mostly subsidized by Government (75%).

The three most profitable systems developed thus far are:

(a) Yam, Irish potato, radish, peanuts
(b) Yam, ginger, red peas
(c) Yam, cow peas, peanuts.

Cropping System - Yam Alone (Costs per hectare)

LABOUR OPERATIONS $10.20 per man-day

Land Preparation	M/Days	Cost $
Ploughing	37.87	
Lifting mound	71.83	
Shaping mound	23.82	
	133.52	1,361.90
Planting		
Digging holes	5.88	
Applying fertilizers	3.23	
Planting yam heads	5.20	
	14.31	145.96
Crop Culture		
Staking	37.29	
Twining vines	16.82	
Fertilizer application	10.85	
Weeding	51.24	
	116.20	1,185.24
Harvesting		
Cutting vines	0.50	
Digging tubers	26.34	
Lifting tubers	22.90	
Separating yam heads	2.96	
	52.70	537.54
TOTAL	316.73	3,230.64

Materials

Yam heads (8 metric tons/ha)	7,048.00
Stakes @ 30¢ each	750.00
Fertilizer	407.49
Yield 28,726 lb/ha = 11,630 lb/acre	8,205.49

The yields and costs of production for each of the crops in these 3 systems are shown below. An important feature is the fact that yields and costs for the same crop vary for the different systems for many reasons.

		Yield per acre Edible product (lb)	Cost per ¢/lb
a)	Yam	8,800	26
	Irish potato	11,800	12
	Radish	1,150	26
	Peanuts (unshelled)	700	80
b)	Yam	8,500	27
	Ginger	12,400	23
	Red peas	300	185
c)	Yam	7,400	27
	Cow peas (African red)	1,340	68
	Peanuts (Unshelled)	420	140

Where yam is concerned it is necessary to take into consideration the value of the new yam heads produced. The information which follows illustrates the point:

System		Edible Tuber		New Yam Head	
		Tuber (m/tons)	Value ($)	Weight (m/tons)	Value ($)
a)		9.80/ha	6,461	9.88	8,704
		4.00/ac	2,616	4.00	3,524
b)		9.50/ha	6,270	8.00	2,860
		3.85/ac	2,538	3.24	2,860
c)		8.22/ha	5,425	9.06	7,982
		3.37/ac	2,206	3.67	3,232
d)	Yam alone	13.03/ha	8,600	9.85	8,677
		5.28/ac	3,482	4.00	3,513

2.10 Marketing

2.10.1 Problems in the existing marketing system which is already inadequate, are likely to be magnified with the increased production expected from the adoption of improved cropping systems unless proper safeguards are made. Many of the issues concern yellow yam which is the major crop produced in the Allsides area, but apply to some extent to the other crops. The problems relate largely to:

- Reaping and assembly
- Sorting and grading
- Storage
- Transportation and distribution

2.10.2 Most of these problems are concerned with·

- the steep terrain of the production ares which makes it difficult to move produce from the field to the selling point;

- inability of yellow yams to store for longer than 5 days because of its very perishable nature. This factor is often attenuated by nematode damage, which is widespread in the yam-growing area;

- the labourious nature of work involved in getting the crop out to market;

- a number of problems which arise in connection with the main channels of distribution, namely -

  - the higglers; and
  - the Agricultural Marketing Corporation (AMC).

2.10.3 The higglers are small traders who provide a service to farmers by reaping the crop and selling same. This is not a "gratis" situation since the prices paid by the higglers take into consideration their services for reaping. In addition, the higglers is often the benefactor where the unit weights are concerned, since these weights (usually referred to as "hundred weight") vary anywhere between 100 and 140 lbs. Although this arrangement does not always work to the financial advantage of the farmer, most farmers prefer to utilize the services provided by the higglers, since the latter also relieve the farmers of problems associated with storage.

2.10.4 A minority of farmers prefer the AMC although they have to transport their yams and other produce to a convenient spot where they can be collected in the AMC trucks. This is often an additional cost to the farmer. However, the farmers claim that the payment by the AMC is more reliable even though the level of AMC rejections is "high", especially during periods of high production.

2.10.5 A combination of the higgler system and the AMC operations results in yams from the Allsides area being widely distributed. There are distribution problems, however, in that there are often simultaneous periods of gluts and shortages which affect prices and thus the ultimate return to farmers.

2.10.6 Transportation rates keep escalating much to the disadvantage of consumers, but the prices which consumers pay are considerably out of line with the farm gate prices paid to farmers. In addition, yams are damaged during transportation, thereby also reducing farmers' income.

Objectives

2.10.7 The main objectives of an appropriate marketing system are:

i) to improve knowledge and information concerning quantities of yam and other produce available and time of availability, through improved production forecasting, working in close collaboration with farmers, extension staff and the Data Bank Section of MINAG;

ii) to demonstrate to farmers the benefits to be gained from proper sorting and grading as well as proper storage of their produce, and to provide appropriate training in this respect;

iii) to explore measures which are known to be able to increase the storage life of yellow yams in particular, working in collaboration with the Storage and Infestation Division of the Ministry of Industry and Commerce;

iv) to seek or utilize facilities for cool storage of produce; and

v) to improve the feeder road system, to facilitate transportation of the larger quantities of produce anticipated.

2.10.8 It has been demonstrated that almost universally farmers cannot successfully handle production and marketing. Farmers should be relieved of the necessity of having to market their own crops, leaving them more time to concentrate on production. Since each produces relatively small amounts of produce individually, it becomes necessary not only to know how much is likely to be produced through the proposed improved crop forecasting system but also to use cooperative effort to achieve the benefits of economies of scale. Failure to improve the technical and other aspects of marketing will create a disincentive for farmers to increase production. On the basis of prices paid to consumers there is little doubt that farm gate prices can be increased and consumer prices reduced if there is an improvement in the marketing system.

3.0 Development Potentials of Cropping Systems for Hillside Agriculture.

3.1 There already exists a number of "cropping systems" even if they are not operated on as structured lines as the purists would wish. The main objective is to ensure that all resources are used to their optimum potential.

3.2 High population density on available agricultural land has created the necessity for more intense use of land resources. The fact that so high a percentage of agriculture practised on hillside lands continues to provide most of the local food production implies that appropriate intensive measures must be developed. These measures require that the land must be suitably conserved.

3.3 The use of tested cropping system is a means to this end. As is observed from the Allsides experience yields of individual crops per acre will not necessarily increase over those for the crops grown in pure stand. The total output of crops will increase due to more effective and optimum use of the land.

3.4 Farmers in general have become accustomed to leaving portions of their already small plots of land fallow to allow the land to recuperate. This is especially the case on hilly lands which are low in fertility and which suffer a further reduction in fertility due to man-made erosion associated with unsound agricultural practices.

3.5 Demonstrations have shown that increased fertility may be assured through the judicious use of fertilizers. Farmers, however, have certain age-worn concepts concerning the effects of fertilizers on the health of people. They also have inhibitions concerning the price of fertilizers (and other chemicals). All these are areas which extension officers can and must explain if farmers are going to adopt practices which will lead to more intensive but sound land use.

3.6 Many farmers in surveys (old and new[11/]) have indicated that lack of credit is a major factor which limits production. In spite of their willingness to adopt new practices they cannot do so without the availability of adequate credit on a timely basis. Accordingly, adequate credit arrangements must be made available if the developmental potentials are to be achieved. One possible way is to unite credit and marketing arrangements very closely.

3.7 Undoubtedly, the intensive use of land will require more labour, some of which may have to be bought. This cost can be included in the credit needs and can be recovered from the crop output.

3.8 The difficult terrain on which much of the hillside farming is practiced requires mechanisms which will take the "irk" out of work. For too long has Jamaica paid too little if any attention to the "invention" of modest types of equipment which will assist farmers in undertaking certain farming operations. The technology exists elsewhere and the time is right to endeavour to adapt some of this type of equipment for adoption by hillside farmers.

3.9 The information and the data presented in this paper refer to a particular situation with specific conditions relating to land, topography and slopes, climate, farmers and traditional cropping patterns as found in Allsides area of Southern Trelawny. The principles involved do not change and it is necessary to develop ecosystems, appropriate cropping mixes and technological packages for other situations.

3.10 Where policy is concerned there is the time-worn argument concerning financing the cost of soil conservation (especially bench terracing). The data available indicate that with intensive cropping and sound use of appropriately soil-conserved land, at optimum performance levels the revenue obtained can pay for the soil conservation measures and still leave a residual income which is greater than that which farmers now earn. While the high cost of terracing dictates that cheaper but effective soil conservation measures be found (such trials are being undertaken at Olive River in Trelawny as a support to the Allsides) the question of the ability of any government to subsidize soil conservation measures at current levels must be seriously addressed. For this, alternative suggestions are already available.

BIBLIOGRAPHY

1. Statistical Yearbook of Jamaica 1978. Department of Statistics. p. 459.

2. Sheng, T. C., and Michaelson, T., 1973. Run-off and Soil Loss Studies in Yellow Yams, F.A.O. S.F. JAM. 505 Project Working Document.

3. IICA/Jamaica, 1979. Agro-socio-economic sample survey of Allsides, Trelawny, Publication No. III-4

4. IICA/Jamaica, 1976. Hillside Farming Study and Implementation Project (Allsides Pilot Development Project). 1976. Private circulation, Government of Jamaica and IICA.

5. Wahab, A. H., 1978. Farming Systems for Hillsides. Hillside Farming in Jamaica. IICA/Jamaica Publication No. III-2 p. 149-161.

6. Aitken-Sous, P., Wahab, A. H., and Johnson, I. E., 1980. The Allsides Post Peasant. IICA/Jamaica Publication No. IV-14. 23pp.

7. Carey-Lawrence, B., 1980. Farming Family and Nutrition in Allsides, Trelawny - a report of six case Studies, M. Sc. Thesis UWI, Kingston, Jamaica.

8. Caribbean Food and Nutrition Institute, 1974. Food Composition Tables - For use in the English speaking Caribbean, C. F. N. I. Kingston 7, Jamaica.

9. Ministry of Agriculture, Fisheries and Food (U. K.), 1978. Manual of Nutrition. Edited by Buss, D. and Robertson, J.

10. Research and Development Department, Ministry of Agriculture (Jamaica), 1980. Legume Seminar - The Nutritive Value of Legumes. pp26-32.

11. IICA /Jamaica, 1980. Agro-socio-economic Survey - Pilot Hillside Agricultural Project (PHILAGRIP).

12. IICA /Jamaica, 1980. The Allsides Project in Jamaica - Development Potentials of Hillside Agriculture - Paper presented at Seminar on Rural Development under the aegis of Iowa State University and IICA/OAS, held in Ames, Iowa Sept. 29 - October 3, 1980.

Table 1. Farms, Number, Size and Acreage in Jamaica in 1968 1/

Farm size	Number	% of total	Acreage	% of total acreage
0 - 5	149,703	78.8	223,818	14.9
5 - 25	36,881	19.0	333,548	22.1
25 - 100	3,004	1.6	125,104	8.2
100 - 500	699	0.4	148,501	9.93
500 +	295	0.2	676,426	44.9
All Farms	190,582	100.0	1,507,397	100.0

1/ Source: Statistical Yearbook of Jamaica 1978.

Table 2. Marketable yields of yellow yam (Dioscorea cayenensis) and other crops grown alone and in a polyculture system at Allsides, Trelawny, during the 1977/1978 crop year.

Cropping System	Crops	Marketable yield (t/ha)	New Yam "head" yield (t/ha)	Change in total yam yield over monocrop (%)
1	Yam alone	31.502	16.917	0
2.	Yam	36.794	16.962	10.46
	Red pea	0.552		
	Onion	0.053		
3	Yam	38.752	17.274	15.71
	Sweet corn	7500*		
	Red pea	0.124		
4	Yam	35.441	16.713	7.71
	Grain corn	0.761		
	Irish potato	0.489		
5	Yam	34.480	17.289	6.92
	Irish potato	9.286		
	Radish	1.587		
	African Red pea	0.296		
6	Yam	38.734	17.840	16.84
	Pumpkin	0.000		
	Sweet corn	3133*		
7	Yam	33.006	17.010	3.30
	Cabbage	0.695		
	Carrot	0.108		
	Red pea	0.093		
8	Yam	26.565	13.668	16.91
	Sweet potato	2.129		
	Red pea	0.105		
9	Yam	36.794	15.861	8.75
	Cassava	0.000		
	Red pea	0.539		
10	Yam	39.899	17.032	17.58
	Ginger	0.000		
	Sweet potato	1.616		

*Ears of corn.

Table 3. Marketable yields of yellow yam (Dioscorea cayenensis) and other crops grown alone and in a polyculture system at Site II, Allsides, during the October 1978 - November 1979 cropping period.

Cropping Systems	Crop	Marketable yield (t/ha) 1	New yam "head" yield (t/ha)	Change in total yam yield over Monocrop (%)
1	Yam alone	14.79	12.11	0
2	Yam	9.79	9.42	-28.6
	Peanut	1.46		
	Irish potato	2.47		
	Radish	1.59		
3	Yam	10.56	8.02	-30.9
	Peanut	1.43		
	Irish potato	2.13		
4	Yam	15.16	9.12	-9.7
	Red pea (African red cv)	0.337		
	Peanut	0.78		

Table 4. Total inputs, outputs and benefits of eight cropping systems validated at Allsides, Trelawny during the period March 1979 - February 1980

Cropping System	Cropping Pattern	Input Costs/System/ha[2]			Outputs by crop component/ha	Return from System[1]	% Increase (Decrease over yam monocrop)
		Labour[3]	Materials	Total			
1	Yam as sole crop	3,230.65	8,499.03	11,729.68	17,277.65	5,547.97	0
2	Yams+				15,165.68		
	Irish potato+				9,110.00		
	Radish+				2,797.81		
	Peanut				1,689.70		
	Total for system	6,520.96	10,527.20	17,048.16	28,763.39	11,715.23	III
3	Yam+				12,643.31		
	Peanut+				5,536.14		
	Red Pea				2,194.50		
	System totals	7,161.22	9,897.66	17,058.88	20,373.95	3,315.07	-4
4	Yam+				13,407.06		
	Cowpea+				6,600.00		
	Peanut				984.74		
	System totals	6,019.73	9,125.46	15,145.19	20,991.80	5,846.61	5
5	Yam+				13,335.62		
	Red Pea+				1,881.00		
	Ginger				15,271.97		
	System totals	5,073.58	14,898.10	19,971.68	30,488.59	10,516.91	90
6	Yam+				9,348.52		
	Sweet potato				577.27		
	System totals	3,641.91	9,470.45	13,112.36	9,925.79	(-3,186.57)	(-)
7	Yam+				17,372.32		
	Corn+				123.92		
	Cabbage				0.00		
	System totals	3,833.77	8,964.94	12,798.71	17,496.24	4,697.53	(-)
8	Yam+				12,515.25		
	Red pea+				4,004.00		
	Cowpea				1,883.20		
	System Totals	7,209.36	10,242.08	17,451.44	18,402.45	951.01	-83

1 Difference between outputs and inputs inclusive of labour

2 All figures are in Jamaica $ = US$0.56

3 Labour costs were computed at J$10.20 per man-day

Table 5. Comparison of monthly labour inputs (man-days) per hectare for cropping systems established at Allsides, during the 1979/1980 crop year with farmers traditional practice.

Month	Farmers*	CROPPING SYSTEM							
		1	2	3	4	5	6	7	8
March	55	147	147	147	147	147	147	147	147
April	50	54	90	203	68	120	69	81	111
May	20	18	31	18	41	18	18	24	18
June	31	0	11	6	3	4	19	3	21
July	0	12	140	16	150	67	12	18	218
August	0	0	44	157	0	22	0	4	0
September	25	17	49	54	53	17	17	31	85
October	6	6	7	8	6	6	6	6	9
November	24	9	10	41	11	9	16	9	14
December	9	0	1	0	2	0	0	0	31
January	50	1	57	52	109	1	1	1	1
February	62	52	52	0	0	86	52	52	52
TOTAL	323	316	639	700	590	497	357	376	707

* Traditional practices of the farmers.

CROPPING SYSTEMS:

1. Yam as sole crop
2. Yam and Irish potato & Radish & peanut
3. Yam & peanut & red pea
4. Yam & cowpea (African red) & peanut
5. Yam & red pea & ginger
6. Yam & sweet potato
7. Yam & corn & cabbage
8. Yam & red pea and cowpea.

Table 6. Manual labour required (man-days) for the establishment, maintenance and harvest of eight cropping systems tested at Allsides, Trelawny, during the 1979/1980 crop year.

Cropping systems	Man-days per hectare	Increase over yam monocrop	% Increase over yam monocrop
Yam as sole crop	316	-	-
Yam & Irish potato & radish & peanut	639	323	102
Yam & peanut & red pea	700	384	122
Yam & cowpea & peanut	590	274	87
Yam & red pea & ginger	497	181	57
Yam & sweet potato	357	41	13
Yam & grain corn & cabbage	376	60	19
Yam & red pea & cow pea	707	391	124

MIXED CROPPING IN GINGER

by
D. D. Henry

Introduction

Next to pimento; ginger is the second most important spice crop in Jamaica. It was introduced here about 1525. In the early years it was planted by the Spanish Colonists in St. Ann for medicinal and commercial purposes. After the Spaniards were defeated in 1655, the English settlers continued growing the crop on some sugar estates as a subsidiary crop to sugar cane. Between 1823 and 1841, German settlers tried to grow it at Seaford Town, and the Scottish settlers experimented with it in South St. Elizabeth. These earlier trials did not prove successful because the elevation was too low, plus the unpredictability of the rainfall pattern.

Between 1823 and 1841 four groups of European immigrants settled in the area formerly included in the Christiana Area Land Authority and grew ginger as a cash crop. The settlers found out that the soil and climatic conditions were particularly suitable to the crop, and the Jamaican varieties were fetching highest prices on the London and New York markets.

Since its introduction, ginger has been planted over a wide area of the island but consistently in the Christiana Area Land Authority, which in recent years accounted for over 70% of the annual production. Most of the remainder is produced in the Kellits area of Clarendon, and districts in St. Andrew and St. Thomas.

Recent production of dry peeled ginger is given in the table below:

Table 1. Ginger production in Jamaica 1975-1979

YEAR	PRODUCTION (tons)
1975	930
1976	995
1977	423
1978	680
1979	590

Varieties

Three types of ginger are recognized:

a) Royal Blue
b) Frog Blue
c) Yellow

The first two have rhizomes which, when cut, exhibit a bluish tinge, while the latter has a yellow flesh. It has been reported by some workers that there is little or no difference between types, but others have observed that the "blue" ginger, especially the frog blue, is harder, more fibrous, poorer yielding and needs a longer drying time. Both blue and yellow gingers are planted without discrimination and the price paid for the product is not based on this colour difference.

Location of Area

The area under discussion is Alston which is located about three miles from Spauldings on the main road to Cave Valley. Other districts involved are: Tweedside, Silent Hill, Borobridge, Smith's Run, Ritchies, Morgans Forest and Wild Cane.

The major soil types in this area are:

1) wire fence Clay Loan (Map No. 32)
2) Wait-a-bit " " (Map No. 95)
3) Donnington Gravelly Loam (Map No. 36)
4) Carron Hall Clay Map No. 94)

This area has an average rainfall of about 80 inches per annum and a mean annual temperature of about 70°F. The elevation varies from 2000-2800 feet.

Planning System

The following cropping sequence is typical of the area:

a) The land in a state of fallow is usually forked in December to March and refined with a hoe one or two times. After this drains are cut.

b) Yam hills are dug about 15 feet by 25 feet apart. The system is to make the holes, leave them to weather for a while, then form the mounds putting the top soil in the bottom.

c) Yam is usually planted on these mounds in March to April, with such varieties as Yellow, Negro, Lucea, Tau. As a rule, three vines are planted to each hill. The Mozella variety is allowed to climb on trees.

d) The ginger is planted in May and June so that it will be reaped in January to March, which coincides with the dry season. This is of paramount importance as plenty of sunshine is needed for the curing of ginger.

e) At this time, varieties of yam such as White, Renta, and St. Vincent, and cocoe are planted through the field.

f) Two plants of cassava are placed at the base of each yam hill, also on the boundaries of the field and along the drains.

g) Most of the farmers plant red peas on the mounds after the ginger is planted. The peas will mature in the rainy season, but because they are usually eaten green this does not pose a problem.

h) The ginger and yam are reaped in December to March.

i) The area is now divided to plant crops during March/April in the following combination:

1) Corn and congo peas
2) Corn and sweet potato
3) Corn and pumpkins

The planting system can be summarized as follows:

<u>Year I</u>

a) Land preparation - December/March
b) Plant yellow yam, etc. - March/April
c) Plant white yam and ginger - May/June
d) Plant red kidney bean and cassava - June/July
e) Reap red kidney bean - September
f) Reap ginger and yams - January/April
g) Plant corn and pigeon peas between cassava - March/April.

<u>Year II</u>

a) Reap corn - June/July
b) Reap cassava, pigeon pea and ratoon ginger - December/March.

<u>Year III</u>

a) Reap residue of cassava and pigeon pea
b) Leave in fallow for approximately one year.

<u>Year IV</u> Start the system again.

<u>Observations and Recommendations for improving the system</u>

1. <u>Soil Erosion</u>

The cultivation of ginger on steep slopes without adequate soil conservation measures is partly responsible for much of the erosion in the area. This was a major factor for the declaration of the Christiana Area Land Authority in 1954 (The area now falls under the Integrated Rural Development Programme). There is need for a comprehensive programme in soil conservation.

2. <u>Disease and Pests control</u>

There is need to control aphids and the Black and Rhizome Rot Diseases of ginger, nematodes of yams, pod borers in legumes and corn ear worm on corn. It will need a good deal of educational work among farmers for them to adopt new plant protection practices.

3. <u>Planting Materials</u>

Farmers are inclined to select their own planting material, but the system can be greatly improved, especially in legumes and corn, by the introduction of certified materials.

4. Plant Population

The farmers are incluned to put too many seeds of corn and legumes in one hole and in addition, the planting distances are too close. They claim that the reason for putting so many seeds in one hole is to allow for destruction of the young seedlings by "puller" (mice and crickets). They should be taught how to control for these pests.

5. Planting of Pigeon Pea

The crop is sensitive to day length, flowering as the days become shorter, and is usually ready for reaping in December-February. In the system under consideration, planting of Pigeon pea is usually done in March and as a result the plants become large by the time the crop is to be reaped causing damage to the trees.

It is thus more desirable for planting to be done in June-July in order to produce plants of more manageable height. The farmers contend that it will take more planting material per acre, but they should be taught that it will mean greater yields, plus less damage to the trees at reaping time.

6. Use of Fertilizer

In this cropping system only a limited amount of fertilizer is used as the farmers claim the following:

a) It runs down the land
b) It makes the taste of the yams watery
c) It reduces the shelf life of yams
d) It makes the crops mature too fast.

As far as is known, only general recommendations are made for yams and ginger in the area. Preliminary investigations have indicated the need for further study into the use of fertilizer in this cropping system.

7. Cassava Reaping

In this area, the people will not reap the cassava before two years, claiming that:

1) Each tuber will be too small and will result in lower yields per root.

2) The starch content is low probably due to reversion from starch to sugar when the crop is about one year old.

Further research is needed to determine the optimum reaping time. After the cassava is reaped the land is put into fallow for at least one year before ginger is re-planted. Livestock used in the fallow system are donkeys, mules, goats, pigs and poultry.

8. Varieties of Ginger

Presently all three types - frog and royal blue, and yellow, are planted mix. The blue, particularly the frog type, takes longer to dry, so it appears that they should be separated. There is also need for research on yields of each variety as well as planting distances.

Due to the high cost of peeling the ginger by hand, consideration is now being given to mechanical peeling and frog blue would easier meet this criteria. Thought is also being given to extraction of essential oils and oleoresin and varieties may show a difference.

9. Propagation

Ginger does not usually produce fertile seed and so is propagated vegetatively. The rhizome produces a number of buds or "eyes" and for planting is usually broken into small pieces, each with at least one good "eye". The preparation of material for planting thus results in exposing large surfaces through which fungi may enter. At the moment farmers break the rhizomes about 7-10 days before planting to give the broken surfaces time to dry, but this is not good enough. It is therefore desirable to dip material in a fungicide such as Benlate or Captan before planting.

10. Harvesting

Ginger is ready for harvesting 6-9 months after planting. Reaping usually commences in January and may extend to April.

When the rhizomes are mature the aerial shoots change from green to yellow and wither. The rhizomes, or "hands" are dug with a fork. Since the aerial shoots disappear, the reaper needs skill and judgement to avoid severe damage to the rhizomes. Consistent planting distances will greatly aid this. Harvesting is best done on dry days since wet soils are difficult to work and sunshine is needed for the drying process.

Planting material for the next season is selected from new rhizomes. These are broken into pieces suitable for propagation then stored in a cool, well ventilated area until time for planting.

During the first reaping, pieces of ginger are left in the ground and these start growing before those put in during the normal planting season. These are called "ratoons" and are usually reaped in December. Most o / this crop is used in the manufacture of sorrel drink.

Drying on barbecues and galvanized sheets should be avoided as this gives the ginger a dark colour. The best method is to put fresh peeled ginger on mats made from ferns and when half dry, it is removed to mats made from the dry mid rib of banana leaves.

REFERENCES

1. Rodriquez, D. W. Ginger, Agricultural Information Service, 1971.

2. Crops and Soils Department - Ginger, Agricultural Information Service, 1975.

3. Economic and Soil Survey, Central Planning Agency, 1978.

CROPPING SYSTEMS INVOLVING COCONUTS IN WET TROPICS

by
D. H. Romney
Coconut Industry Board

1. Technical suitability of coconuts for wet tropics

As modern agriculture results in replacement of natural vegetation by crops - often monocrops - farmers have problems in maintaining soil chemical and physical levels. This is especially so in wet tropical soils which have to contend with high temperature year-round and heavy rainfall. Fertility can be maintained with fertilizers, but soil organic matter maintenance is more difficult yet perhaps more important: humus contributes substantially to soil structure (and hence to soil aeration, internal drainage and reduced erodibility), to cation exchange capacity, to provision of trace nutrients and to an active rhizosphere.

Maintenance of soil organic matter is done mainly by:

(a) Organic manures. It is expensive and impractical to treat more than a small fraction of farmed land in this way.

(b) Fallow. Most small farmers in Jamaica use this method but modern pressure for land makes it usually unsuitable.

(c) Growing temporary humus - restoring crops. These include sugar cane (especially cut green), grass leys or crops deliberately grown for the purpose. Use of grass leys requires a grass species which is easily established and easily removed - a condition hard to satisfy. Growing a crop to be ploughed in or cut as mulch *in situ* can be expensive and its effect is of limited duration.

(d) Growing forest or tree crops. There are many species adapted to Jamaican environments, including coconuts in wet tropical areas. Tree cropping systems are also well suited to Jamaica because they tend to require more labour per acre than mechanised arable cropping, e.g., corn or legumes (which are

more efficiently grown in, and imported from, N. America in exchange for tree crops adapted to, and exported from Jamaica).

2. Feasibility of coconut cropping in Jamaica

Coconuts grow well in tropical temperatures (low lands) with well distributed rainfall on well aerated soils. Planting material of improved varieties and hybrids with disease resistance can be delivered to farms in any quantity at all times at short notice. A package of planting and maintenance techniques, backed up by research, is available to farmers through specialist advisory staff. An automatic and contractual windstorm insurance scheme is in force, with cover up to $20 per bearing tree. Farmers who contract to sell their coconuts for copra can obtain fertilizer and weed control subsidies and free planting material. The price of coconuts for copra is reviewed every year or two and is based on a calculated 15% profit margin. At present, for fully bearing trees, an average gross return of $930/acre/annum can be expected, with a corresponding automatic windstorm insurance cover of $909/acre.

3. Coconut cropping systems

3.1 Pure stand coconuts. Planting is done at densities which give maximum yield per acre consistent with good ground cover (to control weeds by competition) and minimal etiolation (for easier reaping). As a result of a series of long-term experiments by Smith (1971) and Barrant (1978), Malayan Dwarfs are commonly planted at 112-123 per acre and Maypan F1 hybrids at 76-85 per acre: the higher densities are used on poor land or in less cloudy situations (Romney, 1976). Strict weed control is advocated on circles around young palms and, for all palms, especially at the end of the rainy season to conserve moisture for the palms for the dry season. Pioneer research has been done into suitable herbicides by Romney (1965) and circle size by Smith (1970). Fertilizer need can be monitored by foliar analysis. Cheap effective rat control systems have been developed (Smith, 1967). The husk is best left under the trees to provide organic matter and potash.

3.2 Young coconuts temporarily intercropped. Young coconuts are retarded by shade: Smith (1967a) showed that coconut yields in the 6th year are reduced from over 80 nuts/palm to 7 nuts/palm by dense banana intercropping. Farmers have consequently been advised not to plant bananas within 7 ft. of young coconut plants. In practice, this usually means that one acre pegged at 9 ft. x 7 ft. (691 pegs) is planted with 115 dwarf coconuts at 18 ft. x 21 ft. and the remaining 576 pegs with bananas.

The corollary of the above is that young coconuts are not retarded by intercrops which do not shade them. Smith (1970a) showed that maize, pumpkin and sweet potato intercropped between newly planted coconuts for 3 years do not affect the first coconut yields compared with controls. When intercropping young coconuts, it is important that the coconut leaves are not cut, burnt or tied up. Intercropping is seldom possible beyond the third year.

3.3 Coconuts undercropped with cocoa and coffee. Experimental work has shown that coffee (Barrant, 1973) and cocoa (Barrant, 1977) can be cropped under coconuts provided that the soil, rainfall and exposure are suitable. To ensure that the coconuts (which require maximum light) keep above the cocoa or coffee, the undercrop should not be planted until the coconuts are about 5 years old. Suitable spacing for cocoa comprises a single row down each coconut interrow, with plants 5-7 ft. apart in the row: for coffee, a single row with plants about 3-4 ft. apart is suitable. Barrant (loc. cit.) showed that undercrops have no effect on coconut yield provided that both crops are fertilized. In fact, coconut trees on soils Belfield and Highgate Clay (Nos. 41 and 43) tend to perform better with a weeded and fertilized undercrop. Weed control is cheaper when an undercrop is present due to the shade and leaf litter. Yields of undercrops depend upon soil and rainfall but, in the experiments cited, average yields of 730 lb. wet cocoa/acre and approximately 40 boxes coffee cherry/acre were obtained.

3.4 Coconuts undercropped with pasture. Cattle (and goats) are very destructive to coconut plants. Young plants put out about 6 new leaves per year, all of which may be grazed in a few moments: often the spear leaf is pulled out, killing the plant. The current value of a Malayan Dwarf coconut plant when just planted is 62¢ ($1.12 for a Maypan hybrid) plus the cost of planting (an estimated 13¢). Even trees in early bearing are seriously damaged by cattle, the leaves being pulled down so that the unsupported bunches tear out before maturity. Coconut palms need to be 7-9 years old before cattle can be grazed under them.

Some heavy clay soils, e.g. Belfield, Highgate and Union Hill - Nos. 41, 43, 75 fail to restructure naturally after cattle paunching in wet weather. Point clay, Chudleigh clay loam and St. Ann clay loam (Nos. 20, 73 and 78) recover after cattle damage, also Killancholly clay, Carron Hall clay and Leith Hall clay (Nos. 91, 94 and 91) to some extent.

The natural "pasture" which develops under pure-stand coconuts often has a low carrying capacity. Depending upon the sward composition, soil type and the availability of drinking water, running cattle under bearing coconuts can be profitable since weeds are kept down and (especially with Indian breeds) coconut thieves are repelled .

Only certain improved grass species thrive under coconut shade, e.g , guinea grass under coconuts on soil 78 (St. Ann Clay Loam) gave 245 cow-grazing-days/acre/year compared with only 128 for pangola grass (Smith, 1971a): the grass competes with the coconuts for nutrients and both crops need to be specifically fertilized.

3.5 <u>Coconuts permanently intercropped with bananas.</u> Intercropping of coconuts with bananas has been traditional in Jamaica. Before the ravages of lethal yellowing disease, Jamaica Tall coconuts were planted at an expanded spacing of 33 ft. x 33 ft. (40 trees per acre). Banana spacings of 10 ft. x 10 ft. changed to 9 ft. x 7 ft., without any attempt to fit coconuts and bananas into some compatible spacing. Farmers estimated that each coconut tree interfered with 4 banana plants: on this basis, the 691 pegs/acre gave rise to some 531 effective banana plants due to 160 being compromised by coconut trees. Farmers liked this mixed cropping because:

(a) The light shade from the coconut trees reduced banana leaf-spot, especially in periods of extended high humidity, and encouraged softer weeds, particularly in dry weather.

(b) The coconut trees reduced wind damage to the bananas.

(c) There was flexibility in use of labour and equipment between the two crops.

(d) Both crops have a high demand for potash and little response or interaction with expensive phosphate. At present, both crops use 12-4-28, and application can be synchronous or even broadcast.

(e) The herbicides suitable for use under bananas can also be used safely under coconuts.

(f) The coconut production buffers income lost when banana yield is affected by replanting or by events such as windstorm, port closure, etc.

Two events caused reduced mixed cropping of bananas and coconuts in Jamaica over the last 10-15 years. The first was the closer planting distance of Malayan Dwarfs to allow for the shorter leaves, which led to the misconception that bananas could not be planted with Dwarf coconuts. The second was the growth of a belief that bananas of export quality needed to be grown in pure stand. Problems have subsequently developed in pure stand bananas, such as uncontrollable leaf-spot, damage from even moderate winds and build-up of light-loving weeds, especially stoloninferous grasses. Some farmers are now cropping bananas and coconuts together using the corridor system, which retains the advantages of this particular crop mix but largely replaces competition by dividing the land between the two crops in an orderly fashion. A typical corridor layout might have Dwarf coconuts 14 ft. apart in rows 54 ft. apart: experiments by Barrant (1978) have shown that a 14 ft. spacing for coconuts down widely spaced rows is high yielding. This spacing gives 58 trees/acre but concentrated in 20% of each acre. The open 54 ft. wide corridors are planted with 5 rows of bananas 9 ft. apart with plants 7 ft. apart in each row, giving 576 bananas per complete acre. The corridor mixed cropping system has the following further advantages:

(a) Farmers like mixed cropping for coconuts and bananas, and most export bananas will have to be produced by private farmers: the corridor system gives them a blue-print by which to work.

(b) Coconuts in rows still give good wind-break effect if the rows are correctly orientated. Fongerouze (1968) showed in Guadeloupe that wind is reduced for a distance from a wind-break of 10-12 times its height. Lorch (1958) in Israel found that a

wind-break 16 ft. high reduced wind speed and raised banana yield up to 50 ft. away. Dessication in dry weather is also reduced.

(c) The coconut trees do not interfere with cultivation, pest control or irrigation of the bananas, nor bananas with care of coconuts.

(d) With the spacing allowed, damage to banana fingers by coconut leaf tips will be negligible in comparison with the damage from the banana leaves.

(e) The wide banana corridor allows banana spacing to be modified in future or a different crop to be grown.

Coconut production from 58 trees/acre, at a conservative 50 nuts/tree and 110 nuts/unit, will be 26.36 units/acre/year: at the current price of $17/unit, the gross income from the coconuts is $448/acre/year. This production will earn $9 09/tree of automatic insurance.

4. Summary

The suitability of coconut cropping for soils in the wet tropics and the feasibility of coconut cropping in Jamaica are outlined. The following effective coconut cropping systems are described:

1. Pure stand
2. Temporarily intercropped when young
3. Pure stand undercropped with cocoa, coffee or pasture
4. Permanently intercropped with bananas.

5. Acknowledgements

This paper is presented with the permission of the Coconut Industry Board.

REFERENCES

1. Barrant, C.I. (1973). Intercropping. 13th Ann. Res. Rept., Cocon. Industry Board, Jamaica, p. 13.

2. Barrant, C.I. (1977). Intercropping. 17th Ann. Res. Rept., Cocon. Industry, Jamaica, p. 18.

3. Barrant, C.I. (1978). Spacing Experiments, 18th Ann. Res. Rept., Cocon. Industry Board, Jamaica, p. 19.

4. Fongerouze, J. (1968). The effect of windbreaks in a tropical trade-wind climate. Agron. Trop. Paris 23 (11) 1137-1158.

5. Lorch, J. (1958). Analysis of windbreak effects. Bull. Res. Coun. Israel, D. Bot. 6D (4) 211-220.

6. Romney, D.H. (1965). Further experiments with herbicides on young coconuts. Trop. Agric. Trin. 42 (2) 177-181.

7. Romney, D.H. (1976). Director's report. 16th Ann. Res. Rept., Cocon. Industry Board, Jamaica, p. 5.

8. Smith, R.W. (1967). A new method of rat control in coconuts. Trop. Agric. Trin. 44 (4) 315-324.

9. Smith, R.W. 1967a). Growth experiments. 7th Ann. Res. Rept., Cocon. Industry Board, Jamaica, p. 25.

10. Smith, R.W. (1970). Herbicide experiments, 10th Ann. Res. Rept., Cocon. Industry Board, Jamaica, p. 42.

11. Smith, R.W. (1970a). Catch cropping. Ibid., p. 37.

12. Smith, R.W. (1971). The optimum spacing for coconuts. Conference on Cocoa and Coconuts. Inc. Soc. of Planters, Kuala Lumpur, paper No. 40, p. 15.

13. Smith, R.W. (1971a). Intercropping. 11th Ann. Res. Rept., Cocon. Industry Board, Jamaica, p. 46.

CROPPING SYSTEMS INVOLVING BANANAS

by
Allan Jones
Banana Company of Jamaica

At present, the Banana Company of Jamaica does not recommend intercropping or mixed cropping of banana. However, in spite of our policy of pure-stand culture, 98% of the growers in the Industry have acreages below 10 acres and all practise mixed cropping to some degree. Out of a total of 72,000 acres on which banana is grown, 20% of 14,400 acres fall within the farm size category of 100 acres or more. Only about 0.5% of the total g rowers control this 20% acreags, and even among these growers there is a continuing desire to interplant banana with other crops.

The recommended spacing for banana is 9 feet x 7 feet (691 mats/acre). However, it is not unusual to find other spacings, among them 8 feet x 8 feet, 9 feet x 9 feet, 10 feet x 5 feet, and 11 feet x 11 feet. With spacings such as these the relatively open space during the first five months of growth offers great temptation towards accepting mixed cropping involving various cash crops.

Banana is grown islandwide but is concentrated in six major areas n mely, Montego Bay, St. Mary, St. Thomas, Portland, Christiana and Bog Walk. Small growers in these areas interplant with a variety of crops ranging from cocoa, coffee, yam, dasheen, pimento to coconut and it is very common to see various combinations of these crops present in a mosaic arrangement. The growing of coconut is, however, more prevalent among farmers having acreage above 10 acres. Basically, the cropping system among small growers all over Jamaica is similar, except for that in some areas there is a definite bias towards certain intercrops. For example, in Portland there is a proliferation of root crops seeming to have some relationship with the loamy soil present, while in St. Mary and Portland coconut is very popular.

For the small farmer, the system of mixed cropping is the one best suited for his need. The financial risks associated with mono-culture, as in pure-stand banana, are too high and he must diversify if he is to survive. In addition, his type of subsistence agriculture will tend to maximise all the advantages to be gained from mixed cropping. Additionally, the success of pure-stand

banana farming depends largely on the level of agricultural technology. Here the financial risks are usually high, as the inputs of fertilizers, pesticides and irrigation etc. are equally high. Because of this, accurate and expert advice on all aspects of banana production are needed. For example, the farmer must know how much fertilizer to apply and when to apply it. In short, pure-stand banana cultivation can only be successful where the detailed and reliable information on all aspects of production is available and can be readily given to the farmer via a proper and efficient extension service.

In considering technology and pure-stand benana cultivation, it is appropriate to mention that the major limitation to a mixed cropping system is simply that efficient cultivation and harvesting practices are very difficult in a system of mixed crops. In the absence of efficient cultural practices there is a low yielding production base which increases the cost of production per pound of fruit. However, it must be appreciated that in mixed cropping systems the need for vigourous weed, insect and disease control is not as urgent as in pure-stand. Furthermore, mixed cropping does not depend heavily on modern farm technology i. e. high inputs of chemicals, fertilizers and machinery.

It is no secret to banana farmers that in mixed cropping schemes the main crop (banana) usually suffers from lowered production. However, it is still encouraged due to the higher price offered for the intercrops e. g. coffee. Also, the general inability to provide necessary inputs e. g. fertilizer, leaf spot control (a problem made even more acute due to the thick growth which normally results from mixed cropping) on a regular basis make farmers less responsive to the drive for increased production. Many crops found as intercrops encourage pests and diseases which affect the main crop. One glaring example is the presence of cocoa, a well known attractant to rats.

Banana plants serve as good nurse plants for young cocoa and coffee plants, protecting and shading the plants. When grown with young citrus and coconuts, banana serve as a good cash crop, providing the farmer with an income before his main perennial crops comes into production. However, after a few years, the banana must be thinned out and finally completely removed. Most farmers who use banana in this system are often reluctant to remove the crop after enjoying the few years return from sales and in the long run the production potential of both the intercrop and main crop will decline if the banana is allowed to remain too long.

As far as the small farmer is concerned, mixed cropping in general provides an insurance against total crop failure and therefore results in greater income stability. This failure of banana is not only related to production per se but also in terms of quality, a very important criteria in the production of banana for the export trade. Low quality fruit results in substantial rejection both at Boxing Plants and ports in Jamaica and at the final assessment in the United Kingdom.

A corridor cropping system involving Malayan Dwarf coconut and banana is being proposed. Banana is planted at the recommended spacing of 9 feet x 7 feet and coconut at a much wider spacing of 56 feet x 14 feet. Benefits that can accrue from such an arrangement are:

a) Shade provided by the coconut will reduce banana leaf spot and also encourage softer weeds especially in dry weather.

b) Coconut is a valuable wind-break. This will reduce windstorm damage and dessication in dry weather (Research carried out in Israel with banana has shown that wind-breaks 16 ft. high reduced wind speed and raised yield in banana up to 50 feet away.)

c) Presense of coconut and banana in the same field does not in any way affect the production practices necessary for both.

d) Great flexibility in the use of labour between both crops.

e) Both crops have a demand for potash (K). At present, both utilize 12-4-24 in their fertilizer recommendation.

f) There is no known insect pest or disease common to both.

g) With the spacing allowed, bunch damage from coconut leaf tips should be negligible in comparison with the damage from the banana leaves themselves.

h) The wide banana corridors allow modification in banana spacing, dependent on the cultivar being used, and also if replanting is necessary.

Drawbacks to this system however, are -

a) Fertilizer recommendations for banana are based on leaf and soil analyses and can vary from place to place. Hence sometimes any of the following NPK formulation may be used on banana: 11-0-27, 16-5-19 and 17-0-20.

b) Large acreages of highly productive coconut fields are established on marginal lands, sometimes very shallow soils overlying limestone - areas in which banana is likely to fail.

If banana is to be successfully planted as an intercrop with coconut, then the nutrition of both crops may warrant use of separate NPK formulations and different quantities of fertilizer.

Another factor needing careful examination is the fact that if coconut is intercropped with banana through the corridor system, the farmer would be realising just about 80% of his potential earnings from his total acreage if he had planted purestand banana fields up to about four to six years after planting, this being the period that Malayan Dwarf should require to come into full production.

Legumes as an intercrop with banana are a rare occurrence in Jamaica. This is so in spite of the fact that legumes have the ability of adding much needed nitrogen to the soil and provide protein, ensuring that the farmers own nutritional standard is improved. However, praedial larceny is a major deterrent to the use of legumes.

Effects on the Export Trade

The effect of mixed cropping on the banana export trade is two-fold. First there is the dilution of money incentives where substantial subsidies on leaf spot control, fertilizer and weedicide inputs are spread across acreages producing banana among a crop mix and where a significant proportion of the banana go directly to the local market. Also windstorm insurance is

frequently not used to resuscitate damaged fields and the inevitable delayed effect on production results.

Secondly, the unit cost of administration and extension service is remarkably high, even while being less effective, due to the small average tonnage/acre supplied to export. Production estimation, upon which shipping is based, has a low accuracy quotient and the cost of unused shipping space is consequently inordinately high. Planning to meet production targets become difficult because of inaccurate data on banana acreage and yield per acre.

Summary and Conclusion

Basically, there are two types of banana growers in Jamaica. First, the small farmer who makes up about 98% of all the banana growers, and whose average farm size is less than 10 acres. For this type of farmer, the system of mixed cropping or intercropping is the one best suited to him. The financial risks involved in pure-stand banana are too high and he must diversify and spread his risks if he is to survive. In addition, his type of subsistence agriculture will tend to maximise all the advantages to be gained from mixed cropping.

In contrast, the relatively few banana growers with medium to large acreages should be encouraged to use the system of pure-stand cultivation. Although the risks involved are great and the inputs high, the yields and profits that can be generated are potentially high provided he controls all the factors that mitigate against maximum crop productivity.

Possibly what is most practical among the small banana growers is a zoning of inter-crops for particular areas depending on soil type, rainfall pattern and the farmer's preference and experience. This has implications for improving the cropping systems used by the many small farmers who constitute the bulk of the active farmers especially operators of small plots and landless farm workers who form the core of food development programmes.

CROPPING SYSTEMS IN WATERSHED MANAGEMENT

by
D. Paul Nicholson and L. C. Latty

1. The Importance of Watershed Management

Watershed Management is defined as the act of controlling or directing water run-off, erosion and vegetation in an area which drains into a single stream. It involves:

(a) Watershed protection
(b) Watershed rehabilitation
(c) Watershed improvement

The size of watersheds varies from small parcels of land to several thousands square miles with slopes ranging from gentle to very steep. The degree of slope has major implications for land use and steep sloping land cannot be farmed safely using level land techniques. Gentle sloping land is found chiefly in low lying areas which usually have deep good soils. Their chief problem is inadequate drainage. Steeper slopes are often well drained, but are usually shallower and prone to erosion. As irrigation is more difficult and on steeper slopes, the rainfall distribution determines cropping patterns and proper cropping systems become essential to land use.

Where there are poor soil conditions on steep slopes, agriculture may be only a minor factor in the overall watershed regime and emphasis should be placed on forest, range land and other land use that can serve as protection only. It is not always possible or prudent to restrict steep slopes to non-agricultural uses, even where the soil is not deep, because in many cases, the mountainous parts of the watershed contains the poorest farmers and the greatest population pressure in relation to the available resources. The gap between actual land use and land capability is often very wide. Lands with a "capability rating" which limits sage use to carefully managed forests or total protection as watersheds for the sole purpose of water harvesting are often used instead for cultivation. The natural balance between erosion, soil formation and fertility is destroyed. When these conditions prevail, run-off and erosion are extensive, causing floods, endangering life and property, creating droughts and seasonal streams and may lead to the creation of man-made deserts.

2. Cropping patterns according to Land Classification

2.1 Cultivable Land Class I

C_1. The soils are usually fertile, well drained and suited for intensive cropping. Crops are mainly plantation type such as sugar cane, and banana. Vegetables and legumes are grown on smaller holdings. This land class requires little or no conditioning. When necessary, it is limited to contour cultivation, strip cropping and rock barriers. On the steeper slopes, and larger holdings, broad based terraces are used. They are particularly suited to mechanization and can accommodate all types of cropping systems.

2.2 Cultivable Land Class II

C_2. The moderately deep to shallow soils can accommodate different cropping systems as any inadequate fertility can easily be corrected. The soils in this class are better drained than the above class and can also be mechanized. More intensive soil conservation measures are necessary, such as bench terracing and mini-convertible terraces. Moderate limitations may be found, for example erosion, wetness, or inadequate fertility.

2.3 Cultivable Land Class III

C_3. Where such soils are fertile and well drained, vegetables can be grown. Cropping systems here are more restricted by the natural characteristics of the land, such as greater susceptibility to erosion especially on the steeper slopes than either of the above classes. Therefore, operations have to be more carefully planned. Soil conservation measures assume greater importance and would include bench terracing, hexagons and mini-convertible terraces on the gentler slopes and discontinuous terraces on the steeper slopes where quick ground cover should be established to minimize erosion and enhance the absorptive capacity of the soil. Only crops that can be established with minimum tillage, such as cucurbits, should be grown on the steeper slopes.

2.4 Cultivable Land Class IV

C_4. In so far as soil depth is related to fertility, where these strongly sloping lands have a soil depth greater than 36 inches

they can be freely bench terraced by manual labour and subsequently used to accommodate all cropping systems. Other treatments, such as discontinuous terraces on the shallower soils, can be done to accommodate specific cropping systems such as plantation type farming or mixed fruit trees.

2.5 Pasture

P. This class should be limited to carefully managed pasture and not planted with annual or bi-annual crops due to the risk of erosion. It is also suited for permanent crops such as fruit trees on individual basins where cultural practices can be better carried out.

2.6 Fruit Trees

F. T. As with the above class P, discontinuous terracing (depending on soil depth) and individual basins are the main treatments for this class of land. The inter-spaces should have a permanent soil cover.

3. Flexibility within the classification scheme.

As outlined before, the ideal situation would be to adhere to the classification scheme and its specifications, but in hilly areas, social factors such as farm size, traditional cropping patterns and family size disallow the standard text book treatment. Special "treatment oriented schemes" have to be implemented in such cases. Bearing in mind that the average subsistence farmer needs to intensify his land use and that discontinuous terraces on the average occupied slopes reduce the land available for cultivation by 10-15%, the treatment would have to be a compromise based on the existing conditions.

On subsistence holdings classified as F. T. farmers have to be allowed some cash crops between the fruit trees to provide a source of income and variety to the household before the fruit trees come into bearing. Such an example can be seen at the Rosemount Demonstration site, located in the Wagwater Watershed. The average farm size is 2.5 acres and with slopes averaging 28° to 32°. Soils (predominantly 52 and 38) are low in the major nutrients and have a low moisture holding capacity. The traditional crops grown, including sorrel, cow peas and sweet potato, are those

needing clean cultivation and high moisture. Consequently, the fertility is reduced rapidly as the top soil is eroded during the rainy season. Apart from the occasional sale of sugar cane and livestock, the sole source of food is off the farm. Currently, arable cropping is allowed between the fruit trees on slopes more than 30°, but more encouraged on the orchard terraces, constructed on less steep slopes.

In any programme, the farmer and his social problems have to be considered and he has to be brought into all phases of the programme since effective management can be achieved only when land owners take an active part in the work.

The construction of terraces and other treatments enable the farmers to better utilize what land they have in terms of the length of cropping season, as better cultural practices such as mulching and fertilizing can be carried out. It is hoped that the classification scheme and its flexibility in offering soil stability and control of erosion can supplant the haphazard manner in which hillsides are traditionally cultivated, allow for more effective cultural practices and cropping programmes, and provide a more stable income to farmers, all being consistent with the objectives of watershed management.

REFERENCES

1. FAO 1977. Guidelines for Watershed Management.

2. FAO 1979. Watershed Development with Special Reference to Soil and Water Conservation.

3. Sheng, T. C., H. P. Stennett, Lecture Notes: Watershed Management and Soil Conservation Training Course. UNDP/FAO Jamaica 505 Project Working Document.

4. UNDP/FAO 1973. JAM 505 Project. Specification Tables for Soil Conservation Treatments.

5. U. S. Department of Agriculture. A Manual on conservation of Soil and Water. Agricultural Handbook No. 61.

THE ROLE OF LIVESTOCK IN CROPPING SYSTEMS

by
D. S. McLeod

The study of cropping systems has been carried out for centuries to the present day in developed and developing countries.

General advantages have been discovered over a long period of agricultural activity. However, because of differences not only in environmental conditions between and within countries but in cultural methods which were applied with varying degrees of consequence and success, it is important that agriculture everywhere should continue the study of cropping systems with no less intensity than before, so that suitable systems be developed to meet particular needs.

Agriculturists should be reminded that it is their responsibility to feed their respective nations. The land is the resource and food the product. In this energy-conscious age, they should make the fact known with humility, that careful use of the land will make the product (food) available without depleting the resource (soil), unlike energy from oil where the product (pertoleum) depletes the resources.

The advantages of having suitable cropping systems are well known and extend from biological factors to economic factors; and a suitable cropping system involves crop rotation.

The benefits to which reference was made earlier include:

(a) Maintenance of soil fertility
(b) Maintenance of crop yields
(c) Limitation of the spread of insect pests and diseases.

A popular measure for the maintenance of soil fertility is the maintenance of soil organic matter. The importance of this as well as the limitations have been well recognised, since yields have climbed while soil organic matter declined. But the general aim is to have the best of both worlds, biologically and economically.

If livestock is to form an integral part of a farming system, the same general consideration given for the growing of alternate or subsidiary crops should be given for the growing of forages which will be consumed by animals, and the question of the growing of forages for use by animals on lands suitable for arable crops should not arise. Livestock has a complementary role in farming systems and should be accommodated. Furthermore, the need for farming systems in developing countries to meet protein requirements in the human diet could be met from those which include livestock.

Forage Production

The production of forages for livestock in cropping systems should be carefully planned and therefore subscribe to the system concept of agricultural production. In this paper, it is considered at the farming level.

Pressure is constantly being exerted on the farm (productive unit) to produce more food due to the demand by increasing human population and livestock population as well. Such pressure calls for extensive use of fertilizer, irrigation and insectcides. Fertilizers, though important for yields, are not the answer to all problems since they cannot compensate for other limiting factors. The quantifying of benefits from irrigation poses several challenges because crop response to irrigation inputs depends largely on weather conditions and these vary from year to year. The interaction between level of available water and crop response is such that the timing of irrigation is more critical than the total quantity of water supplied. The consequences of excessive use of insecticides have been expressed by scientists from time to time since many chemicals remain and accumulate and affect species of insects which were not original targets. This situation therefore demands an integrated approach for the development of suitable cropping systems.

Forages in rotation

Farmers have recognised the fact that continuous growing of the same crop on a piece of land lowers the productivity of the soil. Corn grown after grass yields several times higher than when corn grown year after year, and this has been extensively recorded in the literature from studies conducted in England and the United States.

Less extensive work has been carried out in the tropics where the need for information is just as great, if not greater, because one of the main differences between the temperate regions and the tropics is the rate of break down of organic matter. There is rapid oxidation of organic matter within the tropics.

One does not wish to be carried away in arguments concerning the importance of soil organic matter as is likely at this point, because the maintenance of organic matter is an important part of soil conservation. It should not be the aim to have a cropping system merely to maintain soil organic matter, the level of which can be maintained in a given soil by the income and outgo of carbon and nitrogen and the amount of tillage. Regardless of the management system, a soil will lose or gain organic matter, and rotation affects its level in the soil. Since this is accepted, attention will be paid to the forages (grasses and legumes) that can be used in cropping systems which include livestock.

i) Types of grasses. There is still fear in the minds of farmers concerning the difficulty of getting rid of certain grasses when this is desired.

Grasses that are used in rotation should be those which can be easily eradicated. Characteristics which contribute to difficulties in eradication are rhizomes and viable seeds. Consequently, rhizome grasses should never be considered for use in cropping systems. This therefore rules out grasses such as: Cynodon dactylon, (Coastal Bermuda) Rhizomatous etc. Sorghum halpense - (Johnson grass) Rhizomatous. Pennisetum clandestinum (Kikuyu) - Rhizomatous. Brachianim decumbens - (signal grass) - produces viable seeds.

What appears to be important in the eradication of a grass in rotation is the time of the year that it is attempted. In work carried out at Grove Place by Richards during 1956, Pangola grass when grown in rotation with corn and peas was eradicated without difficulty when the ploughing of the grass plots was done during the dry season.

ii) Types of legumes. Legumes cultivated in pure stands can be ploughed into the soil when grown in rotation. Legumes used for such purpose include Centrosema pubescens, Desmodum intortum (green leaf), Desmodum uncinatum (silver leaf), Dolichos spp, Glycine wightii, Pueraria phaseoloides (tropical kudzu), Siratro, as well as several others. All these are perennials.

The use of Grasses and Legumes

The forage that is produced in the cropping system can be harvested and fed to the animals, made into hay and fed at a later date, or the cultivated area grazed.

There could be instances where the crop residue is ploughed into the soil following grazing or harvesting by mechanical equipment for either hay or silage. In another instance, the whole crop is ploughed into the soil as mentioned earlier. The benefits to be derived will be influenced by:

(1) the animals used within the the system
(2) the period of rotation
(3) the extent and frequency of removal of the harvested portion of the crop by the animals that are used within the system.

Grain crops can and should be grown within the system and would be used mainly to feed monogastric animals. Forage crops would be offered to large and small ruminants.

In a farming system where various crops are cultivated and forages are grown in a rotation for use by livestock, a continued supply of feed is more assured in the form of by-product.

The Animals

All human beings and animals depend on the product of the process of photosynthesis for existence; therefore, the animals to be fed from what is produced in cropping systems cover an extremely wide range. However, we will confine ourselves to those animals commonly reared in Jamaica; namely, cattle, sheep,

goats, pigs, poultry, horses, and rabbits. Monogastric animals are more efficient in the conversion of feed dry matter than ruminants. This group of animals cannot handle roughage and should be offered grain crops such as corn, sorghum, and cowpeas, in their diets.

The 'inefficient' ruminant being maintained on a cropped grass/legume area is increasing the farmer's income while the advantages of crop rotation for that particular area are being realized.

<u>Summary</u>

1. Suitable cropping systems include crop rotation.

2. The use of grasses and legumes in crop rotation has long been recognized.

3. Grasses and legumes in rotation maintain soil fertility, prevent and control soil erosion, prevent deterioration of the physical properties of the soil, aid in the control of weeds, insect pests and diseases.

4. Forages grown in rotation should be easily eradicatable.

5. The forage grown in rotation provides feed for livestock, and livestock has a complementary role.

6. With the rearing of livestock in such systems, farm income is increased.

7. It is necessary, particularly in developing countries, that cropping systems be developed to include livestock so that maximum advantage is obtained from each bio-economic complex (farm).

REFERENCES

1. USDA (1975). Agriculture Technology for Developing countries. Tech. Bull, No. 14. A.I.D., Washington D. C., U.S.A.

2. Dent, J. B. and Anderson, J.R. (1971). System analysis in Agricultural Management. John Wiley & Sons Ltd., N. Y., Lond. Toronto.

3. McLeod, D. S. (1976). Annual Report. Ministry of Agriculture.

4. Meyer, B. S. and Anderson, D. B. 1952). Plant Physiology. D. Van Nostramd Co. Inc., N. Y., Lond., Toronto.

5. Richards, J.A. (1956). Annual Report. Grove Place Agricultural Station.

6. Thompson, L. (1952). Soils and Soil Fertility. McGraw Hill Book Co., Inc., N. Y., Lond. , Toronto.

7. Uhland, R. E. (1948). Grass and Rotation. U.S.D.A. Yearbook of Agriculture.

CROPPING SYSTEM APPROACH TO CROP PRODUCTION IN THE PINDARS RIVER TWO MEETINGS WATERSHEDS

by
S. H. Dacanay and H. Aikman

Yam is one of the most important staple crops in Jamaica. Most of the farmers in the Pindars/Two Meetings watersheds grow yam on farms, ranging from .25 to about 1 acre at the most. The average farmer owns .5 to 3 acres, mostly on hillside and are dependent on rain. Generally vegetables, legumes, and other upland crops are planted after one or two crops of yam. Some farmers grow only one yam crop while others intercrop, but these are only a small fraction of the total.

The primary goal of the Integrated Rural Development Project, (IRDP), is to improve the standard of living of small hillside farmers in rural Jamaica, and establish an agricultural production model that can be replicated on such farms elsewhere. This model will be based on cropping techniques suitable for land that has been appropriately treated with soil conservation measures. IRDP's aim is not only to control erosion but also to increase agricultural production on these farms.

Because cropping systems are determined largely by local environment, IRDP's expanded trials and efforts have been strongly oriented towards field application. Work is done at the IRDP's five demonstration centres, which are situated within the two watersheds, prior to taking results to the farmers. Although most work is done at the demonstration centres some of the IRDP's yam-based cropping system trials are conducted on farmers' holding or sub-centres. The IRDP is to establish fifty (50) subsentres (16 at Two Meetings and 34 at Pindars Watershed) which are typical of the area. The farmer, his family, and his labour supply become components of the work process.

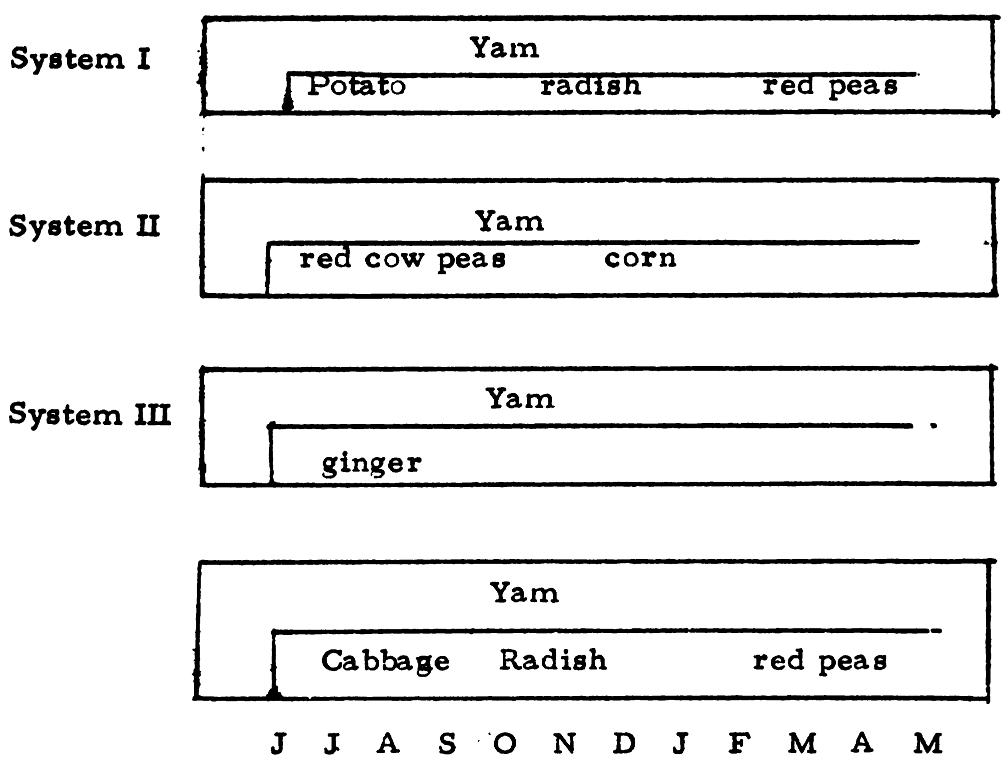
IRDP's Approach to Crop Production

Cropping System

A cropping system can only be one of the main methods that small hillside farmers throughout rural Jamaica can use to transform their resources into products to meet their needs and improve their standard of living.

Cropping systems can be broken down into cropping patterns, that is, crops grown on each piece of land over one period, usually a year. A cropping pattern, in turn, may consist of crop sequences, intercropping, interplanting, continuous cropping, or multiple cropping.

Fig. 1. Cropping systems are being tested by IRDP.



The study of cropping patterns requires knowledge not only of the sequence but also of the duration of each crop and of special management characteristics which may be required. Knowledge is also required of their resistance to insects and diseases, ability to stand adverse drought conditions, deedling vigour, high population densities, shade requirements, and harvesting characteristics. The cultivars also influence the quality of the finished product. It also includes market value and consumer or farmer preference.

[illegible]. Figure 1 shows four of the cropping systems which are currently being tested by IRDP. Yam is used as the base crop because it is widely grown throughout the project area and is easily marketed at a good price. In selecting suitable inter-crops, consideration was given to the adaptability of various short-term crops to the differing ecological conditions to be found within the two major watersheds, as well as to such factors as marketing arrangements and the expected net returns.

All of the crops being used, such as irish potato, cabbage, ginger, red peas, peanuts, cow peas, and corn were selected from crops grown (pure stand) on the major demonstration farms during 1979.

Credit

The role of agricultural credit in the IRDP is to augment the farmer's cash resources whereby he can best utilize his other resources including land, labour, and managerial capacity. The focal point in providing credit to the farmer is to maximize his profit rather than to maximize his production.

Loans are primarily for input cost of crop production - however, loans are also made to support small and large livestock enterprises as well as facilities needed on the farm.

As of August 31, 1980, loans have been made to 234 farm families for a total of $536,628. These loans are actually a 'line of credit' and the borrower does not receive a loan advance until he is ready to use that portion of his loan and interest does not accrue until an advance is taken by the borrower.

The farmer's "contact person" is an agricultural extension specialist who advises the farmer of his total operation including a duly approved cropping pattern to properly utilize his loan.

Marketing

One of the most important segments of a farm plan is marketing. Marketing is the end product of all that has gone on before including the planning. A farmer makes his first marketing decision when he decides what to grow, when to grow it, what quantity to produce, and what price level he can expect at time of reaping.

In a developing country much of this information is difficult to come by, but through contacts with exporters, importers, and marketing people, much information can be gained relative to marketing potentials. Once a listing of crops can be assembled, test plantings at a demonstration centre or area will make it possible to determine the growing patterns and quality factors, and afford an opportunity to calculate costs of production data. Once the crop is grown, market testing can be conducted to gain the necessary information .. Yes, the market wants it!

In Jamaica, the following list of crops has been obtained from the marketing people and the next step is test plantings and test marketing:

DOMESTIC MARKET

Crops	Month when need most+
Negro yam	April and May
Yellow yam	September
White yam	April to December
Sweet potato	May to June
Cocoe	April to July
Cassava	Year round
Corn (shelled)	April, May, June
Red peas	April
Congo peas	May and July
Carrot	Jan., Feb., March, July, Aug.
Cucumber	Feb., March, Dec.
Cabbage	June and November
Pumpkin	March, April, May
Radish	Year round
Cho-cho	Feb. and May
Peanut	Feb. and May
Lettuce	Year round
Celery	Year round
Sweet pepper	Feb., July and Aug.
Egg plant	Jan., July and Aug.
Plantain	April, May and Aug.
Papaya	Jan., Feb., May, June, Sept., Oct., Nov.
Turnip	March and August
Pak choy	Jan., Feb., March, June, July, Nov., Dec.
Hot pepper	Feb., March, April, July and August.

EXPORT MARKET

Crops	Season+
Red peas	Year round
Cola nuts	-do-
Ginger	-do-
Round leaf yellow yam	-do-
Pink cocoe	-do-
Sweet yam	-do-
Hard white yam	-do-
Negro yam	-do-
Egg plant	-do-
Cho-cho	-do-
Yampies	-do-
Dasheen	-do-
Yardlong bean	-do-
Pumpkins	-do-
Sweet pepper	-do-
Bitter melon+	-do-
Breadfruit	-do-
Solo paw-paw	-do-
Scotch bonnett pepper	-do-

+ Gathered from the National Suppliers Association, Agricultural Marketing Croporation, Higglers, McNeil, Limited, and Garfield Thomas, Exporter.

SUGARCANE (*Saccharum officinarum*) INTERCROPPING PROBLEMS AND ADJUSTMENTS

by
Adet Thomas[1] and D. C Stanford[2]

1. Introduction

Sugarcane intercropping in Jamaica has traditionally been the occupation of small farmers. The obvious benefits of increased utilization of land and water, increased food production and enhanced soil fertilization are well known and documented.

Although many small farmers have been practising this intensive form of agriculture for a long time, the collective impact of increased food production has not been evident. A number of reasons have been advanced for this. Among these are:

(a) very few farmers practise this type of farming;

(b) much of the additional food produced is consumed by the farmer and his family, hence not publicised;

(c) only very small plots of land are devoted to intercropping.

Recently, tremendous interest has been aroused concerning the economic productivity, value and role of intercropping ventures and the extent to which they may contribute to total food production.

This paper highlights some experiences of the researchers in their attempts to transfer the intercropping of newly planted sugarcane from the realm of what was considered to be a subsistence type of "backyard farming" to a semi mechanised and/or mechanised form of intercropping suitable

[1] Agronomist, Caribbean Agricultural Research and Development Institute (CARDI), UWI Campus, Mona, Jamaica.

[2] Agronomist, Sugar Industry Research Institute, Bernard Lodge.

for medium and large-scale farms where intercropping of sugarcane is likely to have its greatest impact. Attention is focussed on some of the problems encountered and the modifications necessary to enable large-scale production of the crops.

2. Choice of Location for Trials

The intercropping project was jointly undertaken by the Sugar Industry Research Institute (SIRI) and the Caribbean Agricultural Research and Development Institute (CARDI). Sugarcane intercropping represents an important component of CARDI's Technical Assistance Programme in Jamaica.

Caymanas was the target area chosen for this series of intercropping trials. The area, with its extensive sugarcane farming is representative of a major soil series of the St. Catherine Plains (Caymanas Alluvial Series).

All trials were located on a 9-acre block on Farm No 2 at Caymanas Sugar Estates Ltd. , on the major soil type, Caymanas Clay Loam, Vernon and Jones (1958), describe this soil as a well drained, deep alluvium, of high fertility with a distinctly alkaline reaction. The area is flat (0 to 2° slope). This area lends itself to mechanization for row crop production. Furrow or surface irrigation is normally practised.

Many of the intercrops grown were legumes; these included red peas (Phaseolus vulgaris), cow peas (Vigna unguiculata), (three varieties), string beans (Phaseolus sp.) and peanuts (Arachis hypogaea). Other food crops intercropped were Irish potato (Solanum tuberosum) and cucumber (Cucumis sativa).

3. Modifications of planting methods to accommodate cane and intercrop

Placement of the intercrop in relation to the sugarcane is an important consideration, since it determines the extent to which competition will ultimately affect both crops. Agronomic information obtained from a previous target area in Jamaica had led to the suggestion that the optimum planting distance for the intercrop was 10 inches either side of the planted seed cane. See Fig. 1.

The furrow-planting of cane practised at the Caymanas location did not permit the recommended distance. Furrows prepared were wider and it meant that the intercrop would fall within the furrow and would be flooded during irrigation. The modification made was for the intercrop to be placed on the bank (see Fig. 2) regardless of the distance from the planted cane.

4. Modifications of the planting methods in order to accommodate the intercrop

Figure 3 represents a schematic diagram of the usual method of planting sugarcane. The smooth line (1) indicated the land preparation prior to planting. The dotted line (2) shows the situation which exists following tillering

Sugarcane is planted by placing the seed cane in furrows and covering lightly with soil. Irrigation takes place by means of the furrow. Approximately 3 weeks later, when tillering has occurred the banks are broken and the canes are moulded so that the original furrows are made into banks and banks are converted into furrows. Irrigation is now effected by means of the newly made furrows.

The above system with its frequent disturbance of soil is obviously unsatisfactory for accommodating an intercrop; consequently, modifications were made. Intercropping was facilitated by covering the seed cane in its original furrow to about half the depth of the furrow. The original furrow was maintained for irrigation throughout the life of the canes and the intercrop was placed on the bank where soil disturbances and flooding due to irrigation no longer presented a problem (Fig. 4).

Following planting of the cane and intercrop a pre-emergence application of herbicide further delayed the need for soil disturbance and enhanced weed control. The distance between rows of intercrop allowed for the accommodation of agricultural equipment necessary for mechanized application of herbicides.

5. Planting of the intercropping system

Any large-scale sugarcane intercropping venture, where precision and speed become important attributes, must include mechanized planting as one of its priorities.

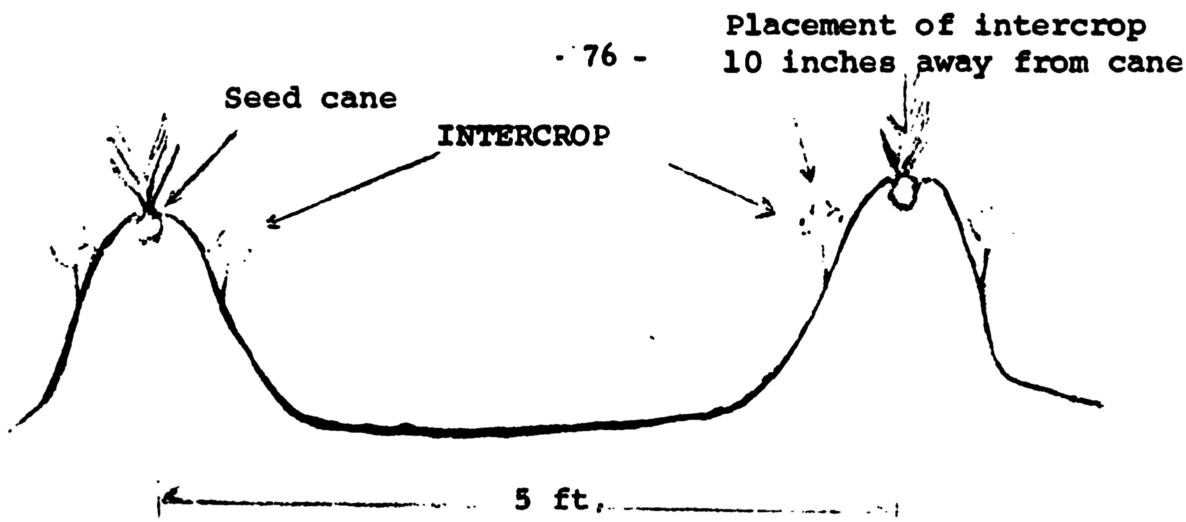


FIGURE 1. INTERCROPPING USING BANK PLANTING OF SUGARCANE

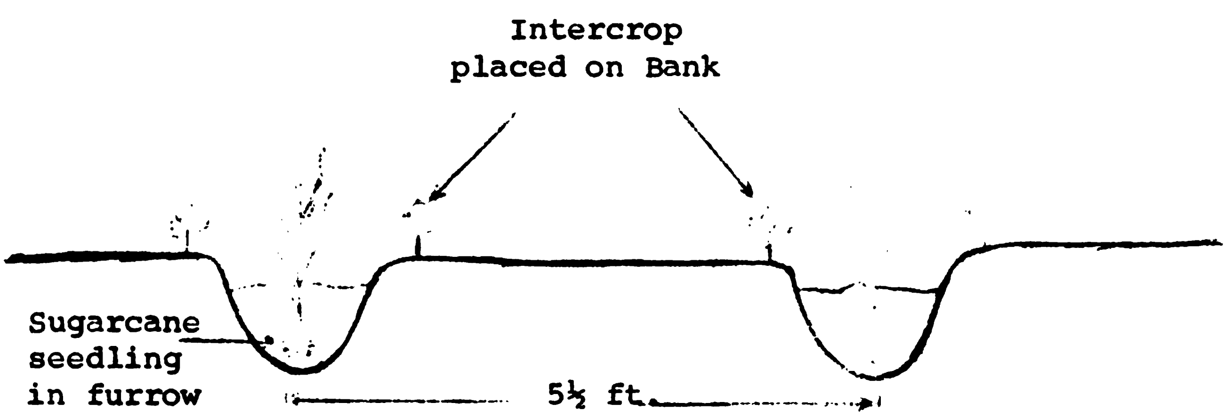


FIGURE 2. INTERCROPPING SHOWING FURROW PLANTING OF CANE

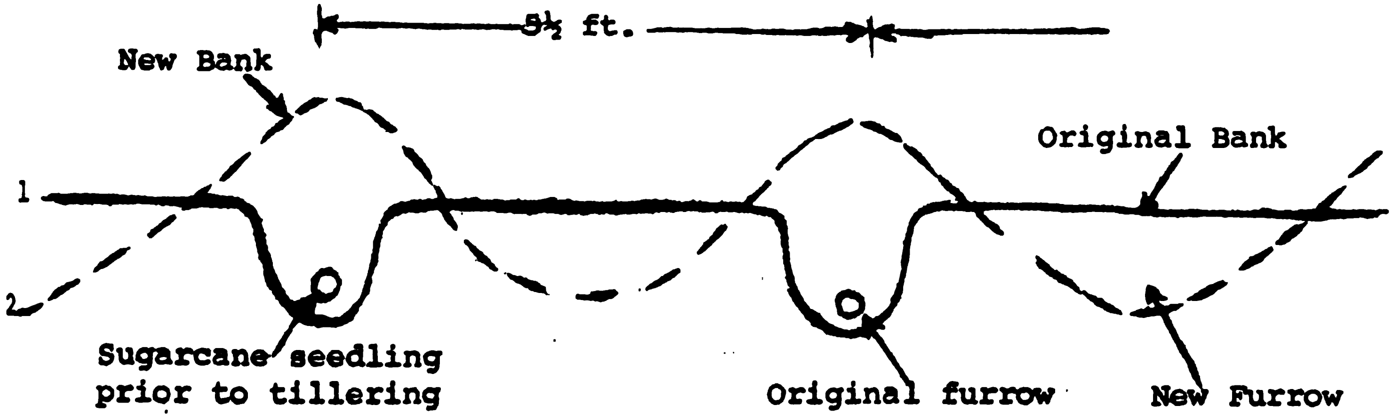


FIGURE 3. FURROW PLANTING OF SUGARCANE

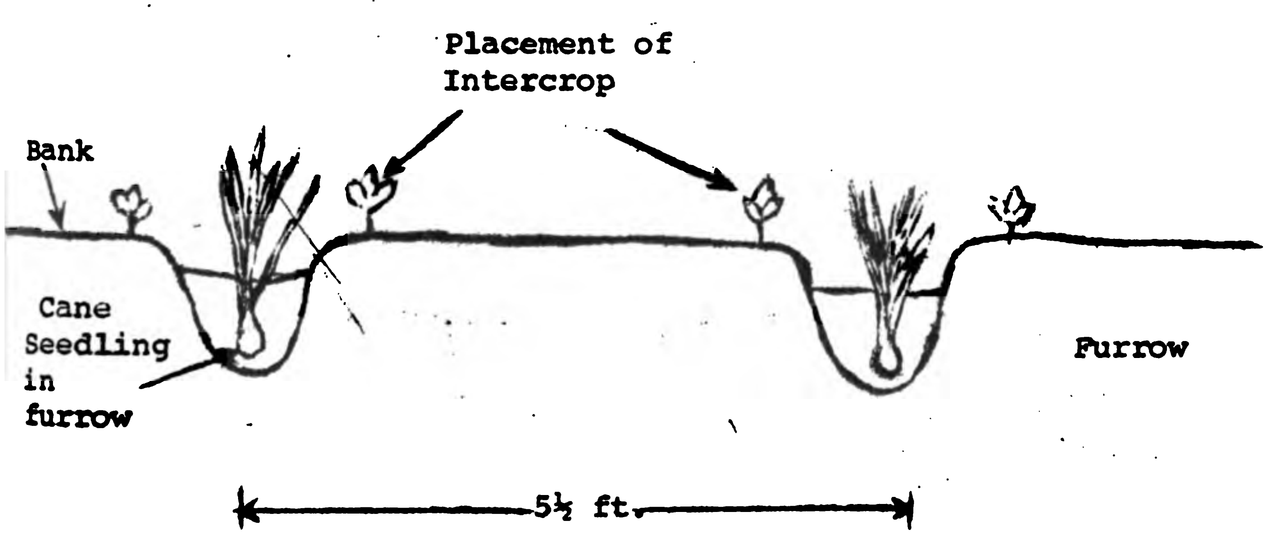


FIGURE 4. MODIFICATION OF FURROW PLANTING FOR INTERCROPPING

Many of the trials, in which precision was important, utilized semi-mechanized planting of the sugarcane and hand planting of the intercrop. Hand planting, particularly for the intercrop, proved to be expensive, time consuming and labour intensive when large acreages were cultivated.

Modification of the Birch planter and adjustment of the seed plates for planting of string beans, produced excellent stands of intercrop. Work is continuing on refinement of the planting process.

6. Weed control in sugarcane - legume intercropping

Overcoming the problems of chemical weed control in the sugarcane/legume intercropping system soon proved to be a most difficult and challenging task. The problems were further compounded by the fact that many of the traditional pre-emergence herbicides used in the cultivation of plant sugarcane were selective for monocots only, and had deleterious effects on the broad-leaf intercrops.

The general solution then was to identify herbicides which would have minimal or no effect on the vigour and growth of sugarcane and the intercrop, while at the same time affording an adequate period of weed-free conditions.

During the course of the trials a large number of soil-acting pre-emergence herbicides suitable for the intercropping system were identified. Although work is still in progress on this aspect of production, promising results have been obtained from a mixture of Dacthal and Diphenamid. Other herbicides with promice were Dacthal and Sencor. Cost of herbicides and methods of effecting adequate application are other areas of concern.

6.1 Method of Herbicide application

In deciding on the level of technology to be employed in the application of the pre-emergence herbicide for the cane-intercropping system, it was thought that the herbicide could be applied by means of a Knapsack sprayer, in a manner similar to that done for the cane crop.

It was soon realized that this method of application did not give adequate coverage of the area being treated.

The bank and furrow land preparation of the intercropping system lends itself to mechanization. It was found that excellent herbicide application could be provided by a tractor with modified row wheels fitted with a 20 ft. boom sprayer. In addition, the time of application was very much reduced.

7. Irrigation practices as they apply to sugarcane intercropping

Furrow, or surface irrigation is the major method by which water is applied to crops in the Caymanas area. Irrigation practices on the sugar estates have been observed to be very crude. Many of the intercrops are delicate, small-seeded plants and there is a tendency for the heavy "furrow stream" to lower populations.

Another serious problem was that open furrows of water tended to act as reservoirs for a wide range of weed species. Much of the new weeds brought into the intercropped region were deposited in furrows.

In intercropped fields adjoining fields treated with weedicides, it has been observed that transport of the toxic weedicide could be effected by means of the irrigation water.

The use of mesh to screen irrigation water prior to its entry into the field, may serve to reduce the transport of many weed seeds. A slower controlled monitoring of irrigation water into fields is expected to enhance the population of the intercrop, and care in the applicationof herbicide could eliminate drift by irrigation.

8. Consideration for mechanized harvest in sugarcane intercropping systems

Although mechanized harvesting of intercrops in sugarcane was not an objective of the present series of trials, serious considerations on this aspect of production are being pursued.

Many of the intercrops which are consumed as green vegetables, such as cucumber and snapbeans, must of necessity be hand picked. Hand picking allows for selection of the produce, which may be at various stages of development on the plants, but can be slow and tedious, especially when large acreage are involved.

Although hand picking affords advantages of selectivity and repeated harvests from a particular area, it can be very labour intensive and costly when practised on a large scale. Some damage may occur to the sugarcane crop as a result of constant movement through the field. The stage of growth of the sugarcane and the hairy nature of its leaves also make c onditions for hand picking of the intercrop uncomfortable.

Red pea, cowpea and other dry bean intercrops could also be hand harvested. However, on large areas where these are intercropped it may be economical to consider mechanized harvesting. The relative merits of mechanized harvesting are well known, but in cane intercropping systems, mechanization will present new and varied problems. These may call for adjustments or modification of existing machinery, or the production of new harvesters designed for working in intercropping systems.

A number of small hand operated combines, capable of being adjusted to travel and operate in the inter-row spaces of sugarcane fields, are being considered. Important considerations in the choice of harvester include -

(a) machinery which will simultaneously cut, thresh and retain the intercrop residue, or

(b) machinery which can cut, gather and transport the intercrop to the end of the row where threshing can take place. It is important to remove all intercrops from the field following harvest, in order to reduce insect and disease build up.

9. Problems of praedial larceny

The problem of praedial larceny has been a recurring one. Many of the trials at the location suffered to varying degrees. The intercrops were stolen on all occasions; this made yield and in some cases growth assessments difficult. Intercrops severely affected were red peas, irish potato and peanuts. In many cases, parameters for assessment of growth and yield had to be changed mid-way in the trial.

10. Conclusions

It is evident that a number of interacting factors (agronomic, social and environmental) together determine the extent to which large-scale intercropping of sugarcane will be successful. While different problems may arise in other areas of Jamaica, the Caymanas experience is expected to provide valuable information on agronomic modifications, machinery designs as well as improved methods of intercrop harvesting. All of the above should play an important part in future sugarcane intercropping.

Finally, from the experiences at Caymanas and the many agronomic modifications, it seems that a significant portion of the production practices can be mechanized successfully. Further work on the important area of mechanized harvest still presents many problems, which, it is hoped will soon be rectified.

REFERENCE

1. Vernon, K. C. and Jones, T.A. (1958). "Soil and Land Use Survey" No. 1, Jamaica, Parish of St. Catherine. Regional Research Centre.

CROPPING SYSTEMS INVOLVING YAM AND IRISH POTATO IN THE CHRISTIANA AREA

by
Roy L Rainford
Extension Specialist, Rootcrops
Ministry of Agriculture.

Introduction

The word "system" is derived from the Greek word Systema which has two roots etymologically viz. syn, together and histenai, to set. The first of the ten meanings given in the Websters' New World Dictionary, embodies the major facets of the other nine. Taken as a whole, system means "a set or arrangement of things so related or connected as to form a unity or organic whole as a solar system, irrigation system, supply system" and as the topic implies "a cropping system".

The Main crops under discussion

Yam and irish potato have been grown successfully in the Christiana Area for many years. This area impinges on the parishes of Manchester, Clarendon, St. and Trelawny, and is regarded as one of the most important foodcrop producing areas in Jamaica. The crops are being grown as sole crops or in mixed cropping systems which have evolved over the years to meet the farmers' need and maximise the use of the land.

Yam growing is of much commercial importance to the area which is of predominantly hilly terrain. It is essentially a base crop and mainstay to the many hundreds of farmers who, of necessity, practise hillside farming. The practice predates emancipation as it is felt that the slaves from Africa brought yam among their native foodstuff and used some of it as planting material in establishing small garden plots.

Yam production on all-island basis for the years 1977 and 1978, was of the order 146,340 and 181,193 short tons respectively. The area under discussion was responsible for producing about 50% of this amount.

Currently, there is an estimated 15,000 acres of yam (all varieties growing in combination with other crops. A more in-depth discussion on these combination systems is given later in this paper.

Irish potato is a relative new-comer to the island, having been introduced by Moravian Missionary interests in the early 1900's, at Bethany, in Manchester. The Devon-Christiana Area of Manchester is the largest potato-growing area in Jamaica, accounting for approximately 80% of the island's production, which has fluctuated immensely over the years, as is shown in the following table:

Table 1. Irish potato production in the Christiana Area compared to the total island production

Years	Total Island production (s/tons)	Approx. production Christiana Area (s/tons)
1973	9,856	7,888
1974	25,360	20,288
1975	14,360	11,488
1976	8,425	6,736
1977	9,280	7,425
1978	14,445	11,560

Source: Data Bank and Evaluation Division, Ministry of Agriculture, Jamaica.

Cropping systems involved

Most of Jamaica's domestic food production takes place on lands with slopes in excess of 35°. In such areas where steep slopes account for as much as 80% of the land mass, great care has to be taken in cultivating the soil for crop production. This is especially so in those places with high rainfall. The farmers employ various practices, chiefly the MULTIPLE CROPPING system which is described by Wahab (1978) as "forms of cropping practices where total production from a unit area of land in a farming year is achieved through growing crops simultaneously, sole crops in sequence, or a combination of mixed

and sole crops in sequence". In the transfer of technology all over the tropical world, wide use is made of this system of multiple cropping by all types of farmers.

The practice of multiple cropping tends to make the maximum use of available space, moisture, time, soil nutrients and incoming solar radiation - the latter as predisposition to maximum photosynthetic activity. In the Christiana Area it ensures an even distribution pattern of farm employment and reduces farming risks considerably. Wahad (1978) reminds us that it has other advantages in that "unemployment and/or under-employment is alleviated and the vagaries of weather, plant disease and pests are rendered less severe than in a system of monocultures".

Most yams mature 10 to 12 months. The crop is planted mainly in early March to take advantage of the light spring rains when the full benefits of fertilizer applications can be gained Yam "feathers" or branches profusely as it twines on stakes, increasing leaf area and canopy. Certain crops are planted alongside the yam to help "keep the pot boiling" while the yam is growing. Quick growing crops like red peas which take ten weeks, or sweet potato which takes six months to maturity, are planted on the backs of "hills" or mounds. Sometimes cassava is planted in scattered fashion throughout the yam field. It can remain in the ground up to twelve months after the yam has been reaped as insurance against hunger. Crops such as ground cocoe and dried beans are companion crops in most yam plantation. In the cool upland valleys on the Clarendon, St. Ann and Trelawny borders where the D. alata types perform well, ginger is also grown as a companion crop.

Preparations for irish potato planting begin as early as December, especially on the heavier clays to allow sufficient time for weathering. During the weathering process (December-January-February) a crop of legumes (red peas chiefly) is planted. This adds nitrogen and helps to condition the soil for planting of the irish potato which begins in late February and ends in the last week of March.

During the 16-week life of the crop, the field, though considered purestand by the farmer, is surrounded with edge-row of corn and dotted, if not spotted, with ratoon cocoes. After reaping the irish potato, sweet potato and corn are generally planted in that order of rotation.

Conclusion

Not much is said about soil conservation which is a must in foodcrop growing in the hilly regions of Jamaica. Stennett (1979) recommends the adoption of one or more of six measures. Terracing, which calls for a complete restructuring of the land, is costly, so each case should be treated on its own merit.

Very little has been discussed on the Economics of Production in these combination systems, except to say that the farmer, over a period of years, has determined by trial and error, that system which gives him the greatest returns within any crop year. He is a skillful innovator in his own right. It seems therefore that, as change agents, Extension Officers might well be advised to go along with existing systems while bringing to the farmer new technological transfer packages. This will require an enlightened, aggressive and dedicated band of Extension and Research Personnel.

REFERENCES

1. Ministry of Agriculture - Jamaica. Agricultural Chemistry Division. Major Soil Types of Jamaica (Revised).

2. Ministry of Agriculture and Fisheries - Jamaica. Crops and Soils Division. Make More Dollars the Rootcrop Way.

3. Rainford, R. L. (1979). Growing Irish Potatoes. Ministry of Agriculture, A. I. S.

4. Rainford, R. L. (1979). Lecture Notes on Rootcrops. Extension Training, Eltham Training Centre.

5. Stennett, H. R. (1979). Watershed of Jamaica and Considerations for an Ordinal Scale of thier Development. IICA Publication, Kingston, Jamaica.

6. Wahab, Abdul H. (1978). Farming Systems for Hillsides. IICA Publication, Kingston, Jamaica.

CARDI'S SMALL FARM SYSTEMS RESEARCH PROJECT IN JAMAICA

by
Lennox Daisley
Agronomist
CARDI, Jamaica.

Introduction

It is evident that traditional farmers are not changing their technology as rapidly as the larger commercial farmers. Small farmers do not accept change at rates which are considered adequate by scientists, extensionists, politicians, academicians, bureacurats, or others.

Small farmers have been motivated in the past to accept change, otherwise they could not have efficiently adjusted to alternatives they now utilize. But, it is important to understand that the efficient adjustment is in terms of the farmers' own understanding and interpretation of his situation, and it is not necessarily efficient according to the perceptions of well meaning, but incompletely informed, third persons.

The small-holder farming system is complex, being comprised of several enterprises which are grown in various sequences or rotations, often intermixed or overlapping on the same piece of land. Much of this system has evolved (over time) in an environment comprised of uncertainties, fears of hunger caused by living and producing on the margin, religious and cultural practices that limit certain alternatives, and poor infrastructural support of farming and social services.

The Caribbean Agricultural Research and Development Institute (CARDI), with an heritage of traditional scientists and research methodology, has recently transformed itself from a purely research organisation to a research and development institution in an effort to tackle the numerous obstacles to agricultural development in the Caribbean. Naturally, the major emphasis is directed at the small farming systems of production, since the small farmer sector comprises the vast majority of agricultural producers in the region.

Given the wide range of conditions in the Caribbean, CARDI has established national units in each territory and a supporting resource group at headquarters in Trinidad to service the entire region.

To define its present lines of action, CARDI sought guidance and identification of priorities from the national Ministries of Agriculture. Based on this consultation the goals were:

(a) to understand the small farmer systems in specific areas;

(b) to contribute to the improvement of the farmers' systems.

To achieve its objectives, CARDI has embarked on a 'systems approach'. The basic working philosophy of this approach requires direct interaction both with the farmers and Extension agents in the working areas to acquire adequate knowledge of the farming conditions, as well as doing experimental work on small farms. Experimental stations, laboratories and greenhouses would be used for support research which may need better environmental control.

The work characteristics of the systems' approach require the participation and interaction of several disciplines in a team (multidicciplinary team). The team should ideally include agronomists, pathologists, entomologists, weed management specialists, ecological systems specialists as well as agricultural economists, statisticians, anthropologists and communication experts.

The Plan/Strategy

The overall plan is to find out what farmers do, how they do it, and why they do it that way (in other words define the agro-socioeconomic conditions of the project area). The information received should guide the technicians in providing appropriate technologies (a set of alternatives) for thevarious farming systems.

Ideally, the strategy should include the following steps:

(1) selection and definition of a work zone;
(2) establishment of a multi-disciplinary team;
(3) execution of a base-line survey of the area;
(4) analysis of the survey information by the multi-disciplinary team;
(5) selection of an adequate number of farmers as collaborators for an in-depth on-farm study;
(6) field experimentation on farmers' plots and at central research stations;
(7) generation of a set of alternative technologies;
(8) technology validation - testing of these technologies by farmers under their particular resource endowments;
(9) a follow-up survey by the technicians (the following year) to determine whether the generated technology was adopted, to what degree, and if not, why;
(10) any adopted technologies would then be passed over to the Extension Department as "appropriate" to those farmers who adopted them.

Work undertaken to date

Activities commenced in Jamaica in June 1979. Consultations with the Ministry of Agriculture and other locally-based research agencies resulted in the selection of south-eastern St. Elizabeth as the project area. A base-line survey questionnaire was prepared in collaboration with the Ministry's Data Bank Department. The questionnaire sought to determine certain general characteristics of farmers and farming in the area such as:

(a) farmer's personal information - name, age, sex, marital status, educational attainment, income;

(b) farm size, number of parcels comprising farm, size of household, etc.;

(c) systems of land tenure;

(d) types of crops/animals grown and type of farmer;

(e) activities undertaken both on and off farm, timing of activities, cropping sequence, etc.;

(f) availability of inputs, credit, labour, technical advice/information;

(g) farming problems.

Two hundred and forty (240) farmers were interviewed during the execution of the survey. This sample size represented ten percent (10%) of the farming population of the area. Preliminary information from the base-line survey was used to select farmers to collaborate in the on-farm study phase. Initial plans were to select a complement of thirty (30) farmers for this phase, but only sixteen (16) were obtained, the great majority were either hesitant, or not at all interested in participating.

During the on-farm study phase, which is currently in progress, CARDI technicians visit each of the collaborating farmers at least once per week to record all activities that were undertaken during the previous week. The data being collected include information on:

(a) labour, material and power inputs;

(c) crop and livestock purchases and sales;

(c) crop and livestock production and utilization;

(d) cash flows;

(e) the particular techniques employed by each farmer in his various farm operations.

In addition, the CARDI technicians visit other farmers in the area for wider interaction among the farming community.

Some observations

In keeping with the philosophy of the project, no positive inferences of conclusions would be presented until a multi-disciplinary team analyses the relevant data. However, some apparent trends may be outlined:

(a) The majority of farmers interviewed were full-time, multiple cropping farmers operating between one-quarter ($\frac{1}{4}$) and three (3) acres of gently sloping to flat land.

(b) Ninety-seven and a half (97.5) percent of all farmers utilized a mulch of dried guinea grass in the production of their crops. The major reasons advanced for the use of the mulch were: to retain moisture, keep the soil cool, and suppress weeds in order to promote crop growth.

(c) Seventy (70) percent of the farmers were either married or existed within a common-law relationship. Less than twenty-five percent were single, and 0.8 percent were divorced or separated. There may be some correlation between the marital status and the stability of farming systems of the area.

(d) 13.6 percent of all households had in excess of eight occupants, and 56.6 percent of the farms had over three (3) dependents.

(e) 53.1 percent of the interviewed farmers were forty-one (41) years old and over. 17.4 percent were over sixty-one (61) years of age.

(f) 97.1 percent of all farmers were users of inorganic fertilizers. 60.0 percent used in excess of six (6) bags per acre; some claimed to use over sixteen (16) bags per acre. The recommended rate by the Ministry is 4-6 bags per acre. Only 15.6 percent reportedly used this rate.

(g) 61.0 percent of all farmers practised irrigation. The bucket and the watering can were the major methods of applying water to the crops in the field. Modern types of irrigation equipment were not reported, except certain types of sprinklers that may be attached to the end of a hose from the domestic supply line. The vast majority of farmers (78.5 percent) claimed to have at least one water tank on the farm.

(h) 64.0 percent of the farmers claimed that they had never changed any farming practices, but persisted with the traditional methods 'handed down' from ancestors. 10.8 percent stated that they had changed their practices and one-half of these reverted to the original methods, which they felt superior. When questioned as to who, or what, motivated the change, the majority of responses identified "other farmers", and to a lesser extent, the radio and other mass media. Few farmers felt that the Ministry and field officers were significant motivating agents for change.

(i) High cost of farm inputs, unavailability of credit and unequal distribution of subsidies were identified as the major problems facing farmers of the area.

Cropping Sequences

Several cropping sequences have been observed. Some of the more popular ones are:

(a) Guinea grass - carrots - tomatoes - tomatoes and beans - gungo peas - guinea grass.

(b) Guinea grass - escallion - escallion and red peas - escallion and water melons - guinea grass.

(c) Guinea grass - tomatoes - tomatoes and cassava - cassava - cassava and yam - guinea grass.

(d) Guinea grass - carrot - cabbage - carrot - carrot - guinea grass.

Many of these cropping sequences are usually modified by the farmer introducing other crops, such as corn, sweet potato, okra, banana, seasonings, etc., basically for consumption by the farm family. These additional crops may be placed on the border within a row, or entire rows within a field depending on the preferences of the farmer. In this way, there can be literally endless numbers of cropping patterns on a single farm as long as the conditions permit. The varieties of the crops grown also depend on the preference of the farmer. Many farmers in the area retain their own seed material from previous harvests for cultivation.

Tools and equipment

The tools used by farmers range from traditional implements to relatively modern equipment. Usually, the modern equipment is limited and not always owned by the farmer - tractor services or pesticide equipment may be borrowed or rented from other farmers, or the Ministry may make certain services available

The traditional tools are uaually owned by the farmers and are very old, if not outdated. It is not uncommon to find farmers using hoes and forks that are over twenty (20) years old, and almost unrecognizable.

In some instances very primitive techniques are employed, as is the case with the weeding of carrots where fingers are primarily used to remove the majority of weeds. This operation is very time consuming, e.g. to weed one aquare chain (one-tenth of an acre) may take in excess of a week by this method.

Certain activities may appear to be irrational to the trained agriculturalist. For example, no farmer stakes tomatoes he would rather stake sweet peppers. Staking of tomatoes is a standard recommendation of researchers. Closer examination reveals that farmers "mould" tomatoes because it allows the development of adventitious roots along the covered portion of the stem, enabling the plants to better withstand the severe dry conditions. The farmers also feel that "moulding reduces the effect of a common soil-bourne fungus in the area since the new roots are produced above the previously affected area of the stem. The particular variety

of sweet peppers grown has a very brittle stem and cannot be "moulded". The stake is however helpful in preventing wind damage. This is but one example of how the farmer modifies available information to suit his particular situation.

In conclusion, it must be reiterated that the project is still young and not at all fool proof. It stands to benefit from the wealth of experience and knowledge that is available in Jamaica. Therefore, scientists should come forward and contribute to the development of the type of programme that is clearly needed for the development of appropriate systems of food production in Jamaica. Many could serve on the multi-disciplinary team, since the wider the expertise on the team, the more ideas could be generated. CARDI would be most grateful for any such assistance.

PEST MANAGEMENT SYSTEMS IN AGROECOSYSTEMS

by
Desmond Hastings Phytopathologist
and
David Ellis, Entomologist
Ministry of Agriculture, Jamaica.

1. Introduction

Pest management is taken here to mean selection of control techniques and their subsequent regulation throughout a certain area or ecosystem despite national boundaries. There is co-operative use of the same strategy by everyone concerned; so a pest management system seeks to govern all aspects of different control techniques used and may give emphasis to one particular technique and this, moreover, can be the case where success is gained without intended integration of methods (Matthews, 1979).

For instance, lacatan, robusta, and .valery varieties of banana, Musa sapientum, resistant to Panama disease, have been bred and used to replace gros michel, a variety very susceptible to that disease in the English speaking Caribbean (Naylor, 1974). On the other hand, in the same area, breeding of varieties of sugar cane, Saccharum officinarum, less susceptible to damage by larvae of the sugar cane moth borer, Diatraea succharalis, together with biological control agents and chemicals have been employed in an attempt to minimise damage by the pest.

It will be observed that in this paper no attempt will be made to suggest the use of any particular chemical for the control of pests or diseases. Instead, only the broad headings such as: Exclusion, Eradication, Protection, Immunization and the Role of Government and its Agricultural Extension Service will be considered. We follow Davis (1952) in giving brief definitions of:

(a) Exclusion as that principle of control which involves those measures by which the entrance and establishment of a pathogen in uninfested areas is prevented. This also involves those areas in which the pathogen is not established.

(b) Protection as that principle of control which involves those measures by which a barrier is placed between the pathogen and the suspect thereby affording the suspect protection. This is achieved by the use of chemicals.

(c) Eradication as that principle of control which involves those measures by which the pathogen is removed, eliminated or destroyed on, or in the environment of plants already in infested areas, and

(d) Immunization as the principle of control involving those measures by which a plant or plant population is rendered immune, resistant or tolerant to its pathogen or insect vectors.

2. Developing pest management systems in the Caribbean

Since much work has been done on pests and pest problems in Europe, North America and elsewhere, we could continue learning from them, for instance in the role of government and an agricultural extension service.

2.1 Role of Government and its Agricultural Extension Service

In pest management the choice of chemicals or group of chemicals with similar mode of action and their alternation is determined for the area and advice given to the farmers through well-informed extension services. This presupposes regular adjustments as more information on the pest becomes available (Matthews, 1979). Pest management becomes more important in larger cash cultivations than in the peasant subsistence cultivations of a myriad 'patch work of miscellaneous crops alternating with bush, characteristic of the Caribbean. The merits of this 'patch work' (van Emden, 1964-1965) are probably outweighed by the pest problems they generate (Way, 1979), therefore this 'patch work' cultivation demands attention.

It is the role of government to attract suitable and proper numbers of relevant scientists, to provide proper facilities for them to research pest problems caused by insects, pathogens, weeds, slugs, mammals and birds (Pimentel and Goodman, 1978); to utilize suitable pest management systems and to provide the necessary extension services. The necessity for this becomes clear when it is realized that most agricultural scientists work in North America and Europe, and that in these areas 79% of pesticide manufactured are used (Pimentel and Goodman, 1978). Yet, in the United States where 34% of pesticides applied in North America is used, total crop losses pre and post harvest (including damage by micro-organisms) was estimated at 34% (Pimentel and Goodman, 1978), whilst the world estimate was 48% (Pimentel, 1976). In the Caribbean with little pest expertise and where comparatively little pesticides is used and where conditions are most favourable to pest attack, crop losses would be expected to be higher than the world average. To minimize such losses, then, better pest management is indicated for Caribbean agroecosystems (monocultures and more diverse systems).

It is true that in Tropical and subtropical zones, insects cause a greater crop losses than do fungi, viruses and bacteria; however, losses from these should bever be underestimated. One must only think of the losses caused by lethal yellowing disease of coconuts in Jamaica, Panama and Sigatoka diseases of banana, smut, rust and virus diseases of sugar cane, *Phytophthora* disease of tomato, potato, citrus and *Cacao*, rust of coffee and anthracnose of fruits, vegetables and ornamentals. Now, since weather can exert great influence on the development of diseases in a crop, government should provide dependable weather forecasting to assist those who make decisions about chemical application.

2.2 Pest exclusion

Organisms may be introduced into new biotic areas and become pests there (Simmonds and Greathead, 1976) as happened in Jamaica lately with sugar cane mosaic, tobacco blue mould and the coffee berry borer, *Hypothenemus hampei*. A pest survey should be made in each territory and a register compiled. Those pests that are absent should be termed dangerous and excluded through quarantine as is the case with the Colorado potato beetle, *Leptinotarsa decemlineata*, a dangerous pest of potato in many

parts of the world (Pimentel and Goodman, 1978) and which has been excluded from England, and the golden Nematode from Jamaica.

2.3 Pest population management

The basis for this is knowledge of the pest population ecology since the ultimate objective is to make the environment unfavourable to the pest such that the numbers of the pest cause only tolerable, if any, economic damage. Pimentel and Goodman (1978) have discussed the three methods available for this: environmental, chemical and genetic.

Way (1978) considered pest control under basically three heads (this is useful in formulating pest management:

1) preventing invaders reaching the crop in damaging numbers;

2) preventing them building up on the crop to damaging numbers;

3) preventing them leaving the crop in numbers damaging to subsequent crops.

The drastic method of chemical control could be used to destroy the pest as is done with the cotton stainer, Dysdercus, under its off season host in Sudan or trap crops could be used to divert the pest from the vulnerable crop (Aiyer, 1949); this is suitable for some exogenous pests. In the West Indies, Plutella xylostella a dangerous pest of cabbage is probably only controlled with difficulty using poisonous insecticides and attempts at biological control agents have been generally unsuccessful (Bennett, 1974). Plutella feeds on many wild crucifers (Harcourt, 1957) so the probable means of control would be to plant cabbage when the pest is naturally least abundant (Pimentel and Goodman, 1978) or by the use of antifeedants (Bennett, 1974).

Endogenous pests such as weeds and nematodes may be controlled in the crop by intercropping, rotation or chemicals. Chemicals or cultural practices can be used to destroy late season survivors; this is done with the coffee berry borer in Jamaica and Central America.

2.4 Decision making

Where application of chemical is contemplated knowledge is required as to the level of pest attack to decide whether or not to apply chemicals and the timing of application. Where little knowledge exists as to the level of pest attack, preventive measures have to be adopted such as 'clean seeding' banana suckers in Jamaica to destroy banana weevil borer, Cosmopolites sordidus, and the burrowing nematode, Rhadophilus similis. Where the crop is of high value and prophylactic treatment has to be done and lack of capital and technology lay constraints on farmers, government may choose to undertake application at a cost to the farmer, payable when the crop is sold or at no cost to the farmer, e.g. in the coffee berry borer control in Jamaica.

It can be quite useful when the decision to apply chemical control is based on economic threshold such as the number of insect eggs in relation to subsequent insect attack and damage levels. Such threshold values can be determined by allocating resources to monitoring the pest and relating the decision to the cost of chemical application, efficiency of application, the price of the crop and the risk of not applying chemicals (Cammell and Way, 1976).

In Jamaica, the decision on when to apply mineral oil to control banana leaf spot, Mycosphaerella musicola is based on previous studies. Innoculum to cause the disease is always present as well as susceptible leaves, but the disease develops only under certain weather conditions, thus, providing it is economically feasible, a decision is made to apply the sprays.

2.4.1 Mixed culture and monoculture

In Jamaica, native mahogany (family: Meliaceae) cannot be grown in pure stands, owing to the ravages of shoot borers. The use of chemicals to control these borers is impractical. The only way to successfully grow mahogany appears to be by sufficient dilution among other trees to put it out of the range of shoot borers dispersing from other mahogany trees (Way and Bevan, 1977). In some cases though, growing crops in very large pure stands can diminish pest attack in that the pest cannot breed fast enough to overtake the crop, so damage is restricted to the edges (true of annuals).

2. 4. 2 Compensation and tolerance in decision making

The extent of loss usually depends on the spatial, temporal and numerical characteristics of attack and the stage of the crop affected, its growth characteristics and stage of development. Coconut trees usually physiologically shed 80% of all fruits set. If there is a rat infestation, it usually affects the remaining 20% whilst the nuts are immature; heavy losses often result, therefore, decision has to be taken to control the rats. One hundred percent defoliation of maize at flowering stage leads to great loss in grain, whereas at the grain filling and vegetable stage, there is no appreciable loss in grain yield.

Roots can branch at any point, so 50% removal of roots in some crops gives rise to no loss in production e. g. citrus intercultivation, where partial root pruning proves beneficial.

2. 4. 3 Choice of sprayers

Matthews (1978) has dealt comprehensively with the types of applicators available to apply pesticides. Most of these are inefficient in applying pesticide sprays. One type of sprayer of particular interest is a centrifugal energy nozzle used to produce droplets of a very naroow range of droplet sizes and uniform droplet spectrum (controlled droplet application or CDA) (Bals, 1975).

It is relatively unknown in the West Indies, but seems to have immense potential for use here. It is light, portable, hand operated, and it requires less volumes of liquid to spray large areas (Bals, 1975) and so could be valuable in hilly terrain and where water is scarce. Its performance should be evaluated in the region with a view to adoption for use in pest management work.

3. Summary

In a pest management system, there is co-operative use of the same techniques and chemicals by all concerned. There is need for more attention to pe st management systems in the Caribbean since it is believed that crop loss here may be higher than the estimated world average of 48%. Improved knowledge of the pest should lead to better decision making in

pest control and controlled droplet application (CDA) seems potentially valuable in pesticide application in the West Indies.

REFERENCES

1. Aiyer, A.K. 1949). Mixed Cropping in India. Indian Journal of Agricultural Science, 19 pp439-543.

2. Bals, E.J. (1975). The Importance of Controlled Droplet Application (CDA) in Pesticide Applications. In: Proceedings, 8th British Insecticide and Fungicide Conference pp136-160.

3. Bennett, F.D. (1974). Biological Control of Insect Pests of Horticultural crops. In: Proceedings of a Symposium on the Protection of Horticultural Crops in the Caribbean, held at the University of the West Indies, Trinidad. pp223.

4. Cammell, M.E. and Way, M.J. (1977). Economics of forecasting for chemical control of the Black Bean Aphid Aphis fabae, on Field Beans, Vicia faba. Annals of Applied Biology, 85 pp333-343.

5. Davis, B.H. (1952). Control of Plant Diseases Part IX Rutgers University Press.

6. Harcourt, D.G. (1957). Biology of the Diamond Back Moth, Plutella maculipennis, (Curt.) (Lep: Plutellidae) in Eastern Ontario. II Life History, Behaviour and Host Relationship. Canadian Entomologist, 89. pp554-563.

7. Matthews, G.A. (1979). Pesticides Application Methods Longmans, p. 4.

8. Naylor, A.G. (1974). Diseases of Plants in Jamaica. Ministry of Agriculture, p. 26.

9. Pimentel, D. (1976). World Food Crisis: energy and pests. Bulletin of the Entomological Society of America, 22 pp20-26.

10. Simmonds, F. J. and Greathead, D. J. (1977). Introductions and pest problems. In: Origins of Pest, Parasite, Disease and Weed Problems. Blackwell, Oxford pp109-124

11. van Emden, H. F. (1964-65). The Role of Uncultivated Land in the Biology of Crop Pests and Beneficial Insects. Scientific Horticulture 17. pp121-136.

12. Way, M. J. (1978). Integrated Pest Control with Special Reference to Orchard Problems. Reprint from East Malling Research Station for 1977. pp187-204.

13. Way, M. J. (1979). Pest and disease status in mixed stands vs. monoculture; the relevance of ecosystem stability Annals of Applied Biology.

14. Way, M. J. and Bevan D. (1977). Dilemmasin forest pest and disease management. In Ecological Effects of Pesticides. Perring, F. H. and Mellanby, K., editors. Linnaean Society Symposium Series No. 5. p. 99.

SELECTED REFERENCES ON MULTICROPPING SYSTEMS WITHIN THE COMMONWEALTH CARIBBEAN

by
G. H. Barker
Agricultural Communication Specialist
Caribbean Agricultural Research and Development Institute.

PREFACE

This Seminar on Multicropping held in Jamaica comes at a time when CARDI programmes within the region are oriented towards investigating farming systems, in which are included inter alia crops and livestock.

As part of this investigation, the Institute is compiling a Bibliography which should serve to indicate the areas in which some research has already been carried out and where further investigations are required.

Access to the card index filed by Miss Laura Roberts, previously with CARDI is gratefully acknowledged. It is hoped that this bibliography will be of value to other workers in the field. This work was financed from the CARDI/USAID Small Farm Multiple Cropping Systems Research Project 538-0015.

December, 1980.

ABBREVIATIONS

A I C T A	Associateship of the Imperial College of Tropical Agriculture
D T A	Diploma in Tropical Agriculture
I C T A	Imperial College of Tropical Agriculture
I D R C	International Development Research Centre
I I C A	Interamerican Institute of Agricultural Sciences
I S E R	Institute of Social and Economic Research
J. Agric. Soc. Trin.	Journal of the Agricultural Society of Trinidad and Tobago
MAJ or MOAJ	Ministry of Agriculture, Jamaica
U C W I	University College of the West Indies
U N D P	United Nations Development Programme
U W I	University of the West Indies
W I N B A N	Windward Islands Banana Growers Association
A I D	Agency for International Development, (USA).

'A'

AHMAD, N. Growing rice in three Caribbean countries. Caribbean Farming v. 1 (4), p. 6-8, 1969.

AITKEN, P., WAHAB, A., JOHNSON, I, & SAHNI, A. Agro-Socio-Economic Survey - Plot Hillside Agricultural Project (PHILAGRIP) Southern Trelawny, Jamaica. IICA/JMAMICA Report No: IV-4, 1980.

'B'

A Bibliography of the Commonwealth Caribbean Peasantry 1838-1974. Occasional Biblipgraphy Series No. 3. Cave Hill, Barbados UWI/ISER, 47 p. 1975 ed. Marchall, T. G.

BARRANT, C. I. Intercropping studies, in Annual Reports of the Coconut Industry Board Research Department 1971-72, 1972-73, 1973-74, 1974-75 and 1976-1977.

BELL, L.A. A Social, Economic and Agricultural Survey of Peasant Agriculture at Aranguez Estate, Trinidad. AICTA Thesis, University College of the West Indies 1951.

BORLAND, C. C. Farming under the Milpa System Proc. 5th West Indian Agricultural Economics Conference, Dept. of Agricultural Economics and Farm Management, UWI, Trinidad 1970.

BORLAND, C. C. An economic study of Domestic Food Crop Production of Agricultural Economics and Farm Management, UWI. Trinidad 1975.

BRADFIELD, R. L. Intensive Multiple cropping. Tropical Agriculture (Trinidad), v. 51 (2), p. 91-93, 1974.

BRATHWAITE, C. W. D. Effect of crop sequence and fallow on populations of Rotylenchus reniformis in fumigated and untreated soil. Plant Disease Reporter v. 58 (3) p. 259-261 1974.

BRATHWAITE, R.A.I. Cropping recommendations for Barbados. CARDI. Technical Bulletin No. 1, 7p. 1976.

BROWN, C.B. Some aspects of Agricultural Land Use. Land Capability Survey of Trinidad and Tobago. No. 1 Tobago 1965.

BURGESS, R.A. and McCATTY, T. Pre-emergence Herbicide Trial in Black Eye Pea, Inter-cropped cane. Sugar Industry Research Dept. Annual Report, Jamaica 1977.

'C'

CAMPBELL, L.G. Production methods in West Indian Agriculture. Caribbean Quarterly v. 8 (2), 1963.

CAMPBELL, L.G., de BARRY, O., et al. Production on small farms in St. Vincent. ISER Agricultural Series No. 4 UWI 1966.

CARR, T.N.A. Succession (Rotation) in Vegetable Growing. Farmers Bulletin 1A Ministry of Agriculture, Lands and Fisheries, Trinidad and Tobago 1968.

COULTER, J.K. and TWYFORD, I.T. Soil and Land-use Problems in the West Indies. World Crops, v. 15 p. 349-354, 1963.

CROPPER, J. (ed.) Texaco Food Crops Farm Report - Annual Report 1974-1975, Faculty of Agriculture, UWI, Trinidad 1976.

CROPPER, J. and FERGUSON, G. (eds.) Texas Food Crops Report - Annual Report 1975-76. Faculty of Agriculture, UWI. Trinidad 1977.

'D'

DANIEL, G.A. Towards the re-diversification of St. Vincent's Agriculture. Proc. 6th West Indian Agricultural Economics Conference, Dept. of Agricultural Economics and Farm Management, UWI Trinidad p. 75-84, 1971.

DEMAS, W.G. The prospect for developing agriculture in small Commonwealth Caribbean Territories - the role of the small farmer. Proc. 5th West Indian Agricultural Economics Conference, Dept. of Agricultural Economics and Farm Management, UWI. Trinidad p. 3-11, 1970.

DINDIAL, C. Growing Food Crops Together with Sugar cane. Extension Newsletter Department of Agricultural Extension, Faculty of Agriculture, UWI. 9 (3); p. 12-14. 1973.

DUNCAN, N. Small Farming in Jamaica - A Social Scientist's view. Anchor Books 1973.

'E'

EDWARDS, D. F. Survey of the practice of mixed culture and intercropping. AICTA Thesis, Trinidad 1952.

EDWARDS, D. T. An economic study of small scale agricultural production in Jamaica with particular reference to possibilities of change. Ph. D. Thesis, London University, 1959.

EDWARDS, D. T. An economic study of small scale farming in Jamaica. ISER, Jamaica UCWI, 370pp., 1961.

EDWARDS, D. T. Report on an economic study of small farming in Jamaica. ISER, UCWI Jamaica 1961.

EDWARDS, DT. Entrepreneurial behavious of farmers in "Selected Readings to accompany Getting Agriculture moving"; Essentials for development and modernisation (R. E. Borton Ed.), A/D/C, N. Y., 1966.

EDWARDS, D. T. Small scale farming in the Commonwealth Caribbean, UWI, Trinidad. Dept. of Agric. Econ. and Farm Management 1971.

EDWARDS, D. T. and MORGAN-REES, A. M. The agricultural economist and peasant farming in tropical conditions in International Exploration of Agricultural Economics. Iowa State University Press 1964.

EDWARDS, D. T. and STRACHAN, O. M. The future of Small Farming in the Commonwealth Caribbean A preliminary consideration of some of the issues. Proc. 5th West Indian Agricultural Economics Conference. Dept. of Agricultural Economics and Farm Management, UWI Trinidad p. 74-77 , 1970.

EDWARDS, D. T. and STRACHAN, O. M. The future of Small farming in the Commonwealth Caribbean. Preliminary consideration of some of the issues. Department of Agricultural Economics and Farm Management, UWI, 1964.

'F'

FAO/UNDP/AID. Economic Study of Small Hillside Farmers in the Lucea/Cabritta Watershed Complex Jamaica F. O. : SF/JAM 5 Rome 1972.

FAO/UNDP/AID. Appraisal Report of Pedro Plain. St. Elizabeth - Agronomy and Sociological Study and Irrigation proposal, Technical Report, Jamaica: AGI: SF/JAM 5 Rome 1972.

FAULKNER, O. T. and SHEPHARD, C. Y. Mixed Farming - the basis of a System for West Indian peasants. Tropical Agriculture (Trinidad), v. 20 p. 136-142, 1943.

FERGUSON, T. U. Studies on the Intercropping of Corn and Sweet Potato. Proc. 12th Annual Meeting of the Caribbean Food Crops Society (Jamaica) 1974.

FERGUSON, T. U. Multiple cropping and its relevance to Trinidad and Tobago. Journal of the Agricultural Society of Trinidad and Tobago, v. 72 (3) p. 359-369/ 1972.

FRAMPTON, A. de K. Land problems in Small scale farming, in 'Small scale farming in the Caribbean'. Caribbean Commission, Trinidad 1954.

'G'

GANPAT, R. Results of Cropping Systems in Texaco Food Crops Farm Report - Annual Report 1974-75 ed. J. Cropper, Faculty of Agriculture UWI. 1976.

GANPAT, R. Results of Cropping Systems in Texaco Food Crops Farm Report. Annual Report 1975-76, eds. J. Cropper and G. Ferguson, Faculty of Agriculture, UWI, Trinidad, 1977.

GURNEY, J.M. Staple Foods for the Caribbean - Nutritional considerations Cajanus, v. 8 (1) 3p. 1975.

'H'

HALCROW, M. and CAVE, J.M. Peasant Agriculture in Barbados. Department of Science and Agriculture, Bulletin No. 11 (New Series) Barbados 1947.

HENDERSON, T.H. and GOMEZ, P.I. A Profile of Small Farming in St. Vincent, Dominica and St. Lucia - Report of a Baseline Survey, Dept. of Agricultural Extension, UWI, Trinidad 1979. (Prepared for CARDI)

HENDERSON, T.H. and MAHABIR, S. Fifty Years of Research in Tropical Agriculture 1922-1972. A Bibliography. Dept. of Agricultural Extension, UWI, Trinidad.

HENRY, D.D. Brief Overall Diagnosis of Hillside Farming in Jamaica. IICA Report Jamaica No. 1-12, 1978.

HILL, I.D. Soil and Land-use Surveys No.'s 19A & B. Antigua and Barbuda. Regional Research Centre, Dept. of Soil Science, UWI, Trinidad.

'I'

IICA/JAMAICA. Pilot Hillside Agricultural Project (PHILAGRIP) Project Document. Vols. 1, II and III. IICA Report No. IV-II, 1980.

IICA JAMAICA STAFF. Agro-Socio-Economic Sample Survey of Allsides - Trelawny, Jamaica IICA Report No. III-4, 1979.

IICA-MAJ. Hillside Farming in Jamaica - A Training Seminar, IICA Report Jamaica No. III-2, 1978.

IICA AND MOAJ. Hillside Farming Technology - Intensive Short Course, Vols. 1 and II IICA Report Jamaica No. 1-9, 1978.

INNIS, D. Q. Peasant farming. Banana Intercropping in Jamaica. Proceedings of the Association of American Geographers. v. 5 p. 111-117, 1973.

IRVINE, N. F. The Effect on Yields of Intercropping Maize with Soya-bean, French/bean and Cowpea. DTA Report, UWI, Trinidad 1953.

'J'

JAMES, L. T. Lot 10 - The introduction of a small farm project in an oilfield area. UWI Trinidad: Occasional Series No. 4. Department of Economics and Farm Management. 1969.

JENKIN, R. H., ROSE-INNIS, R. et al. The Agricultural Development Potential of the Belize Valley, Belize. Land Resource Study 24. Land Resources Division, Ministry of Overseas Development, England, 1976.

JOINT CONFERENCE OF EDUCATION AND SMALL SCALE FARMING, TRINIDAD 1954. Selected documents on "Small Scale farming in the Caribbean". Caribbean Commission 1954.

JOLLY, A. L. Peasant Farming in the Bejucal Area of Trinidad. Tropical Agriculture 22 (5) p. 83-88, 1945.

JOLLY, A. L. Report on Peasant Experimental Farms at the Imperial College of Tropical Agriculture, Trinidad. Central Secretariat, Caribbean Commission, Trinidad 1954.

JOLLY, A. L. Mixed farming in the Caribbean, Turrialba, Vol. 8, p. 52-54, 1958.

'L'

LANCELOT, H. Traditional Systems in Hillside Farming, Upper Trelawny, Jamaica. IICA Report No. IV-10, 1980 Jamaica.

LANG, D.M. Soil and Land Use Surveys No. 21 Dominica. Regional Research Centre, Dept. of Soil Science, Trinidad 1967.

LANG, D.M. and CARROL, D.M. Soil and Land Use Surveys No. 16. St. Kitts and Nevis. Regional Research Centre, Dept. of Soil Science, UWI, Trinidad 1966.

LITTLE, B.G., BUCKLEY, D.K., et al. Land Resources of the Commonwealth of the Bahamas, v. 5a Grand Bahamas. Draft Land Resource Study, Land Resources Division, Ministry of Overseas Development, England 1975.

'M'

MAHARAJ, D. The Small Farmer in the Trinidad Sugar Industry. Proceedings of the 5th West Indian Agricultural Economics Conference, Dept. of Agricultural Economics and Farm Management, UWI Trinidad, p. 104-128, 1970.

MARSHALL, T.G. (ed.) A Bibliography of the Commonwealth Caribbean Peasantry 1838-1974, Occasional Bibliography Series No. 3. Cave Hill, Barbados UWI/ISER, 47p. 1975.

MINAG, JAMAICA. An Agro-Socio-Economic Sample Survey. Pindars River and Two Meetings Areas, Data Bank and Evaluation Division Ministry of Agriculture, 1979.

MOMSEN, J.D. Small Scale Farming in Barbados, St. Lucia and Martinique. Proc. 5th Agricultural Economics Conference, Department of Agricultural Economics and Farm Management, UWI, Trinidad, p. 78-84, 1970.

MOMSEN, J.D. Report on a Banana Survey of the Windward Islands, WINBAN St. Lucia. 40p. 1966.

MOMSEN, J.D. The geography of Land use and population in the Caribbean (with special reference to Barbados and the Windward Islands). Report tof the Windward Islands. University of London 1969.

MOMSEN, J.D.C. Small-scale farming in Barbados, St. Lucia and Martinique. Proceedings 5th West Indian Economic Conference. Department of Agricultural Economics and Farm Management, UWI Trinidad, p. 78-84, 1970.

MORRISON, C.J. Peasant Farming in Barbados, The Farmer v. 55, p. 31-35, 1951.

MULHOLO, S. Yield and Response of corn to Nitrogen following (1) Fallow, (2) corn and (3) Blackeye Peas. Extension Newsletter 9 (4): 8-9. Department of Agricultural Extension. Faculty of Agriculture, UWI Trinidad 1978

MacMILLIAN, A.A. The development of Market Gardening inAranguez, Trinidad. Ph. D. Thesis. Department of Agricultural Economics and Farm Management, UWI Trinidad 1967.

'N'

NURSE, O.J. Small-scale farming in Barbados. Proceedings 5th West Indian Agricultural Economics Conference. Department of Agricultural Economics and Farm Management, UWI Trinidad, p. 85-102, 1970.

NOEL, D. and MARECHEAU, G.I. A strategy for small-scale farming in the Commonwealth Caribbean with special reference to Grenada. Proc. 5th West Indian Economics Conference. Dept. of Agricultural Economics and Farm Management. UWI Trinidad, p. 162-165, 1970.

'O'

OHLER, J.H. Cattle grazing under coconuts intercropping. Journal of the Agricultural Society of Trinidad and Tobago v. 74 (4) p. 352-361, 1974.

'P'

PANE, H.J. Peasant Agriculture Investigation at the Imperial College of Tropical Agriculture. Proceedings of the Agricultural Society, of Trinidad and Tobago 47 (4), 293-310, 1947.

PARASINOS, C.C., SHEPHERD, C.Y. and JOLLY, A.L. Peasant agriculture. An Economic survey of the Las Lamos District, Trinidad. Tropical Agriculture (Trinidad), v. 21 (5) p. 84-88, 1944.

PARASRAM, S. and PHELPS, R.H. Small Farm Multiple Cropping systems. Journal Agricultural Society, Trinidad and Tobago v. LXXIX, p. 181-193, 1979.

PETERS, D.U. Mixed cropping and peasant agriculture: A Survey in Trinidad and Tobago. AICTA Thesis, 1941.

'R'

RAO, M.N. Banana Cropping Systems. Second Annual Report June 1979 - May 1980, Project financed by IDRC, Canada. WINBAN Research and Development Division 1980.

RAO, M.N. Report on Banana - Intercropping Survey (Cropping System) Windward Islands Banana Grower's Association (WINBAN) 1979.

RAO, M.N. Banana Cropping Systems. First Annual Report June 1978 - May 1979. Project financed by IDRC, Canada. WINBAN Research and Development Division, 1979.

'S'

SCHRODER, D. An Economic Analysis of Intercropping systems. Case Study, Allsides Development Pilot Project. Jamaica. IICA report 1979.

SHANNON, J.L. Growing more food through mixed farming. Journal of the Agricultural Society of Trinidad and Tobago. v. 51 (2) p. 238-241, 1951.

SHEKOUR, G. A Study of Systems of Intercropping Corn (*Zea mays* L.) and Pigeon Pea. (*Cajanus cajan* (L.) Millsp.) in Trinidad. M. Sc. Thesis, UWI, Trinidad, 1973.

SHEPHARD, C. Y. Peasant agriculture in the Leeward and Windward Islands ISER, ICTA, Trinidad 1945.

SINGH, N. D. Effects of intercropping maize with soybean on crop yields and populations of several plant-parasitic nematodes. Journal of Nematology v. 10 (4), p. 299, 1978.

SKEETE, C. C. The condition of peasant agriculture in Barbados. Department of Science and Agriculture, Bridgetown 1930.

SMITH, R. W. Catch Cropping and Intercropping studies in Annual Report of the Coconut Industry Board Research Department. 1970-71.

STANFORD, D. C. Studies on present and potential use of marginal and submarginal cane lands including trials on Irish potatoes, sunflower, sorghum, soya bean, peanut and onion. Screening for salt tolerance of these and also of salt bushes for forage, cassave, sweet potato and other root crops. Sugar Industry Research Dept. Jamaica Annual Report 1978.

STARK, J. Soil and Land Use Surveys No. 14, Jamaica. Parish of St. Elizabeth. Regional Research Centre, Dept. of Soil Science, UWI Trinidad. 1963.

STARK, J. Soil and Land Use Surveys No. 17, Jamaica. Parish of Manchester Regional Research Centre, Dept. of Soil Science, UWI Trinidad 1964.

STARK, J., LAJOIE, P., and GREEN, J.A. Soil and Land Use Surveys, St. Lucia No. 20, Regional Research Centre, Dept. of Soil Science UWI Trinidad 1966.

SUGAR INDUSTRY RESEARCH DEPARTMENT, JAMAICA. Investigations on Rotation of Crops as a means of controlling nematodes. Annual Report Research Dept. 1959.

A SYMPOSIUM. Planning Agriculture in Low income countries. Reading University Dept. of Economics and Management 1974.

'V'

VAN HECK, B., and McCULLOCH, C. Small Hill Farmers in Jamaica. Report on socio-economic and socio-cultural problems of the Hill farmers in Lucea Cabritta watershed in the Parish of Hanover, Jamaica. UNDP/SF/FAO and Ministry of Rural Land Development in Jamaica, 1969.

VERNON, K.C. and JONES, T.A. Soil and Land Use Surveys No. 1. Jamaica. Parish of St. Catherine. Regional Research Centre, Dept. of Soil Science UWI Trinidad 1958.

VERNON, K.L. and CARROLL, D.M. Soil and Land Use Surveys No. 18, Barbados, Regional Research Centre, Dept. of Soil Science UWI Trinidad 1965.

'W

WAHAB, A., JOHNSON, I., AITKEN, P. et al. Highlights of the Pilot Hillside Agricultural Project. IICA Report Jamaica. No. IV-12, 1980.

WATSON, J.P., SPECTOR, J.; and JONES, T.A. Soil and Land Use Surveys No. 3, St. Vincent. Regiona; Research Centre, Dept. of Soil Science, UWI Trinidad 1958.

WEDDERBURN, M.R. The Co-operative Input in the Development of the Pilot Hillside Agricultural Project (PHILAGRIP). IICA/JAMAICA, Report No. IV-8, 1980.

WEIR'S AGRICULTURAL CONSULTING SERVICES LTD. Small Farming study in the less developed member territories of the Caribbean Development Bank. Country Reports. v. 1(a) Prepared for the Caribbean Development Bank 1974.

WICKIZER, U.D. The small holder in tropical export crop production. Food Research Institute studies. I (1) Feb. 1960 p. 49-99.

WILLIAMS, C. H. B. Peasant Farming in the British Caribbean. Journ. Agric. Soc. of Trinidad and Tobago, v. 54 (2), p. 226-236 1954.

WILLIAMS, E. E. The Importance of Small farming in the Caribbean IN "Small scale Farming in the Caribbean." Caribbean Commission. Trinidad 1954.

'Y'

YANKEY, B. and WATTY, F. A small agricultural economy in CARIFTA: The Case of Dominica. Proceedings of the 4th West Indian Agricultural Economics Conference, Department of Agricultural Economics and Farm Management, UWI Trinidad, p. 114-120, 1969.

CROPPING SYSTEMS AS THEY AFFECT HUMAN AND NATURAL RESOURCE UTILIZATION ON SMALL FARMS ON THE HILLSIDES OF JAMAICA

by
Horace Payne

Introduction

Small farms provide a sound basis for gainful employment of excess labour with limited skills and at the same time are capable of high levels of productivity. Unfortunately, in Jamaica many of our small farms are characterised by low levels of productivity causing average performance to be unsatisfactory. For example, production is about 500 lbs. per acre for red peas, about 6 tons per acre for yam while banana does not average better than 3 tons per acre.

The purpose of this paper is to describe some of the more commonly employed cropping systems on small farms on the hillsides. Attention is focussed on their technology and management in order to give an indication of their efficiency and effectiveness. A three-tier cropping system involving coconut, banana and dasheen is used as a case to show how permanent intercropping systems of production make better use of our natural and human resources on hillsides while reducing dependence on foreign inputs. Relay cropping involving fruit trees provides a strategy for transforming our much abused hillside and allowing the largest farming community to play a more meaningful role in the country's economy.

Types of Cropping Systems

Cropping systems can be considered as belonging to two major groups:

(1) pure-stand cropping systems
(2) mixed cropping systems

Each of these groups has a number of advantages and disadvantages according to circumstances.

1. A pure-stand cropping system is said to exist when an area of sufficient size to be managed as a separate unit is occupied by plants of a single economic species throughout its life span. Within the easily defined boundaries of this unit, competition for space, light and nutrients are between plants that are genetically similar. Except for weeds which are removed as quickly as possible, interactions with other economic plants occur peripherally and or to a minimal extent being part of the total environment of the farm.

(a) Mono-cropping develops where the same area is repeatedly established in the same crop without any intervening economic use of the land. Diagram I showing time frame of Crop A,

Crop A		Crop A
Jan.	June	Dec.

Examples are to be found in the continuous cropping of sugar cane or banana or rice, the areas involved do not necessarily have to be large. Monoculture represent the highest degree of specialization in land use.

(b) Rotational Cropping develops when there is change from one crop to another; each completing its life cycle before the other is established.

Diagram 2. showing time frame of crops A, B and C.

Crop A		Crop B		Crop C	
Jan.	Apl.	May	Sep.	Oct.	Dec

The merits of crop rotation are too well known to warrant discussion here except to state that advantages are derived from differential feeding of nutrients from the soil by planning the sequence of short term crops - say a fruit crop, followed by a root crop in turn followed by a legume. Opportunity for the build-up of specific groups of pest and diseases associated with the environment of monocropping systems is eliminated by the change from one crop to another. The significance of obtaining

better utilization of fertilizer from a crop like peanut that benefits from the residual effect of fertilizer as well as supplying atmospheric nitrogen or the effect of following tomatoes with corn to reduce nematode build-up come to mind as means for increasing productivity as well as saving foreign exchange for chemicals.

(c) Strip Cropping in which crops are established on the contour or across the slope to reduce soil erosion complete the grouping of pure-stand cropping systems encountered on small farms.

2. Mixed Cropping Systems occur when two or more crops occupy the same area at the same time. In this system there is considerable competition taking place between plants of different species at least for a part of their life spans.

A number of types of mixed cropping system can be distinguished on the basis of time and duration of interactions of the crops involved.

(a) Relay Cropping. The crops may be planted together with the commencement of the rainy season. Combination of potatoes and red peas in the Christiana Area comes to mind readily.

(b) Permanent Intercropping. Temporary shade is established by banana after which permanent tree crops of cocoa or coffee are planted. The establishment of pineapples amongst citrus groves fall in this group.

Farm size and Cropping Systems

The areas described as small farms vary considerably in size. The very small holding with home gardening and where the produce is used mainly for the home is not considered in this exercise as being sufficiently large as to qualify as a management unit in farming as a business enterprise of crop production.

It is important to point out the difference between mixed stand cropping systems and mixed farming. Mixed stand cropping systems like pure stand cropping systems may be regarded as the building blocks that comprise the farm. In this analogy the farm is the building. Many farms possess both pure stand and mixed

stand cropping system; much confusion exists in the literature and everyday use of the terms to characterise farming enterprises and terms such as multiple cropping and companion cropping are used inter-changeably. There is need to standardise terms so as to avoid confusion between systems of production on a micro scale and what is occurring on the macro scale either involving the entire farm or area of the community. Generally a strip cropping system is taken to refer to the layout of a pure stand cropping system, but there is no reason why the layout should not describe a mixed stand cropping system. Similarly rotational cropping usually emphasises the change in the sequence of pure stand cropping systems, but mixed stand cropping systems can also be rotated. Whenever emphasis is placed on layout or sequence of cropping it is taken to refer mainly to short term crops. The dominance of machine technology is such that several crops are referred to as row crops. Finally the term cash crops is used to include all crops in which returns can be made within periods of a year. These distinctions all lead to confusion in establishing the special merits of pure and mixed stand cropping systems. There are advantages of specialization with pure stand systems and there is no need to mix the systems so to speak in order to get the advantages of diversification such as reduced risk.

Low levels of production and productivity

Problems of hillside productivity are complex socio-economic ones rooted deeply in our colonial past and there is no panacea or quick cure. Many factors have combined to cause small farmers generally to realise low returns from their effort. Although the hillside farmer must be given credit for his courage, it must be realised that a disregard for soil conservation, improved agronomic practices and management are the prime causes for his hardship. Changes in attitude and skills are essential. Scientific objectivity demands accurate assessment of the situation as a forerunner to possible solution in the best interest of the country.

Soil erosion

The soil and land use surveys of Jamaica carried out by the Regional Research Centre of the University of the West Indies show that incalculable soil losses have occurred and the fact that small farms on the hillsides are still capable of

producing most of the food that feed the country attest to the speed of weathering and rejuvenation of the soil that occur on many parent materials, for example the shales, the granodiorites and trappean conglomerates.

Uneconomic use of land

Poor farm planning reflected in the haphazard layout of crops that preclude the use of modern technology have combined with the backbreaking traditional practices of the cutlass/hoe/fork to cause uneconomic use of land. Indeed, field investigations reveal that some of the worst offenders of under-utilised and idle land occur on small holdings. Forms of restricted "shifting cultivation" occur. There is inadequate fertilizing and no scientific justification in the sequence of cropping. Irregular shaped areas correctly described as patches are intensely cultivated to short term crops and on exhaustion are allowed to regenerate into ruinate pasture.

The efficiency of labour in cropping systems

In most short term crops, legumes and grains - production technology involving machines (capital intensive technology CIT) have reached a high level of sophistication. Every operation from land preparation, seeding, fertilizing through to harvesting can be carried out by machines. To use hand methods aided by simple tools (labour intensive technology LIT) to carry out any of these operations will be slow and deplorably inefficient. For these crops, the cost of labour in terms of its productivity is high. A completely different situation however obtains in tree crop operations simply because the necessary machines have not yet been either developed or extensively used. Coffee operations serve as a good example where hand methods are most efficient and effective. There are no machines to plant coffee, prune the tree or pick its berries. Labour employed in any of these coffee operations and similarly for most fruit tree operations can be efficient and the resulting products competitive on any market.

It follows from this situation that the best way the Jamaican farmer with limited skills and simple tools can become efficient is to go in for those crops in which his labour will <u>not</u> be competing with highly skilled labour aided by sophisticated

machines. It can be shown that small farmers in Jamaica actually enjoy what is called a comparative advantage in the production of Blue Mountain Coffee. The peculiar combination of climatic factors particularly at high elevation interact with the Arabica typica to give its berries and enviable flavour that earns perferentially high prices as a blend to other coffee.

Reducing foreing inputs in cropping system

If the requirements for various crop production systems are examined to ascertain what inputs have to be supplied from abroad as against those that can be provided locally, it will be realised that in permanent crop production systems that the Jamaican input is maximised. All crops require fertilizer and pesticides for efficient production but in tree crop production systems there is minimum need for tillage operations involving expensive fuel and machinery; inputs sudh as seeders, threshers and combines. In many of the vegetable crops, the very seed have to be imported.

The effectiveness of cropping systems in natural resource utilization

Conservation refers to the optimum utilization of land in perpetuity in support of human life. Man-made or accelerated erosion sets in whenever the natural vegetative cover is removed and the best strategies for land utilization of hillsides for erosion control must have as its objective creation of conditions approximating that of its original protective cover so that only geologic erosion takes place.

Although there is considerable differences in the soil binding properties of plantroots, their soil protective qualities depend largely on the duration, completeness and to a lesser extent on the height of those covers. The diagram below reflects the principle without any pretence of completeness or indication of the order of merit Indeed, accuracy in this respect, is an area rich for investigation.

Short Term		Medium Term	Long Term
Very short less than 4 months	Usually more than 6 months	Usually more than 12 months	Usually for several years
Most vegetables and potatoes, tomato, cabbage, red peas, peanuts, irish potato, onion, lettuce, callaloo, etc.	Most root crops - yam sweet potato, dasheen, congo peas, sweet and hot pepper, sorrel, etc.	Cane, banana plantain, pineapple, pawpaw, etc.	Permanent crops Coco, coffee, -pimento. Orchard crops mango, pear, citrus. Misc. fruit breadfruit, ackee, grapes

Cropping systems that ensure continuous cover are to be preferred for soil conservation reasons. Pure cropping systems of short term crops afford the least protection against soil erosion.

Solar energy - With our 365 days growing season, maximum utilization of solar energy and water all call for a continuous crop cover and the cropping system that does this best is proceeding consistent with utilization of our climatic resources. Systems of crop production that utilize the land for only a part of the year must be down graded as to its suitability. Hence the value of crop rotation of pure stands admirably suited to temperate climates where they cannot be avoided, must be questioned in Jamaica as the very change from one crop to another represents a waste of solar energy. The reasons for high efficiency of sugar cane in this regard comes to mind.

Water - The benefits of permanent cropping system involving fruit trees are so well known that this a spect does requir e e la boration. Fruit trees and forest will safeguard our underground water s upplies and make our s treams flow clear. Indeed Jamaica will again be the land of wood and water.

Relay cropping provides a strategy for a shift from short term cropping systems to more permanent crops. Areas in which temporary crops are already established are interplanted with a more permanent crop thus providing a period of overlap in which two or more crops occupy the same land simultaneously. Landlords often exploited the peasant by allowing them the use of wooden areas temporarily for the cultivation of cash crops. The Landlord eventually establishing his permanent crops. The small farmer can conserve his land in a similar way. The temporary crops will sustain him until such time the more permanent crops come to bearing. With old age of the farmer the amount of intercropping can be reduced.

Three tier cropping systems take on several forms but the most popular one involves coconuts, banana and dasheen. The advantages are:

(1) solar energy is fully utilised for 365 days at three levels and dasheen does well at the low level.

(2) erosion control is at a maximum as the cover is complete.

(3) underground water supplies are safeguarded as run off is minimal.

(4) weed controk is at a maximum with the crop shading out weed growth. There is reduced need for weedicides that have to be imported and often serve to pollute our water supplies.

(5) enchanced fertilized uptake in a recycling process. Whatever nutrients escape the shallow ground level crop is captured by the deep rooting crop. Also the litter of the crops are used to maximise advantage.

(6) minimum tillage advantages are derived as there is no need for tillage.

Comparison of yield levels of pure stands and mixed stand cropping system.

Much higher yield levels can be obtained from pure stand systems of production as a result of the higher levels of technology and management that have been developed. It pays to specialise, economicies of size come into play and subsequent marketing of produce is simplified. Crop competition will always reduce yield levels in mixed stands even where spacing arrangements are made as compatible as possible, amount short term crops, but if the mixed stand includes crops varying appreciable in their duration basis efficiencies of solar energy utilization, nutrient uptake from different depths etc., will all favour the mixed stand system. With the small farmer land is the limiting factor and the aggregated returns of mixed cropping stands will be greater, although the individual crop yield levels will be lower. This advantage of mixed cropping stands will be appreciatable where the farmer does not have the skills for higher pure stand yield. Furthermore, he obtains his income more evenly. Unfortunately many small farmers have taken the merits of mixed crop stands to a ridiculous point.

Volunteers plants are tolerated and they fail to fertilize adequately and as a result yeild levels become low. Hence, it is the level of management associated with pure stands cropping systems that is primarily responsible for their better record of performance.

Conclusions

Small farmers on our hillsides should be devoted to fruit trees with intercropping of short term crops. Such a system will make best use of all their limited resources, conserve their soil as well as meet their social needs and carry Jamaica to a state of prosperity.

AGRICULTURE IN JAMAICA

Collection of papers of the Office of IICA in Jamaica

1977 - 1978

No. I - 14 R.C.E. McDonald, A.H. Wahab, "Fertility Assessment of Newly Terraced Hillside Soils Using the Microplot Technique - The Allsides Case Study", 1978

No. I - 15 IICA - IDB, "Course in Preparation and Evaluation of Agricultural Projects", Vols. I and II, November 1977

No. I - 16 Neville Farquaharson, "Production and Marketing of Dasheen in Allsides and Christiana", June 1978

1978 - 1979

No. II - 1 O. Arboleda-Sepulveda (IICA-CIDIA), "Agricultural Documentation and Information Network in Jamaica"

No. II - 2 Victor Quiroga, "National Agricultural Information System" (NAIS-Jamaica) Project Profile, September 1978

No. II - 3 Joseph Johnson, "A Review on Land Reform in Jamaica for the Period 1972 - 1978", September 1978

No. II - 4 Neville Farquharson, "ABC of Vegetable Farming", A Draft High School Textbook, Vols. I, II, III and IV, February

No. II - 5 Jerry La Gra, "Elements of an Agricultural Marketing Strategy for Jamaica", March 1979

No. II - 6 D.D. Henry, I.E. Johnson, "Agricultural Extension Service in Jamaica", March 1979

1979 - 1980

No. III - 1 H.R. Stennett, "Watersheds of Jamaica and Considerations for an Ordinal Scale of Their Development", July 1979

No. III - 2 IICA-MAJ, "Hillside Farming in Jamaica", A Training Seminar, December 1978

No. III - 3 A.L. Wright, A.H. Wahab, H. Murray, "Performance of Six Varieties of Red Peas (Phaseolus vulgaris L.) on a Newly Terraced Ultisol in Jamaica", September 1979

No. III - 4 IICA Jamaica Staff, "Agro-Socio-Economic Sample Survey of Allsides - Trelawny, Jamaica", September 1979

No. III - 5 IICA-MOAJ, "An Approach to Agricultural Settlement of Hilly Lands", October 1979

No. III - 6 IICA-MOAJ, "Tree Crops of Economic Importance to Hillside Farms in Jamaica", October 1979

No. III - 7 Canute McLean, "Production and Marketing of Peanuts" November 1979

1980

No. IV - 1 Joseph Johnson, "Production and Marketing of Red Peas in the Hilly Areas of Jamaica", January 1980

No. IV - 2 Lyn Snuffer, "Rural Women: An Annotated Caribbean Bibliography with special reference to Jamaica", January 1980

No. IV - 3 Vincent Campbell, Abdul Wahab, Howard Murray, "Response of Peanut (Arachis hypogaea L.) on a Newly Terraced Ultisol in Jamaica", January 1980

No. IV - 4 P. Aitken, A. Wahab, I. Johnson, A. Sahni, "Agro-Socio-Economic Survey - Pilot Hillside Agricultural Project "PHILAGRIP" Southern Trelawny, January", February 1980

No. IV - 5 Glenys H. Barker, "Bibliography of Literature relating to Research and Development in the Agricultural Sector of Jamaica 1959 - 1979," March 1980

No. IV - 6 Milton R. Wedderburn, "Allsides Farmers Pre-Co-operative A Socio-Economic Assessment", March 1980

No. IV - 7 Adele J. Wint, "The Role of Women in the Development Process", April 1980

No. IV - 8 Milton R. Wedderburn, "The Co-operative Input in the Development of the Pilot Hillside Agricultural Project (PHILAGRIP)", April 1980

No. IV - 9 MOJ/IICA/CARDI, "Fruit Trees Seminar - Research & Development of Fruit Trees", June 1980

No. IV - 10 Henry Lancelot "Traditional Systems in Hillside Farming, Upper Trelawny, Jamaica", June 1980

No. IV - 11 IICA/Jamaica "Pilot Hillside Agricultural Project" (PHILAGRIP), Project Document. Vols. I, II and III, June 1980.

No. IV - 12 A. Wahab, I. Johnson, P. Aitken, H. Murray and H. Stennett "Highlights of the Pilot Hillside Agricultural Project at Allsides", July 1980.

No. IV - 13 I. Johnson, A. Wahab, P. Aitken, H. Payne "Benchmark for a Project Profile for Developing a Peanut Industry in Jamaica", July 1980.

No. IV - 14 P. Aitken, A. Wahab, I. Johnson, "The Allsides Post Peasant", August 1980.

No. IV - 15 Norma Munguia, Percy Aitken, Abdul Wahab, Irving Johnson, "Salt Extraction by Solar Energy" A Mini-project, September 1980.

No. IV - 16 Abdul H. Wahab, Percy Aitken-Soux, Irving E. Johnson and Howard Murray, "The Allsides Project in Jamaica - Developmental Potentials of Hillside Agriculture", September 1980.

No. IV - 17 P. Aitken, A. Wahab, I. Johnson, A. Sahney and N. Munguia, "Rural Women Survey", Vols. I, II and III, October 1980.

No. IV - 18 P. Aitken, I. E. Johnson, A. Wahab, "Assessment of Employment Among Small Hillside Farmers of Jamaica", November 1980.

No. IV - 19 IICA/Jamaica "Pilot Hillside Agricultural Project", (PHILAGRIP), Final Project Document. October 1980

No. IV - 20 P. Aitken, A. Wahab, I.E.Johnson, Bo-Myeong Woo, "IICA Evaluation of the First Phase FSB Allsides Project", (Internal Document of Work), November 1980

No. IV - 21 MINAG/IICA/CARDI - "Seminar on Multiple Cropping", December, 1980

FECHA DE DEVOLUCION

COVER DESIGNED BY

api

AIS

NOVEMBER, 1980.