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AN APPROACH TO AGRICULTURAL SETTLEMENT OF HILLY LANDS FOR DIVISIONAL AND AREA EXTENSION OFFICERS

JAMAICA

MINISTRY OF AGRICULTURE

TRAINING DIVISION

and

INTER-AMERICAN INSTITUTE OF AGRICULTURAL SCIENCE

(I. I. C. A)

AN APPROACH TO AGRICULTURAL SETTLEMENT OF HILLY LANDS

for

DIVISIONAL AND AREA EXTENSION OFFICERS

RESIDENTIAL TRAINING COURSE
ELTHAM TRAINING CENTRE
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AGRICULTURE IN JAMAICA

Collection of papers of the Office of IICA in Jamaica

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

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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

INTRODUCTION

The manner in which the rural population is arranged on the land is one of the most important aspects of rural organization. The farms of rural settlements are used by various authors to refer to the relationships of the dwellings to one another as well as to the cultivated land.

The nature of the agricultural settlement in Jamaica which shows a great imbalance in the land tenure, made the different Government's of the country adopt a system of redistribution of the land which can be divided in the periods of:

Land settlement
Land lease, and
Pioneer farms

In Jamaica the problem is not only one of land tenure imbalance, but a problem of an efficient utilization of the land. In many cases the lands distributed to the small farmer were marginal in quality, and in others the technology applied to the usufruct of the land speeded the impoverishment and soil loss of the area.

The short course on "An Approach to Agricultural Settlements of Hilly Lands" has considered appropriate to deal not only with the tenure and spatial problems but with the technological system of land exploitation. This approach puts emphasis on the potential income from the land and its effect on the standard of living of the farmer and the quality of life for the household.

The course which was honoured with a lecture from the Permanent Secretary of the Ministry of Agriculture, Mr. Derrick Stone, was directed to Divisional and Extension Officers from that Ministry. The arrangements for the course were made by the Training Division of the Ministry of Agriculture. It is due at this time to give credit to Mr. Leonard Henry, Marilyn Clark, and the Eltham Training Centre for the excellent organization and service which made the course a success.

INTRODUCTION (Cont'd)

The excellent lectures presented in the course merit their collection and presentation an another document in the continuing series of papers prepared by IICA/Jamaica, "Agriculture in Jamaica".

Dr. Percy Aitken-Soux
Director
IICA-Jamaica

Kingston, October 1979

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M A J O R

S O I L

T Y P E S

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Prepared by: The Division of
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Lecture Presented by: PERCY MILLER

AGRICULTURAL CHEMISTRY DIVISION REVISED

FORWARD

In November 1940, the Department of Agriculture published an Extension Circular No. 14 describing the main soils in the Islands.

Since that time a detailed soil survey, parish by parish, has been carried out by soil surveyors attached to the B.W.I. Soil Research Scheme operated by the Regional Research Centre with headquarters at the Faculty of Agriculture in Trinidad and detailed reports on nearly all the parishes of the Island are now available.

Over one hundred soil types have been recognized and described in the field by the soil surveyors from 1951 to the present time and instead of speaking in general terms about Alluvial soils or Richmond Shale soils, the Land Use and Extension Officers of the Ministry of Agriculture are now able to determine the exact soil type of any piece of land for farmers all over the Island. Each soil type has been given a number for easy reference, and also carries the name of the district where it was first described. The name given to each soil type also bears some relation to the textural class in which the top-soil falls, e.g. sand, sandy loam, loam, clay, etc. For example in the Richmond Beds area at least four major soils with different properties have now been found. These are:-

No. 41 - Belfield Clay Loam
No. 43 - Highgate Clay
No. 46 - Halls Delight Channery Clay Loam
No. 47 - Llandewey Clay Loam

For some time the need has been felt for a simple guide to the new system of soil classification with a simple description of each soil type to enable farmers to recognise the soils on their farms and the Agricultural Chemistry Division of the Ministry of Agriculture has prepared this revised circular which should be regarded as presenting additional information on these soils.

As all general fertilizer recommendations for crops are based on a knowledge of the soil types listed on this circular it is suggested that Extension Officers, Branch Organizers and farmers should study this Circular and make a serious attempt to learn how to recognise the soils which occur in their districts and on individual farms.

MAJOR SOIL TYPES OF JAMAICA

Only soils with a total extent of 1,000 acres or greater are described.

For easy reference, the soils have been grouped into soil series. To find your soil in these tables:-

(a) determine the soil series by field observation
(b) study the various soils under the appropriate series as given in Table 1 - V111
(c) match the soil descriptions with the appearance of your soil in the field
(d) select the description which fits your soil then read "soil No." and "Soil type" from table.

TABLES	SOIL SERIES
1	Recent Alluvial soils
11	Old Alluvial soils
111	Red, Brown and Yellow coloured soils derived from Hard White Limestones.
1V	Marl soils and soils derived from soft white limestones and yellow limestone soils.
V	Richmond Shale soils
V1	Purple conglomerate soils (Wag water conglomerate soils).
V11	Soils derived from other shales conglomerates, tuffs (volcanic in origin), and sandstones.
V111	Soils derived from Granite and Porphyry.

TABLE 1

RECENT ALLUVIAL SOILS

These soils occur on the flood plains, along the banks and at the mouths of the main river system in Jamaica, mainly the Rio Cobre, Rio Minho, Wag Water, Rio Grande, Swift River, Plantain Garden River, Johnson and Yallahs Rivers and Milk River. These Rivers transport pieces of shale, sandstone, limestone and other materials which are present in the topography from which they originate and flow to the sea.

These soils vary in texture from sands and loam to clay loam and are in general, the most fertile soils in the Island. They usually occur on A and B slopes and are generally regarded as Class I lands. Crops grown on these soils respond very well to fertilizer, particularly Sulphate of Ammonia. Main crops are:- Bananas, tree crops, food crops, Improved pasture, sugar cane, vegetables and (tobacco).

SOIL NO.	Soil type	Description and Main Location	Important Characteristics
15	Cave Valley Clay Loam	Topsoil - black loam Subsoil - dark brown loam (Upper Clarendon)	A deep soil, slightly acidic, high fertility good internal drainage poor surface runoff.
21	Water Valley Silty Clay	Topsoil - dark grey "Mealy" clay Subsoil - paler coloured than topsoil; a "mealy" clay (St. Mary flat lands and Hanover)	A deep soil free lime, high fertility, fair internal drainage poor surface runoff.

Soil No.	Soil type	Description and Main Location	Important Characteristics
24	Agualta Sandy Loam	Topsoil - dark reddish brown sandy loam. Subsoil - paler colour than topsoil and more sandy. (All over the Island).	A deep soil neutral medium fertility, rapid internal drainage, a droughty soil
25	Frontabelle Clay	Topsoil -dark grey brown clay Subsoil - much paler colour than topsoil clay. (St. Mary, St. James, Hanover).	A deep soil, free lime, high fertility, medium internal drainage poor surface runoff.
103	Agualta Loam	Topsoil - dark reddish brown clay loam to loam. Subsoil - dark brown clay loam. (Rio Minho drains Clarendon)	A deep soil, neutral high fertility, good drainage, poor surface runoff.
124	Whim Sandy Loam	Topsoil - dark brown sandy loam. Subsoil - paler coloured than topsoil and heavier. (Plains of the Fowers Gully in St. Catherine).	A deep soil, free lime, high fertility, rapid internal drainage, poor surface runoff.
127	Caymanas Clay Loam	Topsoil - dark grey brown clay loam Subsoil - brown to yellow becomes coarse with depth. (Rio Cobre Plains in St. Catherine).	A deep soil, free lime, high fertility, good internal drainage, poor surface runoff.

Soil No.	Soil Type	Description and Main Location	Important Characteristics
128	Caymanas Sandy Loam	Topsoil - dark grey brown sandy loam. Subsoil - Yellow brown sandy loam, becomes coarser with depth. (Rio Cobre Plains St. Catherine).	A deep soil, free lime, high fertility, rapid internal drainage, poor surface runoff.

TABLE 11

OLD ALLUVIAL SOILS

These soils are generally heavier in texture, acid or highly acid than recent alluvial soils and in many areas are alkaline. These soils occur mainly in the plains of St. Catherine and Clarendon. Where high salt concentrations are not present, the soil is fertile and responds well to fertilizer, particularly applications of nitrogen.

This group also includes the "inland basin soils" which are highly acidic. These soils are found mainly in St. Thomas Ye Vale and Queen of Spain Valley. Main crops are:- Sugar cane, tree crops, pasture, food crops, rice and (tobacco).

Soil No.	Soil Type	Description and Main Location	Important Characteristics
106	Lluidas Gravelly Sandy Loam	Topsoil - dark reddish brown gravelly loam to clay loam. Subsoil - dark reddish brown gravelly sandy loam becomes more gravelly with depth. (Lluidas Vale in St. Catherine).	Moderately deep soil, very small amount of free lime, medium fertility, rapid internal drainage, a droughty soil.

Soil No.	Soil Type	Description and Main Location	Important Characteristics
122	Fellowship Clay	Topsoil - dark brown clay Subsoil - dark grey clay to clay loam with reddish yellow mottles. (In the vicinity of Fellowship in Portland).	A deep soil, small amount of free lime, medium fertility, very slow internal drainage, poor surface runoff. High water-table.
202	Rymesbury Clay	Topsoil - dark brown clay Subsoil - yellow brown clay with fine shot and slight mottle when wet. (Rymesbury and Clarendon Plains).	A deep soil, acid medium fertility, very slow internal drainage, poor surface runoff, may be saline.
203	Four Paths Clay	Topsoil - dark brown clay with soft shot. Subsoil - yellow brown clay which grades into a red mottled grey clay. (St. James, Clarendon, St. Elizabeth).	A deep soil, very acid, low fertility, very slow internal drainage, poor surface runoff.
204	Four Paths Loam	Topsoil - very dark grey brown loam to sandy loam with shot. Subsoil - yellow brown clay with grades into a red and grey mottled clay, shot increases with depth. (Clarendon).	A deep soil, very acid, low fertility, slow internal drainage, poor surface run off.

Soil No.	Soil Type	Description and Main Location	Important Characteristics
207	Brysons Clay	Topsoil - dark brown clay loam. Subsoil - brownish yellow clay with grey and red mottles with abundant concretions. (Clarendon and St. Elizabeth).	A deep soil, very acid, low fertility, slow internal drainage, poor surface runoff.
210	Churchpen Clay	Topsoil - brown to dark brown silty clay with small black shot. Subsoil - brown to dark brown clay, slightly mottled when wet. (In the vicinity of Churchpen, St. Catherine).	A deep soil, slightly acid, low fertility, slow internal drainage, poor surface run-off.
212	Lodge Clay Loam (Low salinity ogase).	Topsoil - dark reddish brown clay loam. Subsoil - slightly paler in colour and stiffer clay than topsoil. (Vicinity of Lodge in St. Catherine).	A deep soil, neutral, medium fertility, moderate internal drainage, poor surface run-off.
217	Bodles Clay Loam	Topsoil - dark brown to dark grey brown clay with some black shot. Subsoil - pale red brown or grey brown clay with some yellow brown mottles. (Vicinity of Bodles in St. Catherine).	A deep soil, slightly acid, low fertility, slow internal drainage, poor surface run-off, may be saline in subsoil.

Soil No.	Soil Type	Description and Main Location	Important Characteristics
220	Sydenham Clay	Topsoil - very dark grey brown to black clay with some white specks. Subsoil - pale brown to pale brownish grey clay with abundant small white specks, becomes sandy with depth and yellow brown loose sand may be encountered.	A deep soil, acidic, low fertility, slow internal drainage, surface runo. f generally poor, erodes readily.
61	Linstead Clay Loam	Topsoil - dark reddish brown clay loam with shot or small concretions erosion. Subsoil - red clay which becomes red and yellow brown mottled clay below. (Uplands of St. Catherine and St. James).	A deep soil acidic, low fertility, slow internal drainage, surface runoff generally poor, erodes readily.

TABLE 111

RED, BROWN AND YELLOW COLOURED SOILS DERIVED FROM HARD WHITE LIMESTONE

This group includes both types of bauxite soils and the soils associated with them. These cover a large area in the central and western plains of the Island, occuring mostly above 700 feet. Some soils consist of iron and Aluminium Oxide in high concentrations and variable amounts of silica. In these soils, (particularly the red coloured group) the maintenance of a satisfactory level of organic matter is of great importance. These soils respond to the application of nitrogen and potash. Phosphate fixation occurs mainly on the red bauxite soil, so that the placement of this fertilizer is important. Drainage is good. This group of soils has been commonly referred to as "Terra Rosa." Main crops are:-

Tree crops, food crops, improved pasture, vegetables.

Soil No.	Soil Type	Description and Main Location	Important Characteristics
73	Chudleigh Clay Loam	Topsoil - strong brown clay loam Subsoil - yellowish red clay (All over the Island).	A deep soil, neutral low fertility, very rapid internal drainage, surface runoff generally good.
74	Lucky Hill Clay Loam	Topsoil - dark brown clay loam Subsoil - paler coloured compact, stiff clay, may be slightly mottled. (All over the Island).	A deep soil, acidic medium fertility slow internal drainage, poor surface runoff.
75	Union Hill Stony Loam	Topsoil - dark brown stony loam. Subsoil - yellow brown or orange brown stony clay, hard white limestone below. (All over the Island).	A shallow soil, neutral, medium fertility, fair internal drainage, surface runoff generally good
77	Bonnygate Stony Loam	Topsoil - brown or red brown loam or clay loam, in crevices or as a thin mantle over hard white limestone. Subsoil - none; hard white limestone immediately below topsoil. (Throughout the Island).	An extremely shallow soil, neutral to slight amount of free lime, low fertility, very rapid internal drainage, surface runoff fair.

Soil No.	Soil Type	Description and Main Location	Important Characteristics
78	St. Ann Clay Loam	Topsoil - red brown clay loam. Subsoil - red or dusky red clay. (Throughout the Island).	May be very deep acidic, low fertility, very rapid internal drainage, erodes rapidly.
79	Bundo Clay	Topsoil - brown or red brown clay often with some shot. Subsoil - red, yellow brown and grey mottled clay. (Throughout the Island).	Acidic, low fertility, very rapid internal drainage, poor surface drainage.

TABLE 1V

MARL SOILS AND SOILS DERIVED FROM SOFT WHITE LIMESTONE OR YELLOW LIMESTONE

These soils occur mainly on the north coast and on the east coast in areas below 700 feet elevation mark and are characteristically dark in colour, shallow and underlaid with marl. In general, these soils are heavy in texture and contain abundant free limestone. Th

Main crops are:-

Soil No.	Soi
91	

Soil No.	Soil Type	Description and Main Location	Important Characteristics
92	Nonsuch Clay	Topsoil - very dark grey brown clay. Subsoil - grey brown mottled clay, marly or rubbly limestone below. (Clarendon, St. Mary, St. James).	A deep soil, neutral to slightly acidic, low fertility, slow internal drainage, poor surface runoff.
94	Carron Hall Clay	Topsoil - dark brown or dark grey brown clay. Subsoil - brownish yellow clay, soft yellow limestone below. (All over the Island).	A moderately deep soil, slight amount of free lime, medium fertility, fair internal drainage, surface runoff generally good.

TABLE V

RICHMOND SHALE SOILS

These soils occur mainly in the parishes of St. Mary and Hanover, with some areas in Portland and St. James. Soils are formed from shales or varying composition and grades but in general they weather rapidly into slightly acid soils rich in potash which are, however, very susceptible to slow erosion mainly because of the steep slopes on which they usually occur. These soils may be regarded as relatively fertile and respond well to fertilizer. Main crops are: Bananas, tree crops, food crops, vegetables.

TABLE V

Soil No.	Soil Type	Description and Main Location	Important Characteristics
41	Delfield Clay	Topsoil - brown clay Subsoil - yellow brown clay or silty clay, weathered shale below (All over the Island).	A deep soil, slightly acid, neutral of alkaline, medium fertility, fair internal drainage, surface runoff generally good. Free line may be present.
43	Highgate Clay	Topsoil - very dark grey brown clay. Subsoil - pale brown mottled clay, weathered shales below. (Throughout St. Mary)	A deep soil, acidic medium fertility, slow internal drainage, poor surface runoff.
46	Hall's Delight Channery Clay Loam	Topsoil - pale brown to grey brown clay loam containing abundant fragments of hard shale. Subsoil - partly weathered shale. (Throughout St. Mary and St. Thomas).	A very shallow soil acidic, low fertility, rapid internal drainage, surface runoff generally good, very erodible soil.
47	Llandewey Clay Loam	Topsoil - dark brown clay loam. Subsoil - yellowish brown or reddish brown loam, weathered shale below. (Yallahs Valley, and other areas in St. Thomas).	A moderately deep soil, slightly acidic, medium fertility, fair internal drainage, surface runoff generally good.

TABLE V1

PURPLE CONGLOMERATE SOIL

(WAG WATER CONGLOMERATE SOILS)

These soils usually occur on steep slopes and are very erodible. The main areas in which they are found are Junction Road and other areas in St. Andrew, Job's Hill in St. Mary, Morgan's Valley area in Upper Clarendon and parts of Portland and St. James. These soils are easily recognised due to their characteristic purplish colour. Main crops are: - Tree crops, pineapples, food crops.

Soil No.	Soil Type	Description and Main Location	Important Characteristics
38	Cuffy Gully Gravelly Sandy Loam	<u>Topsoil</u> - dark brown or dark gravelly sandy loam. <u>Subsoil</u> - dark red brown gravelly loam, gravel increases with depth until rotten conglomerate is met. (St. Mary, St. Andrew Clarendon).	A shallow soil, neutral, medium fertility, rapid internal drainage, rapid runoff, very erodible

TABLE V11

SOILS DERIVED FROM SHALES, CONGLOMERATES, TUFFS AND SANDSTONES

These soils are mainly heavy clay, highly acid and low in fertility and usually present some problems of internal drainage. They occur mainly in areas of St. James, Hanover, Guys Hill area and in some areas of Clarendon.

TABLE V11

Soil No.	Soil Type	Description and Main Location	Important Characteristics
30	Sunbury Clay	Topsoil - very dark brown to very grey brown clay. Subsoil - very pale brown clay with rust coloured mottles. (Clarendon Uplands).	A deep soil, slightly acidic, low fertility, slow internal drainage, poor surface runoff.
32	Wirefence Clay Loam	Topsoil - dark reddish brown clay loam. Subsoil - dark reddish brown clay over highly weathered tuffs conglomerates. (Throughout the Island).	A deep soil, strongly acidic, low fertility, fair internal drainage, surface runoff generally rapid, very erodible.
34	Diamonds Gravelly Clay Loam	Topsoil - dark brown to very dark brown gravelly loam to clay loam. Subsoil - brown to weak red gravelly sandy loam. (Uplands of Clarendon, St. Catherine, St. Thomas, Portland).	A shallow soil, acidic, medium fertility, rapid internal drainage, surface runoff rapid, a very erodible soil.
36	Donnington Gravelly Clay Loam	Topsoil - purple brown, grey brown or brown gravelly loam. Subsoil - same as topsoil with pebbly conglomerate and fine volcanic ash below. (St. Mary, and Uplands of St. Catherine and Clarendon).	Moderately deep soil, acidic, medium fertility, rapid internal drainage, rapid surface runoff, a very erodible soil.

TABLE V11 (CONT'D)

Soil No.	Soil Type	Description and Main Location	Important Characteristics
95	Wait-a-bit Clay	Topsoil - brown clay. Subsoil - yellow red to yellow brown clay, some reddish and grey mottling as depth increases, rotton shales below. (Throughout the Island).	A deep soil, acidic, medium fertility, fair internal drainage, surface runoff fair.
96	Wild Cane Sandy Loam	Topsoil - brown sandy loam. Subsoil - yellow brown or brown sandy loam, rotten sandstone below. (St. Catherine and Clarendon).	A moderately deep soil, acidic, low fertility, rapid internal drainage, rapid surface runoff, very erodible.
98	Deepdene Clay	Topsoil - very dark grey brown clay. Subsoil - reddish yellow clay with faint mottles, inter-mottled red and grey clay below. (Uplands of Clarendon).	A deep soil, highly acidic, low fertility slow internal drainage, surface runoff fair to poor.
99	Boghole Clay	Topsoil - dark brown clay. Subsoil - dark brown clay with reddish yellow and pale brown mottles. Yellow or light grey mottled clay below. (Uplands of Clarendon).	A deep soil, highly acidic, low fertility, slow internal drainage, poor surface runoff.

TABLE V11 (CONT'D)

Soil No.	Soil Type	Description and Main Location	Important Characteristics
140	Moretown Clay Loam	Topsoil - dark brown clay loam. Subsoil - yellowish red to brown clay loam becomes gravelly with depth, rotten shales below. (Uplands of Portland).	A deep soil, acidic, high fertility, fair internal drainage, surface runoff generally good, an erodible soil.

TABLE V111

SOIL DERIVED FROM GRANITE PROPHYRY

Soils derived from the granodiorite in the Salisbury Plains and Lawrence Tavern areas of St. Andrew and Glengoffe areas in St. Catherine. In general, these soils occur on steep slopes are acidic, of low fertility and easily eroded. There characteristic colour is pale brown.

Soils derived from the Newcastle prophyry in St. Andrew hills and parts of St. Thomas are shallow and of low fertility. They consist mainly of physically weathered rock, the topsoil having been eroded. Main crops are:- Food crops, pineapples, tree crops.

Soil No.	Soil Type	Description and Main Location	Important Characteristics
50	Flint River Sandy Loam	Topsoil - grey brown to yellow brown sandy loan. Subsoil- same as topsoil with light yellow brown sandy or gravelly gravelly rotten granodiorite below. (St. Catherine, St. Andrew, Portland).	A very shallow soil neutral to slightly acidic, low fertility, rapid internal drainage, rapid surface runoff, a very erodible soil.

TABLE VIII (CONT'D)

Soil No.	Soil Type	Description and Main Location	Important Characteristics
52	Valda Gravelly Sandy Loam	Topsoil - dark brown gravelly sandy loam. Subsoil - same as topsoil. Gravel increases with depth until shattered prophyry rock is reached. (St. Andrew and Uplands of St. Thomas).	A shallow soil acidic, low fertility, rapid internal drainage, rapid surface run-off, very erodible.

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M A J O R

S O I L

T Y P E S

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J A M A I C A

Prepared by: The Division of
Agricultural Chemistry,
Ministry of Agriculture

Lecture Presented by: PERCY MILLER

MAJOR SOIL TYPES OF HILLSIDE LAND

There are five main factors associated with soil formation viz:

1. Climate - Rainfall, Temperature
2. Time
3. Biosphere - Earthworm, Plant Life etc.
4. Topography - Slope, Hills and Valleys
5. Parent Material

In Jamaica Topography and Parent Material are the main contributing factors in soil formation.

Parent Material

There is a wide range of rocks in Jamaica contributing to the development of soils. Soils change where parent material differs. The rocks range from very hard (porphyry) to very soft (tuffe). The depth of soil developed over these materials is dependent on the hardness of rock and the weathering processes.

It cannot be denied that a sound knowledge of the soil is very important in order to develop and maintain sound land-use practices. The continuing use of hillside land in Jamaica is dependent on:

Proper root room
Management practices.

1. Proper Root Room

Root room is the volume of soil which is available for the development of the plant. This is dependent on stoniness of land, depth of soil and ease in which the soil erodes.

11. Management Practices

In order to maintain the root room and the fertility status of the soil the following are important:

1. Preservation of the top soil
2. Land preparation which does not enhance erosion or bring unfavourable material to the surface (e.g. marl)
3. Choice of crops
4. Cropping pattern
5. Mulching - to create a better moisture regimo

MAJOR HILLSIDE SOILS

The following is a short description of the major soil types found in the hilly areas of Jamaica.

1. Soils derived from Hard Limestone

These are red, brown, and yellow coloured soils occuring mostly above 700 feet.

Soil No.	Soil Type	Description and Main Location	Important Characteristics
73	Chudleigh Clay Loam	Topsoil - strong brown clay loam Subsoil - yellowish red clay (All over the Island)	A deep soil, neutral low fertility very rapid internal drainage, surface runoff, generally good.
74	Lucky Hill Clay Loam	Topsoil - dark brown clay loam. Subsoil - paler coloured compact, stiff clay, may be slightly mottled. (All over the Island).	A deep soil, acidic medium fertility slow internal drainage, poor surface runoff.
75	Union Hill Stony Loam	Topsoil - dark brown stony loam. Subsoil - yellow brown or orange brown stony clay, hard white limestone below. (All over the Island).	A shallow soil, neutral, medium fertility, fair internal drainage, surface runoff generally good.

Soil No.	Soil Type	Description and Main Location	Important Characteristics
77	Bonnygate Stony Loam	Topsoil - brown or red brown loam or clay loam, in crevices or as a thin mantle over hard white limestone. Subsoil - none; hard white limestone immediately below topsoil. (Throughout the Island).	An extremely shallow soil, neutral to slight amount of free lime, low fertility, very rapid internal drainage, surface runoff fair.
78	St. Ann Clay Loam	Topsoil - red brown clay loam. Subsoil - red or dusky red clay. (Throughout the Island).	May be very deep acidic, low fertility, very rapid internal drainage, erodes rapidly.
79	Bundo Clay	Topsoil - brown or red brown clay often with some shot. Subsoil - red, yellow brown and grey mottled clay. (Throughout the Island).	Acidic, low fertility, very rapid internal drainage, poor surface drainage.

11. Soft Limestone

These are mainly marls and rubbly limestone materials. They are usually very shallow and contain an abundant of free lime ($CaCO_3$).

Soil No.	Soil type	Description and Main Location	Important Characteristics
91	Killancholly Clay	Topsoil - very dark grey brown clay. Subsoil - brownish yellow to reddish brown clay, marly or chalky limestone below. (All over the Island).	A shallow soil, free lime, low fertility rapid internal drainage, rapid surface runoff.
94	Carron Hall Clay	Topsoil - dark brown or dark grey brown clay. Subsoil - brownish yellow clay, soft yellow limestone below. (All over the Island).	A moderately deep soil, slight amount of free lime, medium fertility, fair internal drainage, surface runoff generally good.

111. Richmond Shales

These are of various composition. They are usually bodded and weather easily to form soils which are rich in potash. These soils are susceptible to land slipping and erosion.

Soil No.	Soil Type	Description and Main Location	Important Characteristics
41	Belfield Clay	Topsoil - brown clay. Subsoil - yellow brown clay or silty clay, weathered shales below. (All over the Island).	A deep soil, slightly acid, neutral of alkaline, medium fertility, fair internal drainage, surface runoff generally good. Free lime may be present.

111. Richmond Shales (Cont'd)

Soil No.	Soil Type	Description and Main Location	Important Characteristics
43	Highgate Clay	Topsoil - very dark grey brown clay. Subsoil - pale brown mottled clay, weathered shales below. (Throughout St. Mary).	A deep soil, acidic medium fertility, slow internal drainage, poor surface runoff.
46	Hall's Delight Channery Clay Loam	Topsoil pale brown to grey brown clay loam containing abundant fragments of hard shale. Subsoil - partly weathered shale. (Throughout St. Mary and St. Thomas).	A very shallow soil acidic, low fertility, rapid internal drainage, surface runoff generally good, very erodible soil.
47	Llandewey Clay Loam	Topsoil - dark brown clay loam. Subsoil - yellowish brown or reddish brown loam, weathered shale below. (Yallahs Valley, and other areas in St. Thomas).	A moderately soil, slightly acidic, medium fertility, fair internal drainage, surface runoff generally good.

1V. Purple Conglomerates

These are like hard marbles cemented together to form a giant stone. The soils developed are purple in colour.

Soil No.	Soil Type	Description and Main Location	Important Characteristics
38	Cuffy Gully Gravelly Sandy Loam	Topsoil - dark brown or dark gravelly sandy loam. Subsoil - dark red brown gravelly loam, gravel increases with depth until rotten conglomerate is met. (St. Mary, St. Andrew, Clarendon).	A shallow soil, neutral, medium fertility, rapid internal drainage, rapid runoff, very erodible.

V. Tuffs and other Conglomerates

These are mainly clays, usually very acid and low in fertility.

Soil No.	Soil Type	Description and Main Location	Important Characteristics
30	Sunbury Clay	Topsoil - very dark brown to very grey brown clay. Subsoil - very pale brown clay with rust coloured mottles. (Clarendon Uplands).	A deep soil, slightly acidic, low fertility, slow internal drainage, poor surface runoff.
32	Wirefence Clay Loam	Topsoil - dark reddish brown clay loam. Subsoil - dark reddish brown clay over highly weathered tuffs conglomerates. (Throughout the Island).	A deep soil, slightly acidic, low fertility, fair internal drainage, poor surface runoff generally rapid, very erodible).
34	Diamonds Gravelly Clay Loam	Topsoil - dark brown to very dark brown gravelly loam to clay loam. Subsoil - brown to weak red gravelly sandy loam. (Uplands of Clarendon, St. Catherine, St. Thomas, Portland).	A shallow soil, acidic, medium fertility, rapid internal drainage, surface runoff rapid, a very erodible soil.
36	Donnington Gravelly Clay Loam	Topsoil - purple brown, grey brown or brown gravelly loam. Subsoil - same as topsoil with pebbly conglomerate and fine volcanic ash below. (St. Mary, and Uplands of St. Catherine and Clarendon).	Moderately deep soil, acidic, medium fertility, rapid internal drainage, rapid surface runoff, a very erodible soil.

Table V (Cont'd)

Soil No.	Soil Type	Description and Main Location	Important Characteristics
95	Wait-a-bit Clay	Topsoil - brown clay. Subsoil - yellow red to yellow brown clay, some reddish and grey mottling as depth increases, rotten shales below. (Throughout the Island).	A deep soil, acidic medium fertility, fair internal drainage, surface runoff fair.
96	Wild Cane Sandy Loam	Topsoil - brown sandy loam. Subsoil - yellow brown or brown sandy loam, rotten sandstone below. (St. Catherine and Clarendon).	A moderately deep soil, acidic, low fertility, rapid internal drainage, rapid surface run-off, very erodible.
98	Deepdene Clay	Topsoil - very dark grey brown clay. Subsoil - reddish yellow clay with faint mottles, inter-mottled red and grey clay below. (Uplands of Clarendon).	A deep soil, highly acidic, low fertility, slow internal drainage, surface runoff fair to poor.
140	Moretown Clay Loam	Topsoil - dark brown clay loam Subsoil - yellowish red to brown clay loam becomes gravelly with depth, rotten shales below. (Uplands of Portland).	A deep soil, acidic, high fertility, fair internal drainage, surface runoff generally good, an erodible soil.

VI. Grinite and Porphyry

These soils are usually shallow and low in fertility. They consist mainly of shattered rock and physically weathered materials. These erode very easily.

Soil No.	Soil Type	Description and Main Location	Important Characteristics
50	Flint River Sandy Loam	Topsoil - grey brown to yellow brown sandy loam. Subsoil - same as topsoil with light yellow brown sandy or gravelly rotten granodiorite below. (St. Catherine, St. Andrew, Portland).	A very shallow soil neutral to slightly acidic, low fertility, rapid internal drainage, rapid surface runoff, a very erodible soil.
52	Valda Gravelly Sandy Loam	Topsoil - dark brown gravelly sandy loam. Subsoil - same as topsoil. Gravel increases with depth until shattered porphyry rock is reached. (St. Andrew and Uplands of St. Thomas).	A shallow soil, acidic low fertility, rapid internal drainage, rapid surface runoff, very erodible.

Topography

A very large proportion of the land in Jamaica is very steep. Different soil types may occur on different slopes. Erosion of soils increase with slopes. The distribution of soils occuring on different slopes is shown below.

SLOPE

Parish	A 0-2°	B 2-5°	C 5-10°	D 10-20°	E 20-30°	F 30°
St. Catherine	55,000	11,000	22,000	20,000	155,000	17,000
St. Andrew	3,330	2,100	525	1,300	28,000	51,250
Clarendon	67,000	24,000	23,000	55,000	60,000	45,000

Topography (Cont'd)

SLOPE

Parish	A 0-2°	B 2-5°	C 5-10°	D 10-20°	E 20-30°	F 30°
St. James	2,900	6,900	8,700	20,900	36,900	60,700
St. Mary	7,500	5,000	12,000	54,000	56,000	-
Portland	4,800	6,580	8,000	29,900	29,350	59,450
Hanover	2,970	5,370	10,740	16,000	37,000	40,875
St. Elizabeth	18,790	27,666	59,347	51,662	54,938	47,618
Westmoreland	3,608	36,541	29,659	24,462	43,244	48,289
Manchester	745	14,449	48,610	26,646	54,219	58,755
St. Thomas	22,105	6,545	7,346	21,355	33,365	52,465
St. Ann	1,075	39,793	56,304	59,223	80,632	59,537
Trelawny	4,085	23,790	36,868	33,720	36,496	84,626
Total	193,908	209,734	323,099	414,168	705,194	625,565

+ Acreages planimetrically computed from 1: 25,000 shoots.

LAND CAPABILITY CLASSIFICATION

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1. Introduction

Land capability classification forms the basis of the planning of any land use programme in any country. Decisions on land use have always been part of the evolution of man through the ages. The need for land use planning is frequently brought about by changing needs and pressures involving the competing uses for the same area of land.

Land capability planning utilizes the sciences of applied geology, plant science and applied soil science in the development of land use plans for a particular piece of land. Efficient land utilization can be achieved when the capability is assessed using both field and laboratory techniques. The land is then classified according to its capability and the appropriate uses for each land unit is indicated, usually by land use and land capability maps.

The primary function of land use planning is to guide decisions on land use in such a way that the resources of the country are put to the most beneficial use for man, whilst at the same time conserving those resources for the future. This is extremely critical in the Jamaican context when the total amount of arable land is limited, and the pressures on those lands from competing uses.

There has been strong pressure on arable agricultural land from competing urban uses such as housing and commercial uses over the past few years. This has resulted in the loss of good agricultural land to other competing enterprises. Kingston has spread beyond the boundaries of Torrington Bridge and Spanish Town Road, to and beyond Hope, Meadowbrook, and even into the surrounding hills over the last few decades. This spread has resulted in a change in the land use from being pastures and "mango orchards" to housing estates and commercial centres.

The basic aim of land capability classification is the use of information on soils, climate, vegetation and other aspects of land, to classify land according to its capability for use. To this end, basic surveys are executed and interpreted in order to do the rating.

2. Concepts and principles of land, land evaluation and land use planning

Land capability classification system allows for the recording of all the relevant data which will lead to a decision as to the combination of agricultural use and conservation measures which will allow the most intensive agricultural use of the land with minimal risk of soil erosion. The technique then makes it possible to determine the most suitable use for any given area of land.

2.1 Land

Land is regarded as the physical environment which not only includes the soils, but also the climate, the topography, hydrology and vegetation, to the extent that these influence the potential for land use. Land is affected by past and present human activity, eg., drainage of swamps, removal of vegetation, etc. From the above description it can be seen that land is a wider concept than soil. The soil is, however, one of the most important factors influencing the land classification and a soil survey forms the basis of any land evaluation exercise. However, soils cannot be assessed in isolation from other aspects of the environment.

2.2 Land Evaluation

Land evaluation is concerned with the assessment of land, and it involves change and its effect. The evaluation process does not determine the land use changes that are to be carried out, but provides data on the basis of which decisions on land use can be logically made. Various land evaluation systems are used in various countries, but they all provide the basis for proper land use planning.

2.3 Land Use Planning

The process of land use planning utilizes data from land evaluation exercises in order to effect decisions as to the specific use that the land is to be employed. Land use planning is involved with the recognition

A) of a need for change

B) the formulation of proposals for specific land use

C) comparison of the various uses for which the land is suitable

D) the selection of a preferred use for the land after the economic, physical and social factors of other uses have been compared.

E) design of proposed land use

F) implementation and monitoring of operations

Land use planning serves to guide the decisions as to the correct use to which land should be employed.

3. Factors Affecting Land Capability

There are several operative factors affecting the quality of land in any country. These factors will limit the use of land for one purpose or another to varying degrees. The important factors influencing land capability include, the soils, the relief or topography, climate, past cropping history, etc. Land evaluation really involves an evaluation of the above factors.

3.1 Soil Factors

The soil is a most important feature and a basic unit in agriculture, its quality profoundly affecting the ability of the land to produce. It can be defined as the outer portion of the earth's crust, and is made up of a collection of natural bodies, supporting plants, and has properties due to the integrated effects of climate and living matter acting upon parent material (rocks) as conditioned by relief and periods of time.

The soil factors to be evaluated in any classification system include;

3.1.1. Soil Depth

This is the depth of soil from the top to the parent material or bedrock. This has a profound effect on the range of crops that can be grown on that particular soil. The penetrability of the parent rocks by roots is also important, and some types of rocks are easily penetrated by roots such as the non-calcareous shales, tuffs, and soft limestones. These should be taken into account in the overall rating of soil depth.

3.1.2 Soil Texture

Soil texture refers to the proportion of particles of different sizes that constitute the soil. The proportions of sand, silt and clay determine whether the soil is a clay, clay loam, sandy loam, silty clay loam, etc. The presence of gravels and stones within the soil profile will also affect its suitability for various crops. Soil texture and structure will influence the root penetration and the movement of air and water. Soils with unfavourable physical conditions will be given a lower rating.

3.1.3. Soil Reaction

This factor will influence the ability of certain exacting crops to grow and produce at the optimum level. This relates to the alkalinity or acidity of the soil. Both influence the fertility status in terms of both major and minor element availability and toxicity.

3.1.4. Soil Drainage

Soil drainage is influenced by the structure and texture of the soil. Generally, heavy clays with hard clay pans exhibit poor internal drainage and usually develop mottles and waterlogged conditions. Many of the soils in the interior valleys and coastal plains of Jamaica are poorly drained, hence land in these areas are classified as having major limitations.

3.1.5. Water Availability

This soil feature is directly related to a number of factors including the soil texture and structure, the presence or absence of ground water table, the rainfall and the evapo-transpiration rate. Soils that have limited moisture availability are likely to be droughty and hence have limitations in the kind of crops that can be grown without irrigation. This soil quality also varies according to the climatic regime.

3.2 Topography & Erosion

Topography and erosion are interelated. Slopes will influence the amount of past and potential erosion. The soil structure will also influence erosions. Previous erosion reduces crop yields by removing the more fertile topsoil. The inputs in terms of fertilizer and other management factors will have to be increased under these circumstances if high crop yields are to be sustained. Generally speaking, soil erosion resulting from cultivation is greater the steeper the slope. Consequently, land on steep slopes is given a lower rating than land on gentlier slopes. Slopes determine the type of soil conservation measure to be implemented in order to keep erosion to a minimum. As slopes increase the soil conservation measure becomes more difficult and costly, hence a severe limit is imposed on the choice of crops. Effective land area may also be lost to cropping by gullying, even in relatively flat land (0-5°). The extent of gullies and erosion influences the capability grouping; the lower the rating as erosion severity increases.

3.3 Climate

Local climate factors interact to influence land capability to varying degrees. The main climatic factors to be considered include rainfall, temperature, wind, and evapo-transpiration.

3.3.1. Rainfall

This is a most important climatic factor that influences the success or failture of many agricultural enterprises. In the Jamaican context the vast majority of farmers depend on rainfall for their source of water. Unfortunately, many fertile soils are in areas of low rainfall, the latter factor rendering those areas marginal for agriculture. Climate here is the major factor influencing capability. This may be removed with irrigation.

3.3.2 Temperature

Temperature affects the types and sequence of crops that can be grown in any specific area. Hot summers render the production of some crops uneconomical and sometimes physically impossible, due to the build up of pests (eg. red peas), or due to the agronomy of the crop. (eg. head lettuce adapted to cool climates)

3.3.3 Wind

Strong wind causes mechanical damage to foilage and fruits. Consequently, land that is subjected to strong wind will require windbreaks to protect herbaceous crops.

Areas susceptible to salt laden sea breezes are unsuitable for some crops. Such areas will require special management practices in order to obtain good yields.

3.3.4 Evapotranspiration

This factor is also influenced by the other factors of climate already discussed. Evapotranspiration will affect the interval between effective rainfall and the wilting of plants. The longer the interval, then the more frequent will the irrigation cycles become if the latter is available.

3.4 Flooding Hazard

Flooding is an important phenomenon that influences the utilization of land in susceptible areas. In tropical areas, vast acreage of cropland may be flooded after flash floods and torrential rains that are typical of the Tropics. The severity of the floods depends on the height and duration and frequence of the storm waters. Naturally land subjected to varying degrees of flooding will restrict the choice of crops that can be grown, hence the capability rating should be adjusted to take cognizance of this factor.

3.5 Past Cropping History

This will affect the present and future use of land. This is affected by the farmers' attitude from the point of view of the decisions he makes in deciding what to plant, how to plant, and where to plant. His cultivation practices will affect the extent of erosion and gullying. Shifting cultivation usually results in degradation of the land, a practice that is still commonly practiced here in Jamaica. Continuous cropping of arid areas with unsuitable irrigation water may result in the development of saline and sodic soils.

4. Present System of Land Capability Classification in Jamaica

There are at present two systems of land capability classification in Jamaica. The Land Use Section of the Agricultural Chemistry Division uses a system that is based of the USDA system of classification. In this system, land is allocated into classes or groupings primarily for agricultural purposes. The following principles are adopted.

a) The criteria used in assessing a land unit are the physical land properties made available after a soil survey.

b) The seriousness of a limitation is a function of the severity with which crop growth is inhibited.

c) The capability of a land unit for crop growth is better when a wider range of crops can be cultivated on it.

The system is one of general appraisal where preferential land use is stated depending on the land characteristics.

In Jamaica the soil survey reports and maps of the Regional Soil Research Centre of the U.W.I. form the basis of the Land Capability Classification System. This basic information is obtained from field surveys and includes an identification of the soil type, slope categories, degree of erosion, etc. These are indicated on a soil map using symbols.

A land capability map is then prepared from this. Seven land classes are usedin Jamaica, including Classes I to VII. Classes I-IV are arable, and Classes V through VIIII are non-arable. Classes II to VII represent land with increasing limitations. Within each class other than Class I, four dominant limiting factors are considered, viz:

(i) sloping land with risk of erosion (e)

(ii) excessive water within or on the soil for part or whole of year (w)

(iii) shallow soil or unfavourable soil conditions, eg.,low moisture holding capacity, soil stoniness (s)

(iv) adverse climatic factors, especially low rainfall (c)

The choice of crops become extremely limited down the classes.

The system utilized by the Soil Conservation Unit utilizes the information on basic soil surveys in order to arrive at a land capability map. The major area of departure is in the representation of the data on the map and in the assignment of land classes based on slope category. The Soil Conservation Unit system developed by Sheng (F.A.O. Consultant) is a treatment oriented system where the classification is geared towards the need for soil conservation treatment.

5. New Developments in Land Capability Classification

With the advent of the setting up of the Rural Physical Planning Units in the Ministry of Agriculture, a new look has been made at the local classification system. A number of obvious deficiencies in the system has been highlighted and proposals are being made for improvements. Some examples of proposed improvements:

(a) The recognition of the important limitation of flooding hazard in areas where this phenomenon occurs.

(b) Drafting of specification tables on limiting soil factors such as electrical conductivity, pH values, salinity, etc.

(c) Attaching values to such factors as soil stoniness, soil depth, gullying, etc.

(d) Attaching specific values to climatic limitations.

These changes are intended to remove much of the subjectivity inherent in the present system, and replace it with an objective system based on measurable values. By so doing, the limitations can be quantified and a more accurate assessment of land capability is then possible.

6. Practical Value of Land Capability Maps

From a generalized point of view, a grouping of land into various capability classes is in effect an inventory of land resource. This is useful from the point of view of being able to recognise at a glance the potential of a region or a whole country for land development.

Land capability maps are essential for the pre-feasibility studies on rural development projects. More detailed land capability studies are further required for the detailed planning of these projects once they are deemed feasible. If an irrigation project is proposed for a particular area, then the potential of the land for agricultural production has to be evaluated before the approval of the project is contemplated.

Land capability maps should form the basis of any farm planning exercise being undertaken, even at the very smallest scale. Land use plans including cropping capabilities and soil conservation needs can then be logically worked out.

Land capability studies can also be utilized for non-agricultural purposes. It can be used as a base for national physical planning by such agents as the Town Planning Department, or in the location and designing of roads, airports, harbours, and siting of dams and other civil structures.

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FARM PLANNING AND MANAGEMENT FOR HILL-SIDE FARMERS

BY: Mr. E. Latibeaudiere

INTRODUCTION:

Before introducing the subject of Farm Planning for Hill-side Farmers it is necessary to review the present structure of Agriculture in the areas of Land Capability, Land Utilization, Size of Farms and Land Availability.

LAND CAPABILITY

The 1968/69 Census of Agriculture showed that agriculture occupied about 1.5 million acres or 55% of total land area. Of this, 1.2 million acres is suitable for the cultivation of crops including pasture, and an additional 462,000 acres some of which is suitable for tree crop production.

The agricultural land capability has been determined on the basis of a combination of natural enviromental factors, and not on present land use.

The Major Classifications are as follows:-

Class I - (5% of agricultural area) - highest capability category - level lands with deep fertile soils - no limiting factor for agricultural use.

Class II - (14% of agricultural area) - suitable for agriculture with moderate limitations.

<u>Class III</u> - (37% of agricultural area) - considered suitable for agriculture but with strong limitations - lands include swamp areas and hilly regions in the central part of the island - significant part of the agricultural resource base.

<u>Class IV</u> - (16% of agricultural area) - marginal for agriculture, but suitable for tree and forest crops in (localized areas) and improved grass (of certain varieties).

<u>Class V</u> - (28% of agricultural area) - marginal for agriculture, with large sections required to remain in natural vegetation.

The above land capability taxonomy indicates that a large percentage of land in Jamaica is suitable for agricultural development of cultivated crops, improved pasture, tree crops and commercial forest. These agricultural lands constitute a major resource of the country. However, the extent of lands in the Class I and II classification is somewhat limited accounting for only 19% of the agricultural area. Other lands have varying degrees of capability with strong limitations of susceptability of erosion, poor drainage etc., which requires special agricultural rehabilitation techniques for proper use. With more emphasis now being placed on various soil conversation measures and drainage than was done when these soil were classified. some of the lands then classified as poor agricultural lands, due to the degree of slope and dampness, could now be given a better classification.

Faced with the limited supply of cultivatable land in relation to the size of the population, steps must be taken to ensure that the best uses are made of this land resource, hence the objectives of this lecture on this aspect of Farm Management.

LAND UTILIZATION

Table 1, presented shows that approximately 1.5 million acres is available to the estimated 200,000 farms. This gives an average of about 7.5 acres per farm. In general only about half of the land on farms may be regarded as arable land. On the basis of a population of 2.1 million the amount of arable land per capita is 0.36 acres.

This land is expected inter alia to produce food for local consumption and export markets, and provide employment opportunities for the labour force. This sets the stage for the intensity of production and the level of productivity which is required.

SIZE OF FARMS

A significant feature of Jamaican agriculture is the diversity between size of farms. The average of 7.5 acres of land per farm does not tell the full story. Details presented in Table 2 indicate that the distribution of farms by size group is highly skewed.

According to the last census of 1968/69 farms of less than five (5) acres in size accounted for 78% of the total number of farms and occupy 15% of land in farms, while at the other extreme, farms of 500 acres and over accounted for 0.2% of the total number of farms and 43% of the total acreage. Farms of 100 acres or more in size accounted for 0.6% of the number of farms and occupy 53% of the total farm acreage.

The lastest Agricultural Census which began in November 1978 will undoubtedly indicate the structural changes in land distribution which have been associated with the introduction of the present Land Reform Programmes.

LAND AVAILABILITY

In addition to the highly skewed (uneven) distribution of land on farms, land availability for farming is made more critical by the fact that 80% of the land area is hilly. Some of this land is so steep that a considerable portion can only be utilized if properly conserved. In this context good quality can be classified as scarce resource.

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FARM PLANNING AND BUDGETING

Farming has become a complex business having a sizeable investment and narrow profit margins. It, therefore, require careful planning for successful operation. Adoption of a single new practice may change the whole farm business. An improved cropping system, for example, may mean changes in the livestock programme, which in turn may require re-planning the buildings, the use of machinery or labour. There are two distinct ways in which a farm can be improved. In the first place, it may be possible to farm better without changing the farm plan by obtaining heavier crop yields or feeding a better dairy ration. Improvements of this kind can have a marked effect on profit and should never be neglected. There may be occasions, however, when the farm plan itself must be altered. The farmer may Be producing beef cattle when dairy cows would give a better return, or growing sugar cane when bananas would be more profitable.

The farmer who expects to obtain satisfactory earnings must have records of his business for analysis and must be constantly considering his future plans. In this analysis for planning he will want to consider:

- How efficiently each crop or livestock enterprise is conducted.
- Whether he has an adequate size of business with the best combination of crop and livestock enterprises.

- How efficiently the fixed resources of the business are presently being utilized.
- Whether a different organisation of the farm would result in an improvement and
- What new organisation of the farm should be considered given a change in future conditions.

The general approach to the above problem has been a two-stage process of diagnosis and prescription. The first stage (by the use of records) is to carry out an economic analysis for the purpose of locating economic weakness and the second to work out an improved plan designed primarily to remedy these weaknesses, the assumption being that the correction of the major economic defects will result in increased profits. Such an analysis will give valuable pointers to directions in which the economy of the farm might be improved. There are generally <u>three</u> main possibilities:-

1. <u>Increasing the farm output</u> by a better use of existing resources or by using additional resources, example, more labour or capital.
2. <u>Adjusting the balance of enterprises</u> in favour of these which appear to give the best returns on the farm in question.
3. <u>Reducing Costs.</u>

These possibilities are very much interrelated. For example, a simplification of the farming system by reducing the number of enterprices may often be an effective method of reducing the wage bill or making labour available for the expansion of the remaining enterprises to a profitable level. Maximum profits, in fact, in many cases depend upon a combination of better organisation with improved methods.

Only actual experience can show how much any plan will in fact improve the economic position of the farm. It is, however, possible and often desirable to prepare advance estimates of the financial effects of a plan before putting it into effect. This process is known as BUDGETING hereby defined as a formal or informal device for setting down the different crops or livestock or combinations of both which can be produced and in deciding which alternative is most profitable.

In setting up a budget or farm plan, the prospective acres of each crop or numbers of livestock is ascertained, the farming practices are evaluated, an estimate is made of production, income and costs are computed and finally an estimate of net income is determined. It should be realised, however, that although budgets are inevitably subject to a wide margin of error and are liable to be falsified by unforseen circumstances such as abnormal weather, outbreaks of diseases, changes in imput costs and market conditions, they can often be of considerable value as a guide to policy. Budgets, provided they are worked out on reasonable asumptions can set up income and expenditure targets against which actual performance can constantly be checked as the plan comes into operation; so that defects in managements can be corrected before they are gone too far. This process is called "budgetary control." Even when the farmer has evolved what he regards as a workable budget he should not expect it to maintain him for the rest of his life. Changes in methods and prices of imputs and outputs are continually occuring and the farmer should adjust for these. It is, therefore, obvious that a farm plan well suited to conditions at one time may be out of date any time later. This does not mean that the farmer should neglect the rules of good husbandry for within the bounds of good farming there is still a wide choice of methods and the (onus) is on the farmer to find the best plan that gives him the best return.

At first sight it may seem difficult to forecast changes in receipt and expenses that will occur if the farm programme is altered. Fortunately, a method has been devised that greatly simplifies this task. This method is called the Gross Margin Method of Planning

GROSS MARGIN METHOD OF FARM PLANNING

This method of planning for the future has certain advantages in helping a farmer reach decisions on the preceding and related questions. The basic ideas of this method is that of dividing all costs into two groups - fixed cost and variable cost.

VARIABLE COSTS

In this category are included such items as planting materials, fertilizers, sprays, feeds, veterinary expenses, casual labour etc. These are costs that vary directly with the area of crop grown or the number of livestock and are relatively easy to allocate to enterprises.

FIXED COSTS

In this category are included regular labour, machinery costs, mortgage payments and other overhead costs such as taxes and insurance. These costs are usually incurred for the farm as a whole and not for any particular enterprise. They are thus "Fixed costs" in the sense that they do not vary directly according to the crops and livestock kept. They are also "fixed" in the sense that once incurred they tend to run on whether proper use is made of them or not. This distinction between fixed and variable costs is a very important one and is fundamental to all budgeting. At first glance it may appear theoretical, but it has a very practical use.

A variable cost such as fertilizer can be measured out and used in exact quantities required. Fixed Costs (e.g. regular labour) are a steady stream and tend to run on whether they are used or not.

It will be seen, therefore, that if the farm plan is changed, the variable cost will change in a way that can be budgeted. The "fixed" or overhead cost may hardly change at all - especially if the alteration to the farm programme is not an extensive one.

The total variable costs of an enterprise are subtracted from the total returns to obtain the GROSS MARGIN. The gross margin is not of course pure profit, but represents the contribution of the enterprise towards covering the fixed costs and producing a return for risk and manag ent. It also shows the gain or loss that can be expected if the enterprise is increased or reduced in size. The gross margin allows only for changes in variable costs, but there are occasions (especially if a large change is made to the farm plan) when the fixed costs do alter.

STEPS IN BUDGETING

The farmer will need to approach his farm planning in an orderly fashion. Different farmers use different methods in making up a budget. An orderly approach is as follows:-

(a) make an inventory of available resources.

(b) set down the amount of capital available and find out how much can be borrowed if credit is available.

(c) decide how much labour is available and at what periods of time.

(d) take stock of the manager as this is one of the most important resources on the farm.
Does the farmer/manager detest some kinds of farm work?
Does he dislike making changes and taking risks?
Does he dislike reading, attending meetings and looking up new information?

If the answer to the above questions is yes the farmer will be well advised to stay away from enterprises requiring constant work and vigil or need a lot of mental effort to stay abreast of markets. The above things set down so far indicate the resources available with which to work. The steps outline below should now be followed.

1. INVENTORY OF SOIL RESOURCES.

The farmer should walk over the farm and while doing so make an up-to-date map. On the map he should lay out each field as it now exists, and show the soils that make up each field. If he does'nt know the soil types by name he should describe them as this will assist the agronomist in his recommendations.

2. TOPOGRAPHY

The slopes will not determine the exact rotations which are most profitable, but they will define the limits of different crops in terms of acreages. They will determine soil consderation and soil management practices to employ and the area for mechanical cultivation.

3. SOIL MANAGEMENT

In order to get a true picture of the soil and its productivity a history of past treatment of each field should be made. This includes the quantity and type of fertilizer used.

YIELD HISTORY

The inventory already completed gives an idea of the capital and labour required, and also describes the soil available for use. A study of present productivity and future yields under present management should now be made. A good guide would be to find out what yields are under similar farms with typical management.

4. BUILDING AND FENCES

All farm buidlings should be listed and appraised as to suitability and adaptability for various uses. Information on their present capacity for livestock equipment and feed will be needed. Requirements for repairs and up-keep must be considered and recorded. Fences should be checked to determine condition and needed repairs.

5. WATER SUPPLY

This is often inadequate and undependable on many farms. Often times water must be hauled during dry periods for both livestock and human consumption. This reduced the time available for productive work and may affect ones choice of livestock and enterprises. Therefore, it is essential that the water supply be checked as accessibility to water is a major factor in laying out the farm and locating pastures.

SOUND FARM PLANNING IN RELATION TO FARM MANAGEMENT PRACTICES

Effective Farm Management cannot be achieved without planning and the Extension Officer must be capable of drawing up a plan that is acceptable and well understood by the farmer. If economic conditions change, these officers must be capable of advising farmers to modify their plans to meet the new situation. These officers should, therefore, possess a knowledge and appreciation of the economic principles of sound farm planning.

There are, however, some severe handicaps to proper farm planning and these relate to the lack of farm managment data and the absence of farm records due to the reluctance of individual farmers to keep records.

There is need for basic information on the business performance of farmers operating under varying type of farming conditions. Farm planners must have this kind of information for use in analysing individual farm businesses and in determining more profitable farm management practices.

Sometimes decisions based on economic viability may not always be acceptable or appropriate. For example, there are farmers who will persist with the growing of certain food crops although their land, as well as conditions external to their farms would be better suited to the growing of other kinds of crops. But these farmers will continue from year to year to grow crops that are on the whole profitable simply because they consider it extremely desirable to be self-sufficient in food for home consumption.

These and other factors expose the difficulties in getting farmers to accept new technology in the hope of moving from a subsistence type of farming to a more commercialized agriculture.

Although very detailed financial and cost accounts are not absolutely essential for planning the re-organisation of the farm business, there are certain minimum data which are required as a basis for the formulation of any kind of farm plan. As mentioned before, the more general-purpose type of economic and physical data relating to farms of a certain type or within a certain area are practically non-existent. Until more farm management surveys are conducted thereby increasing the supply of this kind of information, farm planning will be seriously handicapped and will not be fully effective.

The problem of arriving at the most suitable organisation for a particular farm involves a consideration of the main principles of farm management, namely, what to grow, how much of each commodity to grow or produce, what resources to use in producing each commodity and how to combine the various enterprises into a profitable farming system.

Any farm plan prepared must be technically possible and secondly, it should take into account the likes and dislikes of the farmer. The plan should also relate to enterprises which the farmer is competent to undertake from a technical point of view. The farmer should not only be willing to do the things suggested, but should be able to command the resources in land and labour necessary for effective operation of the plan. The extension officer in discussion with the farmer should discuss and assess the merits of the plan in relation to the problems and risk involved. The above procedure is not always adhered to by many field officers with the results that many farm investment plans are doomed before they even start.

The absence of the above-mentioned type of economic and physical data relating to farms does not imply that a certain amount of rudimentary farm planning cannot be undertaken. Such rudimentary farm planning should be a useful tool for improving the organisation and management of farms under present agricultural programmes and generally for making agriculture in this country a more businesslike undertaking.

(55)

FARM INCOME ANALYSIS OF RURAL PROJECTS

by

Dorothy Dunkley

FARM INCOME ANALYSIS OF RURAL PROJECTS

Project preparation is one aspect of agricultural development planning. Careful project preparation and planning is the best available means to ensure economical use of capital and increase the chances of prompt implementation of projects.

As was discussed earlier, planning and, in particular, rural planning requires an integrated approach. This is because it is necessary to see how any Government-sponsored activity will affect the overall development of a particular community.

In previous Government farm programmes, farmers were given a set acreage. The size most often being determined by the number of farmers who needed land. One finds, therefore, that large acreages were subdivided quite arbitrarily into parcels which were not always economically feasible, i.e. not capable of providing the required guaranteed income to the farmer. The result quite often is failure, frustration and waste of resources. To solve this problem, the Rural Physical Planning Unit is using a new approach. Lots are now subdivided based on their physical and economic potential. The physical potential is determined by soil and land capability analyses. The economic potential is determined by a financial analysis which compares the stream of investment and the production cost of the varied agricultural undertakings with the flow of benefits they will produce. It is closely linked with the land capability analysis as the crops used are based on recommended land uses for the area. A financial analysis examines various land uses in terms of costs and returns. Various crop combinations are examined by developing farm models and cash flows to determine the best combination of crops.

METHODOLOGY

Pioneer Farms - A minimum income, to be met by returns from the farm, is set for each farmer. In the case of the pioneer farms, the farmers are employed for an average of 250 days per year at $7 per day. This provides $1,750, thus necessitating an additional $2,250 for each pioneer to achieve the $4,000 level.

Pioneer Farms can obtain loans from the Ministry of Agriculture at an interest rate of 6%. Based on this and a scheduled repayment rate, a cash flow is worked out to determine the cost of production, the expected revenue and, finally the net benefits of the farm.

Cost of production or outflow includes two types of expenses. Capital expense and operating expense.

Capital expenses include expenditures for the erection of buildings, purchase of machinery and other equipment, initial heavy clearing of land and initial establishment of the proposed enterprises.

Operating or recurrent expenses include expenses for maintenance of the enterprises on the farm and for repairs to buildings.

In cases where loans have been received by the farmers a third expense is added, debt servicing. Here repayment interest is calculated over a set period.

Revenue or inflow includes all money coming into the farm from enterprises and loans.

When total inflow and outflow have been determined, they are compared to arrive at a net benefit for each year of operation. Using the annual net benefit for the pioneer farm and the minimum income required for each farmer it is then possible to arrive at the number of pioneers which can be accommodated on the farm.

A summary of cash flow for one pioneer farm is shown in Table 1. (See attached)

It should be noted that loan repayment can be calculated over any specified time period but it is also important to consider the (crops) enterprises that the farms will undertake. For example, if tree crops will be a major enterprise, the farm will not begin to accrue income until the fourth year of operation. Therefore, individual farmers could not begin to repay their loans before then. However, by planting some short-term crops such as vegetables, for the first three years, the farmer could at least pay interest on the loan during the moratorium period.

It is important to note here that the number of pioneers that can be accommodated on a farm based on the annual net benefit may not supply all the required labour for the farm. It is therefore necessary to look at the labour required for each crop to ensure that both labour requirements and minimum income can be satisfied.

Land Lease Farms - Whereas pioneer farms are large operations with considerable acreage and many workers, land lease farms are much smaller, each farm being operated by one farmer. Here again, a net base income of $4,000 a year is targeted for each farmer. Each acre is given a production value based on its capability. This is used as a preliminary tool for determining size for the farms. The fixed cost of rent on the land, debt service and farm implements are estimated at $500. In addition, produce eaten by the farm family is assumed to value $800. This means that the total value of output from the farm must be greater than $5,300, the fixed cost plus the value of food consumed plus the farmer's target income. In addition, the farm must earn enough to provide for the cost of the variable inputs such as seeds, fertilizer, and any extra costs incurred.

The figure below indicates the required income generation on the farm.

				Labour Input) Hired & Family
Value of Output	Added Value Req.	$4,000	Net cash to farmer	
		$750	consumed on farm	
		$450	rent, debt services implements etc.	
			variable inputs viz seeds, fertilizer	) Non-labour input

Using the cost of production and the average yield per acre for each crop, it is possible to compute the potential income from each enterprise as shown below. (Table 2).

CROPS	Value of Output (1)	Non-Labour Input (2)	Added Value (3)	Labour Input (4)	Net Income (5)
Vegetables	4633	851	3782	926	2856
Yams	4456	1833	2623	874	1749
Bananas	1080	567	513	418	95
*Mango	2625	212	2413	208	2205

Column 1 = 2 + 3 i.e. 12794 = 3463 + 9331
" 5 = 1 - (2 + 4) i.e. 6905 = 12794 - (3463 + 2426)

With these per-acre costs models can be formulated to indicate the best combination of crops which will obtain the required returns.

This however must be considered in relation to other factors such as market opportunities for the crops. This is important since money to continue accrues from the sale of crops in the previous year.

The labour requirement for each crop is also important and should be considered since the farmer should depend as much as possible on his own labour.

* These figures will change with various changes in price indices.

EFFECTS OF AGRICULTURAL DEVELOPMENT ON RURAL COMMUNITIES

- Rutty Mitchell, Ph.D
10. 5. 79

In a certain village, which for the purpose of this introduction will be named Village, there is abject poverty - poverty of the land, poverty of the pocket and poverty of even the mind. One-third of the inhabitants of Village live on small scattered farms and eighty percent of these farm holdings are less than fifteen acres. The land is stony, steep and poorly watered, yet it is the people's primary source of income. Village school is poor and irregularly attended and children leave at age eleven or twelve. Opportunities for continued education exist only outside of Village and only the rich can afford such a luxury. The nearest hospital to Village is five hours away by car.[1] The residents of Village comprise seven occupational classes; they are labourers, farmers, artisans, merchants, office workers, professionals and landed proprietors. But the higher the occupation in terms of socio-economic values, the smaller the number of incumbents in that occupation; that is, there is an inverse relationship between occupational class and number of incumbents.

You are given a total of five guesses to name the Village.[2] But the Village is not to be found in Jamaica at all; Village is really Montenagro in Southern Italy and is described by Edward Banfield[3] who conducted an indepth analysis of the Village. There Banfield found extreme poverty and backwardness explained by a principle he termed "amoral Familism". The unarticulated but operationalized maxim of amoral familism is to "maximize the material short-run advantage of the nuclear family; assume that all others will do likewise". In other words, look after you and yours and forget all others. It is the persistent behaviour consistent with this principle that has perpetuated the backwardness of that Italian village.

The description of Montenagro, if not the explanation of its backwardness, is

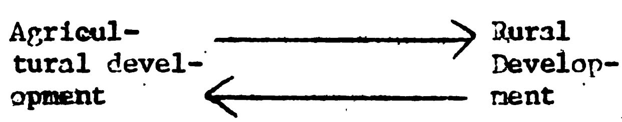
[1]Colin Bell and Howard Newby, Community Studies: An Introduction to the Sociology of Local Community, Praeger Publishers, New York, 1974, pp. 150-157.

[2]The Seminar participants named five Jamaican villages that seem to fit the description perfectly.

[3]Edward Banfield, The Moral Basis of a Backward Society, The Free Press, New York, 1958.

typical of a great many of our rural communities in Jamaica. Such communities are <u>ipso facto</u> agricultural communities. Consequently, backwardness in agriculture (whether in terms of moving to the back or remaining at the back) has negative implications for the rural community. Similarly, agricultural development, which must be equated with rural development, has positive and far-reaching significance for rural communities.

This agricultural development must encompass a total rural development programme because, to maximize the development of agriculture, there must be other developments to facilitate the agricultural development. For example, agricultural development will affect a programme of constructing adequate roads which facilitate transportation of field technology and material as well as marketing and distribution of the products of the field. The picture looks like this:



Each is at the same time a cause and an effect of the other. In essence they become one and will be used synonymously.

Agricultural development (or rural development) must be concerned with more than merely keeping (others) alive or staying alive. It must perceive what can be accomplished politically (not in terms of narrow party politics) at the level of distinguishing between world ideologies and ideas and how man's ideas can be operationalized for community advancement and for individual enhancement. The political dimension of agricultural development will include the ability to obtain and use facts and make interpretations and judgements of facts. At this level, there must be a suspension of the ideological and philosophical stances of divisive party politics in order to discharge a common commitment to a common development; there must be collaboration.

This development includes a positive weltanschuung (life out-look) and the desire, confidence and determination to make things happen. This is perhaps the most crucial ingredient in any programme of development. This life out-look must be grasped and synchronized into a homogeneity of interest and action even where there had been a heterogeneity of class and mass. The effects of this agricultural development for the rural communities are manifold, having repercussions in various societal institutions and in the formulation and development of a positive self concept.

From one perspective, education can be seen as a strong causal factor in agricultural development. At the rural community level, however, it is essentially an effect of agricultural development. This includes (1) general education since farmers themselves become more exposed and are also better able to school their children; and (2) farm education whereby the farmer obtains skills in management, farm technology and crop culture and in-service training programmes such as seminars, field days and agricultural literature. This education effect spills over into the entire community and generates educational activities such as literacy classes, youth programmes, community projects and an overall awareness of and appreciation for improved education and the benefits that accrue therefrom.

The economic effect is obvious and self-evident. The Reggae number speaks of "stepping out of Babylon and stepping into Jerusalem." Agricultural development is like stepping out of the Babylon of mere subsistence and sub-subsistence into the Jerusalem of growth and profit. For agriculture is a science as well as a business and must be perceived as such and worked as such. Agricultural development, then, means greater production, increased income, increased employment opportunities for the rural labouring class, more vibrant community economy and, ultimately, increased foreign exchange and improved balance of trade for the nation.

Agricultural development has repercussions for health at the community level. The higher the standard of agriculture for any community, the greater the ability to supply the nutritional requirement for both its children and its adults. This is a correlation that is not always recognized but is very real and very important. It is an adequate agricultural system that is able to provide the variety of food values in quantities and at costs that the community can afford.

Developed agriculture also enhances health indirectly through better roads, water supply, lighting system, recreational facilities and other physical and social infrastructures and through a satisfied sense of wellbeing .

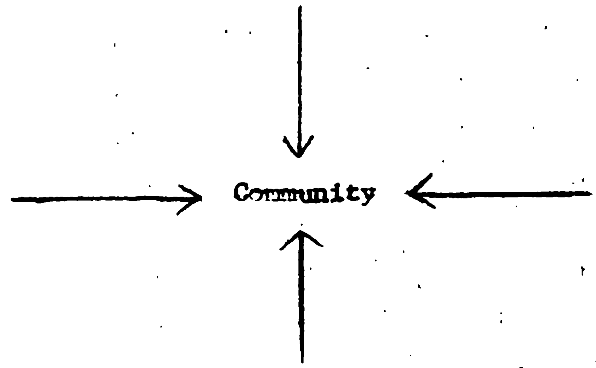
Agricultural development has its effects upon rural communities at the socio-psychological levels of individuals. It is said that the cashew nut makes a major contribution to the economy of Coby in St. Elizabeth. During the out-of-crop season, if a Coby resident is asked where he comes from, he will hang his head in embarrassment, dig his toes in the ground and answer in subdued tones: "Me come from Coby, Sah". On the other hand, when he is asked the same question during the cashew season, he looks the enquirer in the face and proudly asserts: "Coby, to be sure". When his economic source is weak and uncertain, he develops a negative, floundering self-concept; when his economic source is strong, he develops a positive, confident self-concept. Similarly, agricultural development produces a higher socio-economic status which, in turn, augments self-appreciation, self-confidence and self-respect. For, you see, our self-feeling depends upon how we perceive that others feel about us or toward us so that the higher our perception of the rating of us by others, the higher the concept we develop of ourselves.[1] Agricultural development will foster an enhanced perception by rural residents of others' perception of them and, therefore, generate a greater sense of wellbeing, self-assurance a positive self-concept.

This socio-psychological effect is of cardinal importance and one that needs to be fully grasped and understood by planners and policy-makers, project and programme implementers as well as by the ordinary man himself. For if agriculture remains undeveloped, then the agricultural man (or Woman) will perceive that others think that he is nothing, then he will think himself to be nothing, and in fact become nothing. Agricultural development ultimately facilitates a better self image, an acceptance of responsibility and a positive response to the rural community's role as feeder of the nation and the mainstay of the social order.

Agricultural development also has positive effects upon the community. That is, it helps to develop a sense of oneness and togetherness in which each works for all and all work for each. Two constructs will be employed to develop this idea; we will speak of the "centripetal effect" and the "centrifugal effect" of agricultural development.

[1] Charles Horton Cooley, <u>Human Nature and Social Order</u>, Schocken, New York, 1964.

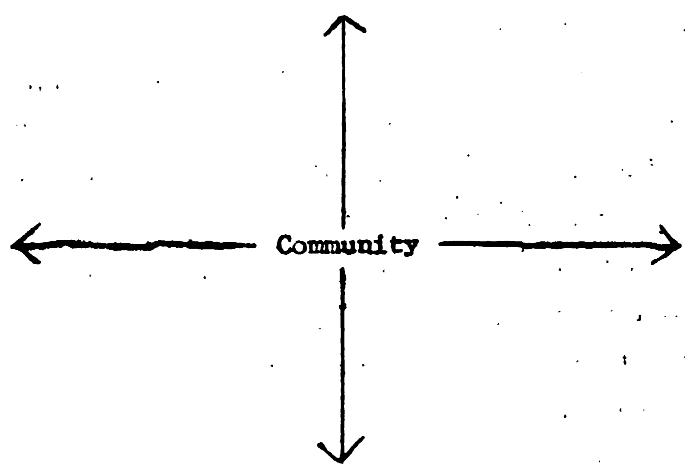
The "centipetal effect" may be diagrammed to look like this:



(Progressing toward the centre)

Here individual members work towards building strong and unified communities. They develop a positive community spirit which manifests itself in community programmes and projects, community goals and community consciousness. The individual plays his part for the building up of the entire structure. A strong community is an independent and secure community.

The "centrifugal effect" is a movement outward from community strength to individual members. It looks like this:



(Radiating from the centre)

Here a strong and unified community looks after the needs and interests of the individual members. In times of sorrow, such as failure and death, as well as in times of joy, such as celebrations and marriage, the community becomes the matrix of action and interaction. When agricultural development takes place, rural communities become economically and socially free to relinquish the principle of "amoral familism" and embrace the spirit of "centrifugalism" and "centripetalism".

Agricultural development has repercussions for rural community economy, education and health; it raises the level of confidence at both individual and community levels and creates a positive self-concept. It creates rural communities with a greater sense of wellbeing.

THE ROLF OF THE EXTENSION OFFICER IN THE IMPLEMENTATION OF RURAL DEVELOPMENT PROJECTS

by R.C. Harrison
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1. Introduction

Rural developments are usually designed with the rural population in mind. Such projects should offer both direct and indirect benefits to rural population. Real benefits could include:

(a) An improved network of roads in a farming community
(b) Increased farm income from planned crop expansion programmes
(c) Increased credit facilities
(d) Introduction of improved technology for higher agricultural production
(e) An improved Extension Service

Generally improvements in specific areas usually result in an improvement in the quality of life (standard of living) of the rural population.

2. Extension officers knowledge of project details and objectives

Extension officers should have detailed knowledge of the objectives and details of the project. One of the best ways of obtaining this detailed knowledge of the project is to be associated with the project from the formative stages. This however, may not be possible as in many instances the persons drafting the project are not the ones to implement. Extension Officers should then arm themselves with copies of the project document. This will serve as a source of reference, and most important also as a working document.

Projects are designed to be completed in a specific period of time. The aims and objectives are stated and specific targets are proposed. These targets are quantified, mainly for the purpose of evaluating the achievements, i.e. the degree of success or failure of the project. Extension Officers should have thorough knowledge of these important areas. Other project details include the cost, method of financing, the scheduling or the phasing of the various activities, the inputs and expected outputs, etc. Project financing may be provided by Governments, International Organizations such as the World Bank, I.A.D.B. etc., or a combination of Government and an International Organization.

Many rural development projects are agriculture based in that they directly or indirectly affect the farming population. This is where the Extension Officer comes in; and for the purpose of the rest of this talk, we are considering projects affecting the farming population.

3. Explaining to farmers their role in the projects

One of the important activity of the Extension Officer is that of explaining to the farmers their role in the project. This is particularly important in the launching stages where farmers will be interested in finding out what is in store for them. Many will be interested in finding out only what they will be getting out of the project. The Extension Officer will be responsible for getting the total involvement of the farmers.

How does the Extension Officer pass on information about the project?

He can do this by usual communication methods that Extension Officers usually use in transfering information to the farming community.

These include:

(a) Holding of meetings with farmers at convenient locations.
(b) Posting of notices about meetings to be held at strategic points, and also information stickers about the project.
(c) Informal house visits and field visits. These are very important as they establish close contact between the farmer and the Extension Officers. Such contacts may serve to clear up misunderstandings, and to convince doubtful farmers to support the project.
(d) Holding of film shows in village squares and community centres on similar projects or about progress of the present project.
(e) Radio broadcasts are also another means of providing information about projects.

4. <u>Promotion of maximum involvement of farmers</u>

Extension Officers should motivate farmers coming under the programme. The success of these projects will be determined mainly by the participation of the beneficiaries, i.e. the farmers and a successful project will also mean success for them. This method used can be any of the usual forms that Extension Officers use in their day to day activities. Farmers should be made aware of the fact that the success of the project will also be their success and as such their total involvement is important.

5. <u>Help farmers prepare farm plans</u>

Help should be given to farmers in the preparation of individual farm plans in accordance with the overall project objectives. Detailed physical planning is not required to be done by Extension Officers as this is the responsibility of the Planning Units. What is necessary on their part is the correct interpretation of the plans. However within this framework, you the Extension Officer are required to guide the farmer in the preparation of farm plans for these individual holdings within the project area. Information from prepared plans from the Physical Planning Units or any other reliable source should be used in guiding your farm planning exercise. Consequently, a knowledge of land capability classification which is an important basis for land use planning is required. This would all be a part of project implementation, by initiating the actual project activities that has to to with the farmer on his individual holding.

6. <u>Extend knowledge and agricultural techniques to farmers</u>

This has to do with the day to day guidance of farmers under the project. This activity would be no different from your usual extension activities within an Extension Area. These would include things like: Advising on crops, fertilizer applications, chemicals for spraying, encouragement in difficulties and even advice on private family affairs.

7. <u>Work in co-operation with Farm Managers</u>

Extension Officers should work in co-operation with Farm Managers in case of (Pioneer Farms) or Project Managers in the case of the other projects. On Pioneer Farms, Extension Officers may be Extension Officers themselves. Where this link exists, co-operation is necessary for successful project implementation.

CROP NUTRITION AND FERTILITY MANAGEMENT

OF HILLSIDE FARMS

by

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INTRODUCTION

In Jamaica approximately 80% of the soils are located on hilly land with slopes ranging from 5 to over 30 degrees. These hilly areas are occupied mainly by small farmers who produce most of the food stuff for local consumption. Yet most of the soil fertility investigations has been conducted on the lowlands viz., alluvial and inland basins soils. This results in a dearth of knowledge on fertility management and crop production problems of hillside soils.

Today there is great need to increase food production to satisfy domestic as well as export markets. It is therefore necessary for the hillside farmer to increase his level of productivity to fill this requirement. To do this he needs to get solutions to the soil fertility and other production problems. It is therefore incumbent on researchers to spend more time to find the answers to soil and other related problems that face the hillside farmer.

In this paper on Soil Management For Hillside Farms the following points are discussed.

(a) Methods of soil fertility evaluation.
(b) Chemical and physical properties of Jamaica hillside soils.
(c) Conserving the fertility levels of hillside soils

(A) METHODS OF SOIL FERTILITY EVALUATION

The nutrient status of a soil may be evaluated by using a number of methods. The following methods have been used with varying degrees of success.

(1) Nutrient Deficiency Symptoms of Plants

Nutrient deficiency symptoms of plants may occur as follows:

(a) Complete crop failure at seedling stage;
(b) Severe stunting of plants;
(c) Malformation of plant parts e.g. deformed leaves;
(d) Abnormal colour patterns e.g. yellowing of leaves, interveinal chlorosis;
(e) Delayed or abnormal maturity;
(f) Reduced yields; and
(g) Poor quality of crop and produce.

This method has the following limitations:

i) The symptoms are observed after the plants are affected;

ii) It is qualitative and not quantitative i.e. it indicates only the type of nutrient which is lacking and not the quantity to be applied to produce optimum growth; and

iii) It requires experienced observers to distinguish between the various symptoms which can be very complicated. However, it is a cheap method and when used in conjunction with other methods serves as a valuable method of determining the nutrient status of the soil.

2. Soil Test

Soil testing involves collection of the soil samples, extracting and determining the available nutrients, interpreting the results and making fertilizer recommendations. It is the fastest method and when used in conjunction with the plant analysis and biological test, forms the most reliable and widespread method of evaluating soil fertility status. However, for this method to achieve success, the person doing the tests must have a thorough background knowledge of proper soil sampling techniques, correct laboratory procedures, chemical and physical properties of the soil, the crops to be grown and management practices to be employed for the particular soil type. Incidentally this method is the most commonly used in Jamaica and elsewhere.

3. Plant Tissue Analyses

This method involves analyses of the tissues or sap of the plant or of the whole plant. Several samples of different parts of the plants at the various stages of development are sampled and analysed. Plants showing deficiency symptoms, healthy plants as well as plants growing in soils with an abundant sypply of nutrients, are analysed to obtain critical values. Reduced crop yields are likely to occur below and far above the critical values.

TABLE 1 gives critical values for some test crops.

Levels below the critical values indicate that fertilizer is needed and levels above either indicate that the nutrient supply is adequate or more than adequate.

In interpreting the results, the factors affecting supply of nutrients to the plant should be considered since the levels of nutrients in the tissues do not necessarily reflect the true nutrient status of the soil. For example, a soil may have adequate supplies of available nutrients as revealed by soil test, but due to low water supply the plants cannot absorb enough nutrients at the critical stages. The plant analyses test will therefore reveal low levels of the nutrients.

4. Biological Tests

Biological tests make use of both lower and higher plants to indicate the levels of nutrient in the soil. The lower plants include bacteria and fungi. Examples are *Azotobacter* (bacteria) and *Aspergillus niger* (fungus). These are used to determine the levels of P and K. Small soil samples are treated with P and K solutions and inoculated with the fungi or bacteria and then incubated for 2 to 4 days. The extent of colony growth of the organism will indicate the levels of the nutrients which are rated as very deficient to adequate. These tests are rapid, simple and require little space.

For higher plants greenhouse tests and field trials are used. Greenhouse trials are very useful in that they provide results in a relatively short time. However, they can be costly. In field trials plants are grown in the test soils in carefully laid out plots to which treatments are randomly assigned. The trial is replicated to give a better estimate of the parameter being studied. Chemical soil test and plant analyses methods are used with field trials to obtain the best possible results.

Various designs and techniques are used depending on the existing conditions and the questions to be answered (i.e. the objectives of the experiments). Among these are factorial design, Latin square, completely ramdomised block design, incomplete block design, micro-plot technique etc. The micro-plot technique is emphasised in this discussion.

The Micro-plot Technique

The micro-plot technique is a minature field trial of factorial design utilising small land space and providing rapid results on nutrient status of the soil. It provides useful data for assessing fertilizer needs or indicating specific problems for further detailed investigations. (Harrison and Wahab 1977). The fresh green materials are analysed after a specified time period to indicate the nutrient status of the soil.

This method was used by Harrison and Wahab in 1977 on a newly bench terraced Wirefence clay loam No. 32 (Ultisol) at Allsides in Trelawny. Each plot was 60 cm^2 and the test crop was corn - Hybrid Pioneer X-306. The corn was reaped 34 days after planting and plant analyses were made on the fresh material. Positive responses to N.P.K. at rates of 150kg/ha, 200 kg/ha, and 100kg/ha respectively were recorded. The results formed the basis for fertilizer recommendation for crops grown in multiple cropping trials on the same terraces. They also indicated areas where future investigations should be conducted. This work was followed by Nitrogen and Phosphorus Fertilizer trials by Wahab, Campbell, Ramsay and Murray in 197? to 1979, using peanut as the test crop.

They reported positive responses to nitrogen. The results of these experiments form the basis for fertilizer regimes for peanut which is presently grown on the terraces soils at Allsides.

The above discussion on field trials shows the usefulness of this method in evaluating soil nutrient status and formulating appropriate fertilizer programmes for crops grown on the test soil and similar soil types.

B. CHEMICAL AND PHYSICAL PROPERTIES OF JAMAICAN HILLSIDE SOILS

Some important chemical and physical properties of the major hillside soils in Jamaica are shown in Table 2. These are:

i) Available phosphate and potash ratings;
ii) Soil reaction or pH;
iii) Water retention;
iv) Depth of soil; and
v) Trace element ratings

Soil Nitrogen

Rating for this element was eliminated because it is almost always low in Jamaican soils. In some cases no laboratory test is done for soil N since it is accepted that it must be included in the fertilizer recommendation. The use of organic matter normally increases the supply of this element, but it is easily lost on the steep hillsides due to accelerated erosion caused by exposure of the land in man's attempt to produce crops in these areas.

Available Phosphate Levels

With a few exceptions, the phosphate levels of Jamaican hillside soils are low and extremely low in soil types such as 77 and 78 Bonnygate Stony Loam and St. Ann Clay Loam respectively. The available supply of P is further reduced in soils such as St. Ann Clay Loam No. 78 and Wire fence clay Loam No. 32 due to chemical fixation, therefore placement of this fertilizer within the root zone (hole) and at the appropriate time is of paramount importance.

Soil Potash Levels

The levels of K in most hillside soils are medium to high. This is particularly true for soils derived from the calcareous Richmond Red Shales in the series 40 to 49 in the local classification. The group of soils (series 70 - 80), formed from the hard white limestone, is an exception to the rule in that the K level is normally low. In soils formed from shales addition of K is not critical except for crops such as bananas and food crops which have high demands for potassium. (Weir 1973).

Soil Reaction (pH)

Most of the hilly soils are slightly acid, neutral or mildly alkaline. With the few exceptions of strongly to very strongly acid soils such as Wirefence Clay Loam No. 32, Valda Gravelly Sandy Loam No. 52 and Wait-A-Bit Clay No. 95, acidity is not a major limitation to production on Jamaican hillside soils. This is in contrast to the lowland soils where the converse is true.

Water Retention and Soil Depth

Many hillside soils in Jamaica are shallow due to very high erosion losses brought about by poor soil management and conservation practices. In some cases erosion is so severe that the remaining soil represents only the decomposed weathered parent materials. Consequently, these thin soils have low moisture retention capacities and tend to be droughty and infertile. The other hillside soils which do not fall in this category are moderately deep and in some cases have high moisture retention capacities. Examples are Belfield Clay, Wait-A-Bit Clay, Wirefence Clay Loam etc.

Trace Elements

The levels of some trace elements such as Manganese and Zinc are low in most of Jamaica's hillside soils as shown in Table 2. Others, such as Copper, occur in larger quantities in these soils. Some of the hillside soils are characterized by low contents of both trace and major elements, and are thus marginal for conventional agriculture. One such example is Flint River Sandy Loam, Map No. 50.

In soils with high pH levels, the availability of some trace elements is reduced due to the high concentration of basic ions such as Calcium and Magnesium. This normally occurs in calcareous soils such as Killancholly Clay and Carron Hall Clay. (Map Nos. 91 and 94).

C. CONSERVING THE FERTILITY LEVELS OF HILLSIDE SOILS

Studies of physical and chemical properties of hillside soils in Jamaica reveal that the majority of these soils are inherently infertile. This problem of low fertility is compounded by the constant loss of nutrient by soil erosion, leaching and crop removal. The need to conserve the already low fertility is even greater today when hillside farmers are required to increase their level of productivity to satisfy demand of food on the local and export markets. To this end the following measures should be implemented to assist in maintaining soil fertility.

i) Crop Rationing

This involves the use of a fallow or rest period in the land utilization system to minimise nutrient loss. Crop rationing allows the natural process of soil weathering and nutrient release to replace some of the nutrients which have been removed in crops and by other processes. However, this is a slow process but beneficial results are derived particularly in soils where the parent materials weather easily to release some nutrients.

Examples are soils formed from Richmond and other soft shales. The results of experiments have shown that after 10 years of growing bananas on Belfield Clay (Map No. 41), the level of available soil potash fell from 550 to 400 lbs per acre although approximately 800 lbs of K was removed in the crop during that period. (Weir 1970).

The return of nutrients through the process of fallowing occurs when the weeds, grasses etc., which concentrate the nutrients in their tissues are incorporated back into the soil. Due to the slow process of weathering on most hillside soils and the short term benefits derived from fallowing this system of crop rationing will only be beneficial if there is no great pressure for land use.

Pasture management which is closely related to crop rationing will assist in conserving the fertility status of the soil if light stocking rate is maintained. Light grazing will allow the natural cover of the soil to be maintained thus reducing loss of soil and consequently loss of nutrients.

ii) Growing of Legumes

Crop rotation, which includes the use of legumes as green manure is another method of conserving soil fertility. Legumes are known to fix nitrogen under favourable conditions of soil pH, soil aeration, drainage, moisture, calcium supply etc. The following figures give an idea of the amount of nitrogen fixed by some legumes:

Alfalfa	-	220 lbs/ac)	inoculated
Soybean	-	105 lbs/ac)	
Field beans	-	55 lbs/ac)	not inodulated
Peas	-	45 lbs/ac)	

The amount of N fixed by peas and beans is not always enough to support satisfactory yields of grains. Therefore additional nitrogen is required to produce the desired yield level. However, legumes remove much less nitrogen from the soil than nonlegumes and under suitable conditions they fix some nitrogen thus resulting in reduced removal of this element from the soil.

iii) Addition of Organic Matter

The return of all crop residues and other forms of organic manure should be practised. On decomposition, an appreciable amount of nutrients is released.

iv) Liming of Acid Soils

As mentioned before a few of the hillside soils are strongly acidic (pH of 5- 5.5). These soils when limed at rates indicated by the lime requirement test provide calcium and magnesium which ameliorates soil acidity over a period of time. These soils include Wirefence Clay Loam, Wait-A-Bit clay, Valda Gravelly Sandy Loam etc.

v) Growing Fruit Trees on very Steep Slopes

Permanent tree crops keep the soil covered over a sustained period, thus reducing soil loss while providing income to the farmer.

vi) Use of other Soil Convervation Practices

Use of all other soil conservation practices such as bench terraces, hillside ditches, individual basis etc., should be encouraged wherever possible. These measures will reduce soil loss and hence loss of valuable nutrients, providing they are properly maintained.

TABLE 2 Selected Physical and Chemical Properties of Some Jamaican Hillside Soils

Soil Name	Soil No.	P_2O_5 Rating	Potash Rating	Soil Reac-tions	Water Reten-tion	Soil Depth	Trace Element Rating		
							Mn	Zn	Cu
Diamonds C.L.	34	M	M	N	L	S	L	M	L
Donnington Gr. L.	36	M	M	M Ac	L	S	M	M	M
Cuffy Gully Gr.Sa.L.	38	L	M	Sl.Ac	L	M	L	M	M
Belfield C.	41	L	H	Sl.Ac	M	M	M	M	M
Halls Delight C.L.	46	L	H	N	L	S	L	L	M
Llandewey C.L.	47	L	H	N	L	MS	L	L	M
Flint River Sa.L.	50	L	M	M Ac	VL	S	L	L	L
Valda Gr.Sa.L.	52	L	M	M Ac	VL	S	L	L	L
Chudleigh C.L.	73	M	L	Sl.Ac	M	MD	M	M	M
Lucky Hill C.L.	74	M	L	N	M	D	M	M	M
Union Hill ST.C.	75	M	L	N	M	M	M	L	M
Bonnygate ST.L.	77	VL	L	N	L	VS	L	L	M
St. Ann C.L.	78	VL	L	N	L	M	L	M	M
Lilancholy C.L.	91	L	M	Sl.AlK	H	S	L	L	M
Carron Hall C.	94	L	H	N	H	M	M	L	M
Wait-A-Bit C.	95	L	H	St.Ac	H	D	L	M	M
Wire Fence C.L.	32	L	ML	St.Ac	M	D	L	L	M

Notations

(M - Medium
(L - Low
(H - High
(N - Neutral
(S - Shallow
(D - Deep

C.L. - Clay Loam
Gr.L. - Gravelly Loam
Sa.L. - Sandy Loam
St.C. - Stony Clay
St.L. - Stony Loam
M.Ac. - Medium Acid
Sl.Ac. - Slightly Acid
St.Ac. - Strongly Acid
Sl.AlK - Slightly alkaline

TABLE 3 Nutrients Removed Per Acre By Selected Crops
(lb. per acre)

Crops	Yield per Acre	Nitrogen	Phosphate	Potash
Bananas	10 tons	40	10	150
Cassava	8 tons	35	22	135
Citrus	10 tons	40	10	45
Coconuts	-	65	20	70
Coffee	1,000 lb.	35	7	50
Gungo Peas	1,000 lb.	50	10	35
Maize	60 bu.	90	25	30
Sugar Cane	30 tons	90	40	120
Tobacco	1,500 lb.	70	10	70

TABLE 1 Critical Values Of Some Test Crops

Crop	Critical Nutrient Levels %						PPM				
	N	P	K	Ca	Mg	S	Cu	B	Fe	Mn	Zn
Coastal Bermuda grass	1.0	.2	1.5	-	-	.12	-	-	-	-	-
Pangola grass	1.2	.12	1.2	-	-	.15	-	-	-	-	-
Corn (ear leaf at tassel)	2.7	.25	1.70	.40	.20	.10	3	4	50	20	15
Peanut (Upper stems and leaves at pegging	3.5	.25	2.0	1.25	.3	.2	10	25	50	50	20
Soybean	4.26	.26	1.71	.36	.26	-	10	21	51	21	21
Rice	3.01	.24	1.52	.16	.12	-	-	-	89	237	22

\- Signifies that data not available

Source: Walsh and Beaton, 1973. Soil Testing and Plant Analysis.

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VEGETABLES IN HILLSIDE FARMING

by

HOPETON FRASER

PAPER 1

"Outline of Vegetable Crops and Relevant Cultural Data".

Spacing	Fertilizing	Weedicides	Insect & Control	Disease & Control	Time to Harvest
	1. 12-24-12 pre-plant		1. Flea beetle web worm. C Dipterex, Surecide Thuricide, Malathion	Leaf spot C Kocide, Cupravit, Dithane Damping off C -do-	10-12 weeks
		TOK E25 pre-post emergence	Flea beetle Caterpillars Looper - Malathion, Surecide, Dipterex.	Rarely serious	3-5 weeks
		-do-	As with Cabbage	As with Cabbage	2-3 mths
		Diphenamid pre-emergence 3 lb/ac Prometryne 1 lb/ac pre-emergence	Beetles C Surecide, Dipterex, Nematodes, C Rotation Nematicide	Mosaic virus C Rotation Disease-free-seed, Field sanitation. Damping off C seed treatment, Rotation, Dithane or Kocide, etc. Leaf Spot C Kocide	Start picking 3-10 weeks, continue for several months

Crop	Varieties	Planting Season
Tomato	Oxheart, Manalucie, Manapal, Walter, Homestead, Roma (F), Tropic, Calypso	Year round with irrigation
Sweet Pepper	California Wonder, Yolo Wonder, Bell Boy, Keystone, Giant	Year round
Egg Plant	Black Beauty	-do-

...vant Cultural Data".

Planting Rate	Spacing	Fertilizing	Weedcides	Insect & Control	Disease & Control	Time to Harvest
1-2lb/ac	3'x1½'	1. 12-24-12 pre-plant 2. S/A 12-24-12 as Side dressing	Diphenamid Enide Treflan	Beetles, Pin worm, C Lannate, Surecide Mole crickers - Chlordane, Basudin. Nematodes - Rotation, field sanitation Nematicide.	1. Bacterial with C Rotate, remove infected plants, sterilise soil in Nursery, plant resets. Cultivars. 2. Fusarium wilt C -"- 3. Early and late blight C Kocide, Cupravit, Dithane. 4. Blossom end rot. C ensure reliable amount water; soil has sufficient Ca. 5. Virus - Resistant varieties, field sanitation. Rotate.	10-14 weeks and continues.
4 oz/ac	2'-3'x 1-1½'	12-24-12 pre-plant 2. S/A 12-24-12 as Side Dressing	Diphenamid	Same as tomato	Virus C Rotation Resistant varieties, field sanitation	2-4 months
-do-	2-3' x 2½x3½'	-do-	-do-	Caterpillars (Horn worm) C Surecide etc. Aphids C Malathion Perfekthion	Bacterial Wilt, fruit rot - Kocide, Anthracnose - Dithane, etc.	10-16 weeks

Crop	Varieties	Planting Season	Planting Rate	Spacing	Fertilizing	Weedic
Cabbage	Danish B' head Early Jersey, KK, KY Shamrock, Round-up King Cole Superette	Oct - Jan or Year round with irrigation	D.S. - 2-2lb/ac. TP. 4 oz/ac	2½x1'	1. 6 bags 7-14-14 pre-plant 2. 2 bags S/A - side dressing	TOK E2 pre + emerge or Dactha
Cauliflower	Early Patna " Market " Snow Ball	-do-	-do-	2'x1'	-do-	-do-
Snap or String Bean	Harvester Processor Extender	Year round	40lb/ac			Treflan
Celery	Tall Utah Florida Green Paschal					

Crop	Varieties	Planti Season
Cucumber	Ashley Poinsett Straight 8 Polcmar	Year r
Pumpkin	-	-do-
Melon	Charleston " Grey Tom Watson Sugar Baby	March-
Carrots	Danvers 126	Oct-De
Lettuce	Mignonette Great Lake & Minette	Year r Sept -

	Planting Rate	Spacing	Fertilizing	Weedicides	Insect & Control	Disease & Control	Time of Harvest
	3 lb/ac	4'x4' 2 seeds' hole		Dyanap 1-1. 5 gall/acre pre-emergence Alanap 3lb/ac. post-emergence	Cucumber beetle, melon worm C Dipterex	Powder mildew C Benlate Difolatan	2 months
	-do-	8'x8'		-do-	-do-	-do-	4 months
1	-do-	8'x8'		-do-	-do-	-do-	4 months
	3 lb/ac	14"x2"	12-24-12 6-8 cwt/ac	Gesagard Kerosene Oil	Thrips C Perfekthion, Aphids - Malathion, Rogor	Leaf Blight C Dethane etc. Cupravit, Difolatan	5 months
:	4 oz/ac	1'x6' or 1'x9"			Roger 40 Perfekthion Aphids - C Malathion		6 weeks to 10 weeks

ertiliz-	Weedicides	Insect & Control	Disease & Control	Time of Harvest
4	TOK E25 pre-post emergence Dacthal	Thrips - C Per-fekthion, Rogor 40, Malathion, Cygon. Caterpillars - Malathion and Basudin. Ants Cutworms - Basudin, Sevin, Chlordane	Purple Blotch, C Dithane, Manzate D, Cupravit Kocide Damping off. C seed treatment Rotation, field sanitation.	**Fall** - 4-5½ months **Spring** 4-4½ months

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VEGETABLES IN HILLSIDE FARMING

by

HOPETON FRASER

PAPER 3

Hand-out on "Harvesting, Handling, etc." of Vegetable Crops.

PAPER 3 - Hand-out on "Harvesting, Handling, etc." of Vegetable Crops.

HARVESTING, HANDLING & MARKETING - VEGETABLES

The harvesting, handling and marketing of vegetables involve a complex series of procedures, which test the knowledge and skills of people in the vegetable industry.

It is very crucial that after harvesting the operations of handling, marketing, wholesaling, retailing all those operations to which a product is subjected between harvest-time and consumption-time be done with the utmost speed.

These operations include:

i. Actual Harvesting Operation.
ii. Initial cleaning and sorting.
iii. Packaging and transportation from the farm.
iv. Grading and selection.
v. Storage.
vi. Packaging and transportation to the consumer.

Fresh vegetables are liable to be mis-handled at any or all of these stages, resulting in reduction in quality, profit to the farmers and higher prices to the consumer.

CLASSIFICATION OF VEGETABLES

i. Fruit vegetables - e.g. tomato, egg-plant, cucumber, water melon, musk-melon. These are generally tender and susceptible to injury via bruises during handling.

ii. Leafy vegetables - Spinach, lettuce, cabbage, cauliflower, celery, calaloo, parsley. These are less susceptible to bruises, but highly susceptible to moisture loss.

iii. Root Crops - Plants whose edible portions develop partially or entirely underground - carrot, turnip, beet, sweet potato, irish potato, onion; these are susceptible to injury mainly during the harvest operations.

QUALITY: includes - flavour, texture, colour, moisture content and other factors associated with the edibility and market-ability of vegetables.

Quality criteria are based on both external and internal factors.

EXTERNAL QUALITY FACTORS: involve the appearance and condition of the produce regarding colour, size, shape, uniformity, skin defects, disease and other injuries, e.g. sunburn, bruises, cuts, texture (firmness, crispness, fibre content), and presentation.

INTERNAL FACTORS: involve, flavour, (sweetness, acidity, juiciness, off-flavour, and freedom from internal injury).

QUALITY: is influenced by many factors, including -

(a) Climate: temperature, moisture and light, via their effects on the development physiology of the products.

(b) Field Management and Practices: Diseases and pests control, stage of maturity at harvest, method of harvest.

(c) Post-Harvest Management Practices: e.g. condition of storage (Temperature and Relative Humidity), duration of storage, storage diseases, effects of mixed commodity storage, e.g. onions and cucumbers or chochoes.

WHEN TO HARVEST: Crops like beets, carrot, turnips, onions, may be harvested over several weeks, depending on market demand, while others like asparagus, sweet corn, string beans, cucumber, okra, sweet pepper, quickly pass through the stage of optimum edible maturity, thus requiring frequent and timely harvesting to ensure high quality produce.

Harvesting: a crop before it is of acceptable quality so as to exploit a good market may reduce product demand later - in the season.

However, early harvesting of some crops may decrease field and handing losses.

High Temperatures: hasten maturity and necessitate more frequent and timely harvesting of some crops.

TIME OF DAY: Those vegetables which lose quality rapidly at high temperatures should be harvested in the early morning and kept as cool as possible, e.g. string beans.

A small degree of wilting may prevent breakage or cracking in asparagus, and spinach.

PREVENTING INJURY: Harvesting and handling damages result in substantial losses in vegetables.

Organisms, enter broken areas causing decay and spoilage.

Slight bruises darken products creating an unsightly appearance.

Injuries increase respiration and loss of weight and quality.

POST HARVEST PHYSIOLOGY: Necessary to know that vegetables (cells) do not die immediately after harvest. Processes associated with life continues, and the objective of the various handling techniques is to control those life processes so that the useful or shelf life of the commodity can be prolonged as much as possible.

LIFE PROCESSES:

(a) RESPIRATION: An integral part of life, living plants and animals, including harvested fruits and vegetables respire; that process which utilizes Enzymes sugars (starch) and liberates Energy, Carbon-dioxide and water.

During post-harvest respiration the produce draws on its reserves for energy input, resulting in weight loss, loss of flavour and sweetness.

Respiration cannot be stopped but can be controlled by:

(a) lowering temperatures and/or increasing carbon dioxide.

For every 10° rise in temperature the rates of chemical reactions are doubled.

(b) TRANSPIRATION: The emission of water vapour from the produce resulting in weight loss, wilting and shrivelling, reduction in Transpiration -

- (a) provision of shade for harvested produce
- (b) wetting
- (c) use of ice
- (d) storage in cool humid atmosphere
- (e) reducing surface area of produce e.g. topping carrots, turnips, beets
- (f) protective coatings, e.g. waxing

(c) GROWTH: observable morphological changes sprouting - or less observable changes e.g. wound healing; some are desirable while others are not, e.g. high temperatures and high relative humidity accelerates curing or wound healing, e.g. sweet potatoes.

PREPARING FOR MARKET:

Trimming - improves appearance, e.g. removal of damaged, diseased, dead or discoloured parts.

Cases where the outer leaves offer protection and enhance appearance e.g. cabbage and lettuce, celery and cauliflower.

Washing - the modern market demands clean produce, hence most vegetables must be washed after harvesting to remove dirt, freshen the product and removal of spray residues. After washing, the produce must be kept cool to prevent the development of rot organisms and most root crops should not be washed until they are marketed.

Musk-melons, cucumbers, water-melons, sweet potatoes are usually cleaned by brushing or wiping dry rather than by washing.

Grading - is the sorting of vegetables so that the contents of each package will be fairly uniform, makes produce more marketable.

Even second-grade products present a better appearance when packed by themselves.

N. B. - UNIFORMITY appeals to the eye and suggests careful handling. Growers further from the market must exercise more careful grading and lacking.

Packaging - One of the requirements of the modern marketing and distribution system and Food containers should -

i. Protect the produce at all stages of distribution
ii. Assist in the rationalization of handling and transport operations
iii. Contribute to proper presentation of the produce
iv. Save storage and selling space
v. Be cheap and easy to be manufactured

Choice container depends on the product to be packaged and the method of transportation, e.g. cartons or wooden crates.

There are two broad groups of containers.

(a) Outer or shipping containers
(b) Retail Containers

Basic functions of both are similar, but their importance varies.

Containers for field use would be sturdy, well ventillated, easily stacked, to facilitate transportation.

Containers being displayed to the consumer should emphasize attractiveness in presentation.

Some commonly used containers -

Baskets, boxes, hand crates (field and shipping) perforated polyethylene bags (display packages) e.g. onions. The use of the crocus or jute bags should be avoided in the majority of cases.

Pack to fit - that is to avoid looseness: as free-movement results in damage due to collision, or if too tightly packed, the produce may be bruised and squeezed out of shape.

Storage - The object is to provide an environment that will permit storage of the produce as long as possible without loss of quality; this can be obtained by controlling temperature, composition and circulation of the atmosphere, humidity and reduction of microbical contamination through sanitation.

Temperature - is the most important factor in the storage of fresh vegetables. Generally, the lower the temperature the less amount of HEAT is generated, since life processes proceed more slowly at low temperatures. Too low temperatures can be quite harmful - causing chilling and or freezing injury.

Cooling - In operating and maintaining low temperature storage, it is necessary to control -

(a) Field Heat or the heat which has to be removed from the produce and its containers in order to reduce their temperature to that which is desired or the holding temperature.

(b) Heat of Respiration and (c) Heat leakage. Heat leakage is greatest when the differential between the inside store-room temperature and outside is greatest and can be controlled by insulation and avoidance of too frequent entry.

Field Heat removal is most demanding on a refrigeration unit and can be lessened by pre-cooling via:

(a) dip products in cold water and cool rapidly
(b) vacuum cooling to obtain rapid temperature, e.g. reduction for lettuce
(c) cold air blast or crushed ice, for vegetables susceptible for high water loss.

MARKETING: The single most important constraint to the development and stabilization of the Jamaican vegetable industry is marketing.

With our high production costs inter-regional marketing is almost non-existent.

A clearly defined policy goal on the Government's marketing agency is not established, that is, whether it is consumer of farmer oriented or both.

MARKETING AGENCIES:

Government - A.M.C. 20 - 30% mark up on produce - Quality oriented.

Most demanding on Quality and Reliability of Supplies	40 - 100% mark up - Supermarkets and Green Groceries.

Higglers - 100% mark up at least

Supplies year round to - Hotels, Restaurants, Hospitals and Supermarkets and to Higglers	Wholesalers - 30 - 40% mark up

(Roadside Outlets) 40% mark up
Sometimes done by farmers' wives.

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VEGETABLES IN HILLSIDE FARMING

by

HOPETON FRASER

PAPER 2

"Weedicide Hand-out for Crops".

PAPER 2 - "Weedicide Hand-out for Crops".

Banana			
Ametryn	3 lbs/ac	Post-emergence	As a directed spray
Dalapon	2 lbs/ac.	Post-emergence	As a directed spray
Paraquat	1 pt/ac.	Post-emergence	As a directed spray
Diuron	2 lbs/ac.	Post-emergence	As a directed spray
Citrus			
Ametryn	3 lbs/ac.	Post-emergence	Direct spray beneath plants
E.P.T.C.	4 lbs/ac.	Pre-plant	Incorporate in soil
Simazine	2 lbs/ac.	Post-emergence	As a directed spray
Dalapon +)	2 lbs/ac.	Post-emergence	As a directed spray
Diuron }	2 lbs/ac		
Diphenamid	2 lbs/ac.	Pre-emergence	Incorporate in soil
Paraquat	1 pt/ac.	Post-emergence	Directed spray
Coffee			
Dalapon	2½ lbs/ac.	Post-emergence	Directed spray
Diuron +)	2 lbs/ac.		
Paraquat}	1 pt/ac.	Post-emergence	Directed spray
Atrazine	2 lbs/ac.	Pre-emergence	Applied around seedlings
Cocoa			
Dalapon	4 lbs/ac.	Post-emergence	Directed spray
Diuron +)	2 lbs/ac.		
Paraquat}	1 pt/ac.	Post-emergence	Directed spray

VEGETABLE CROPS

Cabbage			
Trifluralin	½ lb/ac.	Pre-plant	Apply to soil before setting out seedlings
TOK	3 lbs/ac.	Pre-emergence	Apply after sowing
Dacthal DCPA	8 lbs/ac.	Pre-emergence	Apply at time of sowing or transplanting
Cauliflower			
DCPA	8 lbs/ac.	Pre-emergence	Apply at time of sowing or transplanting
TOK	3 lbs/ac.	Pre-emergence	Apply after sowing seeds
		Post-emergence	Apply 2 weeks after transplanting
Trifluralin	½ lb/ac.	Pre-emergence	Apply prior to transplanting

Carrot			
Dasanex	2 lbs/ac.	Post-emergence	Apply when carrot have at least four true leaves
Trifluralin	1 lb/ac.	Pre-plant	Incorporate 2-4" in soil
TOK	2 lbs/ac.	Pre-emergence	Do not disturb soil after application
Treflan	residual effect - 2 months.		
Celery			
Trifluralin	1 lb/ac.	Pre-plant	For direct seeded crop
		Pre-emergence	Apply prior to transplanting
Eptam	2 lbs/ac.	Pre-plant	Incorporate in soil
Prometryn	1 lb/ac.	Post-emergence	Apply 2 weeks or more after transplanting
Lettuce			
Senefin	1 lb/ac.	Pre-plant	Apply up to 10 weeks before crop. Incorporate in soil.
Benthiocarb	3 lbs/ac.	Post-emergence	Apply up to 10 days after transplanting
DCPA	6 lbs/ac.	Pre-emergence	Do not disturb soil after application
Okra			
Diphenamid	3 lbs/ac.	Pre-emergence	Soil should be wet just before or after application
Trifluralin	1 lb/ac.	Pre-emergence	Incorporate in soil
Promatryne	1 lb/ac.	Pre-emergence	Soil should be wet after application
Onion			
TOK	3 lbs/ac.	Pre-emergence	Wet after application
DCPA	8 lbs/ac.	Pre-emergence	Do not disturb soil after application
Ioxynil	½ lb/ac.	Post-emergence	For control of broadleaf weeds
Prometryne	1 lb/ac.	Pre-emergence	Apply before weeds emerge
	½ lb/ac.	Post-emergence	
Pepper			
Diphenamid	3 lbs/ac.	Pre-emergence	Incorporate in soil
	2 lbs/ac.	Post-emergence	May be applied as an overtop spray

Trifluralin	½ lb/ac.	Pre-plant	Incorporate in soil
DCPA	8 lbs/ac.	Post-emergence	Apply 2 weeks after transplanting but pre-emergence to weed.

Tomato

Diphenamid	3 lbs/ac.	Post-emergence	Spray
Trifluralin	½ lb/ac.	Pre-plant	Incorporate in soil
Tribunil	2 lbs/ac.	Pre-emergence	Soil should be moist at the time of application

LEGUME CROPS

Beans

Trifluralin	1 lb/ac.	Pre-plant	Incorporate 2-4" in soil
EPTC	3 lbs/ac.	Pre-plant	Incorporate in soil
Dalapon	2 lbs/ac.	Post-emergence	For the control of grassy weeds

Peas

EPTC	2 lbs/ac.	Pre-plant	Incorporate in soil
Prometryn	1 lb/ac.	Post-emergence	As a directed spray
Dalapon	2 lbs/ac.	Post-emergence	Control grassy weeds

Peanut

Diphenamid	4 lbs/ac.	Pre-plant	Incorporate in soil
Senefin	1 lb/ac.	Pre-emergence	Water soil immediately

Soyabean

Diphenamid	2 lbs/ac.	Post-emergence	As a directed spray
Diuron	½ lb/ac.	Pre-emergence	Control broadleaf weed and grass

CEREAL CROPS

Corn

Prometryn	1 lb/ac.	Pre-emergence	Wet soil lightly
Atrazine	1½ lb/ac.	Pre-emergence	Control both broadleaf weeds and other grasses
	1 lb/ac.	Post-emergence	Apply when weeds are up to 1½" tall
Simazine	1 lb/ac.	Pre-emergence	Apply as a band or overall treatment
Cyanazine	2 lbs/ac.	Pre-emergence	Irrigate or wet soil immediately after application

Rice			
Propanil	4 lbs/ac.	Post-emergence	Apply when rice grass is in the leaf to early tiller stage
Benthiocarb	3 lbs/ac.	Post-emergence	On transplanted rice - apply 3 days before and up to 10 days after transplanting. On drilled rice apply up to 15 days after seedling
2,4-D	1 qrt./ac.	Post-emergence	Apply 7-10 weeks after planting when rice is fully tillered.
Sorghum			
Atrazine	1 lb/ac	Post-emergence	Apply before weeds are 1½" tall
2,4-D	1 pt/ac.	Post-emergence	Apply when sorghum is 4-12" tall

ROOT CROPS

Sweet Potato			
EPTC	2 lbs/ac.	Pre-plant	Incorporate in soil
Diphenamid	3 lbs/ac.	Pre-plant	Incorporate in soil
Cassava			
Atrazine	3 lbs/ac.	Pre-emergence	Control broadleaf and grasses
Diuron	3 lbs/ac.	Pre-emergence	Control broadleaf and grasses
Coco and Yams			
Atrazine	3 lbs/ac.	Pre-emergence	Control broadleaf and grasses
Diuron	3 lbs/ac.	Pre-emergence	Control broadleaf and grasses
Prometryne	2 lbs/ac.	Pre-emergence	Control broadleaf and grasses
Irish Potato			
Dalapon	2 lbs/ac	Pre-emergence	Control only grasses
Diphenamid	4 lbs/ac.	Post-emergence	Spray on top
Prometryne	2 lbs/ac.	Post-emergence	Apply early post-emergence
Paraquat	1 pt/ac.	Post emergence	Apply as directed spray
Eptam	2 lbs/ac.	Pre-plant	Incorporate in soil

MISCELLANEOUS CROPS

Pineapple

Simazine	2 lbs/ac.	Post-emergence	Apply immediately after planting
Atrazine	2 lbs/ac	Post-emergence	Apply immediately after planting or when harvesting has been completed
Ametryn	2 lbs/ac.	Post-emergence	Apply as blanket spray immediately after planting

Sugarcane

Ametryn	2 lbs/ac.	Pre-emergence	Apply to soil at time of planting
Atrazine	2 lbs/ac.	Pre-emergence	Apply before planting
Dalapon	4 lbs/ac.	Post-emergence	Apply as a directed spray
Paraquat	1 pt./ac.	Post-emergence	Apply as a directed spray

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LECTURE NOTES ON ROOTCROPS

Speaker: R. L. RAINFORD

INTRODUCTION

When slaves were brought to the New World from Africa they took along some of their native foodstuff and planted these in their little gardens on the edge of the plantations on which they worked. Yams, Cacaos along with Cassava and Sweet Potato were the main crops grown. Following emancipation in 1838 the "freed" slaves expanded their rootcrop cultivation to steep hillside lands. This was the beginning of small farming in Jamaica, and today nearly 140 years later, rootcrop production is associated with small scale farming in hilly upland areas. Today when we speak of rootcrops we think of Yams, Cacaos, Cassava, Sweet Potato and Irish Potato.

ECONOMIC IMPORTANCE

Rootcrops are a rich source of carbohydrate and may be eaten as vegetables, as dehydrated products and flour, etc. With the exception of Irish Potatoes very few diseases and pests affect these crops, they are easy to cultivate and though highly labour-intensive can be maintained with little difficulty.

Rootcrops have many uses in industry, most important of which are their use as starch, as a flocculant in the Bauxite industry, in making adhesives, alcohol, paints, baby food, animal feed, as a substitute for wheat flour in the baking industry, and as a gel or thickener in convenience foods in North America and Europe.

Rootcrops are of great value to the Jamaican economy. Only a small amount of the total production is exported to Canada, U.S.A., England and Carifta countries. The rest is consumed locally. The value of sales of rootcrop at farmgate prices in 1974 was calculated at approximately $48,000,000.00.

Rootcrop production has increased significantly over the years and with restrictions on imports of basic food commodity items the trend is towards further increase over the years ahead. The following table gives an idea of recent production trends.

TABLE 1 - ROOTCROP PRODUCTION IN JAMAICA

CROP	Production (Short tons)		Average Yield (Tons/ac)	
	1977	1978	1977	1978
Dasheen	22,160	22,151	5.7	6.1
Cacao	15,980	22,550	3.1	4.1
Irish Potato	9,280	14,445	3.3	4.0
Sweet Potato	30,260	58,563	3.5	5.0
Bitter Cassava	23,280	23,745	4.2	5.2
Sweet Cassava	13,710	15,772	3.4	4.4
Yams (All varieties)	146,340	181,193	4.9	5.5

Source: Compiled from data supplied by Data Bank, Ministry of Agriculture

The export market is also increasing as can be seen below:

EXPORTS - MAJOR ROOTCROPS OF JAMAICA

Crops	1977	1978
Dasheen	1,572,556 lbs.	1,923,038 lbs.
Cacao	724,775 "	1,573,319 "
Irish Potato	Nil	Nil
Sweet Potato	512,414 "	1,015,112 "
Bitter Cassava	Nil	Nil
Sweet Cassava	34,931 "	20,645 "
Yams (All varieties)	3,456,788	4,858,074 "

Source: Figures supplied by Produce Inspection Division - Min. of Agriculture

SOME PROBLEMS ENCOUNTERED

Yams - Over 16 major yam types have been identified so far, and classified as follows:

Lucea, Mozella, Negro	Dioscorea rotundata
Round Leaf, Yellow, Afou	Dioscorea cayensis
White, Renta, Sweet, Guinea, Moonshine, Snake, St. Vincent	Dioscorea alata
Yampie	Diascorea trifida
Acom	Dioscorea bulbifera
Chinese	Dioscorea esculenta

The main problems encountered so far are:-

a) Availability of desease-free planting material

Nematodes infect the hardier varieties like Lucea, Negro and Yellow. Infected "heads" are described as "burnt" heads by farmers who are now being exposed to field training in selection of "clean" seed. Vine cutting experiments are being conducted by the Agronomy Division to investigate the production of clean seed material for distribution to farmers.

b) Scarcity of planting material of the softer early maturing varieties

EB., St. Vincent, White Yam, Sweet Yam. Farmers may have to reserve the whole or part of the tubers for rapid multiplication to preserve vanishing species.

c) Seasonal Glutting in certain food basket areas, eg., Hanover

A proper system of distribution should take care of "gluts".

d) Storage problems for certain varieties

The ministry of Agriculture might well embark upon a programme of positive investigations into methods of improving the shelf life of certain varieties - Yellow Yam in particular.

Sweet Potato

Several varieties are grown in pure stands or in combination with other crops, viz., yams, corn, peas. It is not uncommon for the same variety to be known by different names in different locations. A detailed study of all local varieties is currently being undertaken, the aim being to arrive at a proper classification.

A shortage of planting materials when required is an annual recurring problem.

Irish Potato

At the most this is a 16-week crop in areas like Christiana, Darliston, Hounslow, Guy's Hill. The main problems are:

a) Proper Land Preparation: Depth of ploughing, depth of drills, proper drainage should receive priority attention.

b) Use of disease free seed: Only certified seeds from approved purchasing agents should be planted.

c) Crop care: Rigid spraying cycles should be maintained throughout the crop life as recommended. Early and late blight can destroy a crop overnight if there is any lapse in the spraying programme.
Proper pest control is an important as disease control.

Cassava

Non-availability of adequate markets for processing. The local "bammy" trade is well satisfied, but large acreages remain unreaped in the "bauxite" parishes of St. Elizabeth, Manchester, and certain parts of Clarendon. The processing factory at Goshen, St. Elizabeth, has not yet come on stream and the community factory at Old Harbour can take limited supplies only. Farmers are somewhat disenchanted and the low price of 6¢ per lb. is a disincentive. Apart from this marketing problem there is the need to determine the performance of local as well as imported cultivars under differing ecological conditions.
Currently, field studies are being conducted at Lawrencefield, St. Catherine, in Portland, St. Catherine, and St. Elizabeth.

The Bitter-Sweet controversy continues unabated while the Ministry continues the search for a high yielding variety with low N.C.N. content, and which shows a high tolerance to local pests and diseases.

Dasheen & Cacaos

These are the Aroids which are grown mostly in the domestic food production effort over the years. They do not present serious problems, except that theere is the shortage of planting material when most needed.

At this point I would welcome suggestions from the group, drawn as you are from a fair cross section of the country, as to problems which you are experiencing with rootcrop production in your particular area. These may be agronomic problems which require on-the-spot training or those which may have to be referred to the Agronomy Division for research.

CONCLUSION

Rootcrops can be produced much more efficiently than is being done at present. Great potential exists in the form of attractive incentivesie., high farm gate prices, attractive local sales market and a possible export market. How much of the existing technology can be transferred to farmers to make their lot better? This I feel is our prime responsibility.

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WEATHER AND CROP SOIL WATER RELATIONS

Warren Forsythe

IICA OFFICE IN BARBADOS

Atmospheric Water Balance and Soil Water Status

The moisture content of a well drained agricultural soil follows cycles determined by climate and irrigation and range between an upper limit of field capacity and a lower limit of wilting point. When the soil driesor when plants extract water from the soil, the drying of the profile is differential, the upper part being drier in the beginning.

When a well drained soil is adequately supplied with water, that is, when it is at field capacity, and has non-saline conditions, crops evapotranspire at the maximum rate which is called potential evapotranspiration. Potential evapotranspiration has been correlated (Brutsaert 1965, Pruit 1966) with the U.S. Weather Bureau type A pan evaporation. There is a constant for each crop, called f, which is multiplied by pan evaporation to determine potential evapotranspiration. This constant depends on the area of soil covered by the active foilage of the crop and the maturity of the leaves. The majority of crops studies have factors that vary between 0.8 and 1.1 with maximum canopy development. Crop height has little influence on its capacity for evapotranspiration; what is important is the area of soil covered. (Bernard 1953, Viets. 1962). The passive action of plants as an evaporating surface has been compared to that of a wet wick.

There are a few notable exceptions to this generalization. Ekern (1965) found that pineapple with a well developed canopy of 12 months has an f-value of 0.2 because its stomata are closed during the day and gaseous interchange between the leaves and the soil air (which is usually very humid) is carried out by means of channels in the roots and stems. This mechanism possibly exists in opuntia and other succulent plants (cacti). Ferri (1961) mentions species found in the "caatingas" of Brazil that only open their stomata in the early mornings even during the rainy season. Hilgeman and Rodney (1961) obtained valves of f of 0.45 to 0.58 for oranges and Van Bavel, Newman and Hilgeman (1967) suggested that oranges have a high stomatal resistance even when well supplied with water. Other xerophytes may have similar mechanisms.

Bare soil that is well drained and at field capacity enters in its first stage of evaporation, known as the constant rate or better still the constant f stage, because this rate of evaporation depends only on climatic conditions (Pan evaporation). (Miller and Klute 1967). In Hawaii, Campbell, Chang and Cox (1959) found f for a bare soil to be 0.4 and Hargreaves (1966) found a value of 0.42. When the soil is covered by a crop with an f value greater than the bare soil, the value of f increases. Table 1 shows this trend for cotton and sugar cane. In the case of cotton, it is noted that f begins to decrease after 80 days, probably due to maturity and leaf-fall. On the other hand sugar cane shows no notable drop in f. The following are some values of f for fully developed canopies: beans 1.0, corn 0.85, (Jensen, Middleton and Pruitt 1961), beans 1.07-1.19, corn 0.98-1.39, flood rice 1.04-1.14, peanuts 1.02-1.23, bananas 0.89-0.92, Canavalia ensiformis 1.10, Crotolaria Usaramoensis 1.16. (Dupriez, 1964).

Mulching to completely cover a bare soil has on the average been found to reduce evaporation by a factor of 0.43 (Jacks et al 1955). As the soil dries to the Permanent Wilting Percentage, mulching looses its effectiveness in reducing evaporation.

Good correlation has been experimentally obtained between potential evapotranspiration and pan evaporation. (Brutsaert 1965, Pruitt 1966) and as a result the ratio of the former to the latter is considered a good estimate of f. The U.S. Weather Bureau Class A pan has been widely used for this purpose. If f is known for a given crop then the potential evapotranspiration can be calculated from pan evaporation. In areas where pan evaporation data do not exist, weather data can be used in its estimation. Studies suggest that for a given locale inside the tropical belt between 15°N and 15°S variations in relative humidity have a primary role in evaporation changes and formulas that use this factor have considerable success. (Garcia and Lopez 1970, Legarda and Forsythe, 1972, Hasan and Jones. 1972). On the other hand, formulas that depend only on temperature such as Thornthwaite's have little success in this belt due to the relatively small seasonal changes during the year. For the Monymusk area of Jamaica, which is 18°N, Cowan and Innes (1955) found that the British pan evaporation correlates well with the Blaney-Criddle formula.

The atmospheric water balance for a given period is the difference between rainfall and evapotranspiration. For soil at field capacity that is covered with a growing crop at full canopy development, the difference between rainfall and pan evaporation is an estimate of the atmospheric water balance. This assumes that the crop has an f value of 1, and is an index of the evaporating power of a particular climate. When the atmospheric water balance is negative then the soil will begin to dry out, and the more negative it is the greater will the climatic capacity for drying the soil. The value of the negative water balance indicates crop water needs to eliminate a soil water deficit. The evapotranspiration from a dry soil will be less than the potential evapotranspiration rate. This will depend on the soil moisture, the depth of the root extraction zone, the total moisture holding capacity of the extraction zone, and the magnitude of the negative atmospheric water balance. Forsythe (1976) has developed a formula which takes these factors into account. A positive atmospheric water balance means that soil moisture will increase until field capacity is reached. This assumes that there is no run-off. Run-off will vary according to the cropping system, the soil and the soil moisture. A continued positive atmospheric water balance will indicate percolation and drainage and its value indicates the drainage load on the farm under poor drainage conditions. Bare soil and young crops with little canopy development will have an f value less than 1 and the potential evapotranspiration should be adjusted accordingly.

A neutral, slightly positive or slightly negative atmospheric water balance will maintain the soil in its previous moisture condition. Thus a dry soil will remain dry and a wet soil will remain wet.

75% Dependable Rainfall and 80% Maximum Rainfall

It is common to express rainfall in terms of monthly averages, but for the farmer it is more useful to know what are the chances that a certain minimum of rain will fall in a given month, when it is known that rainfall of this minimum value or greater will give a good crop. In practical farming terms one should aim to obtain a good crop on the average 3 out of 4 years, or 75% of the years. Thus 75% dependable monthly value will supply this minimum figure. Common monthly averages will tend to be 50% dependable; generally not enough for economic farm planning. Figure 1 illustrates the 75% dependable rainfall and the 80% maximum rainfall which means that, on the average, 4 out of 5 years this monthly rainfall will not be exceeded. This figure is useful to estimate the steady flow drainage coefficient for an on-farm drainage system. This will not handle 24 hour surges in the water table above this point nor run-off carrying capacities of field drains and drainage canals. Table 2 shows monthly rainfall probability distributions in per cent probability for the Georgetown Botanic Gardens, Guyana. The 75% dependable rainfall and the 80% maximum rainfall have been extracted from the tables, and rainfall values with other probabilities may be extracted according to needs.

Crop Water Needs: Irrigation Needs: Salinization: Steady Drainage Needs: Soil Moisture: Planting and Reaping Dates:

Tables 3 and 4 shows 75% dependable monthly atmospheric water balance derived from 75% dependable monthly rainfall and monthly average type A pan evaporation. The monthly average evaporation is used since evaporation fluctuation is very small compared to rainfall fluctuation. The 75% dependable atmospheric water balance may be interpreted as the minimum water balance (Maximum deficit if negative) that will occur 3 out of 4 years, on the average. This interpretation is similar to that of the 75% dependable rainfall, but now we are talking in terms of crop water needs. The data for Georgetown Botanic Gardens show that May, June, July and December are positive water balance months when soil moisture increases, the rest are negative, during which time, a soil that is covered with a crop with f = 1, begins or continues drying out. The negative atmospheric water balance indicates the amount of water that has to be supplied to or stored by the soil to sustain maximum crop growth for a given month, 3 out of 4 years on the average. This figure is used to plan the water supply delivery of an irrigation system that is designed to maintain good crop growth at least 3 out of 4 years. Thus in the Georgetown area a system which can deliver 5.18" of water to the crop in March will have a 75% certainty of good production. This figure serves as a guide for irrigation water needs as the area under irrigated agriculture increases. A total annual negative atmospheric water balance of approximately 22 inches indicates the area's need for additional water. An estimation of run-off will improve the accuracy of this value. Salty water from water tables may rise in the soil profile, concentrate by drying, and cause salinization. Salty irrigation water can do the same by concentrating in the root zone due to the drying of the soil by the plants.

Thompson (1950) cites the following inequality as a guide for taking probability into consideration in estimating irrigation costs for a given negative water balance.

$$P > \frac{C}{L}$$

Where:

P = probability of the negative water balance (here 75%)

C = annual cost of irrigation for that deficit.

L = annual loss if not irrigated.

For the Georgetown area the 80% maximum atmospheric water balance for June is 17.1 - 4.47 = 12.63 inches, and this figure divided by 30 gives a daily net excess water of 0.42", which provides a drainage coefficient for steady in-field drainage, which on the average would be exceeded only 1 out of 5 years.

In the Georgetown area, the month of May is the first month of the year with a positive 75% dependable atmospheric water balance, when soil moisture begins to increase. Planting when the soil has become sufficiently moist should be initiated at this time, if the length of the crop growing cycle is convenient. Soil moisture increases to field capacity and remains there during this period if the soil is well drained. In the case of black-eye peas the positive water balance period should last until the pod filling stage. Drying and maturing stages of the crop should coincide with a period of negative water balance during which the soil begins to dry out. Assuming that black-eye peas needs 70 days to end the pod-filling stage, June 15-20 would be an appropriate planting date since although August has a negative water balance, it is only slight and follows a period when the soil was at field capacity, whereas definite drying starts in September. Values to the pod-filling stage for some varieties of the Phaseolus vulgaris bean, and corn are 60 and 100 days respectively. Sporadic heavy rains during an established dry season (period of negative water balance) should not be interpreted as an appropriate time for planting.

Soil storage capacity for available moisture to plants is an important factor in interpreting the effect of atmospheric water balance on soil moisture. McClean (1972) has found that many coastal clay soils of Guyana demonstrate a storage capacity of 4 inches of available water for sugar cane for about 24 inches of root zone. The available water storage in a clay soil in the Georgetown area charged in May, June and July, can support plant growth without irrigation in August and part of September.

Field Drainage: Surge of Water Table: Surface Run-off Removal

In addition to considering the drainage coefficient for the design of steady flow of water from the field water table to the field drains, one has to consider the surge of the water table after a heavy day's rain and the removal of surface run-off in the field drains. Table 5, 6, and 7 shows maximum rainfall intensities for different return periods for 5 minutes to several hours.

A return period of 2 years means that the given intensity is expected to be exceeded once every 2 years, a return period of 5 years, once every 5 years. For agricultural purposes return periods of 5 to 10 years are generally used, being considered an economical guideline. The time lapses in Tables 5, 6 and 7 are appropriate to estimate design run-off rates for canals, for small catchments in urban areas or small agricultural water-sheds with low concentration times. Table 8 shows rainfall rates for 1 to 5 day time lapses. These figures can be used for run-off estimates of larger watershed areas and also to estimate water table surge frequencies in an agricultural field. In addition to annual 1 day maximum rates in Table 8, for Georgetown Botanic Gardens it has been estimated that 1 day maximum rains (of 5 year return interval) between March to

April, September to mid November, and May to July are respectively 3.2, 3.3 and 3.9 inches. A maximum 1 day rain in May to July will be more effective in causing a water table surge than in September to November or March to April. Studies to associate water table rises with daily rainfall would be of use in this area. In the case of a flooded rice field, the rise would be equivalent to the rainfall, and 1 to 3 day rainfall figures have been used to estimate the drainage coefficient to prevent rice damage by submergence. (Ministry of Economic Development 1971).

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TABLE 1

THE "f" FACTOR FOR COTTON* (160 DAY CROPPING CYCLE)

Age (Days)	20	40	60	80	100	120	140	160
"f" Factor	0.42	0.75	0.95	1.0	0.96	0.9	0.5	0

* Taken from Hargreaves (1969)

THE "f" FACTOR FOR SUGAR CANE**

Age (Months)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
"f" Factor	0.4	0.45	0.54	0.84	1.0	1.02	1.06	1.1	1.08	1.2	1.18	1.15	1.16	1.15

** Taken from Chang (1961)

TABLE 2

MONTHLY RAINFALL PROBABILITIES (%) (1951 - 1975)

GAMMA DISTRIBUTION

GEORGETOWN BOTANIC GARDENS, GUYANA

	O	N	D
[illegible]7	2.38	3.71	5.28
[illegible]4	5.99	5.13	4.55
[illegible]7	-3.61	-1.42	0.73
[illegible]	-91.7	-36.1	18.5

[illegible]ALL INTERVAL - INCHES							75% DEPENDABLE RAIN	805 MAXIMUM RAIN
14 – 16	16 – 18	18 – 20	20 – 22	22 – 24	24 – 26	26 – 28		
5.6	3.8	2.5	1.6	1.1	0.7	0.4	4.89	12.92
.1	.03	.01					1.48	5.13
0.1	.03	.01					1.47	5.12
							2.89	5.51
8.2	6.7	5.4	4.3	3.3	2.5	1.9	6.52	17.22
20.5	12.2	5.8	2.3	0.7	.2	.06	11.20	17.1
2.5	.2	.01					8.81	11.78
5.8	4.0	2.7	1.7	1.2	.8	.5	4.31	13.17
.7	.3	.2	.07	.03	.01		2.07	6.78
.02							2.38	5.28
4.8	3.4	2.4	1.7	1.2	.9	.6	3.71	12.4
5.7	3.7	2.3	1.4	0.9	0.5	.3	5.23	12.77

TABLE 3

DEPENDABLE RAINFALL AND WATER NEEDS

GEORGETOWN BOTANIC GARDENS (GUYANA)

	J	F	M	A	M	J	J	A	
75% Dependable Rainfall	4.89	1.48	1.47	2.89	6.54	11.20	8.81	4.91	
Evap. Tank A. In.	4.95	5.34	6.65	6.08	5.46	4.47	5.10	5.65	
At. Water Balance 75% In.	-0.06	-3.86	-5.18	-3.19	1.08	6.73	4.96	-0.74	-
At. Water Balance 75% mm	-1.52	-98.04	-131.6	-81.03	27.4	170.9	125.0	-18.8	-1(

TABLE 4

DEPENDABLE RAINFALL AND WATER NEEDS. LOG - NORMAL DISTRIBUTION. BELLE, BARBADOS

ALTITUDE 124ft. 1957-76 (GOVT. OF BARBADOS 1978)

A	M	J	J	A	S	O	N	D
1.34	1.06	1.41	2.77	4.2	3.96	4.8	3.43	2.31
6.35	6.41	5.9	6.11	5.95	5.02	4.59	4.75	5.08
-5.01	-5.35	-4.49	-3.34	-1.75	-1.06	+0.21	-1.32	-2.77
127.2	-135.9	-114	-84.8	-44.4	-26.9	+5.3	-33.5	-70.3

TABLE 5

GEORGETOWN BOTANIC GARDENS, GUYANA, (1957-1976)

RAINFALL INTENSITIES - INCHES/HOUR (PERSAUD and FORSYTHE 1977)

RETURN PERIOD - YEARS	TIME LAPSE OF RAIN FALLEN							
	5 min	10	15	30	1 hr	2	6	12
2	5.6	4.6	3.9	2.7	1.8	1.2	0.54	0.30
5	7.6	5.6	4.6	3.4	2.3	1.4	0.72	0.37
10	8.8	6.2	4.9	3.7	2.6	1.5	0.82	0.41
20	9.8	6.7	5.2	4.0	2.8	1.6	0.94	0.45
50	11.2	7.4	5.6	4.5	3.2	1.7	1.1	0.50

TABLE 6

SMITHFIELD, JAMAICA. (1970-75)

RAINFALL INTENSITIES. INCHES/HOUR. (PAULET, 1978)

RETURN PERIOD YEARS	TIME LAPSE OF RAIN FALLEN					
	15 min	30	1 hr	2	4	6
2	7.6	3.9	2.18	1.18	0.65	0.24
10	9.9	5.0	3.0	1.37	0.78	0.43
50	11.5	5.7	3.6	1.5	0.92	0.62
100	12.1	6.0	3.84	1.55	0.98	0.70

TABLE 7

GRANTLEY ADAMS INTERNATIONAL AIRPORT STATION (ALTITUDE 183ft)

INTENSITY - INCHES/HOUR (LIRIOS, 1971)

YEARS RETURN PERIOD	LAPSE OF RAIN FALLEN						
	5 mins	10mins	15	30	1 hr	2 hrs	24 hrs
2	5.04	3.6	3.28	2.04	1.31	0.86	0.15
5	6.48	4.56	4.12	2.8	1.89	1.26	0.21
10	7.32	5.16	4.72	3.24	2.28	1.52	0.26
50	9	6.6	6.08	4.34	3.12	2.11	0.35
100	9.84	7.2	6.56	4.8	3.5	2.36	0.39

TABLE 8

GEORGETOWN BOTANIC GARDENS, GUYANA

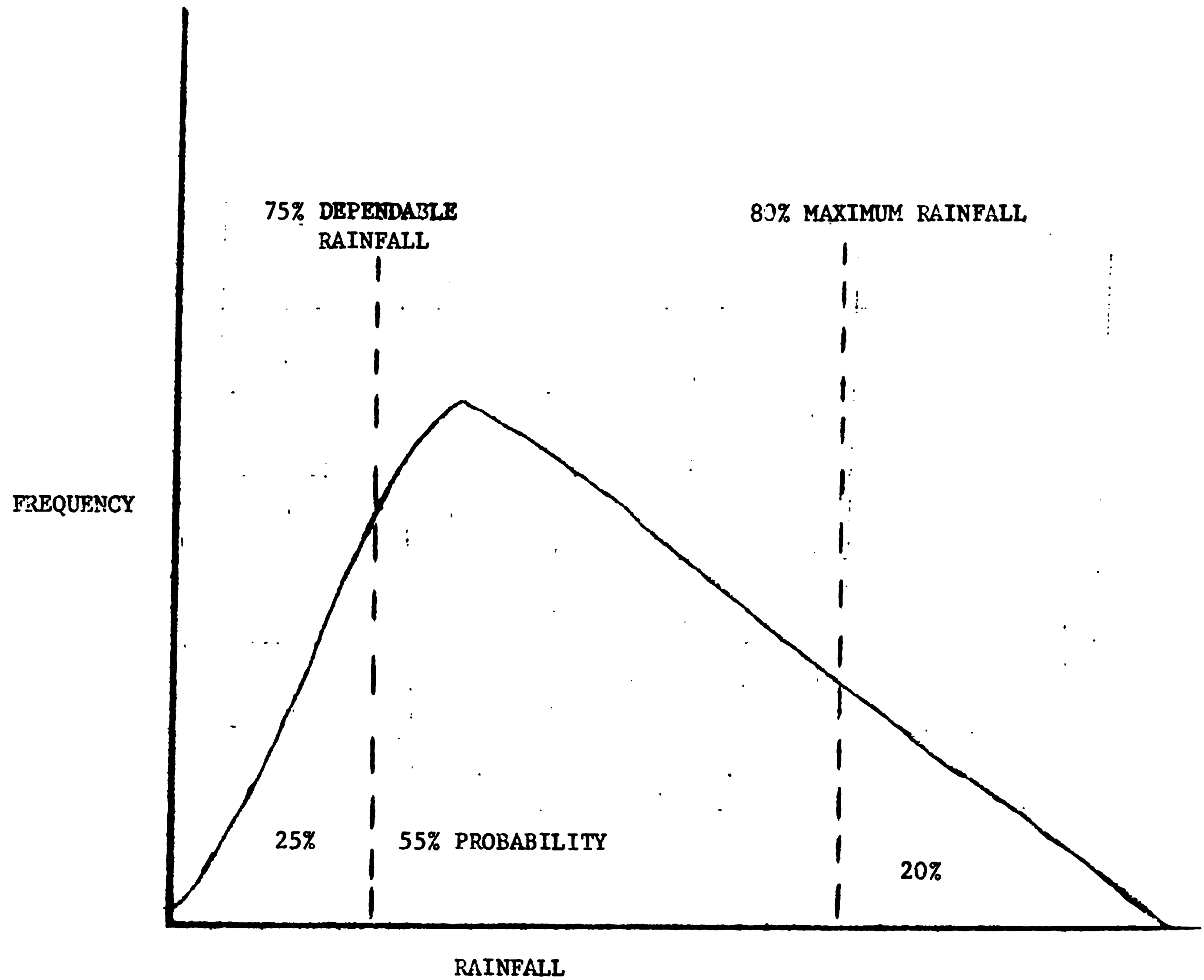
RAINFALL INTENSITIES - INCHES/DAY

(MIN. OF ECON. DEV. 1971)

RETURN PERIOD-YEARS	TIME LAPSE OF RAIN FALLEN				
	1 DAY	2	3	4	5
2	4.01	2.71	2.15	1.77	1.56
5	5.43	3.57	2.91	2.35	2.09
10	6.37	4.14	3.39	2.73	2.45
20	7.58	4.86	4.01	3.22	2.91
50	8.44	5.39	4.46	3.57	3.22

FIGURE 1

PROBABILITY DISTRIBUTION OF MONTHLY RAINFALL



SOIL WATER RELATIONS IN BEAN PRODUCTION

(*Phaseolus vulgaris* L.)

IICA Barbados Office

Warren Forsythe

Land Preparation, Surface and Internal Drainage

The most important objective of tillage in agriculture is to change the soil so that it will have the proper conditions for optimum plant production from an economic stand-point (Cooper 1971).

Tillage is performed for a number of reasons, but all reasons do not apply to each specific crop production system. The following objectives are common in many production systems:

1) The only tillage objective that is applicable to every system of crop production is the moving of the soil to insert the seed or plant in the planting or transplanting operation. This objective also applies to "zero tillage" where the land, soil condition, crop residue condition, and all other conditions are satisfactory for crop production, without the need for further change.

2) To modify the topography to facilitate irrigation (furrow) and maximum water use under conditions of moisture deficit, to facilitate surface drainage (cambered beds, ditches, sloping furrows) while avoiding erosion, and to organize planting procedures.

3) To control weeds. The soil surface that is covered with weeds and their seeds, is inverted and submerged during ploughing, which kills or weakens the weeds' competitive capacity with the crop. In other cases, the roots of the weeds are separated from the tops and the tops of the weeds are left on the surface before planting.

4) To change the physical condition of the soil. The major physical change considered by ploughing is the loosening of the soil (generally dry) thus reducing its mechanical resistance to a value favourable to planting, seed germination and plant development. Other favourable physical changes accompanying ploughing are increased porosity and thus increased soil air space and increased infiltration.

5) To promote granulation or the crumbling of soil aggregates. Harrowing is chiefly responsible for this. This process has the purpose of controlling the size of soil aggregates to one compatible with controlled depth of seed placement in the soil, and adequate seed-soil contact. Thus the relatively small seeds of corn or beans will require a soil with finer soil aggregates than the planting material of sugar cane or cassava.

6) To manage crop residue. Stalks of the preceding crop may be chopped and incorporated into the soil or left on the surface. Weeds and crop residue may be ploughed under to allow ease of mechanical planting.

7) To control insects and diseases. Examples are the control of cotton-root rot and white mould on peanuts by deep ploughing in the U.S.A. Also turning the soil and burying trash deeply has reduced insect infestation.

The preceding principles apply to land preparation for beans, with special reference to providing an adequate mechanical resistance, soil moisture, fields free of surface ponding and adequate internal drainage.

Ideally the soil should be ploughed in the friable range, that is at a moisture content lower than the Lower Plastic Limit (LPL) where the soil stops being plastic but not so dry that a soil subject to cementation on drying, will be hard. Ploughing a soil wetter than the LPL so that it is plastic, or so dry that it is hard will result in large clods and a higher traction effort.

In rain-fed agriculture seeds should be planted after the top 10cm of the soil is at field capacity. In irrigated agriculture the field should be irrigated after planting. Seeds are planted at a depth of 4 to 4.5cm. Appropriate sanitary and fertilizer treatments are added.

If the field is subject to ponding, this should be eliminated by land smoothing and grading and installing shallow ditches, or establishing cambered beds. The Phaseolus bean is very sensitive to ponding. Forsythe and Pinchinat (1971) found that surface flooding of 12 hours every 7 days done five times during the development stage reduced yields of the 27-R variety by approximately 90%. No damage due to pathogens nor pests was observed on the plants grown in previously fumigated soil and thus plant response can be attributed to the direct effect of the flooding. Since soil aeration was adequate between floodings, the effect is attributed to temporary floodings. It was found that up to 19 days growth from germination, plant growth was little affected by flooding.

Gomez (1973) found that between 1-5 hours of flooding done twice during the 19-60 day growth interval was enough to reduce yields by 90%. Field observations have often been made where ponding in bean cultivations left patches of poorly developed or dead plants. Very often this was accompanied by disease attacks. The effect of rainfall which facilitates bacterial and fungal attack on wet foliage and pods is a well recognized problem in cultivating beans. The effect of ponding is substantial but more elusive. It has been pointed out that temporary floodings followed by good aeration conditions reduced yields. This means that plants do not recover from temporary floodings and it is important to avoid ponding in the field, in the soil preparation stage. Areas in the field affected by ponding which are subsequently drained do not recover.

As mentioned earlier the cambered bed is often a form of ensuring quick surface run-off thus reducing or eliminating ponding. It can be built manually without the aid of topographical instruments and thus is suitable technology for the small farmer. Victor and Forsythe (1976) found that a field of corn (Zea mays L. Var. "Tuxpeno 1) sown at a density of 40,000 plants per hectare and in association with beans (Phaseolus vulgaris L. var. "Turrialba 4") sown at a density of 100,000 plants per hectare responded to surface drainage by cambered beds. The bean yields increased up to 40 per cent compared to the control. Beds 2-3m wide were considered most economical. Corn yields showed no significant increase. It was considered that the drainage in the control plot which was flat, 15m x 10m, and surrounded by trenches was good enough not to affect the corn, which is known to be affected by flooding but is more tolerant than beans. Lal and Taylor (1969) subjected corn to one 48 hour and one 96 hour flooding per week for 3 consecutive weeks, when the plants were 4 weeks old. Hybrid corn "Ohio 524" was used. Both flooding treatments reduced yields by 37%.

Adequate internal drainage should be provided for beans, when the water table is high, (less than 50cm) by introducing a system of drains at a depth and spacing corresponding to climatic and soil conditions. A water table of about 80cm seems adequate (Victor and Forsythe 1976). Legarda and Forsythe (1978) found that grain and aerial dry matter production was a maximum in the 27-R variety of Phaseolus vulgaris L, when the average soil air space in the root zone (0-25cm) was greater than 25% or when oxygen diffusion rate between 5-15cm soil depth was greater than 24-28g x 10^{-8} x cm^{-2} x min^{-1}. Most crops that have been studied require a non-limiting soil air space of 10-15% (Vomocil and Flocker 1961) and an oxygen diffusion rate of 20 x 10^{-8} x cm^{-2} x min^{-1}. (Stolzy and Letey 1964). Thus 27-R is more demanding for good soil aeration than most crops studied. Soils that are sticky plastic clays in the 0-25cm layer should have organic matter incorporated to improve the aeration.

One of the objectives of tillage previously mentioned is the loosening of the soil thus reducing its mechanical resistance to a value favourable to planting, seed germination and plant development. Resistance to a 5mm diameter stainless steel circular piston intruduced 5mm into the soil has been found to be a good indicator of soil mechanical resistance in relation to plant growth. (Taylor and Burnett 1964). The pressure (bars) of the maximum thrust needed to introduce the piston of this static penetrometer is measured. They found that soils at field capacity with a resistance between 25-30 bars limited root penetration. The penetrometer is portable and suitable for field use. Huertas (1975) found that grain, aerial dry matter and root production of the 27-R variety of beans increased when penetration resistance at field capacity in the 0-25cm layer or the 12.5-25cm layer was increased to 6-10 bars and this was attributed to better contact between the roots and the soil. Further increase in penetration resistance up to 21 bars reduced yields by approximately 50%. On the basis of studies and field observations the writer has proposed a soil resistance classification: Excellent 0-6 bars; Acceptable 7-12 bars; Not Acceptable 13-25 bars; Inhibits root growth, greater than 25 bars.

Water Consumption and Soil Moisture Needs for Production

The lecture on "Weather and Crop Soil Water Relations" has developed the idea of the crop constant, f, which can be multiplied by the Class A pan evaporation to estimate the potential evapotranspiration of a crop. For a bare soil f is approximately 0.4. If the soil is completely covered with mulch this should be reduced by a factor of 0.43 to give a value of 0.17. For maximum canopy developments. Grassi (1968) has used a value of 0.86, Hargreaves (1969) one of 0.90 and Dupriez (1964) values of 1.02 - 1.19. The average of these values is 0.96. For 27-R, Forsythe and Legards (1978) found that maximum f occurred during the 8th week of a 81 day crop cycle, or about 69% of the crop cycle, which is judged to end at the formation of mature pods. Hargreaves estimates that maximum f occurs at 50-60% of the growing season. After the maximum, f, decreases due to leaf maturity and leaf fall. Table 1 has integrated these values to construct a working plan for the variation of f. A mulching reduction factor of 0.43 is applied to the 0% and 100% values and to 20% of the 60% value considered due to evaporation.

Local values of pan evaporation or estimated pan evaporation are applied to the values of f in Table 1 to estimate the variation of potential evapotranspiration during the growing season.

When the soil is wet by rainfall or irrigation, the wetted zone is at field capacity and plants extract water at the potential evapotranspiration rate. As the soil drys, the evapotranspiration rate may fall as explained in the lecture on "Weather and Crop Water Relations". The soil moisture tension or suction also increases as the soil drys and reaches a value which becomes limiting for crop growth and yield. Forsythe and Legarda (1978) found that grain and aerial dry matter production was found to be a maximum in the 27-R variety of Phaseolus vulgaris L., when the mean maximum soil moisture suction was 0.8 bars at 5 cm depth and 0.6 bars at 15 cm depth. Greater suctions reduced yields. Bernardo et al (1970) found the variety "Vi 1013" gave maximum yields at 0.5 bars at 10cm depth, while Guzman and Fernandez (1963) found that the variety "Canario 101" gave maximum yields at 1.0 bar suction. Thus optimum maximum suction values range between 0.5 to 1.0 bar in the studies cited.

Field beans are commonly thought to be a crop that is favoured by dry conditions. Forsythe and Legarda (1978) found that while 27-R will give a crop at high maximum suctions (12 bars) the yield is much lower that that obtained at the optimum maximum suction (0.8 bars) which corresponds to a relatively moist soil. The importance of dry conditions is most likely linked to the need for good surface drainage and the absence of rainfall which would wet the foilage and pods when they are mature. These problems are solved by proper drainage, and a suitable planting date.

The value of the limiting maximum suction will determine what storage if water at a bib-limiting energy level, the soil will have.

TABLE 1: Estimated variation of f values for beans according to the % of the growing season.

Cultivation Practice	Percentage of growing season		
	0	60	100
Clean Cultivation	0.4	0.96	0.4
100% mulch cover	0.17	0.88	0.17

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SOIL WATER RELATIONS IN CORN PRODUCTION

(Zea mays L)

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Land Preparation, Surface and Internal Drainage

The lecture "soil Water Relations in Bean Production" has discussed the objectives of tillage. In relation to corn (Zea mays L) reference here will be made to adequate mechanical resistance, soil moisture, fields free of surface ponding, and adequate internal drainage.

As in the case of beans, ideally the soil should be ploughed in the friable range. In rain-fed agriculture seeds should be planted after the top 10cm of soil is at field capacity. In irrigated agriculture the field should be irrigated after planting. Seeds are planted at a depth of 4 to 4.5cm. Appropriate sanitary and fertilizer treatments are added.

If the field is subject to ponding, this should be eliminated by land smoothing and grading, and installing shallow ditches or establishing cambered beds. Corn is tolerant to some flooding but strong flooding can reduce yields. In soils suffering from severe ponding, field observations have been made in corn cultivations, where ponding has left patches of poorly developed or dead plants. Lal and Taylor (1969) subjected hybrid corn "Ohio 524" to flooding treatments. Corn four weeks old was subjected to one 48 hour flooding and one 96 hour flooding per week for 3 consecutive weeks. Both flooding treatments reduced yields by 37%. The flooded plants developed respiratory adventitious roots at the soil surface, which apparently served to alleviate the inadequate aeration during flooding. The root system of the flooded plants was largely restricted to the upper 10-15cm of soil.

As in the case of beans, surface drainage may be carried out by handmade cambered beds 2-3m wide or machine-made cambered beds 10-30m wide. Land may be smoothed and graded and shallow ditches installed.

Adequate internal drainage should be provided for corn when the water table is high (less than 50cm), by introducing a system of drains at a depth and spacing corresponding to climatic and soil conditions. A water table of about 80cm seems adequate. Williamson and Van Schilfgaarde (1969). A general requirement of minimum soil air space that is non-limiting to crop growth is 10-15%. (Vomocil and Flocker 1961). Soils that are plastic clays in the 0-30cm layer should have organic matter incorporated to improve the aeration.

The generalized soil resistance classification mentioned in the lecture

"Soil Water Relations in Bean Production" can be used for corn. Thus a field may be evaluated using this system.

Water Consumption and Soil Moisture Needs for Production

Similarly to the case of beans, a table can be constructed for the variation of f during the growing cycle of corn. Grassi (1968) estimates for maximum canopy development that f is 1.05, Dupriez (1964) estimates values of 0.90. Hargreaves evaluates that maximum f occurs at 50-60% of the growing season. Lal and Taylor (1969) estimate a growing cycle of 98 days until the pods are mature for "Ohio 524", whereas Victor and Forsythe (1976) found the growing cycle for "Tuxpeno 1" to be 108 days. The average value of maximum f is 1.02 and is used in Table 1 which is a constructed working plan of the variation of f. A mulching reduction factor of 0.43 is applied to the 0% value and to 20% of the 55% and 100% values considered due to evaporation.

Local values of pan evaporation or estimated pan evaporation are applied to the values of the f in Table 1 to estimate the variation of potential evapotranspiration during the growing season.

Soil moisture suction limiting to corn growth has been found to be 1.3 bars for the 15-30cm depth. (Hagan and Stewart 1972). They also cite values of 1.5 bars in the root zone, 0.4-0.5 bars in a 0-54inch layer, 0.4 bars at 6 inches depth and 8-13 bars for corn in the ripening stage. Rhoads and Stanley (1973) found values of 0.3 bars at 15cm depth for the Funk's 4949 variety and 0.2 bars at 15cm depth for the Locker 71 variety. Rhoads, Mansell and Hammond (1978) found that tensiometer scheduled trickle irrigation of Locker 77 gave greater yields and was more efficient in water use than irrigation using a standard daily rate. There was also less nutrient loss from the plough layer. A maximum soil moisture suction of 0.1 bars at 15cm depth was used.

The value of the limiting maximum suction will determine what storage of water at a non-limiting energy level, the soil will have.

TABLE 1: **Estimated variation** of f values for corn according to the % of the growing season.

Cultivation Practice	% of the growing season		
	0	55	100
Clean Cultivation	0.4	1.0	0.6
100% mulch cover	0.17	0.91	0.55

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EXTENSION METHODS

by

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For purposes of this paper emphasis will be paid to the following headings:

(A) Programme Planning

(B) Techniques in Communication

(C) Some Factors Affecting Communication

A. PROGRAMME PLANNING

This is of paramount importance in Extension Work, is a vital process, and requires the determination of problems, with the selection and execution of the appropriate methods to be used in the solution of such problems. Any meaningful programme should possess the following integral ingredients:

(I) programme planning is a continuous educational process that helps to develop knowledge, attitudes, and techniques in the participants.

This principle is directly related to Extension;s basic function - education. The attainment of desirable changes in the human conduct is of paramount importance to a democratic society. The development of skills in problem-solving and decision-making, based on practical situations leads to the development of good citizens, and a pleasant community life.

(2) programme planning should provide opportunities for the democratic participation of the people to whom the programme is directed.

The participation of people in the Extension planning process leads to a more effective learning; fills phychological needs; is conducive to a greater interest, acceptance and backing of the programme; provides for the development of leadership; and develops democratic spirit and procedures.

(3) programme planning should be based on an analysis of technological, sociological and cultural data applicable to the people and the situation.

A programme based on real facts provides the basis for helping people to solve their problems and plan programmes that are realistic, attainable and justifiable.

(4) programme planning should provide for the identification of the needs and wants of the people.

Basing an Extension programme on the needs and wants as identified by the participants is a stimulating force for action. Greater satisfaction and support of the programme is attained when it is based on the needs and wants as expressed by the people themselves.

(5) programme planning should provide opportunities to the participants to establish goals and objectives of long and short-range nature.

Objectives are useful to the Extension planning process in order to give direction to the programme and to provide a basis for evaluating the progress attained; priorities can be determined and resources can be efficiently used to attain changes.

(6) programme planning should provide for the coordination of educational efforts, activities and resources of leaders, organizations and interested agencies.

A programme resulting from the coordination of efforts and resources in its planning is more comprehensive. There is more involvement of people, more interest and support, and a more efficient development. Planning in a cooperative way by leaders and representatives of agencies and organizations greatly helps in the attainment of the goals established.

(7) programme planning should be flexible enough to provide opportunities for adjustments and changes.

Flexibility in the programme planning process is essential to attain a programme adjusted to the needs, interests and changing situations. The flexibility offers greater freedom of action and increases the interests of the participants.

(8) programme planning should provide plans and opportunities for evaluation.

Including plans and opportunities for evaluation is of paramount importance in the Extension programme planning process Evaluation helps to determine if the planned activities were successful; where changes and improvements are needed; and provides a basis for interpreting to and informing the public as to Extension achievements.

The major steps in programme planning are:

1. Facts of the situation or base-line information which is usually collected by surveys. The data should be authentic, as it is similar to the foundation of a house.

2. Compilation and Interpretation in which you tabulate the data from the survey. This will show for example, that there are 100 farmers who own 150 acres of land and rent 400 acres. This means that you would have to avoid long term programmes, to a lesser extent medium, and concentrate on short-term ones.

3. The actual programme. After the needs and interests have been identified the people working with the help of the Extension Personnel can decide on their objectives which should be Broad or Specific. They can also be short, medium or long term. The objectives should be clearly stated, eg., to get 10 farmers in area 34 to increase their yields of citrus from 3 to 4 boxes per tree by applying 5 lbs. of 10-10-20 fertilizer per tree, per year in May and October, by March 1980. The programme should include:

a) Increase of acreage or numbers, eg., Coffee - from 400 to 600 acres; chickens - 3,000 to 4,000 birds.

b) Increase per unit, eg., Citrus - 3 to 4 boxes per tree. Chickens - 60 - 75 eggs per bird.

c) Introduction, eg., new varieties or breeds.

d) Farm Plans based on Land Capability Maps.

4. The Plan of work. After the needs and interests are identified and the objectives agreed upon, the plan to be followed for putting the programme into action must be developed. Sound principles of social action must be followed in developing such a plan. Involved are such things as determining:

a) The specific jobs that need to be done.

b) The subject matter that is needed.

c) The teaching techniques to be used.

d) The activities to be undertaken.

e) The division of responsibilities.

f) The calendar to be followed.

The Plan of Work for each Instructor's area can be best tabulated to show:

a) Districts - Smoogle Look Behind

b) Enterprize - Citrus or Broiler Chickens

c) Subject - Fertilizers. Control of Anthracnose.

d) Objective - To increase production by teaching farmers the correct use of fertilizers.

e) When - The month of the calendar year when the subject is to be taught.

f) Who Will Teach - This should be the Area Officer as much as possible, to get a closer link with farmers.

g) Resource Personnel - It is good to have a back-up for the subject being taught.

h) Methods (eg.,) - Lecture, Method and Result Demonstration, Field Days, Residential Courses, Farm Visits, etc.

i) Attendance (eg.,) - Farmers, 4H Clubbites, Pioneer Youth

5. Execution - Many good programmes fail because of poor implementation. A good plan of work presents the most effective way, considering existing circumstances to accomplish the agreed upon objectives, An action programme based on such plan of work and built on a foundation of sound education, managerial, reporting, budgeting and social action principles, requires systematic and persistent effort from all concerned.

6. Evaluation - The extent to which objectives are being accomplished is the basis for determining how well a programme has succeeded. Evaluation of progress helps determine what remains to be done. When objectives are satisfactorily reached, new ones can be included in the programme and plan of work at any stage. If the objectives are not accomplished, a revised plan of work on the same problem may have to be carried over into the new programme. In addition to data for future programmes, progress evaluation also provides tangible and objective data for use in annual and other periodic reports. It is also a tower of strength in production and marketing forecasts, as we would know ahead of time what the yields are likely to be. Finally, evaluation helps tremendously in assisting Extension Officers on the reasons why the objectives were not achieved.

B. <u>TECHNIQUES OF COMMUNICATION</u>

As Extension Officers we are primarily concerned with delivering messages to farmers which will influence a change of behaviour and attitudes for them to accept new technology. This is not an easy task if the change agent is not familiar with how communication works. According to Wilbur Schramn (1955) there are four basic conditions that must be fulfilled if the message produced by a change agent is to arouse a positive response from the audience. These are

1) The message must be designed and delivered as to gain the attention of the intended receiver or receivers.
2) The message must employ signs which refer to experience common to both source and receiver in order to get the meaning across.
3) The message must arouse personality needs in the audience and suggest some way to meet those needs.
4) The message must suggest a way to meet those needs which are appropriate to the group situation in which the receiver finds himself at the time when he is moved to make the desired response. According to Cutlip and Center (1958) there are 7 C's in communication. These are:
    a) <u>Credibility</u> - the audience must have confidence in the agent of change. The agent should be versed with the subject matter.
    b) <u>Context</u> - a change agent has to prepare Communication Programmes which must square with the realities of its environment.
    c) <u>Content</u> - The message must have meaning to the receiver who is inclined to pay more attention to the messages which promise the greatest reward.
    d) <u>Clarity</u> - The message must be in very simple terms which can be clearly understood.
    e) <u>Consistency</u> - Whereas the message should be consistent, repetition with variation contributes to both factual and attitude learning.
    f) <u>Channel</u> - Agents of change should always use a channel which will connect them to the largest number of farmers who need the information.

g) Categories - Farmers, in accepting new ideas are classified as follows:

a) Innovators are those farmers who adopt new ideas first.

b) Early adopters who are usually younger and are considered influentials of the community.

c) Early majority who are close to the average, their leadership is usually informal and place a high rating on opinions of neighbours and friends.

d) Majority - they are older and less well educated than farmers in the early majority. They too are traditional in their thinking.

e) Late Adopters - Their mental rigidity does not allow them to accept without strong resistance, changes in their traditions.

C. SOME FACTORS AFFECTING COMMUNICATION

In the previous chapter mention was made of these factors in general terms, so I would like to deal with them in more specific terms. The Extension Officer should always be aware that for him to be an efficient promoter of development programmes, he must be able to:

1) Attract and hold the attention of those he wishes to influence.

2) Use words or create mental images which are relevant to the experiences of his clients.

3) Arouse a sense of need in his clientele.

4) Instil confidence that the changes or alternatives which he is recommending can effectively fill these needs.

Some factors which affect the above are:

1) Religion - The farmer is a highly religious person and this should not be ignored. In fact in many districts a large percentage of extension work is done through the church by the minister being a key personnel. This pattern was set from as far back as 1897 when the Extension Service was started by the Jamaica Agricultural Society.

2) Tradition - Due mainly to the fact that many of our farmers cannot read and write, they are inclined to hold on to old principles, they are also inclined to be persuaded by the opinions of friends and neighbours. It is observed that some

Extension Officers do not spend enough time listening to them so it is not known why the farmers are resenting the change. These few lines explain it very well:

"A Wise Old Own sat on an Oak,
The more he saw the less he spoke.
The less he spoke the more he heard,
So why can't we be like that old bird."

In other words, it would be to the advantage of the Officer to do some listening.

3) Age - There is a long belief among farmers that officers just graduating from college are "Theorists" while they have the practical experience. The officer should try to remove this fear as soon as possible. This point is very important because some of the older officers are siphoned to other projects and replaced by junior men. The other point to remember is that the number of area officers was increased by three times in 1977.

4) Group Conflicts - Whenever these exist the officer should stay clear of them at all times. There are times when members of the group will try to get the officer involved.

5) Approach - The way that an officer approaches a farmer has a definite bearing on whether he will accept the message. If the officer went to contact him about "A" but when he gets there the farmer is having a problem with "D" than that should be cleared first before you put forward "A". The farmer sees the Extension Officer as his leader, that will provide guidance and counselling, so the officer should live up to that reputation, bearing in mind the norms of that environment.

6) Subject Matter - The farmers loves to know when he approaches the officer for information he can get it of a high standard. If the farmer feels that he is in need of additional training then he should take steps to have this done by Inservice methods. As far as further training is concerned, the officer should aim at doing most of it. When this is done there is greater scope for officer-farmer relationship. It is a good policy to

get a resource personnel as the subjects demand when farmers are being trained.

7) Markets - When a farmer comes to an officer seeking advice on investing in certain enterprizes the marketing outlet should be discussed. If this is not done, then it will be left until reaping time, when is bound to result in chaos and the farmer resenting to hear anything from the officer.

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