SOME ECONOMIC ASPECTS OF ROOT CROP PRODUCTION

WITH PARTICULAR REFERENCE TO THE ECONOMICS OF PRODUCING CARBOHYDRATES FROM ROOTS AS COMPARED WITH OTHER SOURCES IN PRIMITIVE, DEVELOPING AND ADVANCED ECONOMIES

— *by* —

A. M. Morgan Rees

School of Agriculture, Aberdeen, Scotland

Both in the tropics and in the temperate regions of the world much dependdence is placed on root crops as a source of starchy food. The sweet potato, yams and cassava are the most important of the tropical root crops, but in certain areas, eddoes, dasheen, cocoyams, taros and tania are also of importance. The Irish potato is the major root crop grown for human consumption in the temperate regions, but it is also found in certain tropical environments, particularly where cool periods occur or where favourable locations exist at higher altitudes.[1] Sugar beet is of considerable importance in some temperate countries, but this crop will be dismissed from the coverage of this paper on the grounds that it is grown for its sugar content and is therefore hardly comparable with the other starchy roots. Fodder roots, such as mangolds and turnips, which are grown for feeding to ruminant livestock and not for direct human consumption, play an important role in the farming systems of some temperate countries and must be considered in any discussion on the economics of root crops. Again, in some of the developed countries root crops have some part to play as a source of supply of raw material for industrial purposes such as alcohol production. There are a host of other root crops including carrots, beetroot and arrowroot, but except in specific areas these can be relegated to the category of minor crops.

THE PATTERN OF WORLD CROPPING

A rough indication of the area occupied by major world crops, together with yield and production estimates, is available from the Food and Agriculture Organisation of the United Nations.

Table 1. Summary of Area, Yield and Production of Major World Crops, 1961/62

Crop	Area (million hectares)	Yield (100 Kg. per hectare)	Production (million metric tons)
Wheat	202.8	11.7	236.7
Rye	28.5	12.5	35.5
Barley	62.5	13.7	85.7
Oats	39.6	13.6	51.4
Maize	103.1	20.8	214.0
Millet & Sorghum	99.1	6.9	68.3
Rice, paddy	119.4	20.3	242.2
Total Cereals	**655 0**	—	**933 8**
Potatoes	25.0	112.2	280.8
Sweet Potatoes & Yams	16.2	70.0	113.5
Cassava*	8.0	93.0	74.8
Total Pulses	**46.3**	—	**29.7**
Total Oilseeds	**104 8**	—	**81 3**
Cotton	34.9	3.1	10.9

Source : F.A.O., *Production Yearbook*, Vol. 16, Rome, 1963.

* Not listed as a major crop.

1 An example of a favourable environment of this character is the Christiana area in the central uplands of Jamaica.

Potatoes, sweet potatoes, yams and cassava occupy only 7.5 per cent of the area taken up by cereal crops; nevertheless, their total production in terms of weight represents 50 per cent of total grain production. But the starchy root crops have moisture contents ranging from 63 per cent for fresh cassava to 78 per cent for potatoes, whereas typical moisture contents for grain crops would range from 10 – 13 per cent.

The bulkiness of root crops and their relatively low value per unit of weight, pose problems in relation to their movement. These features of the starchy root crops to a large extent explain their lack of importance in the international trade in agricultural commodities. They are essentially food crops produced for local consumption on domestic markets, but it would be erroneous to classify them simply as subsistence crops. In addition to production for subsistence they are also produced for sale on domestic markets, and in small quantities, may enter into the export trade. Thus the root crops are not only subsistence crops, but are also cash crops being sold or exchanged mainly for local consumption. The extent to which crops are grown for subsistence as opposed to their production for sale will vary considerably depending on the region, the season and the type of crop in question, but fairly complete figures are available for the Congo to show the percentage of African production of certain crops that were marketed in the period 1955-59.

The proportion of production marketed ranged from 11 per cent for millets and sorghums and sweet potatoes to 65 per cent for rice, with cassava holding an intermediate position. Much of the demand for marketed food crops stems from the population of the urban centres and this is often expressed in the form of a preference for the higher-grade cereals such as rice, maize and imported wheat rather than the starchy roots.

Table 2. Sales as Proportion of Estimated Total African Production of Selected Crops : Congo (former Belgian), Average 1955/59.

Crops	Percentage
Maize	32
Millet & Sorghum	11
Plantains	65
Groundnuts	11
Rice	21
Sweet Potatoes	22
Cassava	55
Bananas	33
Peas & Beans	28

Source: K.C. Abercrombie, 'The Transition from Subsistence to Market Agriculture in Africa South of the Sahara', *Monthly Bulletin of Agricultural Economics & Statistics*, F.A.O., Vol. 10, No. 2, 1961.

DIETARY PATTERNS

Dietary habits vary markedly from country to country, and in fact, also exhibit considerable regional and group differences within a country. The dietary

pattern may reflect the agricultural production that predominates in the area, but this itself may be determined by the physical environmental conditions as well as by other factors such as tradition, the extent of technical knowledge, the man-land ratio and other forces. Again, apart from being influenced by considerations arising on the supply side, the dietary pattern may be moulded by demand conditions. The price of foodstuffs, price differentials between different foods on the market, the purchasing power of the consumer and custom and tradition all have marked influences. This paper is concerned primarily with production rather than consumption, but the two topics are closely interwoven and are virtually inseparable segments of a single problem.

The diet of the mass of the population of the tropics depends essentially on the foodstuffs that are produced locally, and at early stages of development, little reliance is placed on food importations except in respect of a fairly narrow range of items. With a locally based food economy considerable importance attaches to the question of whether restrictions exist in relation to the range of crops that can be grown successfully in a particular environment. Difficulties arising from physical causes such as soils or climatic conditions can therefore be important determinants of the pattern of production and of the pattern of diet. Starchy foods represent the major items in the dietary of the subsistence and less developed economies, but the degree to which different communities rely on grain or on roots as their staple food crop varies considerably. Some economies are almost entirely grain orientated, others rely basically on root crops as their source of starch, while some fall into an intermediate category relying on both sources of supply. Root crops can be grown in the tropics in a variety of soil types where rainfall is adequate. Their production is widespread, but they are associated particularly with the tropical rain forest zone. Grain production, on the other hand, is favoured in drier areas of lower rainfall. In Africa, for example, as one moves from the drier areas towards the tropical rain forest, the importance of cereals in the diet declines steadily and there is a tendency for them to be replaced by the starchy roots and plantains. Table 3 illustrates this point by reference to the consumption of selected foodstuffs in savanna and tropical forest areas.

Table 3. Consumption of Selected Foodstuffs in Savanna and Tropical Forest Areas

Geographical Zone	Latitude (North)	Cereals	Roots & Tubers (including plantains)	Legumes
		(Kilograms per person per year)		
Sudanian Zone (Mali)	15°	229.1	1.2	9.9
Sudanian Zone (Togo)	11°	108.3	25.6	32.5
Guinean Zone (Togo)	8°	70.2	349.8	7.5
Guinean Equatorial Zone (Togo)	6°30′	52.5	432.6	7.6
Guinean Equatorial Zone (Ivory Coast)	6°30′	9.8	766.1	1.8

Source: F.A.O., *Africa Survey,* Rome, 1962.

The same source has shown that farmers in the Warri Province of Southern Nigeria derive 75.5 per cent of their total calorie intake from roots and tubers (cassava, yam, sweet potatoes) and only 2.5 per cent from cereals (millet and Guinea corn). In the case of farmers in the Niger Province of Northern Nigeria, however, the importance of starchy roots and cereals is reversed. Here only 1.7 per cent of total calorie intake is derived from roots and tubers, while 91.6 per cent comes from cereals.

As one moves from a country where the economy is based on subsistence agriculture to one possessing a more diversified economy with a broader based commercial agriculture, one finds that diets become more varied and more nutritious. Wright[2] has illustrated this point by reference to the pre-war patterns of food consumption in different European countries at varying levels of development. As one moves from Eastern and South-Eastern Europe, through the Mediterranean and Southern European countries, to Central and Western Europe and on to Scandinavia and finally to the United Kingdom, the percentage of total calories supplied by grain and potatoes declines from 75 per cent to 34 per cent, while the contribution of animal products, oils and fats, sugar and other foods (including fruit and vegetables) increases. Again, as national income rises and industrial development takes place, food imports may become of increasing importance and these allow for further diversification of food consumption. The marked change that has occurred in the pattern of diet in the United Kingdom over the period 1880-1955 can be used to illustrate this trend towards improvement in the balance of diet.

Table 4: Estimated Percentage Distribution of United Kingdom Calorie Supplies, 1880 and 1955

Kind of Food	1880	1955
Grain and Potatoes	55	32
Animal Products	21	27
Oils and Fats	5	18
Sugar	13	16
Other Foods (including fruit and vegetables)	6	7
ALL FOOD	100	100

Source: N.C. Wright, *Proceedings of Conference 'Agriculture in the British Economy'*, Imperial Chemical Industries Ltd., London, 1957.

The type of change that occurs with economic development is one involving a decrease in dependence on the starchy foods in the form of cereals and root crops and an increase in reliance on animal products, fats and oils, sugar and other miscellaneous foods. From a nutritional viewpoint these dietary changes are to be welcomed and they also provide for increased palatability of the food intake as opposed to a dull and monotonous diet based primarily on the more starchy foods.

2 N. C. Wright, **Proceedings of Conference 'Agriculture in the British Economy'**, Imperial Chemical Industries Ltd., London, 1957.

Nevertheless, starchy foods still represent an important constituent of food supplies in the developed countries while remaining major items in the dietary of primitive and developing ones. Data for certain selected countries to show the net food supply per caput and the proportion of total calories derived from cereals and from potatoes and other starchy foods are given in the Appendix Table.

A CASE STUDY OF FOOD CONSUMPTION IN JAMAICA

Food balance sheets for Jamaica have been prepared for the years 1942 and 1958 and these provide indicators of per capita food consumption and of changes in the availability of locally produced and imported foods in the West Indies environment. Inevitably, the degree of accuracy of these estimates will depend upon the soundness of the data relating to the volume of local food production, but despite certain limitations, they at least provide information which allows for generalisations.

A radical change in consumer habits occurred between 1942 and 1958. The per capita intake of cereals increased by 101 per cent while there was also a notable increase of 87 per cent in the figure for animal products. On the other hand, the per capita intake of roots, tubers and other starchy foods declined by 48 per cent. Reduced consumption of pulses and nuts also occurred, but considerable increases were shown in the per capita intake of fats and oils, sugars and syrups, and vegetables and fruits. Although the per capita increase in total calories consumed per day was relatively small there was a striking increase of approximately 28 per cent in protein intake and in all probability the quality of the protein consumed had also improved. It was concluded that on average the population was better fed in 1958 than in 1942.

In 1958, 78 per cent of the total food consumed was supplied from local production. But almost all the cereals (94.5 per cent of total supplies) were imported, compared with only 1.6 per cent of the total in the case of the roots, tubers and other starchy foods. These two groups, cereals and roots etc., provided more than one-half of the bulk of the Island's food supply, but twice as many calories were supplied by the cereals as by the starchy roots. This latter group, for example, provided 38 per cent of the total food in terms of kilograms per capita, but provided only 17 per cent of the total calories and 11 per cent of the protein. Corresponding figures for cereals were 16 per cent of the bulk, 34 per cent of the total calories and 40 per cent of the total protein. In the West Indian context, however, breadfruit, banana and plantains provide a considerable proportion of the total intake falling in the category roots, tubers and other starchy foods and when these items are excluded the contribution of roots and tubers to the food supply becomes correspondingly less.

Table 5. The Consumption of Starchy Foods and their Contribution in Terms of Calories and Protein, Jamaica, 1958

Food Item or Group	Kilograms per year	Calories per day	Protein per day (grams)
	(..... Per Caput Consumption.....)		
Potatoes - Irish	5.74	11.01	0.27
Potatoes - Sweet	6.69	17.78	0.20
Cassava	3.06	9.15	0.08
Cocoes (Taro)	6.66	15.70	0.27
Yams	37.78	93.17	2.17
Yampies	0.09	0.22	0.01
Total Roots and Tubers	*60.02*	*147.03*	*3.00*
Breadfruit, Banana, Plantains	130.13	236.91	3.34
Total Roots, Tubers & Other Starchy Foods	*190.15*	*383.94*	*6.34*
Cereals	81.35	790.62	23.06
Total Roots, Tubers Other Starchy Foods & Cereals	*271.50*	*1,174.56*	*29.40*
ALL FOODS	*505.91*	*2,292.01*	*58.02*

Source: Based on data contained in *'Food Consumption in Jamaica'*, Division of Economics & Statistics, Ministry of Agriculture and Lands, Kingston, Jamaica, 1962.

CROP YIELDS AND PRODUCTIVITY

In any economy where a large part of the agricultural output is retained for subsistence consumption, problems inevitably arise in relation to the valuation of the products consumed. To overcome problems of this type and to assist in the measurement of output of different crops under circumstances where only a small portion is traded for money, there has been a tendency to apply as a unit of measurement the kilogram of grain rather than the money value. The outputs of different crops can be converted to their grain equivalents at the rate at which they exchange against grain in local markets for the purpose of making comparisons. F.A.O. has adopted a weighting system based on regional wheat relative price weights, and food consumption data or agricultural output for different products can then be expressed in terms of their wheat equivalents. Under such a system of weights, Irish potatoes have been given a weight of 0.65, sweet potatoes 0.30, cassava 0.23, and maize 0.75, – compared with the unit weight of 1.00 attaching to wheat. Clark and Haswell have applied the wheat equivalent system to yield data for different crops derived from various sources.

Table 6. Cereals and Root Crops in terms of Kg. Wheat Equivalents/per hectare

Crop	General Estimate for All Africa		Ghana	
	Crop Kg./ha.	Kg. Wheat equivalent/ha.	Crop Kg./ha.	Kg. Wheat equivalent/ha.
Maize	1,790	1,340	712	533
Eleusine millet	953	650		
Cassava	14,280	3,285		
Sweet potato	6,080	1,824		
Yams	9,790		9,850	4,660
Rice (rough)	795	646		

Source: Colin Clark and M.R. Haswell, *The Economics of Subsistence Agriculture*, MacMillan, London, 1964.

Thus, on the basis of productivity per area of land expressed in kilograms of wheat equivalent per hectare, the root crops compare very favourably with the cereal crops. Calculations of this type depend heavily on the levels of yield which are capable of being achieved for different crops in the same locality. There is evidence to show that crop yields fluctuate considerably and this fluctuation applies both to roots and to cereals. But the root crops can form a valuable food reserve at times when other crops have failed or have been attacked by pests and diseases. They can be harvested over a period of time, and in some instances, can be stored best in the ground and drawn upon as required or in times of famine.

The yield factor is a decisive one in relation to the economics of crop production and this applies both to cereals and to root crops. A certain breakeven level of yield has to be achieved before the fixed inputs are covered but these fixed inputs are generally higher in the case of root crops than cereals. The investment of inputs (whether in the form of unpaid labour or cash labour, in fertilisers and planting material), tends to be greater and hence the elements of risk is a factor to be taken into account.

Research into the problems of food crop production in the tropics has lagged in comparison with work on the export commodity crops. The impact of modern technology has hardly made its appearance and there is a natural reluctance to incur cash outlays on the purchase of inputs such as fertilisers, for crops that are destined for consumption rather than for sale. There are likely to be fairly spectacular improvements in relation to the levels of yield of all food crops, cereals and roots included, as research and technological breakthroughs are achieved and the results are disseminated and applied. Even in the developed countries advances are still taking place in relation to crop yields and some figures from the United Kingdom can be used to illustrate this continuing upward trend.

Table 7. Crop Yields per Acre, United Kingdom, 1950 – 1964 (Av.)

Period	Wheat (cwt.)	Barley (cwt.)	Oats (cwt.)	Potatoes (tons)	Turnips (tons)
Average 1950-59	24.2	22.6	19.3	7.7	16.5
Average 1960-64	31.1	27.5	22.2	8.8	18.9

In countries, such as the West Indies, where land resources are limited, one of the principal ways of raising production to keep pace with expanding population, is by raising yields per acre. This applies particularly in the case of developing countries which have to rely largely on their own resources for food and can ill-afford foreign exchange for heavy food importations. Increasing the productivity of land, however, need not imply only the raising of crop yields, but may also embrace changes in the pattern of farming and a switch towards high-value crops as opposed to low-value crops. Here it is important to bear in mind the distinction between increases in land productivity in terms of calories or other measurements of food values and its measurement in money values. Increasing the acreage devoted to roots at the expense of cereals, for example, may increase the output of calories per acre, but productivity measured in money values may go up or down depending on the relative prices of roots and cereals.

LABOUR REQUIREMENTS AND LABOUR PRODUCTIVITY

In many subsistence and developing economies the main limiting factor to increased agricultural output is not the lack of available land, but the availability of labour to undertake the essential seasonal tasks. Mechanisation is in its infancy in these economies and the digging stick and the hoe are still the main tools in the hands of the peasant. What he is able to produce depends essentially on the amount of labour that he is able to apply to the land and the extent of his cultivation will depend on the quantum of labour that he is able to deploy, particularly during the busy seasons. The average investment of labour to land is high in peasant farming, and root crops in particular, tend to be labour-demanding: their labour requirements per acre are greater than those of cereals. Raeburn, Kerkham and Higgs have provided some data relating to labour requirements and their distribution for the main tropical savanna crops in Africa. They have also related these labour-requirements to the yields per acre to arrive at the yield per man day.

Table 8. Labour Requirements of Selected Tropical Crops

Crop	Preparation of land	Establishment of crop	After Cultivation	Harvesting, threshing, store work, etc.	Total	Yield Per Acre	Yield Per man day
	(..... man-days per acre .....)					(lb.)	(lb.)
Maize	15	9	13	19	56	16,00	27
Sweet Potatoes	16	19	16	21	72	5,430	75
Yams	27	17	61	39	144	8,750	67
Cassava	6	19	63	38	126	12,650	109
Large Millets	6	3	11	11	31	852	27

Source: J. R. Raeburn, R. K. Kerkham, J.W.Y. Higgs, *Report of a Survey of Problems in the Mechanisation of Native Agriculture in Tropical African Colonies,* H.M.S.O. London, 1950.

Notes: (a) Costs of opening land from bush or grass are not included.

(b) Yields are expressed in terms of threshed grain, seed cotton, shelled nuts and fresh roots per acre.

The total labour requirements per acre for the starchy root crops are considerably higher than those for maize and millet. Much of the difference arises due to the heavy demands that the root crops make in after-planting cultivation such as weeding, and also in harvesting the bulkier crops. In terms of yield of product per man day expended, the root crops produce a larger bulk per unit of labour, but this takes no account of value either in money or nutritional units. Clark and Haswell, however, have converted these and other data from African sources to kilograms of wheat equivalent per man hour.

Table 9. Productivity of Labour in terms of Kg. Wheat Equivalent per Man Hour for Selected Crops - Africa

Crop	General estimate for all Africa	Nyasaland (1938)			Ghana
		Hill Village	Foothill Village	Lake Village	
	(.....Kg. wheat equivalent per man-hour.....)				
Maize	1.49	1.19	0.86		0.81
Eleusine millet	1.30	0.08	0.28		
Cassava	1.75			3.39	
Yams	1.58				2.96
Rice (rough)			0.45		

Source: Colin Clark and M.R. Haswell, *The Economics of Subsistence Agriculture,* MacMillan, London, 1964.

These and other similar data suggest that the starchy root crops, despite their heavy labour requirements per unit of land, represent a sound form of land use as a food crop under a wide range of African conditions and that a unit of labour devoted to their cultivation produces a higher quantum of product, measured in terms of Kg. wheat equivalent, than cereals. Where climatic and soil conditions are less or more favourable the results obtained may differ considerably from those shown in Table 9. In most countries labour is the most important cost item in agricultural production, and to a very large extent, differences in labour requirements for different products are reflected in their relative prices, except insofar as this tendency may be offset by the forces of demand.

Wide differences exist in the number of man-hours required to produce 100 kilograms of crop product in countries at different stages of economic development. For example, F.A.O.[4] has published figures to show the range in the man-hours required, on a national average basis, to produce 100 kilograms of wheat, barley or rice. In the United States and Argentina, under conditions of extensive cultivation, the labour requirement was 1-2 man-hours compared with 4-5 man hours in most Western European countries and 30-50 man-hours in the less developed countries. For potatoes the corresponding man-hour requirements were 1,2-5 and 6-16 for these different countries at different stages of development. Where lower productivity of labour exists this is often compensated for by its lower cost, but the wide differences in labour productivity reflect differences in levels of yield, intensity of farming and the extent to which labour is aided by mechanisations. The extent to which different agricultural products and different

4 **The State of Food and Agriculture,** F.A.O., Rome, 1963.

tasks in relation to these products lend themselves to the application of mechanisation will obviously vary. In similar fashion, the complexity of applying mechanisation and its costs, will also vary. Raeburn, Kerkham and Higgs have examined some of the problems associated with mechanisation of African agriculture and their findings indicate that greater scope exists for mechanising the production of cereals than starchy roots.

Table 10. Proportions of various Labour Tasks that could be accomplished with the aid of mechanised equipment : Selected Tropical Crops, Africa

Crop	Preparation of land	Establishment of crop	After Cultivations	Harvesting, threshing, etc.	Total for all Operations
	(.....Per cent of man-days per acre.....)				
Maize	100	100	60	50	73
Sweet potatoes	100	60	40	30	57
Yams	100	80	40	30	54
Cassava	100	Nil	60	Nil	33
Large millets	100	100	60	100	85

Source: J.R. Raeburn, R.K. Kerkham, J.W.Y. Higgs, *Report of a Survey of Problems in the Mechanisation of Native Agriculture in Tropical African Colonies,* H.M.S.O., London, 1950.

Under United Kingdom conditions the same conclusion has been reached by Nix who has drawn attention to the relatively poorer economies in labour that have been achieved for potatoes compared with certain other crops. But looking ahead to 1970 he anticipates the labour demand for potatoes to change more markedly with the application of further mechanisation and new husbandry methods.

Table 11. Labour Requirements for Cash Crops, United Kingdom 1930–70

Crop	1930	1950	1960	1970(?)
			hours per acre	
Potatoes	215	195	140	60
Sugar Beet	235	180	120	20
Wheat	53	33	17½	6½
Barley	54	23	12½	6

Source: J.S. Nix, 'Labour for Cash Crops, 1930–70' *Agriculture* Vol. 68, No. 3, 1961.

Spectacular reductions in labour requirements can be achieved in agriculture by the application of mechanisation. The benefits accruing stem not only from the substantial reduction in the amount of labour required to carry out various farm tasks, and from the lessening of drudgery, but also from the ability to undertake cultivations quickly and at the proper time. Many of these potential benefits, at the present time, are beyond the reach of the mass of producers of cereals and

starchy roots in the developing countries, but scope still exists in these countries for increasing labour productivity by other means. Much benefit can result from the application of farm planning methods to maximise the returns from resource use, particularly from the scarce resource – labour, and to iron out the peaks in seasonal labour requirements. The work of Edwards[5] in Jamaica and Collinson[6] in Tanganyika has highlighted some of the seasonal variations in labour requirements for different tasks on peasant farms. The application of such data for the derivation of model farm systems for peasant farming areas has also been developed by various workers including Clayton[7] in Kenya.

SOME ECONOMIC ASPECTS OF ROOT CROP PRODUCTION IN THE UNITED KINGDOM

Certain broad generalisations can be made in relation to the economics of crop production. Firstly, the profit per acre depends on the relationship between the cost per acre and the value of the product. But the cost per acre is itself the resultant of a number of highly variable factors such as the individual cost of seed, fertilisers and other inputs. Again, the value of the product itself depends on the yield per acre and on the selling price realised per unit, together with the value of any by-product. Thus one can say that the profit per acre is determined largely by the relationship between the cost per acre, the yield per acre and the selling price per unit. Broadly speaking, the price of the product is beyond the control of the farmer, except insofar as it may be influenced by quality or by the time at which it is marketed. On the other hand, both the cost and the yield per acre are, at least partly, under the farmer's control. Yields, of course, will vary considerably from one geographic area to another depending on the environmental conditions under which the crop is grown, but they will also vary from year to year on the same farm due to differences in seasonal conditions. It is one of the aims of good management to prevent undue fluctuations in the level of crop yields and to maintain them at a high level compatible with other considerations.

Looking at costs of production of potatoes and cereals in the United Kingdom on the basis of data derived from enterprise costs studies, one is struck immediately by the far greater outlay that is involved in respect of potato production.

Total costs for potato production averaged nearly £115 per acre compared with average figures of from £17 to £24 for cereals. In arriving at enterprise costs of this type a good deal of purely arbitrary allocation of items of an overhead nature has been involved, and today, farm costs are normally looked at on the basis of whether they are variable or fixed cost items. This division of costs into these two categories recognises the fact that the farm as a production unit is an integrated business and not merely a collection of independent enterprises. Variable costs are those costs that are readily allocatable, are clearly specific to the particular enterprise and vary with the scale of production, while fixed costs are those costs which are part-and-parcel of the system of farming as a whole, not readily attri-

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5 D. T. Edwards, **An Economic Study of Small Farming in Jamaica,** University College of the West Indies, 1961.

6 M. P. Collinson, **Farm Management Survey, Report No. 3,** Ministry of Agriculture, Tanganyika, 1964.

7 E. S. Clayton, 'Economic and Technical Optima in Peasant Agriculture', **Journal of Agricultural Economics,** Vol. XIV, No. 3, 1961.

Table 12. Crop Costs Per Acre, United Kingdom

Crop	Potatoes(1)		Cereals(2) (Harvesetd by binder)		Cereals(2) (Harvested by Combine)	
	(£ s.)	(%)	(£ s.)	(%)	(£ s.)	(%)
Variable Costs						
Seed	22 5	19.0	2 2	8.5	2 4	12.5
Fertiliser	9 8	8.5	3 5	13.5	3 4	18.5
Casual Labour	11 3	10.0	0 8	1.5		
Contract Work	7 11	7.0	1 8	6.0		
Sundries	5 14	4.5	0 17	3.5	0 4	1.0
Total Variable Costs	**56 1**	**49 0**	**8 0**	**33 0**	**5 12**	**32 0**
Fixed Costs						
Regular Labour	20 2	17.5	5 5	22.0	2 2	12.0
Tractor Costs	6 6	5.0	2 2	8.5	1 8	8.0
Specialised Equipment	5 12	5.0			1 9	8.5
Rent	5 6	4.5	4 0	16.5	4 0	23.0
Overheads	21 6	19.0	4 16	20.0	2 18	16.5
Total Fixed Costs	**58 12**	**51 0**	**16 3**	**67 0**	**11 17**	**68 0**
Total All Costs	114 13	100.0	24 3	100.0	17.9	100.0

Sources: (1) *Potato Costs,* 1965 Crop, North of Scotland College of Agriculture.
(2) Unpublished Crop Costs data, North of Scotland College of Agriculture.

butable to any particular enterprise and not avoidable in the short-run. This concept of variable and fixed costs is used increasingly today in the gross margin system for farm analysis and planning, the gross margin for an enterprise being the difference between the output of a crop and its variable costs, and representing that enterprise's contribution towards covering the fixed costs of the farm and profit. Some idea of the relative level of current gross margins for different crops under Scottish conditions is provided in Table 13.

In the United Kingdom context, potatoes are a cash crop whereas cereals may be grown either for sale or for consumption by livestock on the farm. Irrespective of the utilisation of the crop, however, the farmer is seeking to equalise his returns from the last acre of land, the hour of labour or the last £1 of capital invested in his various enterprises. If we apply as our criterion of selection the yardstick gross margin per acre, then in relation to cereals, his returns are maximised by growing as many acres of potatoes as the various constraints allow. However, these constraints in the shape of rotational considerations, basic potato acreage allotment, labour availability at peak periods, capital uncertainty and an unwillingness to over-invest in a relatively risky crop, result in early limits being placed on the acreage of potatoes that can be grown on most farms. Generally,

Table 13. Gross Margins Per Acre, Scotland (current values)

Crops	Yield (tons per acre)	Price (per ton)	Gross Output (£)	Variable Costs (£)	Gross Margin (£)
Potatoes :					
Earlies	6	£22	132.00	81.20	50.80
Maincrop Ware	9	£13	117.00	71.25	45.75
Maincrop Seed	5 seed; 3 ware	£27 seed; £11 ware	168.00	86.20	81.80
	(Cwt. per acre)	(Per Cwt.)			
Oats :					
Crop on High Ground Bindered	22	18.6s.	27.55	6.85	20.70
Crop on Low Ground Combined	28	18.6s.	33.14	5.40	27.70
Barley:					
Combined & Sold Sept. to Oct.	32	18.00s.	34.60	6.55	28.05
Combined, dried, stored and sold Jan. to Feb.	32	19.25s.	39.40	6.55	32.85
Wheat :					
Combined & Sold, Oct.	40	18.0s.	43.05	9.20	33.85
Combined, dried, stored and sold Mar. to Apr.	39	20.5s.	53.10	9.20	43.90

acreage constraints on the area of cereals that can be grown on arable farms do not operate at such an early point as they do with potatoes, and thus there is a tendency on farms endeavouring to maximise their total gross output to expand their cereal acreage very considerably. In fact one of the features of arable farming today, particularly where efforts are being made to take advantage of economies of scale by spreading fixed costs over a large output, is to plant an increasingly larger proportion of farm acreage to cereals and to follow a trend towards continuous cereal growing. However, profitable production of cereals and of potatoes, as with other farm enterprises, depends essentially on the manner in which the various enterprises fit into the economy of the farm as a whole.

Because of the high costs of potato growing a high output is essential for profitable production. But fairly violent fluctuations in yield take place and these cause unstable supply conditions. On the other hand, in the short-run, consumer demand is stable and is relatively unresponsive to changes in price. Thus the value of output per acre of potatoes shows a high degree of variability, but nevertheless there is a close relationship between the level of the yield and the level of gross margin per acre.

Fodder roots such as turnips and swedes still play an important part in the economy of British livestock farms even though the acreage grown has decreased considerably over recent years. In Scotland, for example, the acreage devoted to turnips declined by nearly 38 per cent between 1945 and 1963. Prior to the 1939/45 war, turnips supplemented by hay were the main foods fed to cattle, but more recently on many farms they have been displaced by silage. One of the main factors behind this trend has been the difference in labour requirements between the two crops. Figures from recent surveys in the North of Scotland show the average man-hours required per acre for turnips to be 56 compared with only 11 for silage. But with the introduction of pre-emergence spraying techniques and more efficient mechanised harvesters there could well be a resurgence of interest in growing of roots for fodder. On farms where turnips were harvested by hand the total labour requirements per acre averaged 96 man-hours, but this total dropped to 57 when turnips were harvested by puller and to 50 when the crop was mechanically harvested. One of the ways in which turnips and silage can be compared is on the basis of the cost per ton of starch equivalent. This calculation will depend heavily on the relative level of yield per acre, and the costs per acre – chosen as the basis of comparison. Some figures based on data from the North of Scotland attempt to make this comparison. They indicate that if only poor to moderate yields of poor quality silage are achieved (i.e. under 7 tons at below 10 per cent S.E.) and high yields of turnips (i.e. over 30 tons) are obtained, the cost per ton of starch equivalent would be less in the case of turnips.

CONCLUSIONS

The data presented in this paper, although not conclusive and very patchy, suggest that root crops as a source of carbohydrates compare favourably with other sources. The exact relationships in terms of economics will vary with the environment and with local conditions, but irrespective of the level of development of the economy, the root crops appear to have an important role to play in terms of both their food and monetary values. As development takes place the importance of starchy roots in the dietary may well decline, but with the aid of modern technology to raise the level of yields and the application of mechanisation to offset the inherently high costs of production per acre, there is little reason to assume that the returns from growing these crops will not remain at a satisfactory level. One of the key factors contributing towards success is the achievement of high levels of yield over which to spread the high levels of input costs. This requirement is likely to call for an increasing degree of specialisation in production as development takes place. In the West Indies this might well result in the production of increasing quantities of ground provisions (apart from Irish potatoes) in the plains where conditions would allow for mechanisation as a means of increasing the productivity of labour. Traditional methods of production are likely to become less remunerative as time goes on due to their heavy labour demands and relatively low yields, and the root crops, like any other form of agricultural production, will have to adapt to changing circumstances. If adjustments in outlook, methods and location of production occur, then the starchy roots can make a very valuable con-

tribution to the economy of the West Indies where land is limited in supply and a high man/land ratio exists.

APPENDIX TABLE I

Net Food Supply Per Caput and Proportion of Total Calories derived from cereals and from Potatoes and Other Starchy Foods, Selected Countries

Country	Period	Kilograms Per Caput Per Year		Per cent of Total Calories Derived from:		
		Cereals	Potatoes and other starchy foods	Cereals	Potatoes and other starchy foods	Cereals, Potatoes and other starchy foods
United States	1961	66	47	21.4	3.0	24.4
Australia	1960/61	86	40	27.2	2.5	29.7
New Zealand	1961	87	61	24.7	3.4	28.1
United Kingdom	1961/62	81	97	24.7	5.8	30.5
Germany, Fed. Rep.	1961/62	79	128	26.8	8.5	35.3
Ireland	1961	107	140	31.0	7.8	38.8
Italy	1961/62	136	55	47.0	3.8	50.8
Greece	1960	163	36	53.1	2.4	55.5
Ecuador	1960	69	96	31.7	8.5	40.2
Mexico	1960	123	9	47.6	0.8	48.4
Brazil	1960	106	123	38.3	13.3	51.6
Honduras	1954/55	118	9	52.1	1.1	53.2
Paraguay	1957/59	84	229	33.2	26.7	59.9
Mauritius	1961	126	12	53.4	1.0	54.4
South Africa	1959/60	138	21	52.7	1.6	54.3
Japan	1960	150	68	62.6	6.8	69.4
India	1960/61	140	11	66.5	1.4	67.9
Pakistan	1960/61	158	4	78.3	0.4	78.7

Source: Based on data contained in F.A.O., *Production Yearbook,* Vol 16, Rome, 1963.

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