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SMALLHOLDER CROPPING SYSTEM OF SOUTHEASTERN NIGERIA: A 'DIAGNOSTIC' STUDY

FELIX I. NWEKE

Department of Agricultural Economics/Extension, University of Nigeria, Nsukka, Nigeria

SUMMARY

This paper describes the cropping system of southeastern Nigeria and aims to objectively identify its problems, priorities, areas of flexibility and hence, relevant micro research priorities. Farm size is small yet farm labour is a constraint despite large family sources because of skewness in demand, system reliance on handtools, etc. Each farmer grows many crops as intercrops with yam (Dioscorea *Sp.*) *as the most important because of its cultural values. Yam production is, however, labour and planting material intensive. 'Prescriptive' research to develop technologies that could reduce yam production costs or to develop those that could reduce skewness in farm labour demand is needed for the system. The farmers would probably welcome such technologies.*

INTRODUCTION

Until the 1960s LDC small farm problems were defined on the bases of such developed country approaches as comparative analysis, planning of individual farm units, etc. Problems defined on such bases led to single commodity or resource-oriented micro-farm research, ignoring the fact that LDC 'farmers produce several commodities and manage several resources in an integrated system' (Collinson, 1979). Consequently, many new technologies are available in LDCs but they are not widely adopted by the small farmers because such technologies 'do not fit the particular circumstances of farmers for whom they are intended' (Byerlee *et al.*, 1979). Certain farm economists working in LDCs (Norman, 1975; Byerlee *et al.*,

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1979; Collinson, 1979) now advocate the study of the farming system in its entirety following a farming systems research (FSR) approach to permit 'areas of management where the farmer is flexible . . .' (Collinson, 1979) to be identified and relevant micro-research priorities to be established.

The FSR approach is a multi-phase approach to farm technology development; Norman (1975) identifies three phases as follows:

(a) A diagnostic phase which aims at 'a thorough understanding of what farmers are doing and why they are doing things the way they do.'

(b) A prescriptive phase involving 'developing relevant technology in conjunction with technical scientists.'

(c) Action or implementation type research which aims at the determination of 'the type and level of infrastructural support (i.e. improved input distribution system, the availability or non-availability of credit and the degree of concentration of extension service)' necessary for the adoption of the technology prescribed in phase (b).

The three phases are carried out in sequence on a group of farmers who have 'similar social customs, similar market opportunities and similar present technologies and resource endowments' (Collinson, 1979). The co-operation of social and technical scientists is necessary at each phase of the FSR because the 'total environment' in which the farmer operates is complex.

This paper is an attempt at phase (a) for two villages in southeastern Nigeria. The aim is to describe the cropping system in the villages in order to identify aspects of the system where change that can lead to improved rural welfare is likely to be acceptable to the smallholders.

METHOD OF STUDY

The two villages – Ogboji in the Awka area and Ndubia in the Abakaliki area of the Anambra State of Nigeria – were deliberately selected on the bases of population density, soil type, topographical and cultural differences. Abakaliki, within the derived savanna vegetation zone, is located at longitude 08°05' east, latitude 06°20' north. The soil type is classified as hydromorphic formed from shale; hence it is hard to till and subject to waterlogging. The topography is mainly flat terrain. The population density was, in 1963, 200–300 persons per square kilometre; the people are identified with farming and they farm within their localities. They live in isolated hamlets surrounded by their farm lands.

Awka, located at longitude 07°05' east, latitude 06°13' north, is also within the derived savanna vegetation zone. The soil is classified as deep porous ferralithic which is easy to till but subject to excessive leaching because it is formed from sandstone.

The topography is mainly hilly and in many parts flood erosion is a major problem. In 1963, the population density was 700-1000 persons per square kilometre; the people are traders and craftsmen, as well as farmers. In parts where the soil is fertile many people are farmers. The farmers live close together in often densely populated villages located away from the farm lands.

A sample of twenty farmers was selected in each village and interviewed, by means of a questionnaire, to obtain information on their socio-economic backgrounds, farming goals and aspirations, cropping pattern, land, labour and capital uses, and market and weather problems. Their wives were also interviewed to determine their role in the cropping system. The questionnaire for the farmers consisted of eight parts and every farmer was visited eight times, one part of the questionnaire being completed on each visit; their wives were interviewed once. The interviews relied upon a respondent's memory, no comprehensive measurements of plots, inputs or outputs being made. However, in many cases the interviewers were able to visit the farmers' plots to confirm some of the responses. In addition, the interviews were conducted in July–September (of 1978), the growing period for most crops (Charts 1–6), so that the information sought was likely to be fresh in the farmer's memory.

No agronomist was directly involved in the survey but some—for example, one at the International Institute of Tropical Agriculture, Ibadan, and another at the Department of Crop Science, University of Nigeria, Nsukka—were consulted both at the questionnaire design stage and at the final reporting stage.

In Ogboji, the survey farmers were 47 years old and had spent about 3·7 years in formal school on average; the average household size was 7, including 1·1 wives, 4·6 children and 0·2 other relatives (mothers, fathers, sisters, brothers, etc. residing with the farmer). In Ndubia, the survey farmers were 35 years old, had spent 1·4 years in school on average and had a household of 9·1 persons composed of 1·7 wives, 4·9 children and 1·5 other relatives.

In both Ogboji and Ndubia villages yam and rice are the major food crops grown, yam mainly for home consumption and rice for sale. Oil palm product collection and processing for sale are more popular in Ogboji—although not as a full-time occupation—than in Ndubia where there does not appear to be any major tree crop production activity. The opportunity for cash income through trading, handicrafts and tree crop activities explains, at least in part, the high population density in Awka as well as the relatively high average age of the farmers. Young people in the Abakaliki area are probably staying on the farm because of limited alternative employment opportunities in the area compared with the Awka area.

The large average household size in Ndubia is probably due to the predominance of agricultural activity in the area; farmers in the area generally marry many wives to enlarge the household labour force. The difference in the number of wives between Ndubia and Ogboji is not reflected in the difference in the number of children. Infant mortality is probably higher in Ogboji than in Ndubia because of the lower income in the former village.

PRODUCTIVE FACTORS

Three farm land 'types'—compound garden, swamp and upland—were identified in Ogboji and three—homestead land, swamp and non-swamp bottom land—in Ndubia. The total area of farm land available per survey farmer was 1·8 ha in Ndubia and 1·3 ha in Ogboji. These consisted of a number of plots in different locations at varying distances from the homesteads. The average number of plots per survey farmer were, in Ndubia, four—of which two were under crops—and, in Ogboji, six—of which three were under crops—in the survey year. The average distances† of the plots from the homesteads were 2·0 km for Ndubia and 0·5 km for Ogboji. A farmer usually leased additional land for farming purposes from neighbours on an annual basis at a minimal cost but the outright sale of farmland was virtually absent.

Farm labour is obtained from non-paid sources such as the farmer's household and non-resident relatives and friends, as well as from hired (paid) sources. In the survey year 52 % of the total farm labour used by the survey farmers in Ogboji and 31 % of that in Ndubia was obtained from hired sources. Hired labour was less important because household size was larger in Ndubia than in Ogboji. The hired labour was used mainly for land preparation and, in some cases, for weeding operations on yam and rice as well as rice transplanting. About 75 % of Ogboji survey farmers reported that if they had money to pay it was not generally hard to secure hired labour but 90 % of Ndubia survey farmers reported that even if they had money to pay it was sometimes (mainly in March, April and July) hard to secure hired labour. This is probably because of wage rate differentials between the survey areas (Nweke & Winch, 1979).

Household members who provide farm labour are the farmers themselves, their wives, some children and other relatives residing with them. About 45 % of the survey farmers said that their children who were at school worked on the farm; the school children work on the farm not only during school holidays but also on school days for 2–3 h after school each day. They assist mainly in weeding and harvesting operations. In general, men perform heavy operations such as land preparation for yam and rice and also yam staking whilst women carry out weeding operations and rice transplanting, which are relatively light operations.

The farmers and their wives do not work full time on the farms; they also carry out such other activities as marketing, house construction and repairs, community work, domestic work and off-farm employment. In the survey year, the survey

† Calculated as:

$$\left(\sum_{n=1}^{N}\left(\sum_{i=1}^{l}\frac{D_i}{l}\right)\right)\Big/N$$

where N = number of survey farmers, l = number of plots owned by farmer n and D = distance of plot l from the homestead of farmer n.

farmers spent an average of 48% of their working time on farm work, 16% on marketing, 10% on home construction and repairs, 6% on community work and 20% on off-farm jobs for cash payment. This is partly because of the seasonal nature of farm work but mainly for other reasons. Most of the smallholders live in thatched houses which they have constructed themselves and which need frequent repair. Certain basic infrastructural facilities, such as rural roads, a water supply, market centres, etc., are provided by the rural people themselves in Anambra State by community effort and not (as it should be) by the public sector. The smallholder farming activities do not yield enough cash to meet the smallholders' cash expenses such as for modern housing, education for their children, medical care, etc., and they need to work off-farm to supplement their cash income.

In addition to cash obtained from the sale of farm products, virtually all the survey farmers obtained cash from off-farm employment, 70% as gifts from relatives engaged in urban employment and 55% as loans from friends and relatives. It was not possible to determine the relative importance of the various sources of cash income because the survey farmers were, in general, unwilling to disclose cash earnings. However, since the survey farmers spent more than 60% of their working time on farm work and on the marketing of farm products, their cash income must have depended heavily on their farming activities.

Seasonal price variations for farm products were as much as 150% between the harvesting and planting months but marketing schedules for the farm products were determined by the farmers' cash needs and not by the opportunity for high prices. In Ogboji the peaks of frequency distribution of the months of rice sales occurred mainly in December to March and also in July. Cash is needed to hire labour and purchase yam setts (the yam planting material which is prepared from the edible tuber) for the planting of yam in February–May and to hire labour for the planting of rice in July.

It was not possible to estimate cash income per farmer directly because the survey farmers were generally reluctant to disclose cash income. However, they expended, on average, ₦1043·0 (₦1·0 = SUS1·65) per farmer† in the survey year: 32% of this went on farm expenses, 52% on family needs (house construction, school, medical care, etc.) and 16% on marriages, funerals, etc. Of the ₦334·0 spent as farm expenditure, ₦217·0 was spent on hired labour and ₦99·0 on the purchase of yam setts. At an average hourly wage rate of about ₦0·63 (₦0·75 in Ogboji, ₦0·50 in Ndubia) in the survey year each farmer hired an average of 344 man-hours of labour.

† Average total expenditure was estimated as follows:

$$\sum_{i=1}^{I} \frac{e_i * k_i}{n}$$

where: i = an item of expenditure, I = number of all items of expenditure, k_i = number of survey farmers who spent on ith item in the survey year, e_i = average expenditure (₦) per k on the ith item and n = total number of survey farmers (40).

Despite this, about 60 % of the survey farmers said that they were unable to hire as much labour as they needed because of shortage of money. On average each farmer bought about 200 yam tubers (at about ₦0·50 per tuber) for yam setts in the survey year. About 50 % of the survey farmers said that they could not purchase as many yam setts as they needed because of cash limitations and 25 % said that if they had more money yam setts was the first item they would purchase more of.

The balance of ₦709·0 after the 32 % (₦334·0) spent as farm expenses may suggest that the smallholders might not have been worse off relative to labourers earning the institutional minimum wage of ₦720·0 per year on public projects, especially because the farmers consumed large proportions of their farm products. However, the sum of ₦1043·0 was not all earned income as it included cash gifts from relatives. The earned portion of that sum was not individual but household income; different household members worked on the farm. Above all, the ₦1043·0 was an average; a futher analysis reveals high skewness in distribution. For example, a quartile of the survey farmers accounted for 60 % of the total expenditure whilst another quartile accounted for only 4·4 % of the total expenditure in the survey year. Hence, most of the survey farmers must have had major cash problems.

THE CROPPING PATTERN

Tables 1 and 2 describe the cropping patterns in the survey villages. In Ogboji, apart from rice (*Oryza* sp.) which is grown only in swamp land, each farmer planted yam (*Dioscorea* sp.), cassava (*Manihot esculenta*), cocoyam (*Colocasia* sp.), maize (*Zea mays*) and vegetables (a wide range of minor crops including *Amaranthus* sp., *Cajanus* sp., *Cucubits* sp., *Esculentus* sp. and *Solanum* sp.) on all the land types. Rice is grown as a sole crop but all other crops are generally grown in various mixtures. Wherever yam appears in a mixture it is always considered as the main crop. In Ndubia, in addition to rice, generally grown alone in swamp, most farmers also grow non-swamp bottom land yam alone. Swamp land is almost exclusively devoted to rice because the soil is subject to waterlogging and fresh yam tubers rot under waterlogged conditions. Non-swamp bottom land is devoted to yam (grown alone) by most farmers; the survey farmers said that maize interfered with yam.

The bases for the practice of mixed cropping are documented by Norman (1971). It is practised in the survey villages mainly as an insurance against loss of heavy labour and capital input in yam production in the case of crop failure. Relative to other crops, yam production is labour- as well as capital-intensive. To determine which activities engaged the farmers at different periods of the year, the calendar year was divided into three four-month periods, according to the cropping calendar as follows: March–June, July–October and November–February. Farmers were asked to rank farm operations on the basis of labour requirements in each period. In March–June, land preparation for the yam-based crop mixture, in November

TABLE 1

FREQUENCY DISTRIBUTION OF CROPS (BY INTERCROP) GROWN IN THE SURVEY YEAR ON DIFFERENT LAND TYPES IN OGBOJI

Crops/Mixture	*Number of farmers by land type*		
	Compound	*Swamp*	*Upland*
Yam (main crop)	19	13	12
Cassava	19	12	12
Cocoyam	14	11	12
Maize	19	13	12
Vegetables	19	13	12
Cassava (main crop)	—	-	4
Cocoyam	—		3
Maize	-	—	4
Vegetables		—	4
Cocoyam (main crop)	14	1	-
Maize	14	1	—
Vegetables	14	1	
Cassava (sole crop)		—	2
Cocoyam (sole crop)	1		—
Rice (sole crop)		16	-

TABLE 2

FREQUENCY DISTRIBUTION OF CROPS (BY INTERCROP) GROWN IN THE SURVEY YEAR ON DIFFERENT LAND TYPES IN NDUBIA

Crops/Mixture	*Number of farmers by land type*		
	Homestead	*Swamp*	*Non-swamp bottom land*
Yam (main crop)	12	1	4
Cassava	1	1	—
Cocoyam		1	
Maize	11	—	4
Vegetables	12	1	4
Cassava (main crop)	3	—	2
Cocoyam	-	-	—
Maize	—	—	2
Vegetables	3	—	2
Cocoyam (main crop)	—	—	-
Maize	—	—	—
Vegetables	-		—
Yam (sole crop)	-		12
Cassava (sole crop)			—
Cocoyam (sole crop)		-	—
Rice (sole crop)	-	15	—

February, harvesting of yam and in July–October, land preparation for rice, occupied the farmers most.

The frequency of use of hired labour was higher in yam production than in the production of any other crop; for example, whilst only 55% of rice growers employed hired labour in rice production, 87% of yam growers employed hired labour in yam production. Consequently, most of the expenditure on hired labour must have been for yam production.

Yam production is so labour-intensive because of its production methods. It is grown on mounds, especially in Ndubia where the mounds are particularly huge; in some places, the mounds measure as much as 50–150 cm high and 100–350 cm in diameter to enhance drainage in soils subject to waterlogging. The mounds are made with short handled hand hoes; available farm machinery, such as tractors and implements, are not suitable for making yam mounds. Most yam varieties are staked, especially in Ogboji; staking is laborious because it involves cutting suitable stakes from the bush before actually staking and coiling the yam tendrils. In addition to labour inputs, about 30% (₦99·0) of farm expenditure in the survey year was used to purchase yam planting material. Hence, failure of a yam crop could mean heavy capital loss to a farmer; such a loss could be minimised by other crops in the mixture.

Mixed cropping discourages innovation in the cropping system. The frequency of use of modern inputs such as fertilisers, improved planting materials, etc., was higher for rice grown alone than for any other crop in the area. In the survey year 44% of rice growers among the survey farmers bought improved planting materials and 96% applied fertilisers. There was no improved planting material available for yam and none of the survey farmers applied fertilisers on yam – according to them because fertiliser adversely affects the keeping quality of yam tubers. In the same year, 46% of the survey farmers who grew maize – and 25% of those who grew cassava – bought improved planting materials but none applied fertilisers. The non-application of fertiliser to those crops interplanted with yam is probably due to the presence of yam in the mixture; whilst the use of improved planting materials for maize and cassava may not have adverse effects on yam, the use of fertiliser may have such detrimental effects and farmers are reluctant to take any risky action that could jeopardise family food security.

The cropping system depends on semi-primitive hand tools for various farm operations. The farm tools found on a typical survey farm included two hand hoes, two cutlasses, one cutting axe and two digging sticks, together valued at ₦30·4 at 1977 prices. The consequence of low level of capital equipment on the farms is low labour productivity. Although farm size is small and household size relatively large and most members work on the farm, labour is nevertheless a major constraint – the farms and the survey farmers spent a disproportionate part (65%) of their fa expenses on hired labour alone in the survey year.

Available farm machinery, such as tractors, is not employed, not only because it

too expensive for the smallholders to own and/or operate or because most African tropical soils are not suitable for operation with heavy farm machinery because of the tendency of soils, such as that of Ndubia, to clog under waterlogged conditions, or because of erosion problems in soils such as that of Ogobji, etc., but also because the available farm machinery is not suitable for farm operations on mixed cropping systems and its use is inefficient on small plots (Wadhwa, 1969).

CROP ROTATION AND LAND MANAGEMENT

The rotation systems in Ogboji are as follows (Table 1).

Compound land:
Yam-based crop mixture in year 1 followed by cocoyam-based crop mixture in year 2 repeated continuously.

Swamp land:
Yam-based crop mixture in year 1 followed by old cassava (considered fallow by the survey farmers) in year 2, followed by fallow in year 3 and the system repeated beginning in year 4. Rice (alone) planted repeatedly every year on the same plot.

Upland:
Yam-based crop mixture in year 1, followed by old cassava in year 2, followed by fallow in years 3 and 4 and the pattern repeated beginning in year 5. Cassava-based crop mixture (or cassava alone) in year 1, followed by old cassava in year 2, followed by fallow in years 3 and 4 and the pattern repeated beginning in year 5.

Hence, in Ogboji, compound gardens are farmed continuously by alternating yam- and cocoyam-based crop mixtures and soil fertility is maintained by depositing compound refuse on a regular basis. This means that yam- and cocoyam-based crop mixtures do not necessarily compete for compound gardens. In swamp and upland plots, different crop mixtures are not necessarily rotated on the same plot; rice is grown every year on the same swamp plot, almost all (96 %) of the rice growers applying chemical fertilisers. In swamp plots devoted to crops other than rice and in upland plots soil fertility is maintained by long fallow periods. Typically, after each crop, the plot is fallowed for a number of years, sometimes for as many as five, depending on the number of plots available to a farmer. The same crops as were previously harvested are replanted after the fallow period. That crops (or crop mixtures) are not rotated on the same plots mean that different crop mixtures compete for swamp and upland plots. Yam-based crop mixture, for example, competes for swamp land with rice and for upland with cassava-based crop mixture. Generally, plots on richer soils are allocated to yam-based crop mixtures and plots

on soils which are not so rich are allocated to other crop mixtures or to single crops. The quality of the soil is determined by the length of time a plot has been in fallow or by the amount of bush growth.

In Ndubia, the community as a whole controls land rotation to accommodate livestock grazing in the farming system. The entire village is divided into three zones. Each zone contains some swampland, some non-swamp bottom land and homestead (compound) land. In year *X* the entire community would farm in zone 1 and zones 2 and 3 would be fallowed and grazed. This means that in year *X* farmers residing in zones 2 and 3 would also fallow the land surrounding their homesteads. Anyone could farm in zones 2 and 3 but at the risk of having his crops destroyed by livestock. In year *Y* all the farmers would move to zone 2, zones 1 and 3 being fallowed and grazed, etc. Every farmer would have at least one plot in all three zones and more probably at least one plot in the swamp, as well as in non-swamp bottom land types, in addition to his homestead land. Each farmer has a homestead plot only in the zone where he resides and since he may farm it only once in three years, compound gardens farmed continuously do not exist in Ndubia in the same way that they exist in Ogboji.

Consequently, the rotation systems are as follows (Table 2):

Homestead land:

Yam-based crop mixture in year 1 followed by fallow in years 2 and 3, the pattern being repeated beginning in year 4.

Cassava-based crop mixture in year 1 followed by fallow in years 2 and 3, the pattern being repeated, beginning in year 4.

Swamp land.

Rice (alone) repeated on the same plot of land once every 3 years with 2 years of fallow in between.

Non-swamp bottom land:

Yam-based crop mixture in year 1 followed by fallow in years 2 and 3, the system being repeated, beginning in year 4.

Cassava-based crop mixture, in year 1 followed by fallow in years 2 and 3, the pattern being repeated, beginning in year 4.

Apart from livestock droppings in non-swamp bottom land and homestead land in Ndubia, compound refuse in compound gardens in Ogboji and fertiliser in swamp land for rice in both villages, the smallholder cropping system depends on land rotation with long fallow periods for soil fertility maintenance. This practice is wasteful of land and is possible only because, given the operational scale, farm land is not yet scarce. However, already 30 % of the survey famers in Ndubia and 40 % Ogboji indicated that they needed more farm land than they had, either to expand their farms or to extend fallow periods. As farm land becomes more scarce alternative to long fallow periods as a means of maintaining and improving soil fertility must be found.

The practice of having a long fallow period as a means of maintaining soil fertility creates land preparation problems because it means that, after each crop, the plot reverts to bush which has to be cleared again when the plot has next to be cropped. Twenty per cent of Ogboji and 25 % of Ndubia survey farmers ranked land clearing as their primary farm land problem. The practice, however, protects the soil from erosion—a problem in the Awka area where the soil is formed from sandstone—more than would dependence on fertiliser as a source of soil fertility maintenance.

CALENDAR OF FARM OPERATION

There is no recorded weather data for any of the survey villages. The closest location for which weather records exist for a reasonable length of time is Enugu airport where a daily weather record has been kept since 1971. (The Nigerian Civil War (1967–1970) disrupted all organised activities, including the routine collection of time series data, in the entire southeastern part of Nigeria.) Enugu, the location of the headquarters of the Anambra State Government, is located at latitude 06°28′ north and longitude 07°33′ east. The weather records for Enugu show that there are two distinct seasons of the year—the dry season in November–April and the rainy season in May–October—with a trough in July–August (Fig. 1). The rainy season is associated with high humidity and low solar radiation (Nweke & Winch, 1979).

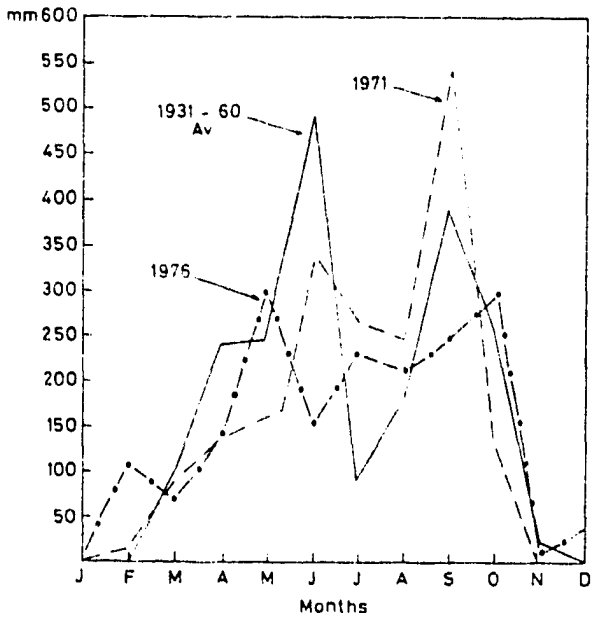


Fig. 1. Monthly rainfall for 1971 and 1976 compared with monthly average for 1931–1960 for Enugu Airport. (Source: Federal Republic of Nigeria: *Agrometeorological Bulletin*. (Published monthly.) Department of Meteorological Services, Federal Ministry of Aviation, Lagos.)

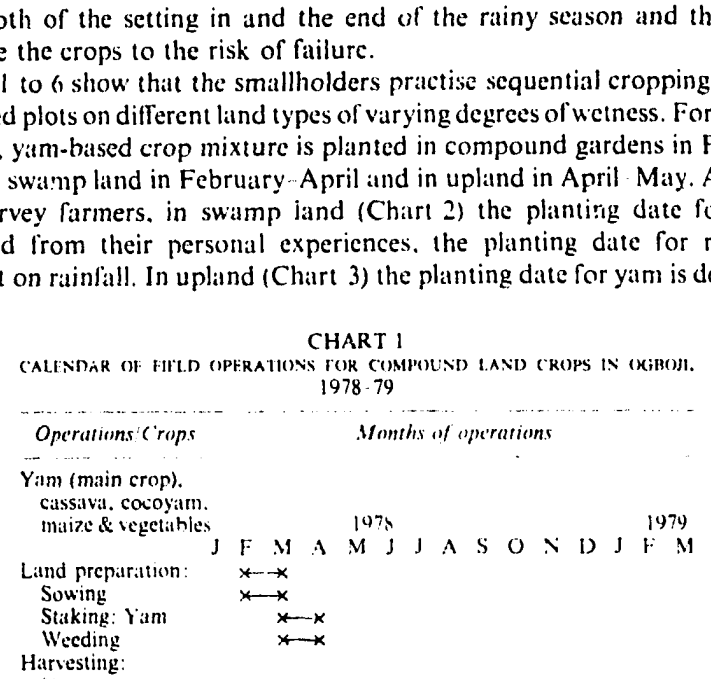
However, given soil nutrient and water, crops perform best under high solar radiation because of associated high rates of photosynthesis and also under low humidity because high humidity is associated with high rates of transpiration and a high incidence of pests and diseases (Okigbo, 1971).

The timing of these distinct seasons and the trough is irregular (Fig. 1). The short duration of the rainy season could limit the growing of most crops to once and restrict labour use on the farm to a few months of the year. The irregularities in timing, both of the setting in and the end of the rainy season and the trough, predispose the crops to the risk of failure.

Charts 1 to 6 show that the smallholders practise sequential cropping based on fragmented plots on different land types of varying degrees of wetness. For example, in Ogboji, yam-based crop mixture is planted in compound gardens in February-March, in swamp land in February-April and in upland in April-May. According to the survey farmers, in swamp land (Chart 2) the planting date for yam is determined from their personal experiences, the planting date for rice being dependent on rainfall. In upland (Chart 3) the planting date for yam is determined

CHART 1

CALENDAR OF FIELD OPERATIONS FOR COMPOUND LAND CROPS IN OGBOJI, 1978-79



* Cassava was harvested all the year round.

CHART 2

CALENDAR OF FIELD OPERATIONS ON SWAMP LAND CROPS IN OGBOJI, 1978-79

Operations/Crops	*Months of operations*														
Yam (main crop), cassava, cocoyam, maize & vegetables						1978							1979		
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Land preparation:		×	—	×											
Sowing		×	—	×											
Staking: Yam					×	—	×								
Weeding					×	—	×								
Harvesting:															
Yam											×	—	×		
Cassava*															
Cocoyam													×		
Maize							×	—	×						
Vegetables						×	—	—	—	×					
Rice (sole)						1978							1979		
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Land preparation:							×								
Sowing							×	—	×						
Weeding									×						
Harvesting											×	—	×		

* Cassava was harvested all the year round.

CHART 3

CALENDAR OF FIELD OPERATIONS FOR UPLAND CROPS IN OGBOJI, 1978-79

Operations/Crops	*Months of operations*														
Yam (main crop), cassava, cocoyam, maize & vegetables						1978							1979		
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Land preparation:				×	—	×									
Sowing				×	—	×									
Staking: Yam						×	—	—	×						
Weeding						×	—	×							
Harvesting:															
Yam										×	—	—	—	×	
Cassava*															
Cocoyam													×	—	×
Maize								×	—	×					
Vegetables							×	—	—	—	×				
Cassava (main crop), cocoyam, maize & vegetables†															
Cassava (sole crop)						1978							1979		
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Land preparation:								×	—	×					
Sowing								×	—	×					
Weeding										×	—	×			
Harvesting*															

* Cassava was harvested all the year round.
† The calendar of field operations was identical to that of cassava for yam-based crop mixtures.

CHART 4

CALENDAR OF FIELD OPERATIONS FOR HOMESTEAD LAND CROPS IN NDUBIA, 1978-79

Operations/Crops	*Months of operations*																					
Yam (main crop), cassava, cocoyam, maize & vegetables					1978																	1979
	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Land preparation:								×	—	×												
Sowing												×	—	×								
Staking: Yam			×																			
Weeding			×																			
Harvesting:																						
Yam									×	—	×											
Cassava*																						
Cocoyam											×	—	×									
Maize					×	—	×															
Vegetables					×	—	—	—	×													
Cassava (main crop) & vegetables					1978																	1979
	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Land preparation:									×													
Sowing													×									
Weeding													×									
Harvesting:																						
Cassava*																						
Vegetables																	×	—	—	×		

* Cassava was harvested all the year round.

CHART 5

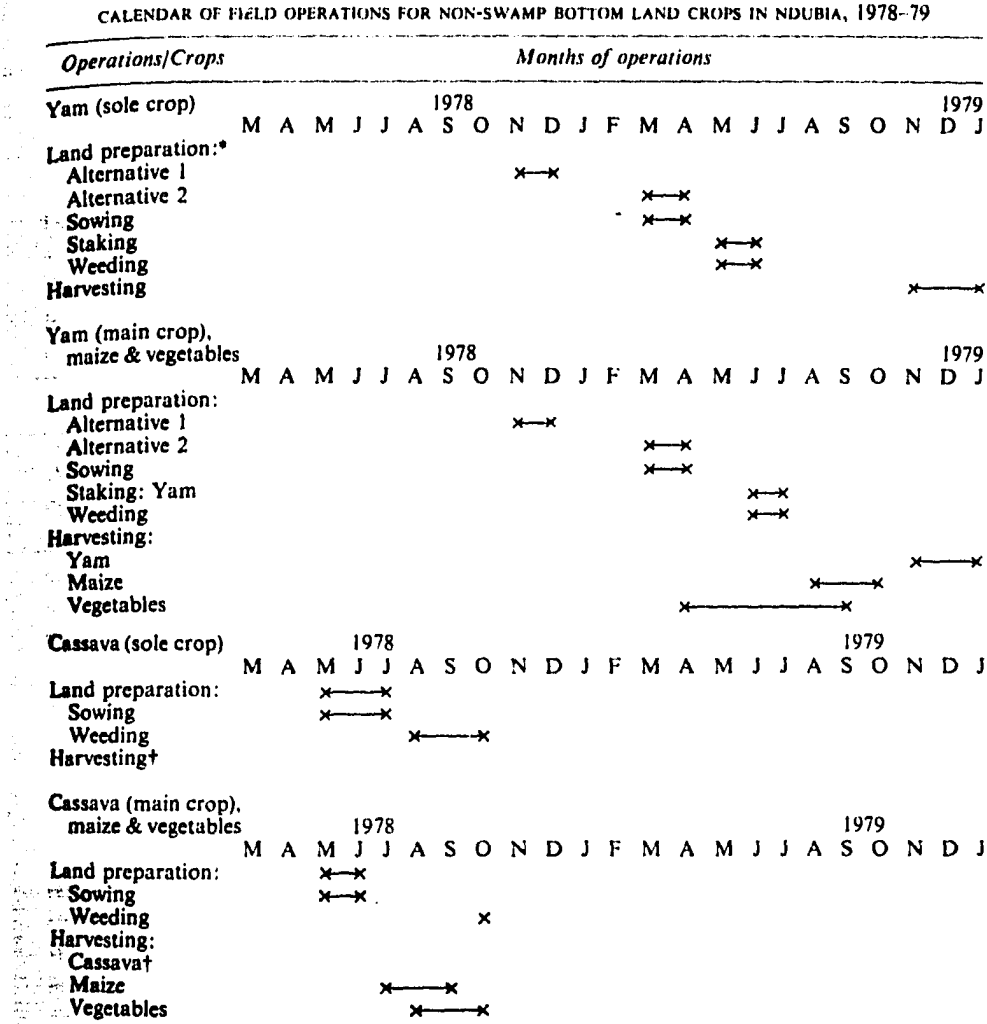
CALENDAR OF FIELD OPERATIONS FOR SWAMP LAND CROPS IN NDUBIA, 1978-79

Operations/Crops	*Months of operations*																					
Yam (main crop), cassava, cocoyam, & vegetables						1978																1979
	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Land preparation:									×	—	×											
Sowing											×	—	×									
Staking														×	—	×						
Weeding														×	—	×						
Harvesting:																						
Yam																			×	—	—	×
Cassava*																						
Cocoyam																	×	—	—	—	—	×
Vegetables												×	—	—	—	—	—	—	×			
Rice (sole crop)						1978																1979
	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Land preparation:					×																	
Sowing					×																	
First weeding							×	—	×													
Harvesting									×	—	×											

* Cassava was harvested all the year round.

CHART 6

CALENDAR OF FIELD OPERATIONS FOR NON-SWAMP BOTTOM LAND CROPS IN NDUBIA, 1978–79



* Some farmers prepared land some months ahead of sowing (alternative 1).
† Cassava was harvested all the year round.

by the coming of the rains, the planting date for cassava alone or as the main crop (in cassava-based crop mixtures) is determined by labour availability. In all land types (Charts 1–3), the planting dates for cassava, cocoyam, maize and vegetables interplanted with yam are determined by the planting date for yam.

In Ogboji (Charts 1–3) tillage and sowing are generally carried out simultaneously but in Ndubia (Charts 4–6), except for rice, for which tillage and sowing are also carried out at the same time, tillage is generally undertaken 2 to 3 months in advance

of sowing, before the rains. Abakaliki soil, which is formed from shale, tends to clog under wet conditions and makes tillage difficult. Advance land preparation permits Ndubia farmers to bury the trash during tillage and allow it to decompose before planting to enhance soil fertility, whilst Awka farmers have to burn the trash before tillage because they till and sow at the same time. Yam is staked in Ogboji but not in Ndubia. Staking is done to save yam tendrils from heat from the soil; in Ndubia the mounds are sufficiently high to make staking for that purpose unnecessary.

Cassava is harvested all the year round, not necessarily because it is also planted virtually all the year round but because it can stay in the field for some years—sometimes as many as 3 years—after reaching maturity without damage to the tuber. Vegetables are an aggregate of a wide range of minor crops which mature at different times; hence, harvesting of vegetables is spread over many months on all land types. Harvesting of compound yam is spread over many months (Chart 1) because food is obtained directly from compound gardens by harvesting yam when needed for immediate consumption. Compound garden yam is harvested for storage in October–November.

The sequential planting practice protects the farmers from the risk of crop failure that could result from variation in the timing of the setting in or ending of the rains. For example, in Ogboji, most of the survey farmers prepared land and planted yam in compound gardens in February and March, in swamp plots in March and April and in upland in April and May in the survey year; the months of yam harvesting on different land types were similarly different (Charts 1–3). Consequently, a given timing of the setting in or end of rainfall would affect the yam crop on different land types differently and a farmer who grew yam on the three different land types would be confident that no matter what the timing of rainfall in the year was, it would be likely to be favourable to his yam crop on at least one land type. Similarly, a given timing of rainfall would affect any other crop on different land types differently.

Sequential cropping also enables the smallholders to distribute labour demand on the farms to most months in the year. Another consequence of the sequential cropping, however, is that, in some months, certain farm operations on crops in the sequence overlap, thus creating labour bottlenecks because, due to the short duration of the rainy season, the gaps between the dates of planting crops on different land types are short.

An Ogboji farmer who specialises in swamp yam would be idle in the months of January, July, August, September and October because land preparation for swamp yam is carried out by most farmers in February–April, staking (by men) and weeding (by women) in May–June and harvesting in November–December (Chart 2). However, the survey farmers also grow rice on swamp land and, for this enterprise, land preparation is carried out in July, weeding in September and harvesting in November–December. In November and December, when the swamp yam and rice harvests come together, there is a labour bottleneck.

The practice of growing yam-based crop mixtures on compound, swamp and

upland plots enables the farmers to fill the remaining idle period. Such a practice extends land preparation for the crop from February to May (Charts 1–3) because land preparation for compound yam is carried out in February–March, for swamp yam in February–April and for upland yam in April–May. However, the farmers face labour constraints in March and April when land preparation operations in the different land types overlap.

The practice also spreads staking (by men) and weeding (by women) from March to July as staking and weeding on compound land are carried out in March–April, on swamp plots in May–June and on upland plots in June–July. But again labour constraints are created in June by the overlapping of staking and weeding operations on different land types.

FARMING OBJECTIVES

About 90 % of the survey farmers ranked yam as the most important crop they grew: according to some because it was the major crop consumed at home and to others because it was prestigious to be a successful yam farmer. Success in yam farming is determined not only by the total quantity of yam harvested but also by the size of individual tubers in the harvest. Forty-two per cent of the survey farmers ranked cassava and 53 % ranked rice as the second most important crop. Cassava and rice are important because they are sold for cash. A small proportion—less than 20 %—of the total output of yam was marketed compared with over 70 % of the total output of rice marketed per farmer in the survey year, partly because a large percentage (30 %) of the total output of yam was replanted and partly because yam was grown primarily for home consumption. Hence, the smallholders farm primarily for food security and secondarily for cash.

The importance of yam as a food security crop has a more cultural than nutritional basis because, except for cocoyam, yam is lower in energy content and, except for cocoyam and cassava, it is also lower in protein per unit weight than all other food crops (FAO, 1970). Yam, however, is traditionally a 'man's crop' whilst cassava, cocoyam, maize and vegetables are 'woman's crops'. All production, marketing and consumption decisions on yam are made by the male head of the household and similar decisions on cassava, cocoyam, maize and vegetables are made by female members to the extent that the 'woman's crops' do not interfere with yam. Rice is not a traditional crop; it was introduced into the areas in the 1950s and was widely adopted because of its cash value.

Yam has a low income elasticity of demand relative to foodgrains, especially rice, the cash crop. In the 1960–1977 period, when GNP per capita in Nigeria increased at a relatively high rate, mainly because of high petroleum revenue, beginning in the early 1970s, rice consumption per capita also increased but yam consumption per capita remained more or less constant (Fig. 2). Because, in general, different crops

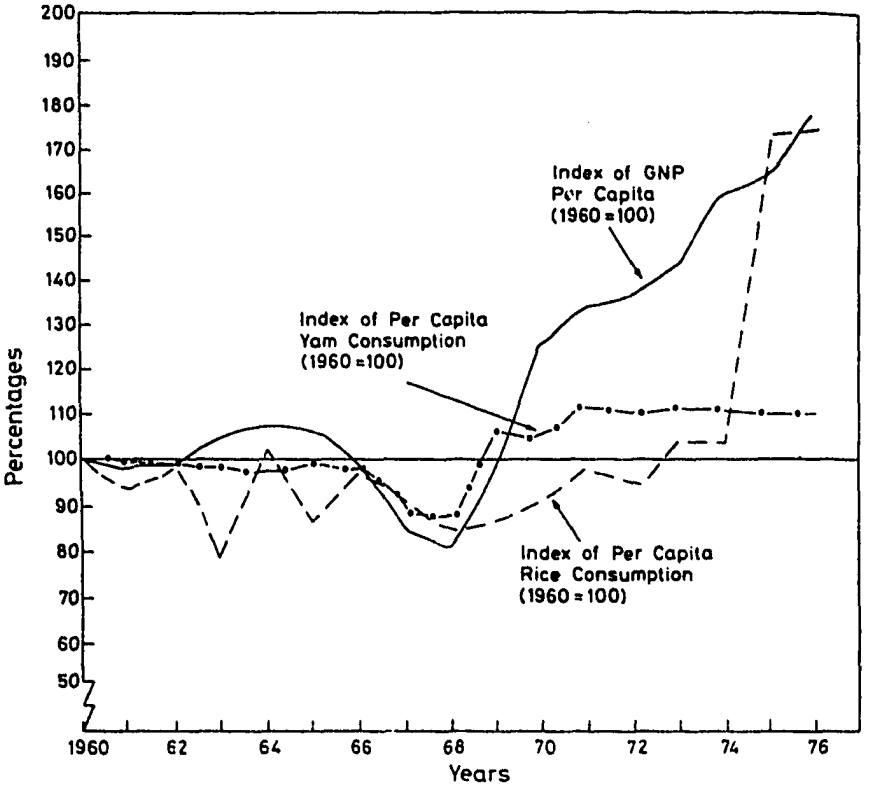


Fig. 2. Indices (1960 = 100) of GNP at constant prices per capita and of per capita consumption of yam and rice in Nigeria, 1960–1976. (Sources: GNP and population data are from the *World Bank Atlas*. Rice consumption data are from the US Department of Agriculture (USDA, 1978). Yam consumption (= production) data are from the US Department of Agriculture, *Indices of Agricultural Production in Africa and the Near East*, Economics, Statistics and Co-operative Services, Washington, DC.)

serve different purposes, the fact that the smallholders grow different crops—some of them at different times of the year—does not solve all the problems associated with weather hazards. Rice is grown once a year and one crop of rice does not generate enough cash income for the smallholders to be able to meet their cash expenses in modern housing, education, medical care, etc. This is because, although yam has a low cash value, it takes priority in resource allocation over rice, thus limiting the production of rice. Figure 3 shows that rice production failed to respond to the increase in demand; that is, partly because of Nigeria's rice import policy but mainly because of limitations in available resources for expanding the production of rice. In 1977, of over 800,000 metric tonnes of rice consumed in Nigeria, 400,000 metric tonnes were imported (USDA, 1978).

Rice production is limited to one crop a year because the duration of rainfall is short and there are virtually no irrigation facilities in the areas (Wadhwa, 1974). It is

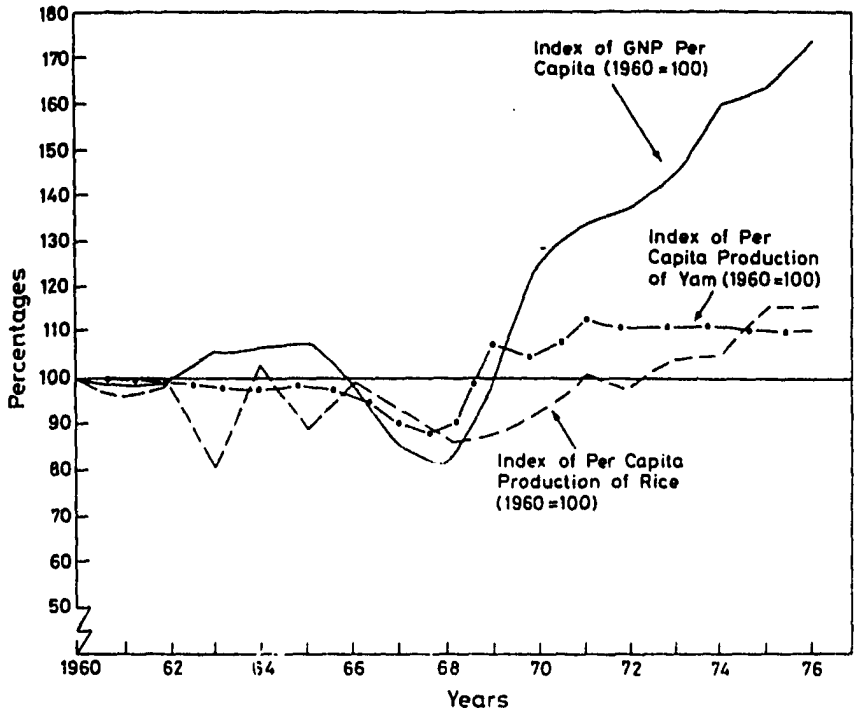


Fig. 3. Indices (1960 = 100) of GNP at constant prices per capita and of per capita production of yam and rice in Nigeria, 1960–1976. (Sources: GNP and population data are from *The World Bank Atlas*; rice production data are from the US Department of Agriculture (USDA, 1978), and yam production data are from the US Department of Agriculture. *Indices of Agricultural Production in Africa and the Near East*, Economics, Statistics and Co-operative Services, Washington, DC.)

grown in July–November when swamp yam is also grown (Chart 2): both compete for swamp land but as a food security crop yam has a competitive advantage over rice. If rainfall were more evenly distributed, in the absence of irrigation water, it would be possible to expand rice production by growing a second crop in November–February after yam has been harvested and before the plot reverts to fallow.

Maize production expansion is also constrained by unfavourable weather: if maize is planted in June or July it would be adversely affected by low solar radiation and high humidity and if it were planted later it would not have enough water. Hence, it is planted on most land types between February and April and harvested between June and September when it grows under the best possible combination of rainfall, solar radiation and relative humidity in a normal year (Nweke & Winch, 1979). However, by harvest time, the relative humidity is so high that drying of the grain for storage is a major problem. Consequently, most of the maize is eaten green at home or marketed at harvest-time at very low prices. Nearly all the survey farmers

said that they sold their maize between June and September—i.e. at harvest—only a small proportion of the total harvest being dried over the kitchen fire (the smallholders cook on open fires with firewood) and marketed at planting time in March-April for seed. This probably explains why maize is grown as a minor crop in yam plots; growing it alone—as rice is—would not be profitable in cash terms and it is not a food security crop, as is yam.

Because cash earning opportunities from expanding the production of cash food crops (mainly rice and maize) are limited by weather and over-emphasis on food security, the smallholders engage in off-farm employment, even in the months when they have work to do on the farm, to supplement cash income. On average each survey farmer spent 20% of his working time on off-farm employment in 1977/78. In Ogboji, most engaged in trading, handicrafts or in palm product processing and marketing. In Ndubia they worked as hired labour on farms, mainly in other parts of southeastern Nigeria where farm wages were higher than in the Abakaliki area.

CONCLUSIONS

The above analysis shows that the cropping system of the survey areas is adapted to cultural and environmental factors but in ways that are inimical to the improvement of smallholder welfare. Yam production is afforded priority in resource allocation over other crops because yam has a food security value which is more cultural than nutritional. Relative to rice, the major farm cash activity, yam production, is intensive in the use of labour and cash and is allocated premium land in the cropping system, thereby discouraging expansion in rice production.

Because of low cash values and high costs, other crops are generally interplanted with yam as the main crop to enhance the value of the resources used in its production and to reduce capital losses that could follow yam crop failure. But the smallholders are inflexible in yam production methods; hence the methods of production of the crops interplanted with yam remain more or less traditional because attempts to change them could jeopardise food security objectives.

Although the smallholders are reluctant to change yam production methods they realise that the present method is expensive because of the high cost of labour and planting materials and they are likely to welcome changes in those areas. At present efforts are under way at certain farm research centres in Nigeria such as the International Institute of Tropical Agriculture, Ibadan, and the National Roots and Tuber Research Institute, Umudike, to develop yam planting materials based on seed or stem rather than tuber, the edible part, used at present (IITA, 1975). Such efforts should be encouraged, but in addition there is a need for innovation in the area of farm tools for yam production operations. The aims of such technology should not be to expand yam production, because yam production expansion beyond present per capita consumption levels (Fig. 2) is unlikely without capital

losses to the smallholders due to probable aggregate demand limitations. But lower yam production costs than at present could release resources for the production of other crops, such as rice, which have high income elasticity of demand, which are often in short supply and which are imported into Nigeria in large amounts annually.

Sequential cropping patterns adopted to deal with skewed distribution and the variable timing of rainfall create labour bottlenecks in certain months because, due to the short duration of the rainfall, the gaps between planting dates of crops in the sequence are short, causing farm operations on the crops to overlap. The smallholders are likely to welcome innovations that could spread out the planting dates of the crops in the sequence, provided that such innovations do not interfere with yam production. For example, rice is planted in July–August (Chart 2) when it would have enough rainfall in September–October to grow and not too much rainfall in October–November to dry. But in those months yam is still in the field; rice and yam compete for swamp land but as a food security crop yam has a competitive advantage over rice. An innovation that would make rice growing possible in November–February is likely to be accepted by the smallholders; first because it will eliminate competition for swamp land between rice and yam as rice would be grown on yam plots after yam is harvested before the plot is reverted to fallow and, secondly, because it will reduce labour demand in July–August when land preparation and sowing operations for rice coincide with weeding and staking operations for upland yam (Charts 2 and 3). Thirdly, it will provide farmers with cash activity on the farm in the months of October and January when they have least to do (Charts 1–6).

Irrigation water can be developed to achieve the above objective. However, experiences in some tropical African countries, such as Ghana, has shown that investment in irrigation development could involve high cost and low returns, partly because of high overhead investment and partly because the introduction of rainfed farmers to irrigation farming takes time to accomplish (Nweke, 1978). An alternative would be the development of drought-resistant or fast-maturing rice varieties which can be grown in the later part of the rainy season.

'Prescriptive' types of research are therefore needed in the areas of farm tools for yam production operations and suitable rice varieties to be grown later in the year than at present. In addition, present efforts at the development of yam planting materials from seeds and stems ought to be intensified.

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REPLACEMENT POLICY IN DAIRY HERDS ON FARMS WHERE HEIFERS COMPETE WITH THE COWS FOR GRASSLAND—PART 1: MODEL CONSTRUCTION AND VALIDATION

J. A. GARTNER

Department of Agriculture and Horticulture, University of Reading, Reading, Great Britain

SUMMARY

It is difficult to evaluate quantitatively the effect of different replacement rates on dairy farm profitability and dairy herd improvement. Computer simulation models were developed to tackle this problem and to formulate hypotheses that might be useful for research and advisory purposes.

A model was constructed and validated against actual average yields of heifers entering the national herd of England and Wales over the period 1962–76. It was used to generate information on the initial state of herds that could be used in experiments. A second model was adapted from this generation model to handle the replacement situation where heifers are reared on the farm where they are to be used and compete with the cows for grassland.

1. INTRODUCTION

Herd replacement policy is important on individual dairy farms (Russell, 1974; Morris, 1976) and in a national context (Beynon, 1978), because replacement heifers consume resources that could be used for other production (Barnard *et al.*, 1970). It is not easy to determine on farms where heifers are home-reared and compete with cows for grassland throughout the cycle of the seasons. The difficulty lies in the conflict between making money and herd improvement as measured by yield per cow, even though one would think that these two objectives were compatible. The links between replacement policy and these objectives are shown in Fig. 1.

The problem for the farm adviser is to quantify the consequences of different replacement policies in relation to the farmer's purposes and to other factors affecting production and profit. The purpose of this research has been to tackle that

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