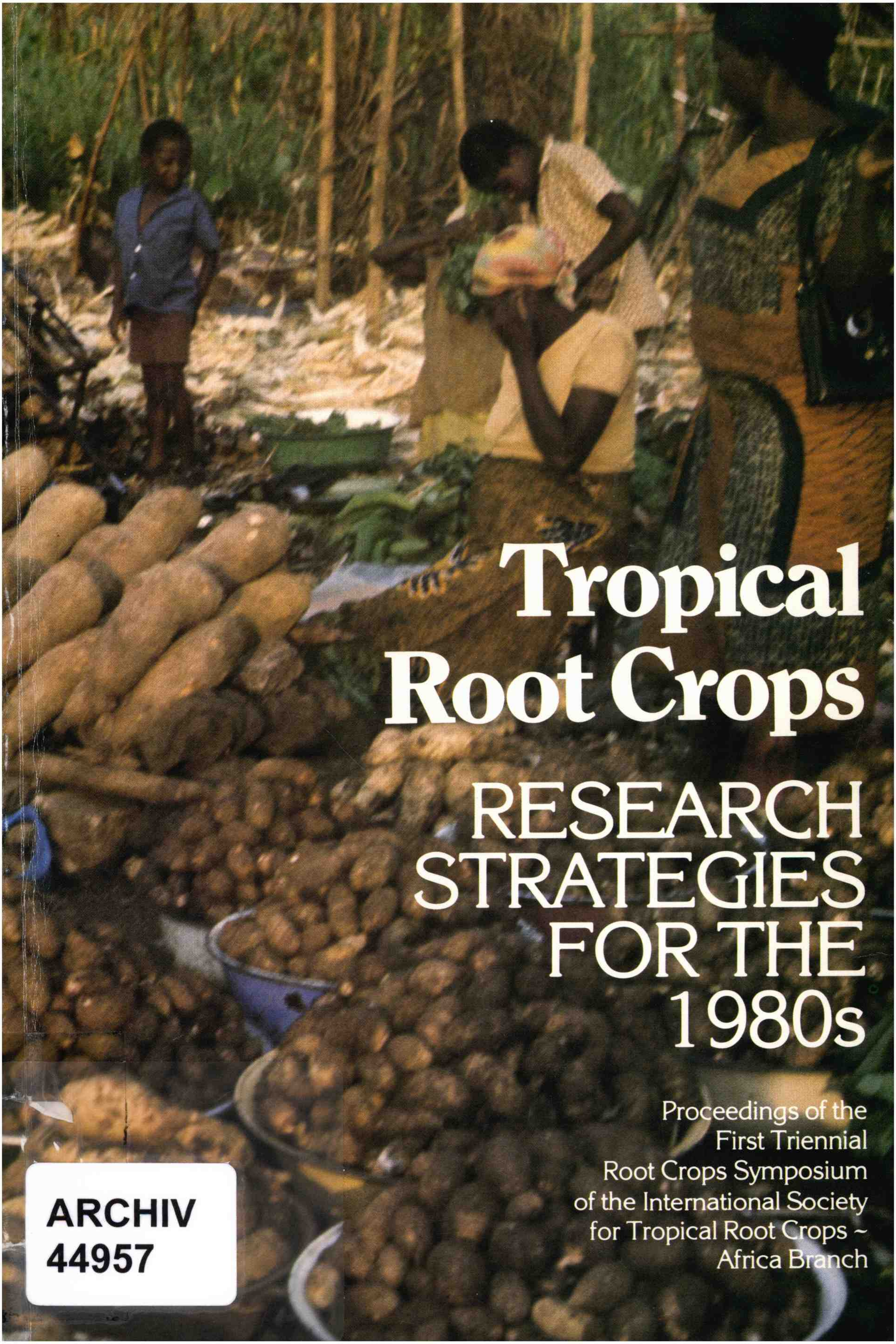

Tropical Root Crops

RESEARCH STRATEGIES FOR THE 1980s

Proceedings of the First Triennial Root Crops Symposium of the International Society for Tropical Root Crops ~ Africa Branch

IDRC-163e

TROPICAL ROOT CROPS: RESEARCH STRATEGIES FOR THE 1980S

PROCEEDINGS OF THE FIRST TRIENNIAL ROOT CROPS SYMPOSIUM OF THE INTERNATIONAL SOCIETY FOR TROPICAL ROOT CROPS — AFRICA BRANCH, 8–12 SEPTEMBER 1980, IBADAN, NIGERIA

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The International Society for Tropical Root Crops — Africa Branch was created in 1978 to stimulate research, production, and utilization of root and tuber crops in Africa and the adjacent islands. The activities include encouragement of training and extension, organization of workshops and symposia, exchange of genetic materials, and facilitation of contacts between personnel working with root and tuber crops. The Society's headquarters is at the International Institute of Tropical Agriculture in Ibadan, Nigeria, but its executive council comprises eminent root and tuber researchers from national programs throughout the continent.

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IDRC-163e

Tropical root crops: research strategies for the 1980s. Ottawa, Ont., IDRC, 1981. 279 p. : ill.

/IDRC publication/, /root crops/, /agricultural research/ — /plant breeding/, /plant diseases/, /cassava/, /sweet potatoes/ , /pests of plants/ , /plant production/ , /weed control/ , /intercropping/ , /harvesting/ , /crop yield/ , /conference report/ , /list of participants/ , /agricultural statistics/.

UDC: 633.4 (213)

ISBN: 0 88936 285 8

Microfiche edition available

Cooperating institutions

CANADA

CONTENTS

THE EFFECTS OF PREVIOUS CROPPING ON YIELDS OF YAM, CASSAVA, AND MAIZE

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In a 4-year continuous cropping trial, 21 treatment sequences of cassava, yam, and maize as sole crops were evaluated for the effects on the yield of each of the crops and the total caloric yield. The plots received annual supplements of N, P, K, and compost. Yield differences among the sequences were significant with respect to the crops. Best yields of yam, after 4 years, were obtained from plots where yam followed 3 years of maize or cassava, whereas worst yields were obtained from plots where yam followed the "basic" rotation (recommended by the Ministry of Agriculture), which is yam followed by maize and, then, cassava. Highest yields of cassava in the fourth year were recorded when cassava followed maize followed by (fb) yam, fb maize. As in yams, worst yields were recorded for cassava following the basic rotation.

Nematode populations in the yam plots and incidence of nematode attack were not influenced by the sequence. Total caloric yields during the 4 years were highest when root crops dominated the sequence. Annual relative mean yields of yam, cassava, and maize showed a steady decline with continuous cropping. It is concluded that the basic rotation of yam fb maize fb cassava is inferior to other sequences in maintaining soil fertility and sustaining high yields. Yields cannot be sustained and fertility maintained under the heavy rainfall typical of the area, even through the use of organic manures and fertilizers.

Rapport des 4 années d'essais comprenant 21 séries de cultures d'assolement associant l'igname, le manioc et le maïs en vue d'apprécier les effets de chaque culture sur la suivante et le rendement calorique total. Les champs ont été amendés chaque année avec N, P, K et du compost. Les rendements des séries de culture ont été très variés. Pour la quatrième année, la production d'ignames a été la plus élevée lorsqu'elle suivait 3 années de culture de maïs ou de manioc alors que la plus faible a été obtenue sur des parcelles où l'igname suivait la succession recommandée par le Ministère de l'Agriculture, soit igname + maïs + manioc. Les rendements de manioc les plus élevés à la fin de l'expérience ont été enregistrés lorsqu'ils venaient à la suite du maïs, suivi par l'igname et encore le maïs. Comme dans les cas précédents, les rendements les plus faibles ont été obtenus en suivant la séquence recommandée.

L'ordre de la séquence n'a eu aucun effet sur l'apparition des nématodes et leur population dans les champs d'ignames. Les rendements en calories ont été les plus élevés au cours des quatre années lorsque les plantes-racines étaient en tête d'assolement. Les moyennes annuelles relatives de l'igname, du manioc et du maïs ont baissé régulièrement en culture continue. En conclusion, la rotation recommandée, ignames + maïs + manioc, est inférieure aux autres séquences pour le maintien de la fertilité du sol et d'une production élevée. Les rendements ne peuvent être soutenus non plus que la fertilité du sol maintenue dans ces régions à forte précipitation, quel que soit l'apport d'engrais ou de fertilisants.

Guesstimates are that by the year 2000, the population of Nigeria will double to 145 million (IADS 1980). At an annual growth rate of 3.2%, about 1.9 million additional people will need to be adequately fed every year. To cope with this expected increase in population and to avert the nightmares predicted by the Malthusian postulate, it is mandatory that agricultural production be increased.

The federal government of Nigeria has already taken a step in the right direction by instituting its laudable Green Revolution program and its predecessor, Operation Feed the Nation. Making the Green Revolution a reality would require the opening up of more agricultural lands or increasing the productivity of the present lands. In the face of the rapid pace of urbanization and industrialization, both of which must compete with agricultural production for the available land, the former alternative seems the less attractive.

Hitherto, the system of agriculture variously described as shifting cultivation (Ruthenberg 1976), land rotation cultivation, recurrent cultivation (Allan 1965), rotation bush-fallow (Faulkner and Mackie 1933; Obi and Tuley 1973), and shifting field agriculture (Morgan 1969) has been the chief means of increasing productivity. The length of the fallow or the resting period has been dependent upon the pressure on the land and the fertility of the soil as indicated by crop yields. But with the introduction of the cash crop economy and the rapid increase in population, this system is becoming too much of a luxury, its obvious advantages of soil fertility restoration, soil conservation, and control of pests and diseases notwithstanding. Finding alternatives to the system is on the priority list of many a national program. All alternatives have as their theme the shortening and, if possible, total elimination of the fallow period (FAO 1966, 1974; Herman 1969). The theme presumes that the soil fertility and productivity can be sustained by other means, such as the use of improved agricultural packages (including the use of fertilizers and manures). This presumption is still to be fully tested.

The continuous cropping experiment reported in this paper was designed to investigate the possibility of maintenance of the soil fertility in a heavy-rainfall forest zone of southern Nigeria under a system of continuous intensive cropping through the use of organic manures and fertilizers. A second objective was to determine the yield potential of the crops under a system of continuous cropping dominated by yams, cassava, and maize.

METHODS AND MATERIALS

The experiment as originally planned was sited on a deep porous yellowish brown sandy clay loam soil at Umudike, which has annual rainfall of 2125 mm. This is one of the dominant soils of Imo State.

The cropping system in this region is dominated by the basic food crops, yam, cassava, and maize. This system has been described for the oil-palm belt of eastern Nigeria in general (Obi and Tuley 1973) and for Umokile and Owerri, in particular (Ruthenberg 1976). Findings from a cropping system survey (NRCRI 1977) in the region indicated that commonly in the first year yam is intercropped with early maize and vegetables and interplanted with cassava; in the second year, cassava is planted and is followed by *Acica bartari* or, more recently, *Eupatorium odoratum* bush fallow; and in the third to the sixth years bush fallow is continuous. Thus 1.5–2 years of normal cropping is followed by 4–7 years of fallow.

In our study, the yields from three major crops yam, maize, and cassava were compared after continuous cultivation in different combinations of rotation. Spacings for the yam (*Dioscorea rotundata*, Obiaoturugo variety), cassava (Nwugo variety) and maize (N.S-1) were 120 cm, 120 cm, and 30 cm, respectively, along 100-cm ridges. Gross and net plot sizes were 0.01 and 0.0067 ha, in that order. Each plot received a blanket application of 336 kg/ha of 10–10–20 NPK fertilizer and 25 t/ha of compost.

The experiment was laid out in a randomized complete block design (RCBD) in four replicates — a total of 84 plots. So that all possible combinations of rotation could be tested, it was scheduled to run from 1976 to 1987; however, because of financial constraints, it had to be terminated in 1979, hence the unbalanced nature of the treatments reported. For the statistical analysis, all the treatment phases that carried the same sequence of crops in 1976–79 were grouped as one treatment. The experiment was thus analyzed as a RCBD with unequal sample sizes as for treatment means adjusted for covariance (Bancroft 1968).

Data collected were yield of fresh yam tubers, cassava roots, and maize grains; nematode populations 2 weeks before harvest (number/250 g soil); and percent of tubers damaged. Total energy yield per treatment was calculated as 381, 409, and 391

Table 1. Total productivity over the 4 years as influenced by the cropping sequence.[a]

Sequence[b]				Energy yield
1976	1977	1978	1979	(cal × 10^7/ha)
Y	Y	Y	Y	19.48
C	Y	M	C	18.97
Y	Y	M	C	18.66
C	Y	M	C	17.43
C	C	C	Y	17.28
C	Y	Y	Y	17.06
C	C	C	C	16.22
Y	M	C	Y	16.21
Y	Y	Y	M	14.84
Y	M	C	Y	14.57
Y	M	C	C	13.50
M	Y	M	C	12.83
C	C	Y	M	12.66
M	C	C	C	11.70
Y	M	C	M	11.31
M	C	Y	Y	10.72
C	M	M	M	7.94
M	M	M	Y	7.90
M	C	Y	M	6.99
M	M	Y	M	4.74
M	C	M	M	4.72

[a]Critical difference for 1% significance by Scheffe's procedure is 1.43×10^7 cal/ha.

[b]Y,M,C = yam, maize, and cassava, respectively, occupying the plots.

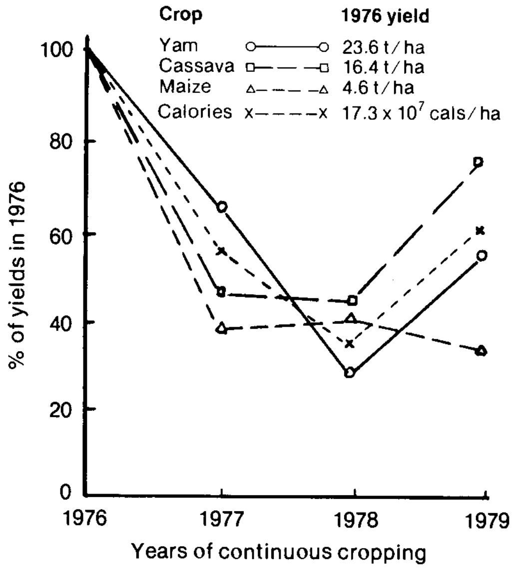

Fig. 1. *Decline in yield of yam, maize, and cassava with 4 years of continuous cropping. Yields are averaged over all phases carrying the respective crops.*

cal/100 g dry weight for yam, maize, and cassava, respectively (Oyenuga 1968).

RESULTS

The 1978 and 1979 harvest data are the only yields for which it is possible to make inferences.

1978 YIELDS

The yam yields from the five treatment phases or sequences differed significantly from one another at the 5% level of probability. Best yields were obtained from the sequences cassava–cassava–yam (7.59 t/ha) and cassava–yam–yam (6.88 t/ha); the sequences yielding least were maize–maize–yam (4.85 t/ha) and yam–yam–yam (4.76 t/ha). Maize–cassava–yam was intermediate (6.22 t/ha). Nematode populations at harvest ranged from 160/g of soil to 255/g; the differences were not significant. The lowest percentage of tubers damaged was with the maize–maize–yam sequence (10.9); the highest with the maize–cassava–yam (19.5), but none of the differences were significant.

Cassava yields after the third year of cropping were significantly different at the 1% level. The yield of the last crop from the yam–maize–cassava sequence was 4.93 t/ha and was significantly lower than were yields from cassava–cassava–cassava and maize–cassava–cassava sequences (7.05 and 7.62 t/ha respectively).

Treatment differences in 1978 maize grain yields were highly significant. Soils cropped with cassava–yam–maize yielded 2.70 t of grain, which was significantly higher than were yields from maize–cassava–maize (1.82 t/ha), yam–yam–maize (1.80 t/ha), and maize–yam–maize (1.61 t/ha). Lowest yields were recorded for cassava–maize–maize (0.58 t/ha) and maize–maize–maize (0.45 t/ha).

1979 YIELDS

Tuber yields from plots where yam followed 3 years of maize (13.86 t/ha) or cassava (13.29 t/ha) were superior to yields where yam followed other sequences. However, yield differences in 1979 were not significant. Lowest yields were recorded in plots where yam followed the basic rotation of yam–maize–cassava (10.16 t/ha). As in 1978, differences in nematode populations and incidence of cracks could not be attributed to the sequences. In 1979, differences in cassava yields attributable to sequence were not significant. Highest yields were from plots of cassava following maize–yam–maize (13.55 t/ha) and, as in the case of yams, lowest yields were given by cassava following the basic rotation (8.44 t/ha).

Very few significant differences in maize yields were obtained again in 1979. Yields where maize followed the sequence yam–maize–cassava were the lowest, as in the case of yam and cassava, and differed significantly from the rest.

Total yield of calories from cropping sequences where the root crops, yam and cassava, occupied the land for a major portion of the period were much higher than were those where maize dominated the sequence (Table 1).

Annual relative mean yields of the respective crops showed a steady decline (Fig. 1) for the years 1977 and 1978; this decline was more pronounced in the case of yam. Thereafter, the yields of yam and cassava rose, relative to 1978 yields, whereas the yield of maize was just under the 1978 level.

DISCUSSION

Our investigation provided answers to the two questions for which the study was designed. Results have shown that the basic rotation of yam fb maize fb cassava is significantly inferior to the other sequences, as far as the three crops are concerned. Best yields for yam and cassava were obtained when these crops followed 3 years of maize; their worst yields were recorded when they followed 2 or 3 consecutive years of themselves. For soils in Umudike, Obi (1965) reported earlier that each of the three crops gave its best yield when it succeeded bush fallow cut down and burned in the year of test cropping, and its worst yield when it succeeded itself.

Judged by the total caloric yield for the 4 years of cropping, the 21 sequences were not of equal productivity. Highest energy was harvested in sequences dominated by the root crops. This is not surprising as root crops by virtue of their high harvest indices and caloric content are better energy harvesters.

The observed yield decline with continuous cropping, even with the heavy manuring and fertilizer additions, highlights a second finding of the study — that yield cannot be sustained and fertility maintained under the heavy rainfall typical of the area through the use of organic manures and fertilizers. Similar reductions following successive croppings had been reported for Umudike (Obi 1965), Malaysia, Trinidad, Guyana, Honduras, Guatemala, and the forest zone of Ghana (Nye and Greenland 1960). At Umudike, yields of a second crop of yam, maize, and cassava declined to 67.5, 82.7, and 59.8%, respectively, of their first yields (Obi 1965). A similar result was recently obtained for continuous cultivation of cassava in Umudike; yield declines in the second, third, and fifth years of continuous cassava were, respectively, 33.8, 45.8, and 49.1% of those in the first (Odurukwe 1980). In the forest zone of Ghana, soils maintained under a continuous rotation of maize and cassava for 8 years showed a steady decline in yield, even with supplemental addition of compost and fertilizers.

Other reports have shown that under certain conditions yields can be sustained in continuous cropping, with or without fertilizer application. For example, yields were fully maintained for 8–11 years in Kano under continuous guinea corn, millet, and groundnut (Obi 1965) and for 9 years with a loss of less than 25% under a continuous rotation of maize and cassava in the savanna zone of Ghana (Nye and Greenland 1960). Results of long-term studies at seven sites in northern Nigeria did not suggest any general decline in maximum crop yields over 5–6 years under intensive cropping, yields being maintained by judicious fertilizer use (Heathcote 1975).

The apparent inconsistencies in the responses are attributable to differences in rainfall and soils in the various ecological zones. Umudike with its high rainfall and sandy soils, typical of most of the rain forest zone of southeastern Nigeria is expected to have a higher rate of organic matter decomposition, heavier leaching losses, higher soil erosion, and more rapid decline of general fertility with continuous cropping.

Considering the heavy supplements of manure and fertilizers in this investigation we believe yield declines reflected a depletion of the trace and minor elements contained in the soil, proliferation of pests and diseases, and the deterioration of the soil's condition. Changes in the soil's nutrient status in the course of this investigation will be the subject of another paper.

This paper is published with the permission and support of Dr L.S.O. Ene, Acting Director, National Root Crops Research Institute, Umudike. The contribution of the late Dr J.K. Obi who designed, initiated, and supervised the first 2 years of the experiment is gratefully acknowledged.