PN-AAR-192

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Facts about IITA

The International Institute of Tropical Agriculture (IITA) – one of the major links in a worldwide network of agricultural research and training centers – was established as an autonomous, non-profit corporation on July 27, 1967. The Federal Republic of Nigeria allotted 1,000 hectares of land for the IITA site, and the Ford Foundation provided initial capital for buildings and development.

IITA is governed by an International Board of Trustees, the membership of which includes representatives from developing countries in areas of the Institute's concern.

The principal financing of the Institute (and other centers) is arranged by the Consultative Group on International Agricultural Research (CGIAR) – an informal group of donor countries, development banks, foundations, and agencies. Support for IITA's research and training core program in 1982 was provided by the Canadian International Development Agency (CIDA), Overseas Development Ministry of the United Kingdom (ODM), U.S. Agency for International Development (USAID), World Bank, International Fund for Agricultural Development (IFAD), Ford Foundation, OPEC Fund for Agricultural Development, and the governments of Australia, Belgium, France, India, Italy, Japan, Netherlands, Nigeria, Norway, and Federal Republic of Germany. In addition, other donors provide funds to the Institute, particularly to support specific research or training programs

The "geographic mandate" of IITA includes the humid and subhumid tropical zones, and the Institute concentrates its research and training in two major areas: farming systems and crop improvement of certain designated cereals (rice and maize), grain legumes (cowpeas and soybeans), and roots and tubers (yams, sweet potatoes, and cassava).

Correct Citation: International Institute of Tropical Agriculture, 1983. Research Highlights for 1982. Ibadan, Nigeria.
ISSN 0331-4340

Preface

One measure of the success of IITA's research is the impact it makes at national levels in Africa and throughout the humid and subhumid tropics. We strongly believe that agricultural research is not an end in itself. It must be used and should contribute to solving developing countries' food problems, which at times appear to be intractable. A food crisis exists in tropical Africa, but the situation is far from hopeless and there is evidence that seemingly static societies can move – and quickly.

The major portion of our research is conducted in three ecological zones in Nigeria – humid forest, transitional, and savanna – and these zones are representative of climatic and soil conditions in many areas of Africa, especially in West Africa. But the Institute is not "Nigeria bound." Research at other sites in other countries, in collaboration with national and regional and other international centers, ensures due attention to real world problems and helps to get agriculture moving. Our basic concept in these cases is to extend the environmental scope of the Institute's research and thereby enhance the prospect of identifying technology relevant and applicable to a wide range of situations. When a country or region invites IITA to participate in research projects, we usually respond in a positive fashion if both can give and gain from them.

Several examples of such collaboration are reported in this publication, including the article on the use of IITA-improved cassava breeding material in nine African countries and our cowpea varieties on farms in Nigeria and Brazil. Others tell briefly of research projects in Cameroon, Ghana, and Upper Volta, and they are only a few of many that could be told.

For the first time, we are including an article on the Institute's training program – one of the largest in the international research network.

If you would like to have more complete information on any of these topics, you may wish to request a copy of our Annual Report.

Ermond Hartmans
Director General

Contents

Root and Tuber Crops

5 *Development, Release, and Adoption of Improved Cassava Varieties 1978-82*

10 *Update on Biological Control of Cassava Mealybug and Green Spider Mite*

13 *Potential of Hybridization and Other Methods for Seed Yam Production*

18 *High Yielding Sweet Potato Lines with Disease and Pest Resistance*

20 *Screening Germplasm of Root and Tuber Crops for Nematode Resistance*

Farming Systems

22 *Efficient Use of Resources Through Mixed Cropping Systems*

27 *Field Effectiveness of a Redesigned Farmobile for No-Till Farming*

29 *Effect of Tillage Methods on Groundnut Yields in Ghana*

30 *Testing Maize Production Technologies in Eastern Cameroon*

32 *Use of* A. barterii *as a Beneficial Mulch in "Alley Cropping"*

34 *Source and Dynamics of Iron Toxicity in Inland Valley Swamps*

39 *Labor Costs and Production Practices on Rice Farms in Central Nigeria*

Grain Legumes

43 *New Cowpea Variety Moves Rapidly into Farming Systems in Kano State (Nigeria)*

45 *Performance of New Cowpea Lines in Brazil*

47 *Extra-Early Maturing Cowpeas with Preferred Seed Colors for Africa, Asia, and Latin America*

49 *Bruchid Resistant Cowpea Varieties*

51 *Resistance to Striga in Cowpeas*

52 *Advances in Cowpea Virus Research*

53 *Bush-Type Vegetable Cowpea Development*

55 *Mating Success in Artificial Rearing of* Maruca *for Plant Resistance Studies*

58 *New Method of Screening Soybeans for Resistance to "Field Weathering"*

Contents continued

Cereals

60 *Rice Varieties with Good Grain Quality and High Yield Potential*

62 *Reliable Rice Screening Technique for Resistance to Stalk Eyed Fly*

64 *Progress in Developing Stemborer Resistant Maize for Africa*

67 *First International Trial with Streak Resistant Maize Varieties*

Training

70 *Sharing Research and Technology Expertise with Staff of National Programs and University Students*

74 List of Personnel

Development, Release, and Adoption of Improved Cassava Varieties 1978–82

Africa produces 48 million tons of cassava annually from 7.4 million hectares, and this staple food crop provides more than 50% of the caloric requirement for 200 million people on the continent. Since its introduction from Latin America many years ago, cassava has played a vital role in alleviating famine conditions in Africa by providing a sustained food supply when other crops failed.

Cassava has these recognized advantages: adapts to diverse environments and farming systems; requires few production skills and limited inputs; stays in the ground for up to 24 months until required for consumption; and remains relatively drought tolerant, surviving four to six months of dry weather.

Regardless of these and other favorable characteristics, the average cassava yield in Africa has been very low 6 tons/ha compared with a potential of 15 20 tons. This low average yield is due primarily to cassava mosaic disease (CMD), cassava

A village woman in Africa prepares "gari" – a cassava product. Cassava provides more than half of the caloric requirement for 200 million people on the continent.

5

bacterial blight (CBB), and more recently to cassava mealybug (CMB) and green spider mite (CGM). The latter two are believed to have been introduced from Latin America.

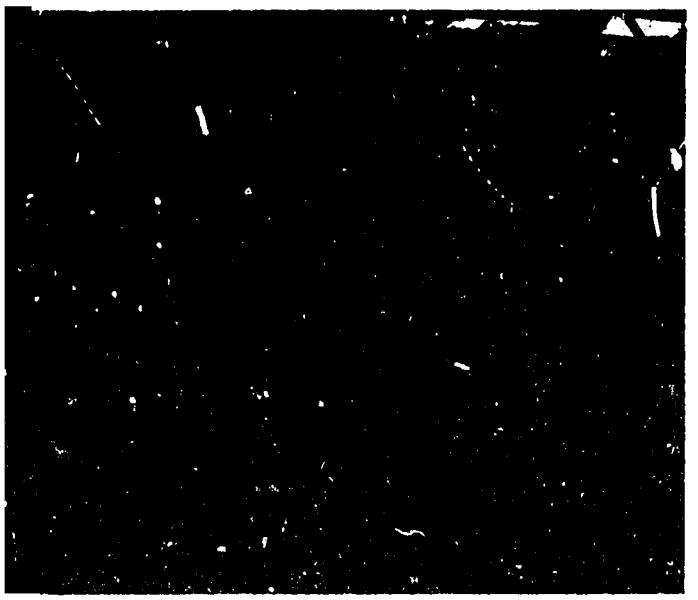
To overcome these production constraints, IITA has developed improved cassava varieties and breeding populations/ families that are high yielding, resistant to diseases and insect pests, good in quality for consumer acceptance, and low in cyanide content.

The improved IITA breeding material in both seed and tissue culture form has been sent to many national cassava improvement programs in Africa for re-selection under their environmental conditions. Among the national programs receiving improved cassava breeding material from IITA, several have developed and released improved varieties in their own countries. They include the following:

Nigeria: Five improved varieties — TMS 30572, 30555, 30337, 30001, and 30211 — have been rapidly multiplied and distributed to thousands of farmers through the National Accelerated Food Production Project (NAFPP), National Root Crops Research Institute, National Seed Service, State Ministries of Agriculture, and private organizations. These improved varieties have been mass adopted by farmers, and recent reports indicate that they are now planted on more than 80,000 hectares.

They give farmers these advantages over local unimproved varieties: 50 to 300% higher yields; stable production because of resistance to CMD and CBB; better and quicker canopy development which speeds recovery from CMB and CGM attack with the onset of the rainy season; reduced weeding by one third or more; and better processing quality.

Demand by farmers for planting material of these varieties in 1982 was high and expected to increase in the years ahead. It is estimated that the present improved varieties will be planted on 3 million hectares by 1990. New promising varieties such as TMS 4(2)1425 and 50395 are being multiplied on a large scale by the National Seed Service for distribution to state ministries and to farmers.



Left, some of the improved cassava varieties rapidly multiplied and distributed to thousands of farmers in Nigeria through national and state agencies; right, a Nigerian farmer's field of TMS 30572 – an IITA improved cassava variety.

Sierra Leone: In 1978, improved cassava varieties – ROCASS 1, 2, and 3 – were released and two years later NUCASS 1, 2, and 3. These six new varieties were derived from IITA breeding material. In performance tests without fertilization in the 1980/81 and 1981/2 seasons, the improved varieties produced higher average yields ranging from 9.7 to 25.5 tons/ha – more than two to four times the yield of the local variety Cocoa.

The new varieties were multiplied at five locations and distributed to local farmers with USAID financial support, and a large quantity of planting material of some of them was sent to Guinea.

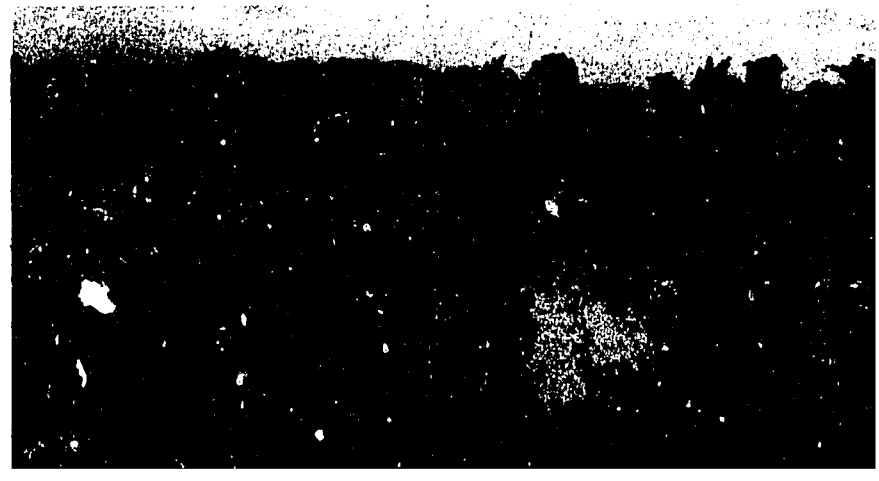
Zaire: Based on performance in multi-location tests over several years, the National Manioc Program (PRONAM) has released two improved varieties – Kinuani (30085/28) and Kivuvu (30070/4). Both were selected from IITA breeding material and are particularly resistant to CBB, which previously

caused severe yield reductions and unstable production. Kinuani is also resistant to CGM. The two varieties, which have consumer acceptance because of good tuber and leaf quality, have been rapidly multiplied on a large scale and distributed to extension agencies and farmers. (PRONAM is a cooperative program with IITA and is financed by USAID.)

Gabon: Since 1981, more than 200,000 cuttings from four improved varieties – CMM 76-6, 76-7, 76-13, and 76-33 – have been multiplied each year and distributed to several thousand farmers through extension agencies. These varieties, selected from IITA breeding material introduced by an FAO project in Gabon in 1976, have produced yields ranging from 20 to 40 tons/ha. During 1982, the Government of Gabon sent planting material of these varieties to Congo, Equatorial Guinea, and São Tomé.

Tanzania: Selections made from the IDRC/FAO-supported cassava project gave average yields of 30–35 tons/ha compared with 15 tons/ha from local varieties. Several of the most promising varieties, derived from IITA breeding material and resistant to CMD and CGM, have been multiplied and distributed to farmers.

Seychelles: IITA-improved breeding material in seed form was introduced into the country in 1975, and the five most promising varieties – Sey 14, 28, 32, 41, 52 – were developed after selection and testing in the country and released in 1978. The best of the varieties could give a yield of 45 tons/ha. They have been multiplied and distributed to farmers.

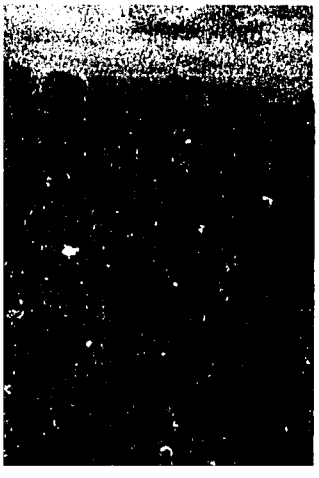


A cassava seed multiplication field in Zaire. Two varieties selected from IITA breeding material have been multiplied on a large scale and distributed to extension agencies and farmers.

Rwanda: A large number of IITA-improved breeding families in seed form were introduced in 1978, and selections were made based on performance in the country during the following years. The 10 most promising clones have been selected and are now being multiplied for distribution to farmers. They have yield potentials of 20–50 tons/ha compared with 8–15 tons/ha from local varieties. The Rwandan National Root Crop Improvement Program is now financed by IDRC.

Liberia: Three varieties—CARICASS 1, 2, and 3—have been released. Selected from IITA-improved breeding material, they have yield potentials of 30 to 50 tons/ha and resistance to CMD. Their consumer acceptance quality has been rated as "good." The Liberian cassava project is now financed by IDRC.

Cameroon: Several promising clones have been identified by the Cameroon National Root Crop Improvement Program (CNRCIP) from IITA breeding material under high rainfall and poor sandy soil selection pressures. Evaluation is continuing. (CNRCIP is a cooperative program with IITA and is financed by both IDRC and AGCD.)



Update on Biological Control of Cassava Mealybug and Green Spider Mite

Within a decade after the discovery of the destructive cassava mealybug (*Phenacoccus manihoti*, MAT-FERR.) and the green spider mite complex (*Mononychellus* spp.) in Africa, they have spread over roughly half the cassava growing areas of the continent. In three-fourths of these areas they occur together, and compete for the same micro-ecological niche – the plant's growing point. The mealybugs and mites attack the plants throughout the year with population peaks in the dry season.

Since the first successful releases in 1981/82 at IITA of the mealybug predator *Scymnus* sp. and the parasitoid *Apoanagyrus lopezi* (Figure 1), additional releases have been made in Nigeria, Congo, and Zaire which resulted in the establishment of these natural enemies. Within one year of the first release, they have been found breeding up to 2 km away from the release site at IITA.

Releasing two natural enemies of the cassava mealybug (CMB) in Zaire in 1982.

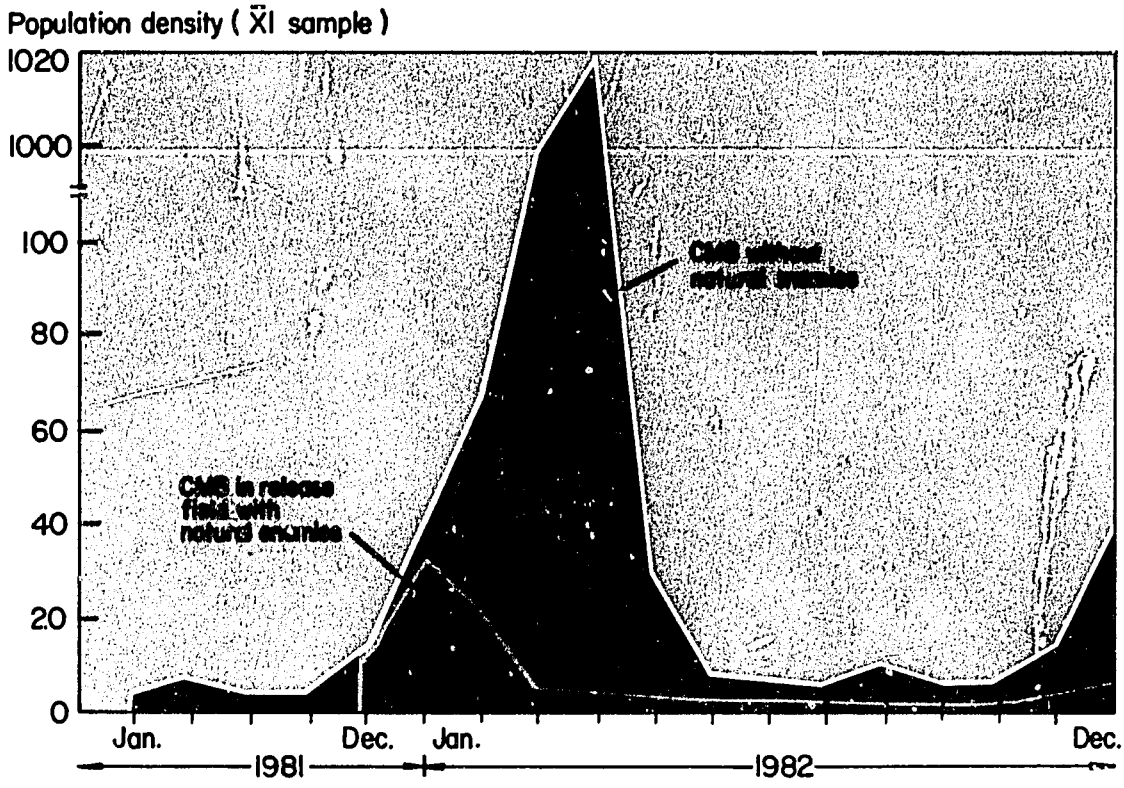


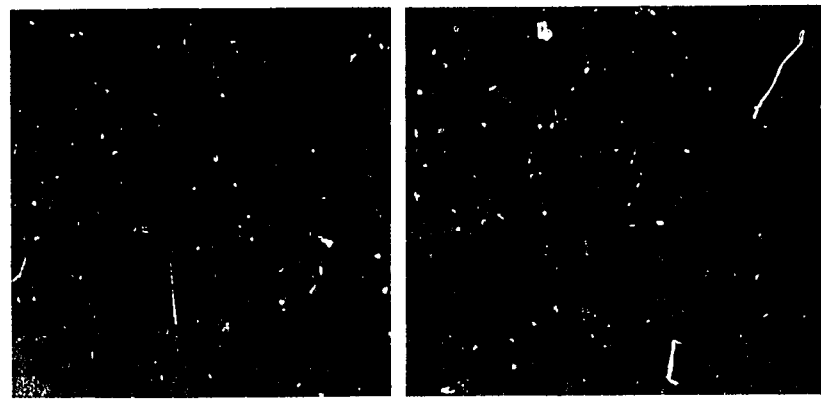
FIGURE 1.
Impact of released natural enemies on cassava mealybug at IITA.

Releases of the two beneficial insects in farmers' cassava fields near Abeokuta, Nigeria, in 1982 resulted in their establishment within six weeks. Later, scientists attending an international conference on biological control at IITA visited one of these fields and were surprised at the dramatic improvement of the cassava.

Biological control is now being extended to the cassava green spider mite species complex. Release of predators against the mealybug in IITA experimental fields cleared the plants of this insect in 1982 but left them at the mercy of the mite, which is usually suppressed by competition from the mealybug. Several species of predatory mites, already identified by the Commonwealth Institute of Biological Control (CIBC) and the International Center for Tropical Agriculture (CIAT), will be used in experimental trials by IITA in Nigeria during 1983.

A new Hemerobiidae species, a natural enemy of the cassava mealybug, has been added to the five species previously at IITA for biological control of the pest.

FIGURE 2. (Right) Predators and parasitoids obtained from South America are sent to quarantine in U.K. and then to IITA for study and testing before release in cassava fields.



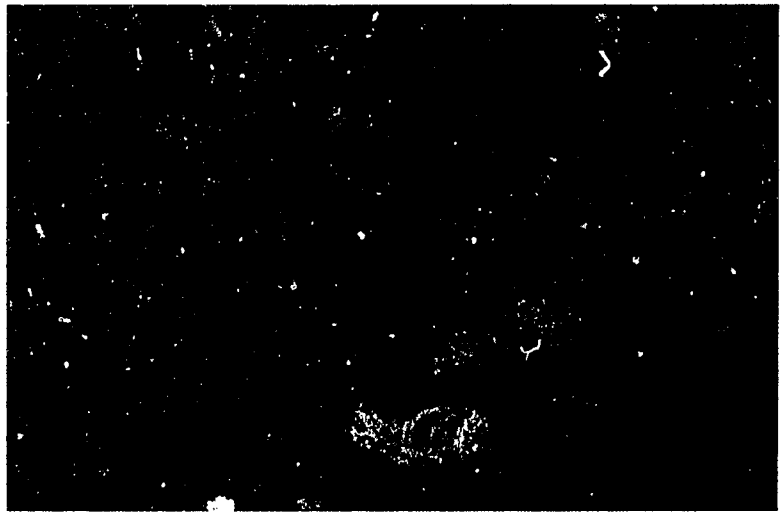
Explorations for new natural enemies for both pests are continuing with financial support from German Agency for Technical Cooperation (GTZ). Added to five species previously at IITA are three more obtained in 1982: *Diomus* sp. (Coccinellidae), *Sympherobius notata* (Hemerobiidae), and a new Encyrtidae wasp of yet undescribed species. Two additional species of natural enemies are still in quarantine at the CIBC laboratory in London. All these species so far have come from Paraguay and Bolivia, but exploration will start in Brazil in 1983 where scientists expect many new species of parasitoids and predators to be found (Figure 2).

A Regional Development Project for biological control of mealybugs and green spider mites in Africa will be started by IITA in 1983. Its goals are to control the two cassava pests and train specialists for regional biocontrol laboratories to be established in Africa. The project will have its mass production center at IITA and beneficial insects will be made available to any country requesting them. In most cases, they will be released on the ground, but some trial releases will be made from the air with specially equipped aircraft. If the program progresses as expected, more than half of the infested areas could be colonized with the beneficial insects within five years.

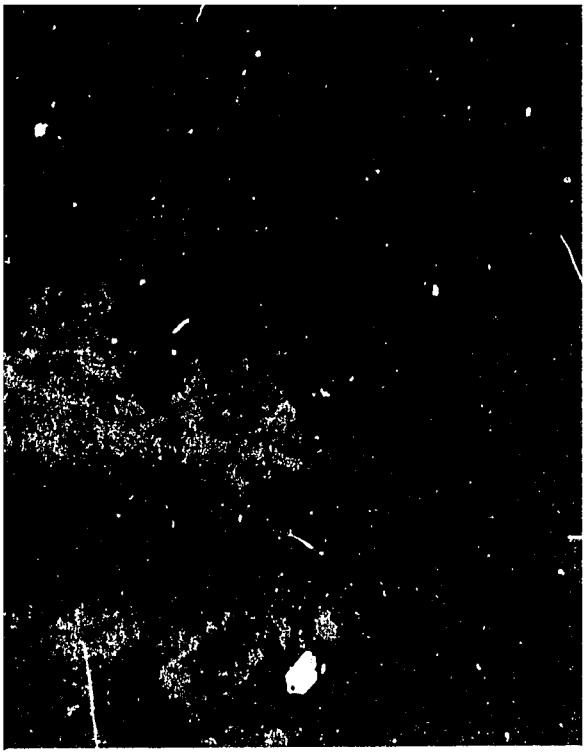
Potential of Hybridization and Other Methods for Seed Yam Production

Throughout most yam producing areas, the availability of planting material has become a major limiting factor and the cost of this seed yam is rapidly becoming prohibitive, especially when propagated by the traditional system. To overcome this constraint, research at IITA has been focusing on the development of a new yam that will give a high yield of uniform and large tubers from true seed.

Progress in the development of such yams is being made after overcoming some of the problems that defeated an initial effort several years ago. It was unsuccessful largely because of the lack of knowledge about flowering and seed behavior. Most of the yam plants would not flower, and the seed set among those that did flower was usually low. At first, it was thought that the seeds were not viable, but later work revealed that they have a dormancy period of three to four months after which viable seeds will readily germinate.



Seed yam produced from true seed (center of photo).



***Left to right, evidence of the progress in breeding improved families by hybridization of the white yam** Dioscorea rotundata.*

Although some limitations still need to be overcome, IITA scientists have succeeded in breeding improved families and lines by hybridization of the white yam *Dioscorea rotundata*. The realization of other earlier and presently major breeding objectives such as virus and nematode resistance, high yield with minimum inputs, and good storage ability now seems feasible. (The first batch of seeds from the water yam *D. alata* were obtained only two years ago and work is continuing with this species.)

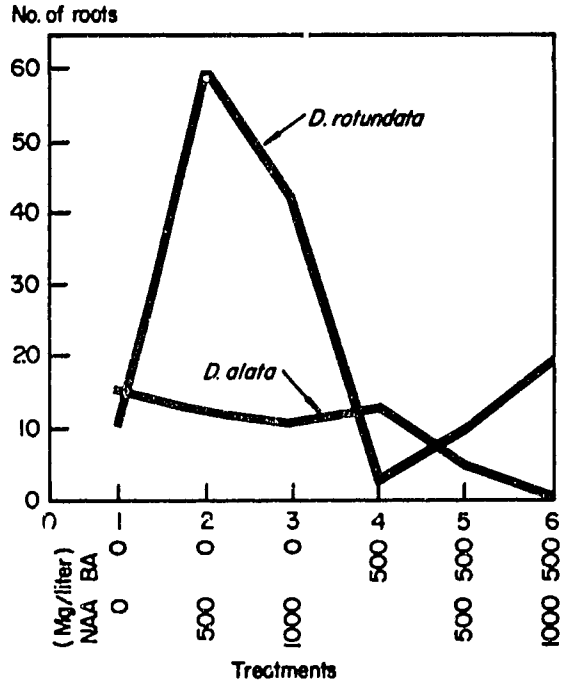
True seeds with a mean weight of 0.1 gm each from several selected *D. rotundata* hybrid breeding lines at IITA were direct seeded or transplanted in well prepared seedbeds. They consistently produced seed yam size tubers ranging in weight from 100 to 1,200 gm and yielded up to 2½ times more than the traditional system (Table 1). Besides the uniformity of tuber size, these families also responded positively to denser plantings. Seeds were planted at 15 cm apart in 30 cm rows. Such a high population allowed for adequate foliage cover, which resulted in good bed coverage and a reduced weed problem.

TABLE 1.
Tuber yield and percent of total tubers of five promising yam families grown from true seeds in well prepared seedbeds.

On a per unit area basis, the system exhibited exceptionally high productivity, surpassing the conventional system. Tuber size, uniformity, and suitability for rapid, efficient hand harvesting have been rated as "excellent." However, the potential adaptation of this system to the farm level or for commercial purposes has not yet been completely established. Although the yields of these seed yam tubers in the field have been promising, obtaining uniformity of tubers within families needs further work.

The yam breeding program is also focusing on rapidly increasing the multiplication ratio through two techniques: the minisette involving the planting of pre-germinated pieces ranging in weight from 45 to 90 gm directly into the field for seed yam production and the microsette using 3–5 gm pieces treated with phytohormones and pre-germinated before planting. Selections are propagated by these systems for extensive testing and rapid evaluation.

During 1980–82, the minisette technique has been used to acquire sufficient planting setts to evaluate breeding lines and test their ability to effectively produce seed yams. The test showed considerable variation among the lines in percent and time of germination. The response of the two yam species to microsette propagation and phytohormones is shown in Figure 3. NAA enhanced rooting of 3–5 gm pieces in *D. rotundata* while BA



Results of microsette propagation for seed yam production.

FIGURE 3. (Right) Rooting response of D. alata and D. rotundata microsette pieces (3–5 gm) to different concentrations of Naphthaleneacetic acid (NAA) and 6-benzylamino purine (BA).

reduced it. Although *D. alata* rooted well without phytohormone treatment, there was a tendency to produce two tubers per plant compared with the control.

Other improved ways to increase the efficiency of seed yam production were tested and compared with the traditional system in which farmers plant 100–150 gm pieces at 50 cm spacing in rows 1 m apart, stake the vines, and hand weed several times before harvest. The stakes are costly and are usually eaten by termites. In these tests, Abi was rated as the best cultivar and should be suitable for seed production without staking. It is a vigorous starter, establishes early, shows resistance to virus and other field diseases, and is consistently productive. Moreover, the tubers are smooth and store well.

Pre-emergence herbicide gave good weed control as did the plastic mulch, which controlled weeds throughout the growth cycle of the yams with no adverse effects. A modified staking

system with termite-proof plastic pipes and plastic mesh allowed the plants to make a canopy which subsequently suppressed weeds. These required less labor than the traditional methods and resulted in substantial savings.

Promising selections are now being evaluated for yields by first producing clean, healthy seed yams. IITA will continue to use this system and inform researchers in national programs of its progress.

Plastic mulch controlled weeds throughout the growing cycle of the yams with no adverse effects.

High Yielding Sweet Potato Lines with Disease and Pest Resistance

Stagnation of sweet potato yields and a decline in production in many tropical countries can be attributed to the use of unimproved local varieties with low genetic potential, high disease infection, insect damage, nematode problems, and inappropriate agrotechnical practices. Unimproved varieties produce an average yield of only 6–14 tons/ha in 180–240 days, but much larger yields are possible in less time as a result of genetic improvement along with agrotechnology easily adopted by farmers.

With new sweet potato lines, IITA plant breeders have obtained from 21 to 41 tons/ha in 140 days without fertilizers (Table 2). Many of these are also resistant to the sweet potato virus disease complex (SPVDC). Moreover, weevil resistant clones have been identified and their resistance is being incorporated into new breeding populations. Two of the best

TABLE 2.
Fresh yield, efficiency of dry matter accumulation, and virus and weevil scores of improved sweet potato lines 140 days after planting.

Sweet potato line	Av. tuber yield (1981–82)		Virus	Weevil
	Fresh (t/ha)	Dry matter accumulation (kg/ha/day)	score*	score*
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TIS 9232	26.4	56.0	.62	.37
TIS 8401	30.9	68.3	.25	.25
TIS 8524	30.8	62.1	.7	.37
TIS 8441	25.6	55.4	1.6	.25
TIS 70399	26.8	62.4	0	.25
TIS 8504	28.1	54.3	.12	.62
TIS 70357	21.6	54.5	.62	.25
TIb 4 (Check)	17.9	38.3	.37	1.12

*Severity rating 0–5: No symptoms – very severe symptoms.

Two of the new best yielding and disease resistant sweet potato lines – TIS 9265 (white) and TIS 2498 (red).

yielding sweet potato lines – TIS 2498 and TIS 9265 – have a high level of resistance to SPVDC and efforts are underway to incorporate a higher level of resistance to the sweet potato weevil (*Cylas puncticollis*).

TIS 2498 has vigorous, early establishing vines which are highly pubescent. The ground is well covered in four to six weeks, establishing a canopy with attractive green leaves. Tubers are uniform with bright red skin and white flesh. When baked, roasted, or boiled, they receive a high rating for consumer acceptance because of their "dryness" and reduced sweetness. This line is widely adaptable and is being grown in several African countries and the Caribbean. Extensive multi-locational, replicated, and repeated field studies have proven its stability and ability to give high yields consistently. Highest yield 45 tons/ha in 140 days.

TIS 9265 has medium vigor, spreads well, and produces high yields. Highest yield 53 tons/ha in 140 days. Tubers are large with deep lobes. Skin color and flesh are white with a "good" quality rating.

A farmer in Mozambique holds a cassava plant that did not develop because of heavy root-knot nematode infestation on the fine feeder roots. Her entire cassava field was heavily damaged.

Screening Germplasm of Root and Tuber Crops for Nematode Resistance

From IITA's extensive germplasm collection, 55 lines of sweet potato (*Ipomoea batatas*) out of 414 screened in greenhouse tests proved to be highly resistant to root-knot nematodes *Meloidogyne incognita*, race 2 and *M. javanica*. Further confirmation of the plant resistance of the 55 lines will be tested under simulated field conditions.

The two nematodes, commonly found in sweet potato growing areas in the tropics and subtropics, readily attack plant feeder roots and frequently disfigure storage roots. They also open infection courts for invasion by secondary rot organisms.

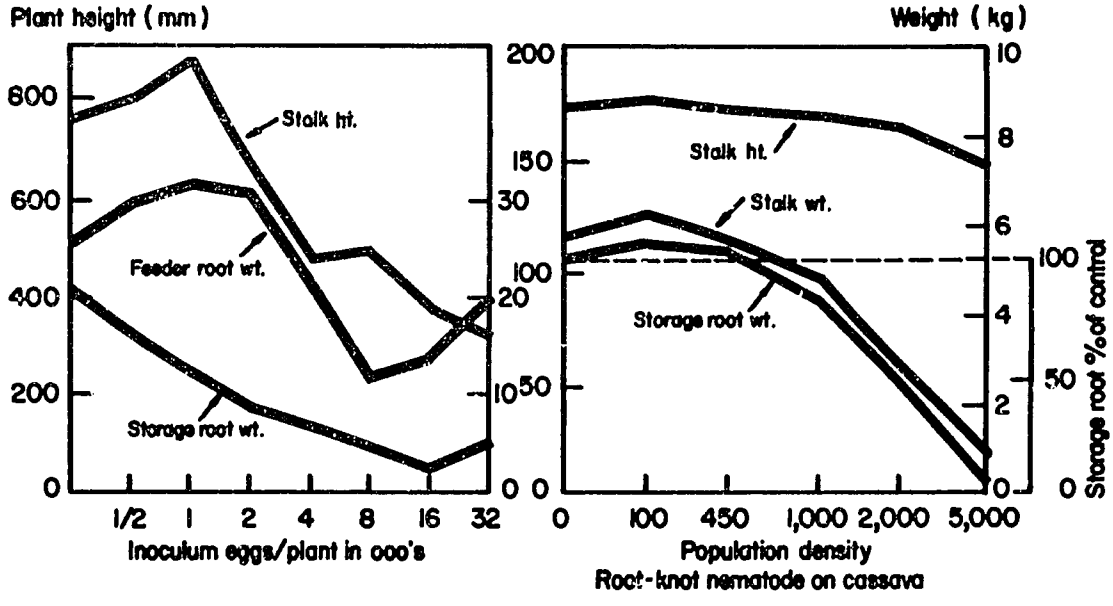
After an eight-week exposure to root-knot nematode attack in the greenhouse tests, the roots were removed from the pots and subjectively rated for the degree of root gall development. The nematode reproductive rate was estimated by an egg count from the roots of each plant. In some of the highly resistant lines, the egg count per plant was zero for both types of nematodes, but the highest susceptible line (TIS 36) had a *Meloidogyne incognita* egg count per plant of 1,978,000 and 46,000 for *M. javanica*.

In contrast, all 21 lines of cocoyam (*Xanthosoma sagittifolium*) in the germplasm collection showed high resistance to both root-knot nematodes in shadehouse pot tests. Cocoyam grown in microplot trials also proved to be highly resistant, which makes the crop an effective choice for nematode control in a rotation program.

Production losses from root-knot nematodes in cassava can be very high, and they are becoming a greater problem as both small farmers and large-scale projects make more intense use of the land. A recent study by the International Meloidogyne Project estimated that about 6% of the world's annual cassava production – representing 6 million tons of carbohydrate – is lost annually to nematode attack.

Scientists screened several families of cassava under agronomic tests at IITA to determine genetic resistance or susceptibility to these nematodes. Cassava seedlings were also evaluated in greenhouse trials (Figure 4). Heavy infestations on some lines reduced plant height as much as 52% and the heaviest nematode attack caused a storage root loss of 87%. Field-grown plants also suffered reductions in plant height, stalk weight, and storage root weight in soils with high nematode populations. As shown in Figure 4, the slight reduction in mean plant height coupled with the severe reduction in stalk weight would provide an inferior and less robust planting stake for the following crop. The graph shows that a storage root yield reduction of about 17-50% can occur without a noticeable decline in plant height. As the root galls are on the fine feeder roots and generally remain unnoticed in the soil, a yield smaller than expected may be attributed to other causes or the problem may pass unnoticed.

FIGURE 4.
Effect of root-knot nematode parasitism on stalk height, feeder root weight, and storage root weight of seedling cassava (left); growth reduction of field-grown cassava under parasitic attack by root-knot nematodes (right).



Efficient Use of Resources through Mixed Cropping Systems

Small-scale, mixed crop farms of [illegible] than one hectare make up the majority of farms in the humid and subhumid regions of West Africa. Farmers in these areas sometimes use cowpeas as the minor crop in their cassava, maize, sorghum, and yam based mixed cropping systems. Maize is often a minor crop in a cassava or yam based system.

In mixed cropping experiments during 1982, the new IITA-developed 60-day cowpea variety (IT 82E-60) not only equaled the yield of the late-maturing or full season VITA-5 in different cropping patterns with maize but required no thinning and fewer harvests to recover over 90% of the total grain yield (Table 3 and

TABLE 3. Performance of early-maturing cowpea variety (IT 82E-60) with late-maturing VITA 5 in mixed cropping with maize.

Planting pattern	Maize	Cowpeas	RYT*	Maize	Cowpeas	RYT*
	First season (kg/ha)			Second season (kg/ha)		
	TZPB			TZESR		
Sole maize	6420		1.00	2430		1.00
Alternate[1]	6060		1.46	2270		1.62
Double row[2]	6160		1.45	2280		1.80
Same row[3]	5590		1.49	1990		1.57
Sole cowpea			1.00			1.00
	TZPB			TZESR		
Sole maize	6420		1.00	2430		1.00
Alternate[1]	6120		1.35	2370		1.52
Double row[2]	5880		1.43	1930		1.59
Same row[3]	5640		1.42	1840		1.47
Sole cowpea			1.00			1.00
LSD 5%	900	223		830	200	

[1] *One row of cowpeas between two maize rows.*
[2] *Cowpeas planted in double rows between two maize rows.*
[3] *Cowpeas planted on same row as maize.*
**Relative Yield Total*

Two different varieties of cowpeas interplanted with maize on the same day. The early-maturing 60-day cowpeas (top photo) have already produced mature pods while the later-maturing VITA 5 (lower photo) has only a few.

Figure 5). Traditional varieties of cowpeas commonly grown on farmers' fields in West Africa have a spreading or climbing growth habit and mature in 100–120 days. VITA-5 has similar characteristics but produces higher yields than most traditional varieties and matures in 90–100 days.

Although the intercropped cowpea yield was lower than when grown in a pure stand, there was no significant reduction in the maize yield. The advantage is the opportunity for an additional crop.

Cowpeas intercropped with an erect-type cassava (TMS X) during the first season gave up to 90% of the yield of sole crop

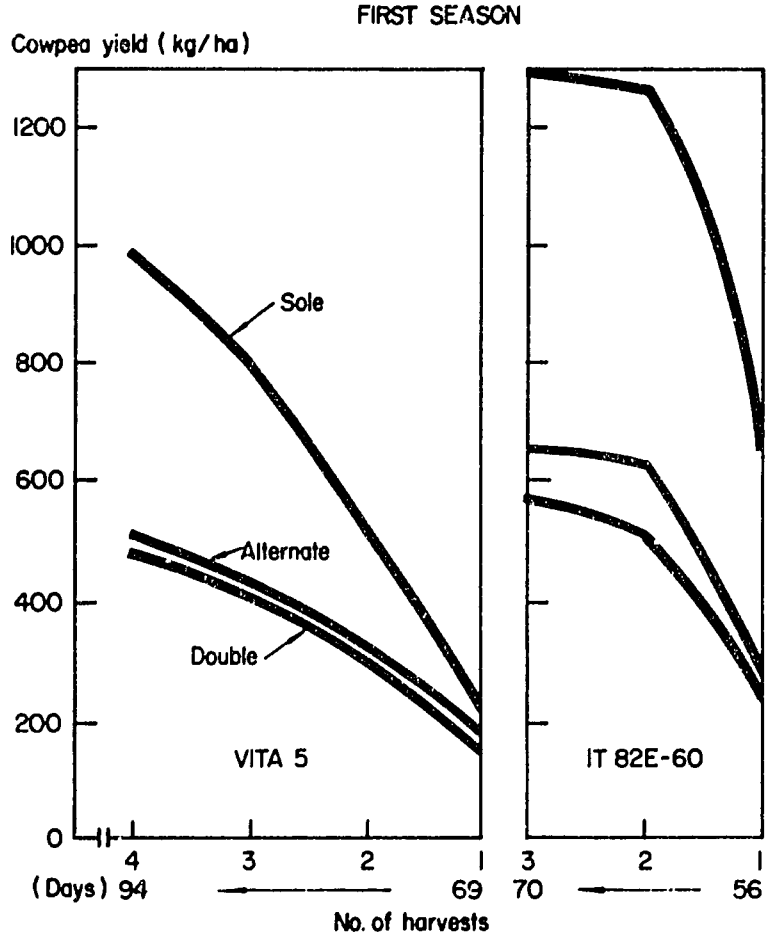
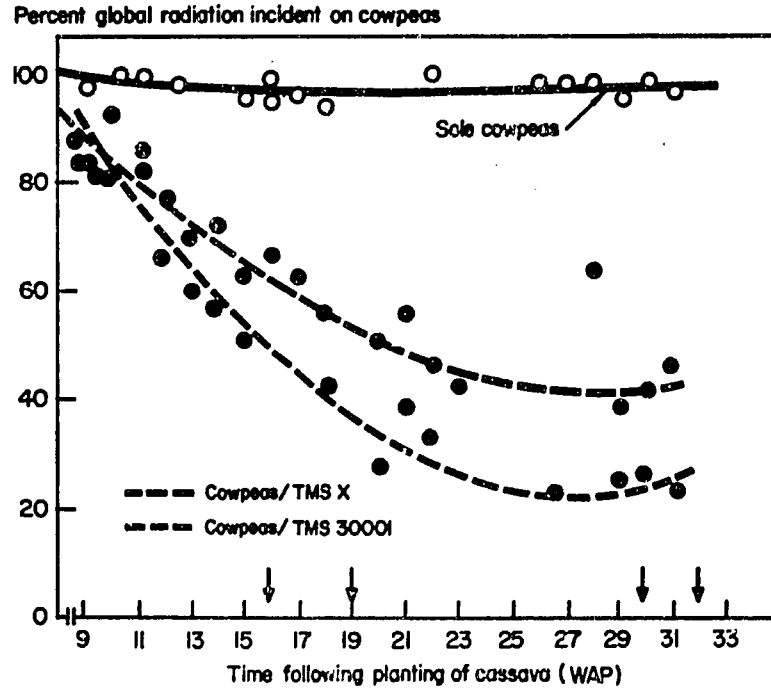


FIGURE 5. *Comparison of the number of harvests and cowpea grain recovery during the first season from late-maturing VITA 5 and early-maturing IT 82E-60 under different planting patterns as described in Table 3.*

FIGURE 6.
Percent global radiation incident on cowpeas planted sole and in mixture with strap leaf (TMS X) and normal leaf (TMS 30001) cassava. Harvests of first season and second cowpeas are marked by arrows.



cowpeas and about twice that from a combination of cowpeas and a more bushy-type cassava (TMS 30001). This was due mainly to more pronounced shading by the latter, which has more and larger leaves than TMS X. During the second season, when the cassava had developed a much denser and closed canopy, cowpeas intercropped with TMS 30001 were completely out-shaded and showed very feeble growth and low yields (Figure 6).

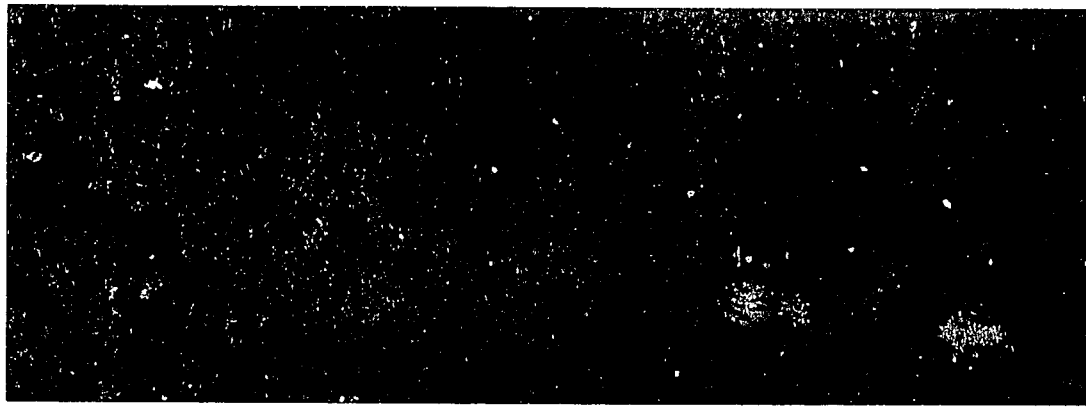
Cultural control of cowpea pests through mixed cropping with cassava was also studied during 1982. The results did not show significant differences in pod borer populations between monocrop and intercropped cowpeas. However, populations of thrips and pod sucking bugs were reduced substantially by intercropping cowpeas (Table 4). In the first season, thrips and pod bugs were reduced by about 50% in the mixed crop. In the second season, there was an even more dramatic reduction (90%) in the population of thrips mainly because of the feeble crop. Reducing pest populations in such proportions certainly has important practical implications for farmers.

Interplanting cowpeas with cassava has major advantages in keeping pest populations low, and the system can be manipulated to maximize grain yield by planting earlier, using early-maturing varieties, and/or increasing spacing, which would singly or in combination minimize the effects of shading by the cassava.

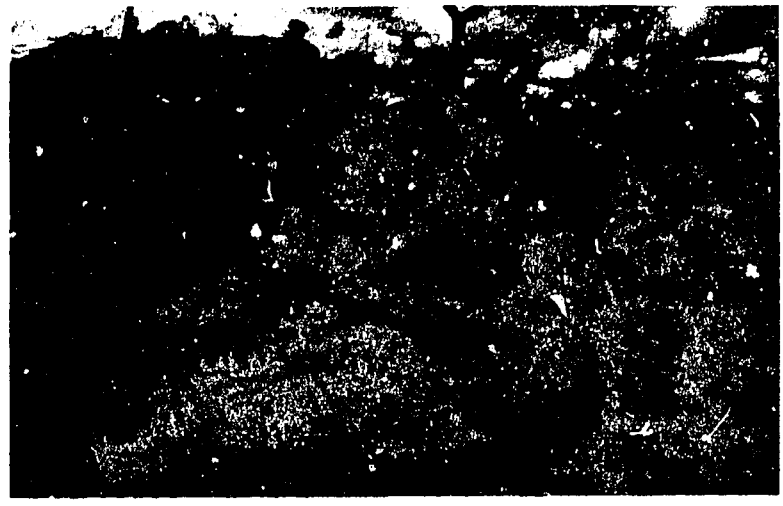
Intercropping maize with cassava caused no reduction in the maize grain yield, primarily because there was little or no competition for light between the two crops at low maize population (30,000 plants/ha). However, increasing the maize population from 30,000 to 60,000 plants/ha resulted in significant reductions in cassava root yields (Table 5).

Greater light interception by cassava intercropped with maize is associated with higher cassava yields. Not only is the size of the maize population a factor but also the architecture of the plants – whether with relatively erect or spreading leaves (Table 5). Large differences in cassava root yields are related to small differences in light transmission. For example, a 5–10% higher light transmission to cassava associated with the erect and narrow leaf Kewesoke maize variety compared with the spreading TZPB variety resulted in a mean increase of 31% in the root yield of the TMS 30572 cassava variety. It is therefore important to consider plant structure when breeding maize for mixed cropping, especially in southern West Africa where crop production is evidently limited by the amount of light received.

TABLE 4.
Insect counts on cowpea variety TVx 3236 interplanted with two varieties of cassava – TMS 30001 and TMS X.



Greater light interception by cassava intercropped with maize is associated with higher cassava yields. Not only is the size of the maize population a factor but also the architecture of the maize plants.



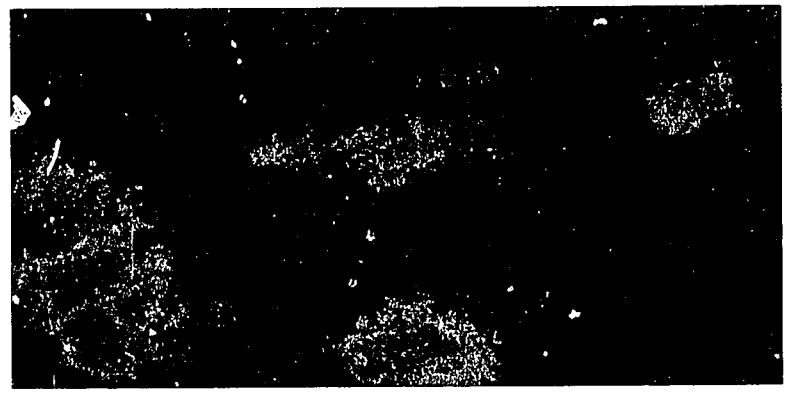


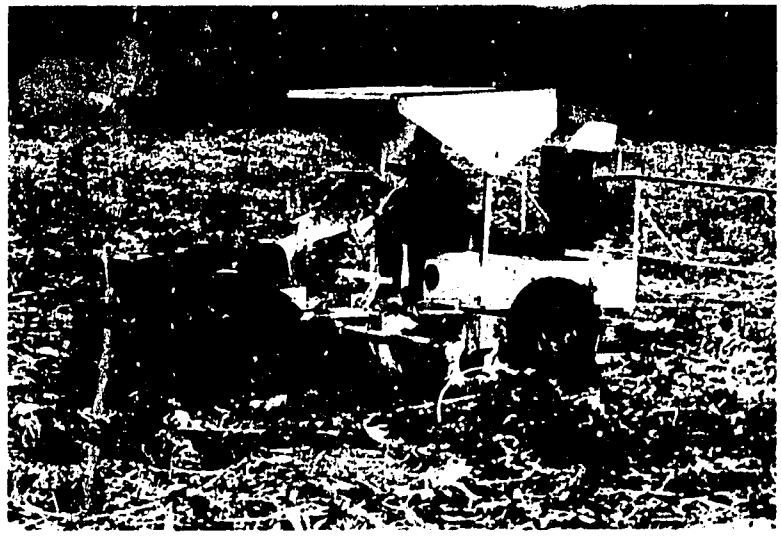
TABLE 5.
Effects of cassava and maize architectures on root and grain yields.

Field Effectiveness of a Redesigned Farmobile for No-Till Farming

During 1982, IITA's agricultural engineers redesigned an earlier model of the Farmobile to make it more efficient for small-scale no-till farming in the tropics. Low-cost, light-weight, and energy-conserving, it is an attempt to fill the gap between hand tools and the costly high-powered four-wheel tractor. The Farmobile can be useful to small farmers who want to expand their holdings from less than five hectares up to 10 or 20 and can obtain herbicides to control weeds.

Based on 1982 costs and market prices in Ibadan, Nigeria, an economic analysis showed that it is possible for a farmer with 10 hectares of first season maize followed by second season cowpeas to recover his investment of ₦6,800 in the Farmobile in two years. (Nigerian Naira ₦ = $1.50 U.S.)

Farm equipment suited for tropical no-till operations should be light and maneuverable with planters which can penetrate



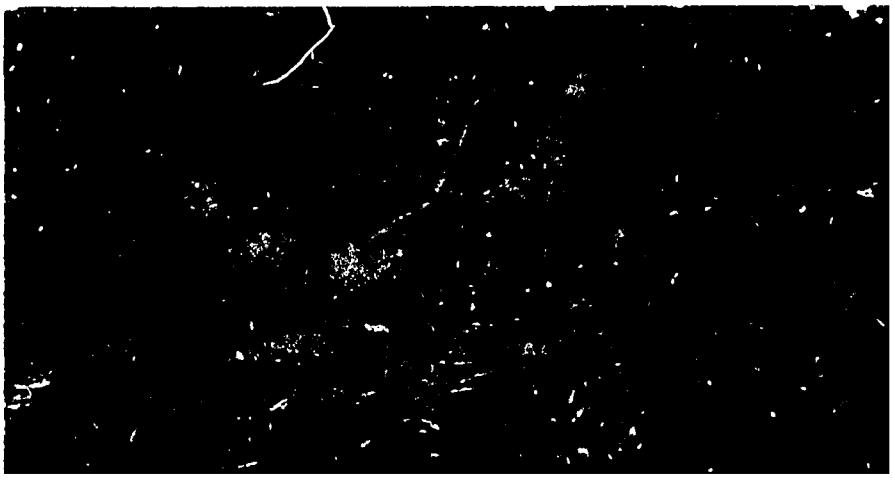
An economic analysis shows that it is possible for a farmer with 10 hectares to recover in two years the initial investment in an IITA-redesigned Farmobile.

through mulch to obtain good plant establishment. The Farmobile, coupled to a four-row rotary injection planter, meets these specifications. In addition, its ability to plant, fertilize, and spray all at the same time reduces the number of passes on the field, and, because of the lightness of the equipment, soil compaction is minimized.

The first model was built a few years ago as a power unit to pull the new rotary injection planters. The latest 1982 design includes steering clutches and a disc clutch on the power train of the small tractor, larger wheels to reduce rolling resistance, a new spraying system, and a fertilizer applicator powered from a tire on the trailer.

In 1982 tests on recently cleared land at IITA, the Farmobile handled 10 hectares for first season maize followed by second season cowpeas. Its effective field capacity was a total of 7 hours/ha – 5 hours/ha to plant, fertilize, and spray a pre-emergent herbicide in a simultaneous operation and 2 hours/ha for a desiccant spray. Comparable figures for 1981 before the design changes were 10½ hours/ha.

Operational costs, including fuel, repairs, maintenance, and operator wages, amounted to N97.98/ha; variable costs of farm inputs such as seeds, herbicides, fertilizers, insecticides, and labor totalled N657.35/ha. Gross value of the two crops was N1,599/ha and the net income N634/ha. (Detailed figures will be supplied on request.)



A good plant establishment of second season cowpeas. (No-tillage and a Farmobile coupled with a four-row rotary injection planter.)

Plowing or ridging resulted in better groundnut yields in Ghana than no-tillage.

Effect of Tillage Methods on Groundnut Yields in Ghana

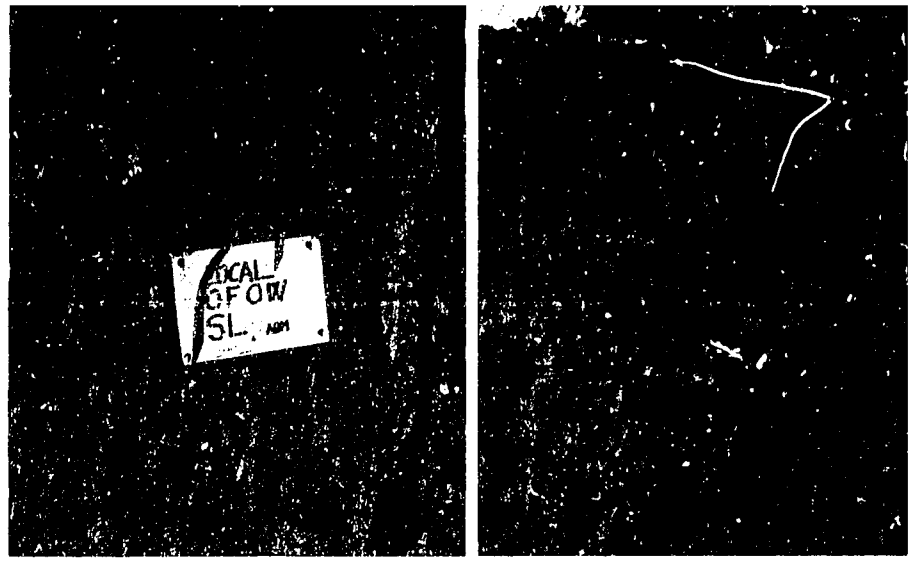
Based on results of soil and crop management trials in Central Ghana, an appropriate tillage to loosen the soil is necessary for good groundnut seed emergence, root penetration and growth, and water-use efficiency. The no-tillage method with an accompanying crusting and hardening of the soil surface significantly reduced groundnut yields compared with plowing and ridging.

Performance of the groundnut crop (var. *Kenkoma*) was tested at Atebubu where the soil is a fine textured, highly compacted Alfisol typical of the savanna zone of central Ghana. During the first and second seasons of 1982, seedbeds were prepared by the three tillage methods and phosphorus applied as single superphosphate at different levels per hectare. Plowing and ridging gave significantly higher yields of groundnut kernels than no-tillage with and without application of phosphate fertilizer (Table 6).

TABLE 6.
Effect of tillage methods and single superphosphate application on groundnut kernel yields (kg/ha) in central Ghana (1982).

Tillage method	P rate (kg P_2O_5/ha) 0	36	72	Mean
	First season			
No-tillage	847	1195	1051	1031
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Second season			
No-tillage	371	469	508	449
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

First season: CV (%) 13; LSD (5%) 129.
Second season: CV (%) 18; LSD (5%) 80.



Maize planted in the traditional random method (left) compared with an improved row method (right) in Eastern Cameroon.

Testing Maize Production Technologies in Eastern Cameroon

Trials were conducted on three farms in humid Eastern Cameroon during 1982 to compare maize production under traditional and recommended practices. They were carried out in collaboration with the Farmer Cooperative ("Fokpayono") at Garoua Boulai, Agricultural Technic School at Abong Mbang, and Institute of Agronomic Research (IRA-Est) at Bertoua, where an IITA scientist is located.

Improved maize varieties failed to significantly increase grain yield when the crop was planted following the traditional method and with no fertilizer. But when maize was planted following recommended practices, grain yield of improved varieties was about double that of the local variety (Table 7).

To maintain soil fertility for longer periods of maize production, trials were conducted at Bertoua during 1981–82 to study the effect of groundnut/maize and cowpea/maize rotations on maize response to nitrogen. Results showed a substantial contribution of nitrogen from groundnuts and cowpeas to higher maize yields. Furthermore, under the crop rotation systems, the yield response of maize to nitrogen fertilizer application at 30 kg/ha was approximately the same as at 60 kg/ha (Figure 7).

TABLE 7.
Grain yield of four maize varieties planted on farms at three locations in Eastern Cameroon in 1982 under traditional and recommended methods.

Variety	Grain yield (kg/ha)		
	Abong Mbang	Garoua Boulai	Bertoua
	Traditional practice[1]		
Local	386	1152	196
EMC*	569	1446	1139
	[illegible]		
Local	2264	2892	478
EMC*	2650	5171	2671
TZB*	3125	5551	2855
TZSR-W*	2463	5312	3075
LSD (5%)	930	1794	804

**Improved*
[1] Traditional method of seeding and no fertilizer or weeding.
[2] Row planting with fertilizer application at rates of 80 kg N + 40 kg P_2O_5 + 40 kg K_2O/ha and one weeding at four weeks after seeding.

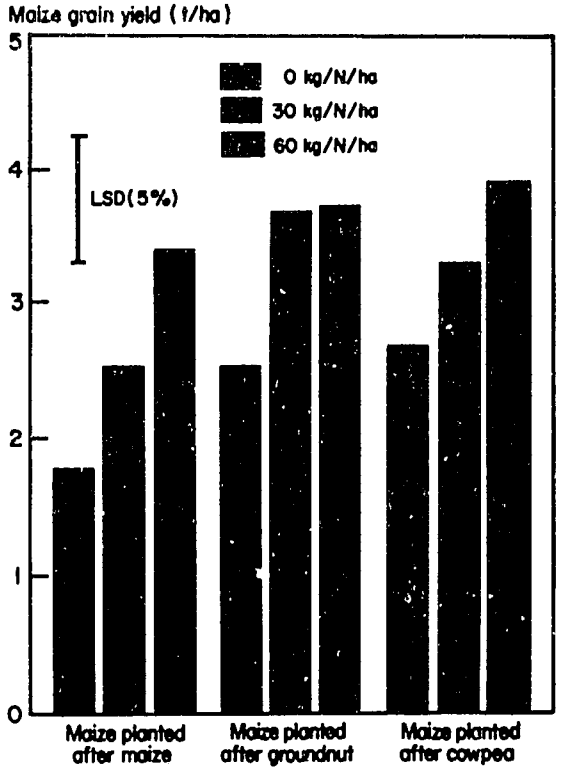


FIGURE 7.
Grain yield of maize variety TZSR-W planted under different cropping systems and levels of nitrogen fertilizer at Bertoua, Eastern Cameroon.

***Weed growth is practically nil in this maize with mulching from** Acioa barterii.*

Use of *A. barterii* as a Beneficial Mulch in "Alley Cropping"

As part of the continuing research on "alley cropping," IITA scientists have found that a non-legume, fast-growing tree species *Acioa barterii* may have benefits that outweigh its inability to fix nitrogen.

Trials during 1981 and 1982 showed the cuttings from this species to have an exceptional ability to control weeds in both maize and cowpeas planted in an "alley cropping" system. Weed control problems are often named as one of the factors holding back the expansion of food production by smallholders in the humid and subhumid tropics, where hand weeding may account for 30% or more of the farm labor input. This could be reduced substantially with herbicides, but most smallholders cannot afford them.

Not only does the mulch suppress weeds, but it also provides ground cover during the early part of the growing season, conserves soil moisture, prevents erosion, and helps maintain adequate organic matter in the soil.

In the trials, fallows of *A. barterii* and a nitrogen-fixing (leguminous) species *G. sepium* were compared with a naturally regenerated fallow (mostly grass). Land that had been under the various types of fallows for four years was recovered by cutting back *G. sepium* and *A. barterii* and adding the leaves and twigs as mulch. The natural regeneration was mowed and the regrowth killed with herbicide (paraquat).

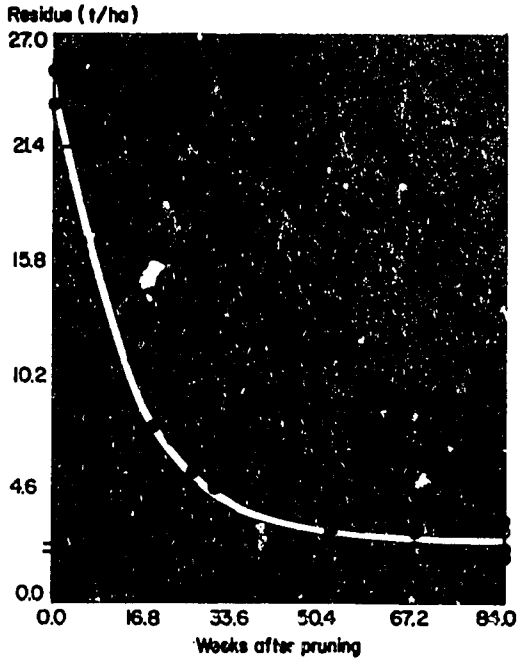
In the first season, a maize crop was planted in a split plot trial in which fallows were the main treatments, the sub-treatments fertilizer and no fertilizer. In the second season, cowpeas were the test crop with the same experimental design and without further fertilizer application. Weeds were controlled by hoeing.

Maize and cowpea yields as affected by preceding fallow showed no outstanding differences, but a striking difference was

observed in the weeding requirement. After natural regrowth and *G. sepium* fallows, weed establishment was fairly rapid and both maize and cowpeas needed two weedings. In contrast, following *A. barterii*, weeding was not necessary throughout the two-year cropping period, and the mulch protected the soil from rain impact and erosion. The excellent weed suppression was due to the heavy initial mulch and its slow rate of decomposition (Figure 8). On the other hand, mulch from *G. sepium* decomposed rapidly and did not suppress weeds. In "alley cropping," *A. barterii* also had the advantage of not requiring additional pruning during the growing period of maize or cowpeas.

FIGURE 8. (Right) Changes in the amount of Acioa barterii leaf residue over time.

Four-year-old Acioa barterii fallow.



Rice growing in the inland swamp above shows acute bronzing symptoms due to severe iron (Fe) toxicity; right, a field of rice showing orange symptoms on the leaves caused by a lesser degree of Fe toxicity. These symptoms are related to multiple nutrient deficiencies resulting from failure of roots to absorb plant nutrients.

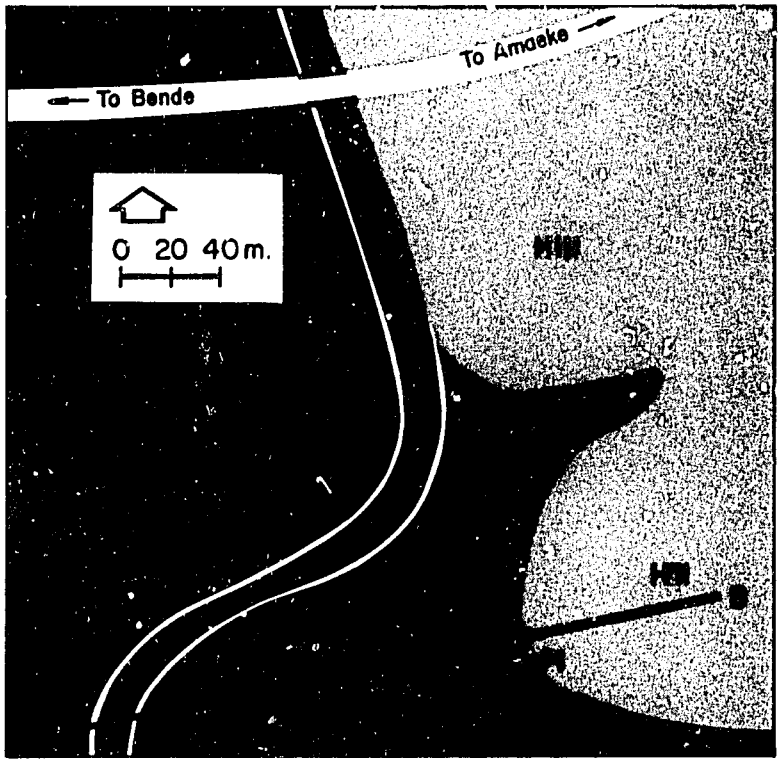
Source and Dynamics of Iron Toxicity in Inland Valley Swamps

Increasing attention has been focused in tropical Africa on the use of inland valleys for rice cultivation. Presently, use of inland valley swamps for rice cultivation in West and Central Africa is by farmers is limited to manual tools and to water control. Sporadic drought frequently damages the crop during the early stage of growth. Moreover, nutrient deficiency and Fe toxicity to rice is common in many inland valley swamps. In addition, these swamps contain a high concentration of iron oxide.

Research at IITA on the iron toxicity problem focuses on selection of resistant varieties and the organization of different types of inland swamps to develop efficient soil and water management practices that can be used to alleviate the problem. In collaboration with the Anambra State World Bank Smallholder Rice Production Scheme, a field study was initiated in 1982 in a small valley swamp near Bendel in southeastern Nigeria to characterize the source and dynamics of dissolved Fe in the swamp, to estimate flow and seasonal fluctuation of the groundwater table.

Field observations showed that the swamp with a severe iron toxicity problem (bronzing symptoms) occurs in the Bendel swamp, a small inland valley swamp, which is located in one of the small side valleys (Figure 1). Soil in the footslope and upper

poorly drained showing a greyish color with very few mottles in the subsoil horizons. Hydromorphic soils in the non-toxic area (Figure 9) have good structure in the surface layer and many mottles which extend to more than 100 cm depth in the subsoil.



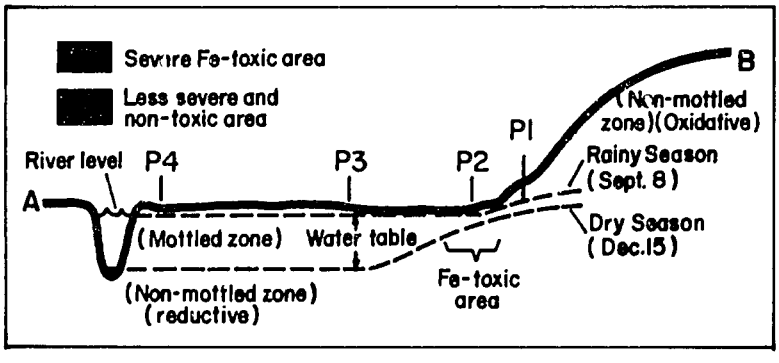


FIGURE 9.
Map and cross section showing a severe iron (Fe) toxicity rice field (orange area) and less severe and non-toxic rice fields (green areas) in an inland valley near Bende, Imo State, Nigeria.

This implies that the groundwater table in the non-toxic area drops to below 100 cm depth, allowing the oxidation process to take place during part of the year.

A series of piezometers was installed along a transect from the foothill to the main stream covering both the Fe-toxic and non-toxic areas of the valley (Figure 9). The groundwater table at each piezometer site was recorded weekly and soil solution samples were withdrawn from the piezometers once a week for analysis of soluble Fe (mainly ferrous).

Results of monitoring the groundwater table at various piezometer sites between August and December showed that soils in the iron-toxic area (piezometers 2 and 5) remained saturated or flooded throughout the growing season (Figure 10), and the

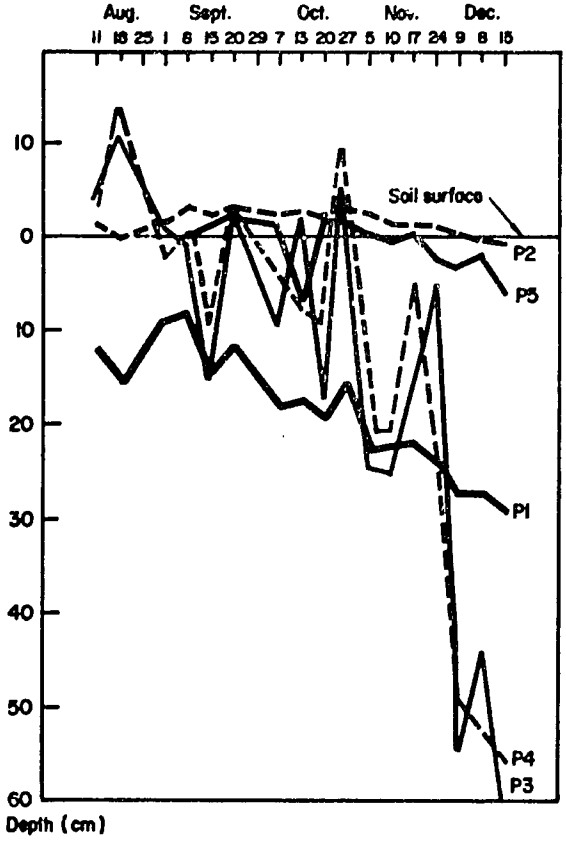


FIGURE 10.
Seasonal fluctuation of ground water table and flooding at various observation sites during 1982 in an inland swamp near Bende, Nigeria.

soil solution contained high levels of ferrous iron ranging from 20 to 50 ppm (Figure 3). The highest soluble Fe content was observed in water samples taken from piezometer 5 which was situated close to the source of seepage flow and continuous flooding.

The groundwater table in the non-toxic area (piezometers 3 and 4) fluctuated greatly during the growing season (Figure 10). Moreover, soluble Fe content in the soil solution taken from the same piezometers was much lower, ranging from 0 to 5 ppm (Figure 11).

The groundwater table in the valley bottom land varied greatly between the rainy and the dry seasons. During most of the rainy season, the groundwater table remained near the surface.

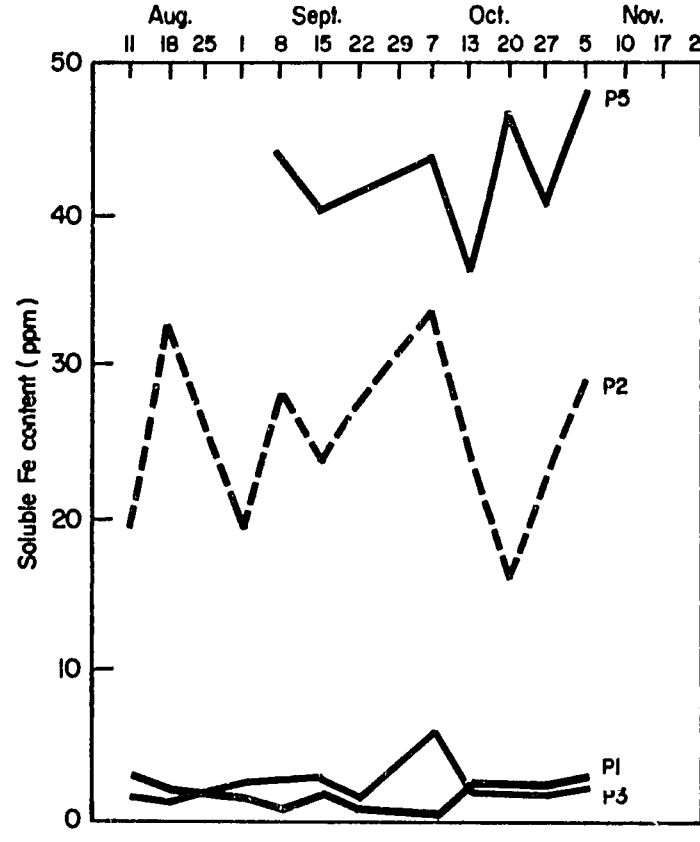


FIGURE 11. ***Seasonal fluctuation of dissolved iron in soil solution sampled at various piezometer sites during 1982 in an inland swamp near Bende, Nigeria. (Piezometers 2 and 5 in iron-toxic rice fields, 1 and 3 in non-toxic fields.)***

These two rice varieties grew side by side in an iron (Fe) toxic field. The susceptible variety on the left shows severe root rot and leaf bronzing; the one on the right is tolerant of Fe toxicity because of its ability to maintain an oxidized rhizosphere.

Thus, the surface soil was enriched by the Fe-rich seepage water causing phototoxicity of Fe in the area near the outlets of the seepage flow. During the dry season starting at the end of November, the groundwater table dropped gradually to a level equal to that of the main stream (piezometers 4 and 6; Figures 9 and 10). Seepage flow from the side valley also diminished during the dry season and the slight drop of the groundwater table in the Fe-toxic area allowed the oxidation process to take place in the surface layer during part of the dry season.

Reclamation of the Fe-toxic area could be achieved by constructing a small drainage canal to lead the Fe-rich seepage water into the main stream. The extent of the Fe toxicity problem of inlet valleys and swamps depends largely upon the volume of seepage flow, source and concentration of ferrous Fe in the seepage water, the groundwater table, and drainage condition of the valley bottom land.

Labor Costs and Production Practices on Rice Farms in Central Nigeria

In a study of rice farmers in Nigeria's Plateau State, agricultural economists found that labor efficiency was a critical issue for the farmers, and exceptionally high manual labor input and labor costs were a major limitation to greater use of recommended technology and the extension of production areas.

The survey, conducted by the University of Nigeria (Nsukka) and financed by the Federal Department of Agricultural Cooperatives, included 90 farmers who produced either irrigated or swamp rice as a major crop but also grew other crops such as maize, sorghum, yam, and millet; 43 had participated in the National Accelerated Food Production Program (NAFPP) and 47 had not. They were interviewed weekly over a six-month period during the last half of 1980, and more than 6,000 labor records were available for evaluation and comparison during 1981/82 by IITA in cooperation with the University of Nigeria.

Half of the farmers sold 75% or more of their rice production; millet ranked second as a cash crop followed by maize and yam.

Land preparation accounted for slightly more than 13% of the labor input for all crops.

With rice as the major cash crop, nearly three-fourths of the total farm labor was invested in it during the rice growing period; 80% of hired and 64% of family labor worked on rice production (Table 8). About 70% of the male labor and half of the female labor came from hired sources. Except for yam, family labor was more important than hired labor for all other crops.

Average daily wages paid hired workers differed for men and women with the former receiving ₦3.70 ($5.55 U.S.) and the latter ₦2.50 ($3.75 U.S.). These differences were due mainly to socio-economic factors and only partly to labor efficiency in certain farm activities. Hired children received ₦1.90 per day and bird scaring was one of their principal duties.

Weeding was by far the most labor-consuming activity in all production areas of the survey, requiring 40% of the total hours of manual labor. Harvesting, land preparation, and planting and seeding followed in that order (Figure 12).

The production "package" under NAFPP supervision included land preparation with a tractor, improved seed, fertilizer, and chemicals for insect and weed control. Total rice yields per hectare on the NAFPP plots were higher in both irrigated and swamp areas than on plots outside the program, but the use of manual labor was still high in spite of the labor-saving technologies. Because of the large amount of labor used on swamp rice (191 days/ha), the yield per day of labor on the

Crop	Family labor (days/ha)	(%)
Rice	70	64
Yam	5	5
Cassava	1	1
Millet	9	8
Maize	4	4
Sorghum/guinea corn	12	11
Groundnut	2	2
Other crops	6	5
	109	100

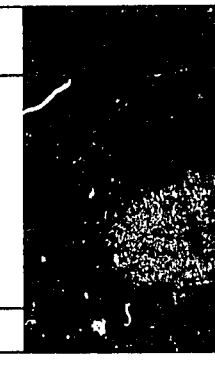


TABLE 8.
Family and hired labor input for different crops during the rice growing period.

NAFPP plots was considerably lower than on the non-NAFPP plots of the program farmers (Table 9). Although the total yield of irrigated rice per hectare for non-NAFPP farmers was only about half that of NAFPP plots, their yield per day of labor input was just as high.

Slightly more than half of the farmers in the survey used tractor services, the others very little or none. Tractor users hired more manual labor for other than land clearing activities. In peak periods of labor demand, the scarcity of manual labor led to higher wage rates and increased labor costs. This may be a major reason for limited expansion of production under various development schemes.

If family labor sources were valued at the same rate as hired farm workers, the agricultural economists estimated that manual labor would amount to 85–90% of total rice production costs, with all other inputs 10–15%.

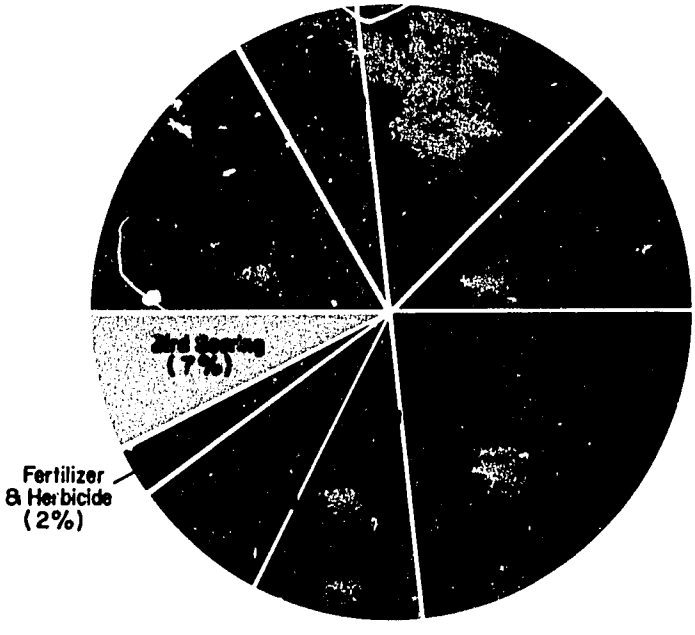


FIGURE 12.
Labor input for different activities (all crops) during the rice growing period in Plateau State, Nigeria. (Based on days of manual labor.)

TABLE 9.
Days of labor per hectare and rice yields for farms in the National Accelerated Food Production Program (NAFPP) and outside the program. (Plateau State, Nigeria.)

Harvesting accounted for almost 16% of the farm labor input.

Local agricultural officials and IITA administrators and scientists visit the Sarkin Gelo farm in northern Nigeria to see the results of the farmer's planting of TVx 3236.

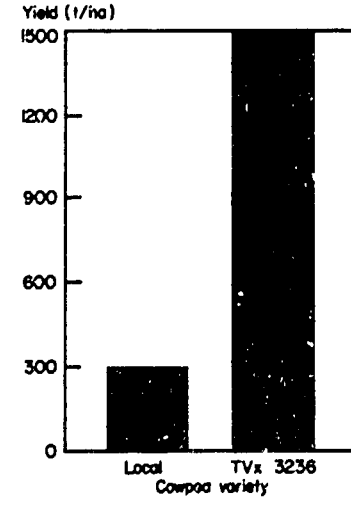


FIGURE 13.
Comparison of yield trials of a local cowpea variety and TVx 3236 in five locations as reported by the Kano (Nigeria) Agricultural and Rural Development Authority.

New Cowpea Variety Moves Rapidly into Farming Systems in Kano State

A principal objective of IITA plant breeders is to develop a variety that has resistance to one or more damaging insects and at the same time produces high yields. This objective has been achieved with a new cowpea variety TVx 3236 which was described in the 1980 edition of *Research Highlights*. In two short years, the seed of this variety has become so popular among farmers that the demand has far exceeded the supply.

Partial evidence of this quick acceptance can be found in Kano State in northern Nigeria – one of the world's largest cowpea producing areas. One of the farmers in that state who grew TVx 3236 during 1982 reported that agricultural officials brought about 20 farmers to him every week, and all of them asked him for seed of this variety. Neither he, other farmers, nor the local government agricultural project could begin to satisfy farmers' requests. However, in 1983 the Kano Agricultural and Rural Development Authority expects to release 50,000 kg of the seed to

approximately 5,000 farmers who will grow TVx 3236 cowpeas on a total of 10,000 acres (4,050 hectares).

Yield trials were conducted on several farms in Kano State by the Authority (Figure 13) and by the farmers themselves in cooperation with local agricultural officials (Table 10). All of the reported yields based on samples from each farm were above 1,000 kg/ha compared with a national average of 212 kg/ha.

TVx 3236 is mature and ready for harvest in 75 days, and it has a moderate level of resistance to thrips. The crop grows close to the ground with synchronously maturing pods in a bunch over the plant's canopy. This reduces the required number of pesticide treatments to two or three.

TABLE 10. Yields of cowpea variety TVx 3236 based on samples from farmers' fields in Kano State, Nigeria (1982).

Name of farmer**	Village	No. of insecticide applications	Yield (kg/ha)
D. Tofa	Kiyawa	3	2639
A. Muyibir	Kunya	3	2222
K. Babangida	Danzubuwa	2	2222
Sarkin Gelo	Tsanyawa	2	1415
Dawaki Tofa	Kadani	2	1389
Ibrahim Dakaw	Saye	2	1217
Alhaji Abubakar	Bici	3	1111
Alhaji Gambo	Kurim	3	1038

*Data collected and submitted to IITA by the Kano State Agricultural and Rural Development Authority.

**Sample area 3m², average of 12 samples per 0.5 ha plot except for Gelo's farms, and Dakaw s farms, where 0.5 ha was sampled.

In mid-1982, Brazil released IITA's cowpea variety VITA-3 as EMAPA 822. Brazilian scientists are shown here inspecting a seed multiplication field of this variety.

Performance of New Cowpea Lines in Brazil

A new cowpea line immune to cowpea severe mosaic virus was tested in Brazil during 1982 under the auspices of the Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA) and its National Center for Rice and Beans (CNPAF). This line (CNC 0434) was created by CNPAF from IITA genetic material.

Cowpea severe mosaic virus (CSMV) can cause extensive damage. Although this virus is important in all cowpea growing regions of Brazil, it is the predominant one in the states of Piaui, Maranhao, Pará, and Goias. CNC 0434 was the only line among several tested that showed immunity to seven races or biotypes of the virus. Other alternate sources of resistance, such as Macaibo and TVu 312, do not transfer resistance to progeny as readily as CNC 0434.

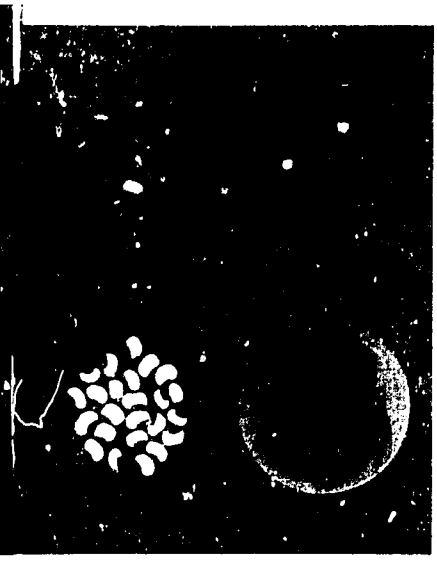
This cowpea line, with an average yield of 969 kg/ha, was the highest yielder in Goiania, Goias, and Bacabal, Maranhao, where a heavy incidence of the virus was present during the test period. However, CNC 0434 gave a lower yield in Teresina, Piaui, where it was severely damaged by a potyvirus transmitted by aphids.

A Brazilian agricultural official (second from left) presents a silver plaque to IITA scientists in October 1982 for the Institute's "cooperation of great value in the development of research on cowpeas in Brazil."

On August 20, 1982, the IITA varieties VITA-6 and VITA-3 were released as EMAPA 821 and EMAPA 822 by the Maranhao State Enterprise for Agricultural Research and EMBRAPA/CNPAF. Seed is now being multiplied by the Federal Foundation Seed Organization for distribution to farmers.

The cowpea variety "Manaus," described in the 1981 edition of *Research Highlights*, has changed a shortage to an adequate supply in Amazonas State. The beginning of this success story goes back a few years when many germplasm lines were introduced into the Amazon Valley Region by the UEPAE/Manaus, with a large influx from IITA through CNPAF after 1978. The material was tested in several locations as part of the state's cowpea improvement program. At that time, several tons of cowpeas were imported annually, some from distances as far away as 2,000 km.

New material was distributed for farmers' trials in 1980. Because of such a heavy farmer demand for the seed of a few lines, the state released "Manaus" from the IITA line 4R-0267-01F in June of 1981 with the distribution of two tons of seed. Yields up to 1,800 kg/ha were produced on fertile land along the banks of the rivers of the Amazon Valley. Traditional varieties produced only about 800 kg/ha. To date, several tons of "Manaus" seed have been produced and distributed to farmers. Late in 1982, the Governor of the state wrote to EMBRAPA officials stating that a deficit of small brown seeded cowpeas no longer existed in the markets in the city of Manaus and that the emphasis should now be shifted to vegetable cowpeas or meter long beans, white seeded cowpeas, and dry beans.



Because of regional preferences for cowpeas of different colors, IITA plant breeders have developed these four colors.

Extra-Early Maturing Cowpeas with Preferred Seed Colors for Africa, Asia, and Latin America

The development of extra-early maturing cowpea varieties has created considerable interest in several parts of the world, particularly in low rainfall regions and in the humid tropics where such varieties can be grown in rice fallows. However, because of regional preferences for seed color and quality, the same varieties are not accepted everywhere. Therefore, continuing efforts are being made by IITA scientists to breed extra-early maturing varieties with desired seed color and quality to suit various regional preferences.

In West Africa, the most preferred types are large, white and brown-seeded varieties with a rough seed coat, but countries in Central America and the Caribbean prefer red, black, or white seeds with smooth testa. Consumers in Mexico, Guatemala, Nicaragua, Costa Rica, and Cuba prefer black. A red color is given first preference in Honduras, El Salvador, Venezuela, and Jamaica. In East Africa and Asia, any color other than black is acceptable, although a tan color is preferred in the former and white and cream colors in the latter.

IITA has now developed several extra-early maturing cowpea varieties with different seed colors: IT 82E-32 (red), IT 82E-9 (black), IT 82E-5 (tan), and IT 82E-56 (white with a rough seed coat). These varieties have acceptable seed qualities for different regions.

The mean yield performance of the most promising varieties, compared with a standard popular variety from Nigeria (Ife Brown), is shown in Table 11. All the extra-early maturing varieties were harvested between 58 to 61 days and Ife Brown between 78 to 85 days. The mean yields of the extra-early maturing cowpeas were as good as or better than Ife Brown.

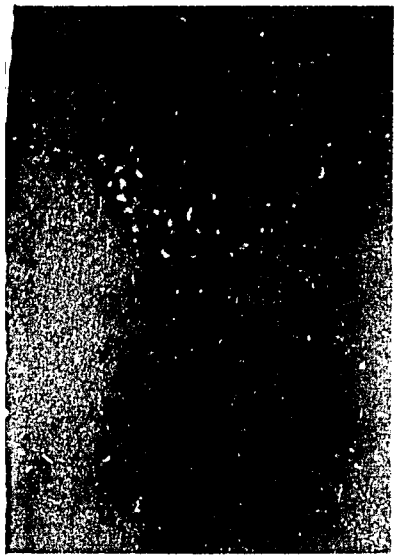
The new varieties are erect-type plants and have a determinate growth habit with synchronous flowering and maturity. The pods are held up above the canopy which makes mechanical or manual harvesting easy and economical. Moreover, they require only 45–50 days of soil moisture, permitting double cropping and relay cropping in several areas of Africa, Central America, and Asia. They also would permit a successful crop in extremely low rainfall areas of the tropics and enable farmers to grow a cowpea crop in rice fallows on residual moisture.

TABLE 11.
Mean yield (kg/ha) of the most promising 60-day cowpea varieties compared with Ife Brown (IITA, 1982).

Variety	IITA (1st season)	IITA (2nd season)	Mokwa	Samaru
IT 82E-32	1961	1143	2109	1809
IT 82E-9	2003	978	2078	1614
IT 82E-56	1810	1713	1875	1049
IT 82E-5	1420	1074	1845	2018
Ife Brown (check)	2151	1205	1481	1264
CV	21	24	14	22
LSD (5%)	428	240	307	444

In the background are extra-early cowpeas and in the foreground a late-maturing variety. Both were planted at the same time.

Bruchid Resistant Cowpea Varieties



A bruchid resistant cowpea line IT 81D-994 (top) compared with Ife Brown variety (below). Both were infected with the same number of bruchids.

Because of the substantial damage caused by the bruchid *Callosobruchus maculatus* to cowpeas in storage, many farmers in Africa, Asia, and South America are compelled to dispose of their crop soon after harvest. This not only reduces an important protein source for their families but forces them to sell at a lower price. The loss in dry weight due to this cowpea seed beetle can be as much as 30% in a six-month storage period with 100% seed contamination, making the cowpeas unfit to eat. Annual losses in Nigeria alone are estimated at more than ₦20 million ($30 million U.S.).

After screening a world germplasm collection of approximately 7,000 cowpea cultivars, IITA scientists identified in 1975 a single source of bruchid resistance — TVu 2027 (Figure 14). But it had some undesirable characteristics such as poor plant type, low yield, and susceptibility to other pests and diseases. Since then the scientists have developed advanced breeding lines which combine bruchid resistance with high yield potential, disease resistance, good seed quality, and desirable plant type. Several of them were evaluated in multilocational yield trials in 1982. Yields and levels of bruchid resistance of the seven most

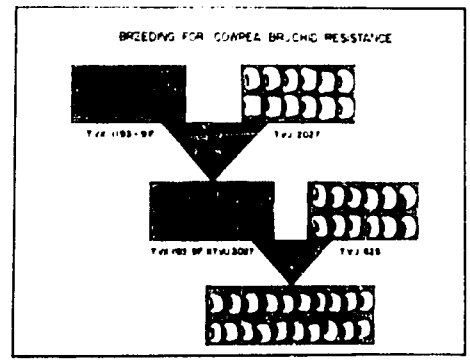


FIGURE 14.
Steps followed in breeding cowpeas for bruchid resistance.

TVu 2027 – the bruchid resistant cowpea parent (above) of the new improved resistant variety IT 81D-1138 (right).

promising lines are shown in Table 12. Data on adult emergence indicate that even the resistant lines permit some bruchid development, but they slow down the overall build-up of seed beetles in storage and minimize the losses.

Seeds of these lines are being distributed to various national programs for evaluation. Also, the Tropical Products Institute in Slough, England, is cooperating by evaluating material for bruchid populations from different countries in Africa, Asia, and Latin America.

TABLE 12. Performance of bruchid resistant cowpea breeding lines (IITA, 1982).

		Yield kg/ha					Bruchid Emergence % Days after festation		
Variety	Seed color	IITA (1st season)	IITA (2nd season)	Mokwa	Samaru	Mean	33	40	50
IT 81D-1157	Tan	1336	1228	2750	2129	1061	0	16	50
IT 81D-1148	Tan	1453	1399	2609	1472	1733	0	15	63
IT 81D-1032	Red	1489	1630	2031	1321	1618	0	9	38
IT 81D-994	White	–	1532	2000	1388	1640	2	35	43
IT 81D-1007	Red	1291	1358	1795	1169	1626	0	25	30
IT 81D-1138	White	1511	1108	1555	1513	1422	3	37	59
IT 81D-985	White	–	1212	1378	1261	1284	5	32	48
Ife Brown (Susceptible check)	Brown	918	1077	1713	1443	1288	77	86	95
TVu 2027 (Resistant check)	White	20	150	–	–	–	–	–	–
CV		38	21	22	20				
LSD (5%)		516	358	463	501				

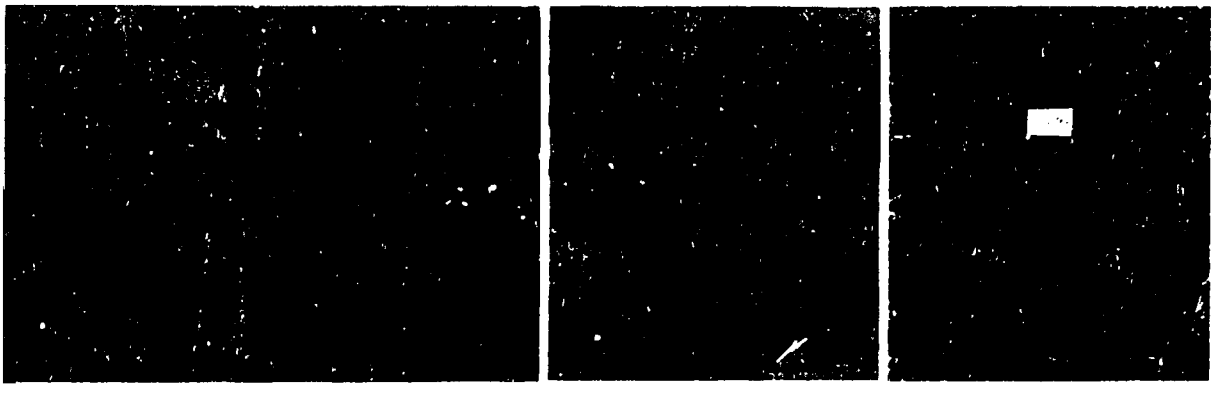
Resistance to Striga in Cowpeas

Two cowpea cultivars – designated as 58-57 and SUVITA-2 by IITA/IDRC/SAFGRAD scientists in Upper Volta – have been found to be resistant to Striga (*Striga gesneioides*). This plant parasite, commonly known as witchweed, is widespread and locally important throughout the Sudan Savanna zone of West Africa. It attaches itself to the cowpea root, often reduces yields substantially, and can completely kill the host plant if it is highly susceptible.

The scientists screened 50 cowpea cultivars in the field and in the screenhouse, and out of this number two cultivars showed the highest level of resistance to Striga and were especially adaptable to dry conditions. SUVITA-2 yields averaged 1,300 kg/ha in field trials in 12 locations. Seed quality was rated as excellent with large, rough, brown seeds.

F_5 generation lines derived from crosses involving SUVITA-2 were also tested. Several of these were found to be resistant to Striga and combined disease resistance with medium to high yields and desirable seed quality. These lines will be further evaluated for agronomic performance in 1983.

Left to right: Striga (with pink to mauve flowers) has established itself in cowpea plants; at the early stage of growth, the plant parasite attaches to its host – the cowpea root; SUVITA-2 showed a high level of resistance to Striga.



Screening cowpeas for resistance to major viruses; right, a new cowpea line IT 82E-10 resistant to six of seven known viruses with the susceptible check next to it.

Advances in Cowpea Virus Research

Cowpeas cultivated in Africa are infested with seven known viruses, the most important of which are cowpea aphid-borne mosaic virus (CAbMV), cowpea yellow mosaic virus (CYMV), and cucumber mosaic virus (CuMV). When present alone or in mixtures, they can cause up to 100% loss in yield when highly susceptible varieties are involved.

Almost every variety tested over the past 10 years by IITA scientists was resistant to only one or two viruses or to none. But during 1982, one selection – IT 82E-10 – from the germplasm entry TVu 128 was found to have resistance to at least six of the seven known viruses. Only inoculation with one virus – cowpea mottle virus (CMeV) – from Nigeria resulted in a symptom expression on IT 82E-10. However, systemic infection with this virus appeared to occur only with great difficulty, indicating a high level of "field resistance." Identification of this multiple virus resistant cowpea introduction is considered a major breakthrough.

During the past several years, efforts have been made to develop large, white, rough-seeded materials resistant to CYMV, but this has been difficult because all the available lines resistant to this virus had small brown or black seeds. However, by selecting from the world germplasm collection of cowpeas at IITA all white, rough-seeded materials and by screening these for resistance to CYMV, two introductions – TVu 5971 and TVu 7483 – have been identified as immune to the virus.

Bush-Type Vegetable Cowpea Development

Several countries grow cowpeas as a vegetable crop, and consumers use the long, fleshy, tender pods as a fresh vegetable. But most of these vegetable varieties need staking to keep pods from touching the ground and rotting, which involves extra costs to growers and restricts the area of cultivation. Therefore, IITA scientists initiated a systematic breeding program to develop bush-type vegetable cowpea varieties that do not require staking, yet have similar yield and pod characteristics.

A number of them have been evaluated along with FARV-13 and TVx 3442-27E as checks. Nigeria released the former, a climbing-type vegetable variety, several years ago under the

Traditional climbing-type vegetable cowpea variety (left) and a new high yielding bush-type (right) with long peduncles protruding well above the canopy.

name of "DINNER." TVx 3442-27E is a climbing-type advanced breeding line developed earlier at IITA. The first picking of green pods was made 53 days after planting and pickings continued each week for several weeks until most of the varieties stopped producing.

The bush-type IT 81D-1228 series, resistant to major diseases, yielded between 14 to 19 tons/ha of green pods compared with 12–15 tons for the climbing-type (Table 13). Pod characteristics and protein content of both types were similar, but the most important characteristic of the bush-type varieties was their extra long peduncles protruding well above the canopy, thereby holding the pods above ground. Picking the pods each week reduced the weight on the peduncles as they remained upright all the time. Frequent picking also stimulated further flowering and podding on the same peduncles which ensured a continuous supply of green pods over the seven weeks. Seed yield of these varieties was also reasonably good and the seeds were large and white.

TABLE 13. Performance of three promising new bush-type vegetable cowpea varieties at IITA compared with two older climbing types (1982).

Variety	Dry seed (kg/ha)	Green pods (kg/ha)	Pod length (cm)	Moisture content (%)	% Protein: Green pods, Fresh	% Protein: Green pods, Dry	% Protein: Seeds
IT 81D-1228-13	1312	18913	25	89.5	2.9	28	24
IT 81D-1228-14	776	16778	29	89.3	2.8	26	25
IT 81D-1228-15	889	15468	28	89.6	2.9	28	26
TVx 3442-27E (check)	982	14767	32	89.3	2.8	26	25
FARV-13 (check)	555	12504	31	89.1	2.7	25	26
CV	34	13					
LSD (5%)	604	3356					

For Maruca mating under artificial rearing conditions, relative humidity, temperature, and duration of the pairing period are very important.

Mating Success in Artificial Rearing of *Maruca* for Plant Resistance Studies

Development of precise and repeatable bio-assays for use in the screening of germplasm and breeding material continues to be a major component of IITA's research on cowpea resistance to the pod borer *Maruca testulalis*. A suitable artificial diet was described in the 1981 edition of *Research Highlights*, and this year important progress has been made to obtain adequate adult mating and oviposition of viable eggs in the laboratory. Large numbers of the insect are needed for use in resistance studies.

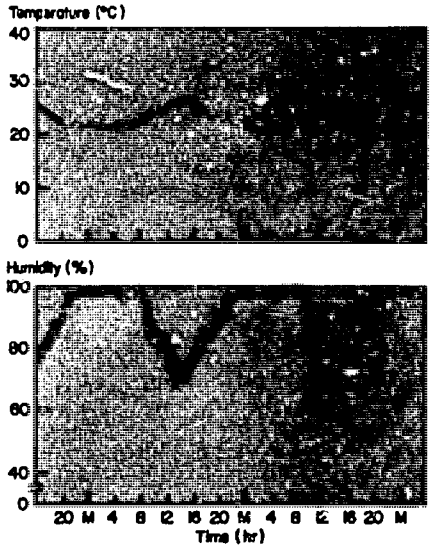
The research, conducted in collaboration with scientists from the International Center of Insect Physiology and Ecology (ICIPE) in Kenya, shows that a number of factors are necessary

for *Maruca* mating, the most important being relative humidity (RH), temperature, and duration of the pairing period.

Adult activity starts at about 1900 hours and peaks between 2200 and 0200 hours. During this period the RH was observed to range between 80 and 100% while the temperature ranged between 20 and 24°C (Figure 15). The highest number of mating pairs in cages was observed between the hours of midnight and 0300 corresponding with the period of high RH and low temperature. In periods of low humidity and very low temperatures (such as during the harmattan months) or low humidity and temperatures above 27°C (such as during the rest of the dry season), the level of adult mating is generally low (20–40%).

When newly emerged adults were paired for 1–5 nights in groups of 5–10 pairs per cage, the highest level of mating (90%) was obtained from five nights pairing (Figure 16). More than

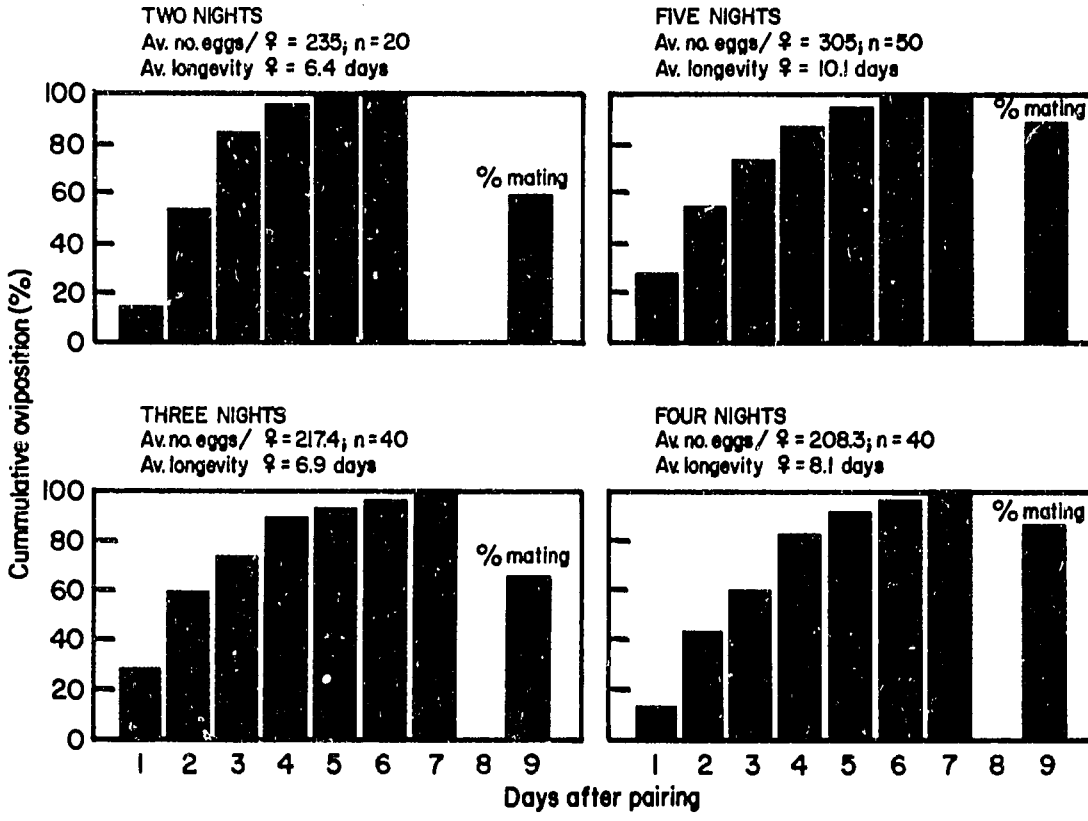
FIGURE 15.
Optimum levels of temperature and relative humidity for *Maruca* ***mating.***



Maruca ***deposit eggs in these small containers.***

50% of all females were mated even with two nights pairing, but no mating occurred with only one night. Egg production was generally higher than most reports indicate, and moths lived for up to 10 days with five nights pairing. Egg hatch was over 75% in all cases. Females mated only once as revealed by spermatophore counts. A method used for egg collection developed in IITA's entomology laboratory is described in *Research Briefs* (Vol. 3 No. 1, 1982). The present culture has been kept now for more than five months, marking the first time more than one generation of *Maruca* has been successfully kept on an artificial diet.

FIGURE 16.
Effect of pairing Maruca adults for two, three, four, and five nights on mating and subsequent oviposition.



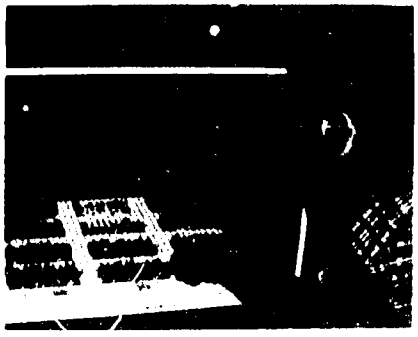
New Method for Screening Soybeans for Resistance to "Field Weathering"

Only limited success has been achieved in growing soybeans in the humid tropics because rapid seed deterioration results in poor stands. Varieties with resistance to deterioration during storage have been identified at IITA and breeding lines are now screened routinely for good seed storability. However, seeds can deteriorate prior to harvest if warm, humid conditions prevail during the time of seed maturation. Scientists generally refer to this as "field weathering."

To breed soybean varieties with resistance to "field weathering," it is essential to have a screening method that both accentuates genetic differences among varieties for resistance and provides a uniform environmental stress to all varieties being tested. In other parts of the world where "field weathering" is a problem, scientists have tried to assess resistance by measuring seed vigor after delayed harvest treatment (three weeks after pod yellowing). But this approach is not adequate when a plant breeder compares varieties that mature at different times.

With a new method – "incubator weathering" – pods are stripped from the plant when they turn from green to yellow and put in cells of a plastic grid in an incubator at 30°C, 95-99% RH for 10 days. The plastic grid provides a uniform environment and minimizes cross contamination of fungi. This method proved to be preferable to two others tested – delayed harvest and "wet bag weathering."

Three replications of 35 varieties were sown on three different dates. After the weathering stress treatments, scientists measured seed vigor by laboratory germination and field emergence. With "incubator weathering," they observed similar mean emergence and germination scores for the different planting dates which implied that the degree of weathering was similar regardless of the weathering conditions in the field. The error variance was generally smaller than that associated with delayed harvest, and



"Incubator weathering" proved to be preferable to two other methods tested for screening soybeans for resistance to "field weathering."

the pods were not subjected to differing periods of weathering stress. (Early maturing pods are subjected to a longer period of weathering stress than late-maturing pods in the delayed harvest method.)

Soybean lines with consistently high levels of resistance included IITA accession numbers TGm 1171, 46, 106, 112, 693, 685, 737P, 737W, 618, 94, 730, and 122. Results of this study confirm earlier observations that many of the lines previously listed as having resistance to deterioration in storage are also resistant to "field weathering" deterioration.

Unweathered seeds from the third planting were also subjected to eight months of ambient storage. The emergence scores following "incubator weathering" and ambient storage were compared to determine the relationships between storability and "incubator weathering." The results (Figure 17) confirm that many of the breeding lines resistant to deterioration of seed in storage are also resistant to "field weathering."

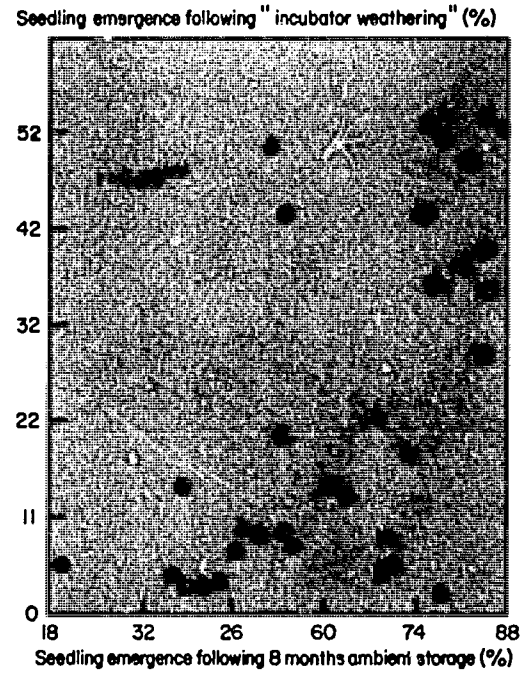


FIGURE 17. ***Relationship between emergence following "field weathering" and emergence following ambient storage for eight months for 35 soybean varieties. (50 seeds were sown from each of three replications; red dots indicate varieties resistant to both "field weathering" and deterioration in storage.)***

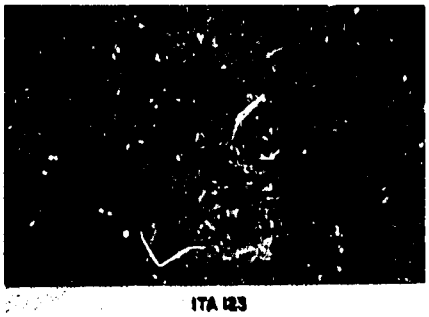
Rice Varieties with Good Grain Quality and High Yield Potential

Rice growers have an interest in good grain quality, as well as high yields, because the market price of milled rice depends on the percentage of broken grains – the lower the percentage of brokens, the higher the price. The amount of chalkiness in rice grains – one of the characteristics used to judge quality – affects this percentage. Chalky portions result in softer grains which break more easily during milling than those that are free from chalkiness and are "translucent." In addition, rice grain quality is judged on length and shape with the latter classified as slender, medium, or bold depending on a length-width ratio.

Consumers also are interested in quality, generally preferring long, translucent rices with a minimum percentage of broken grains.

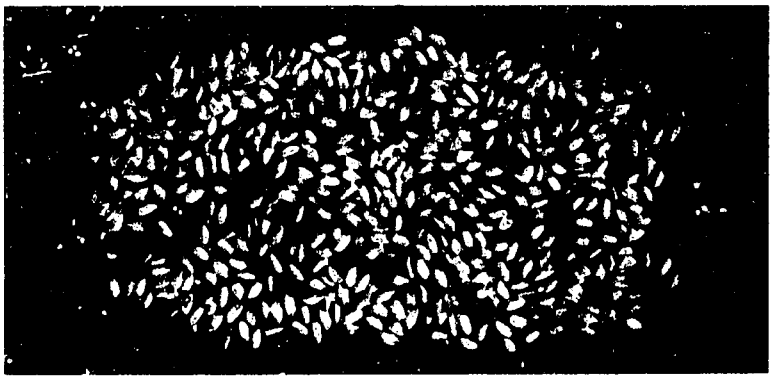
Taking cognizance of these aspects, the rice improvement program of IITA has emphasized quality as well as high yield potential and resistance to various stresses. The top 10 elite ITA varieties with good grain quality and high potential are shown in Table 14.

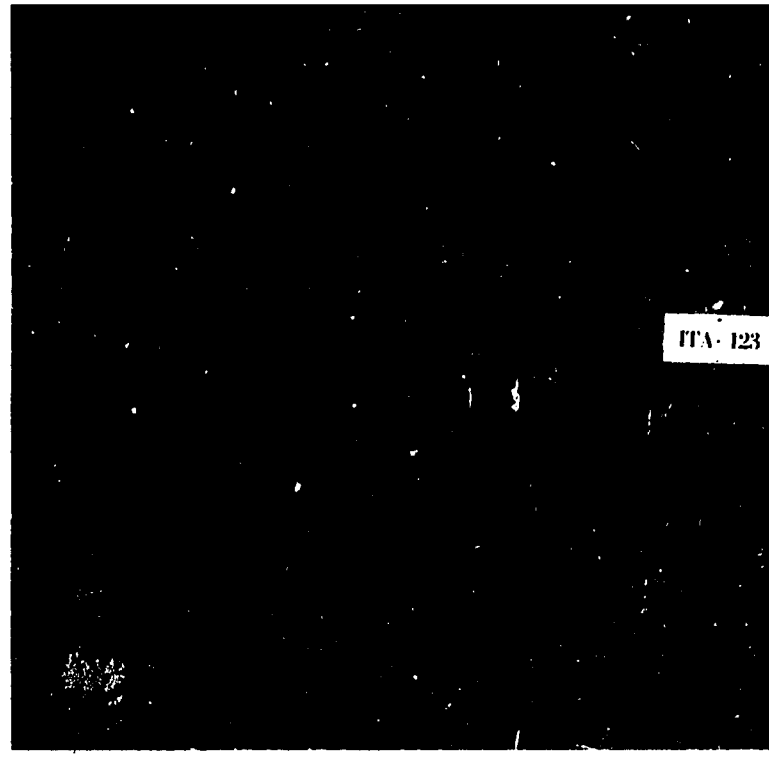
Below, two of the top 10 IITA rice varieties based on desirable grain characteristics; right, poor quality rice with short and broken grains and too much chalkiness.



ITA 123

ITA 141





The top quality IITA lowland rice variety growing in a paddy.

TABLE 14.
Grain characteristics of the top 10 IITA rice varieties.

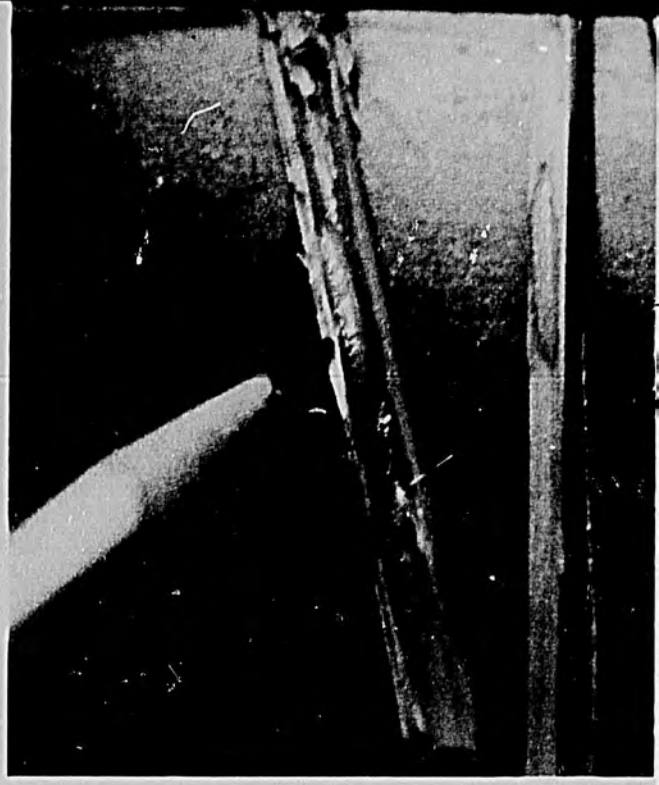
Variety	Adapted ecosystem	Grain characteristics: Length* (1–7)	Length-width ratio* (1–9)	Endosperm* chalkiness (0–9)
ITA 116	Upland	3	5	1
ITA 117	Upland	3	5	1
ITA 141	**Upland**	**3**	**1**	**1**
ITA 150	Upland	3	5	1
ITA 235	Upland	3	5	1
ITA 257	Upland	3	5	1
ITA 123	**Lowland**	**1**	**1**	**1**
ITA 247	Lowland	5	5	0
ITA 231	Lowland	3	5	1
ITA 249	Lowland	3	1	1

**Scores adapted from "Standard Evaluation System for Rice," IRTP, IRRI, 2nd edition.*

Length:
1. Extra long (<7.5mm)
3. Long (6.6–7.5mm)
5. Medium (5.5–6.6mm)
7. Short (>5.5mm)

Length/width ratio:
1. Slender (<3.0)
5. Medium (2.1–3.0)
9. Bold (>2.0)

Endosperm chalkiness:
(% of kernel area)
0. None (translucent)
1. Small (less than 10%)
5. Medium (11 to 20%)
9. Large (more than 20%)

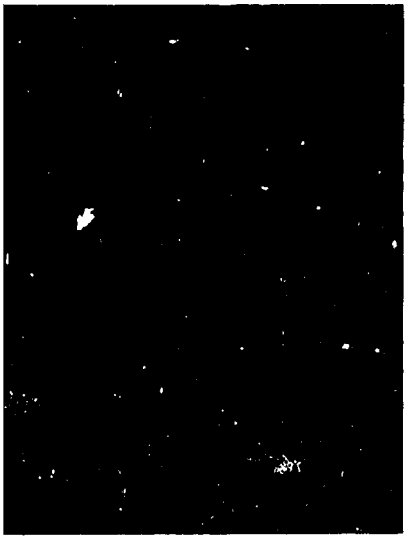


Left to right: the stalk eyed fly is the most serious stemborer of rice in Africa; larva of this pest feeds inside a rice stem, evidence of rice tillers killed by the stalk eyed fly.

Reliable Rice Screening Technique for Resistance to Stalk Eyed Fly

The most serious stemborer of rice in Africa is the stalk eyed fly *Diopsis thoracica* West. A single larva can kill up to 10 rice tillers in one hill during its lifetime. Indigenous to Africa, this pest generally attacks the rice plant at the tillering stage. Feeding inside the stems on the central shoots of young rice plants, it causes the tiller to die, which is known as "dead heart."

Use of resistant rice varieties is an inexpensive way to control the stalk eyed fly, but success in breeding for this resistance depends heavily on effective screening techniques. Therefore, IITA scientists developed a simple and reliable technique for systematically screening rice germplasm and breeding materials under greenhouse conditions. They maintain high insect populations inside a 24 × 24 × 2 m greenhouse and continue the screening throughout the year. With this technique, cultivars can be evaluated within 70 days.



During 1982, almost 1,000 rice cultivars (*O. sativa* and *O. glaberrima*) from 39 countries of the world were screened. (Approximately three-fourths came from Africa.) Infestation of the stalk eyed fly ranged from 1.2 to 67% compared with a maximum of about 15% under natural field conditions. Out of the total number of cultivars screened, 57 with less than 10% infestation were selected as promising. The best 20 of these and sources from which they originated are listed in Table 15.

TABLE 15.
Twenty of the best cultivars selected for resistance to the stalk eyed fly** D. thoracica **in a mass screening test of 988 rice cultivars at IITA in 1982.

Designation/ IITA acc. no.	Source	Infestation* (%)	Designation/ IITA acc. no.	Source	Infestation* (%)
TOs 5827	Liberia	1.2	ITA 121	IITA	3.1
3213	Ivory Coast	1.8	TOs 5267	Ivory Coast	3.3
285	USA	1.8	657	USA	3.3
372	Indonesia	2.0	373	Indonesia	3.3
3212	Ivory Coast	2.2	x.2. D.T	Vietnam	3.4
5792	Liberia	2.2	TOx 936-153-5-3-3	IITA	3.5
TOx 916-6-1-101-2	IITA	2.4	TOs 663	Nigeria	3.5
TOg 6390	Liberia	2.5	5734	Liberia	3.6
TOs 272	USA	2.8	TOx 891-212-2-102-1-1	IITA	3.6
TOs 5677	Nigeria	2.9	TOg 6481	Liberia	3.8

** Infestation ranged from 1.2 to 66.7% in the mass screening test.*

Progress in Developing Stemborer Resistant Maize for Africa

The pink stalkborer *Sesamia calamistis* – one of five different species of maize stemborers causing significant yield losses in Africa – is widespread in the lowland humid tropics. In the humid environment of southeastern Nigeria, for example, the attack of this stemborer is most serious during the latter part of the season (June–November), so most farmers do not plant maize at that time. A solution to the borer problem would allow them to do so.

The existing practice to control stemborer larvae on large maize fields is to place insecticide dust or granules into funnels of young plants, but this does not control larvae already in the stems. Another drawback of this method is the cost of the chemicals, which most small farmers cannot afford. The most effective, economical, and environmentally acceptable method of control is through the use of resistant plants in combination with good cultural practices.

IITA scientists initiated a maize breeding program in 1975 to develop resistant lines. Screening and selection were done mainly under heavy natural infestation as a result of late planting at a sub-station of the Nigerian National Cereal Research Institute (NCRI) at Umudike. More than 2,500 families or lines of improved germplasm and local varieties have been screened. Selected plants were recombined later to accumulate the genes for resistance and the progenies retested again under the same conditions.

Realizing the need for a more accurate and reliable screening technique, IITA embarked on a program in 1981 to develop mass rearing and artificial infestation techniques for various species of maize borers. A new laboratory building was completed in 1982 which makes possible the rearing of large numbers of insects of two borer species – *Sesamia calamistis* and *Eldana saccharina*. Twelve maize families, selected and bred

Evidence of the damage caused by the pink stalk borer; susceptible check (right) compared with the new resistant maize line BR 45-5 (left) under artificial infestation.

previously for *Sesamia* resistance, were compared under controlled artificial infestation in the screenhouse in 1982 with TZPB – a widely grown variety in Nigeria. Only 5% of the control variety TZPB plants survived after infestation with 25 larvae/plant. Under the same conditions, the average survival of the 12 families tested was about 50%. From the best family – BR 45-5 – approximately 80% of the plants survived (Figure 18).

These results are encouraging, indicating that by proper breeding methods it is possible to identify and accumulate genes for *Sesamia* resistance in maize. With the uniform artificial infestation technique, progress in stemborer resistance breeding should be faster and agronomically acceptable resistant varieties available in the future for farmers in Nigeria and other countries through their national programs.

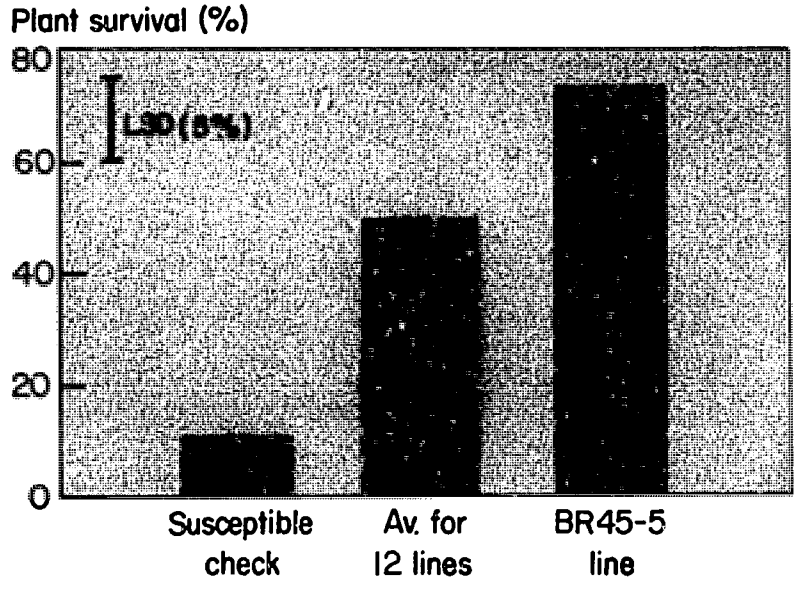


FIGURE 18.
Percent survival of 12 new IITA borer-resistant maize lines under heavy artificial infestation by *Sesamia calamistis.*

International testing of IITA streak resistant maize in the Ivory Coast

First International Trial with Streak Resistant Maize Varieties

Because maize streak occurs in all African countries south of the Sahara, IITA has placed major emphasis on the development of resistant varieties to this yield-depressing virus disease. It, along with other diseases, is among the main factors responsible for the low productivity of maize in tropical Africa — an average of slightly less than 1 ton/ha compared with more than 3 tons/ha for the rest of the world.

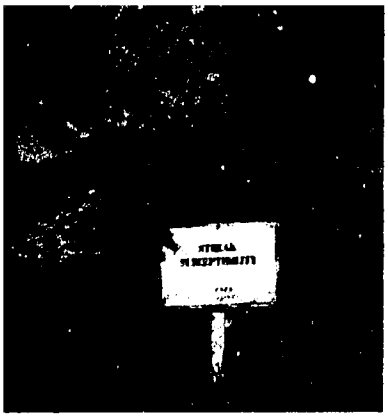
Once maize plants are infested by the viruliferous insect vector *Cicadulina* spp., particularly within the first three weeks of planting, a complete crop failure can be the result. Streak resistant maize populations developed by IITA, such as TZSR-W-1 and TZSR-Y-1 described in the 1980 edition of *Research Highlights*, have been deployed in the national programs of many countries of Africa.

A maize streak resistant variety on the left compared with a susceptible variety on the right. Both were planted at the same time under streak infection.

In 1981, one set of 250 full-sibs of TZSR-W-1 and one of TZSR-Y-1 were sent to the Republic of Benin, Cameroon, Ghana, Ivory Coast, Nigeria, and Upper Volta. Six entries were supplied by the trial collaborators. Based on the performance of the full-sibs across the six locations, 60 and 58 full-sibs were selected for the regeneration and further improvement of TZSR-W-1 and TZSR-Y-1, respectively. Simultaneously, the best 10 full-sibs at each location were recombined by bulk-sibbing during the 1981 dry season for the formation of experimental varieties specific to the test locations.

During 1982, the first organized International Trial was conducted with streak resistant varieties by IITA in cooperation with national collaborators. Six experimental varieties described and designated by the trial location and the parent population were included in the Experimental Variety Trial-Late Streak Resistant (EVT-LSR). Experimental varieties from TZB and TZPB populations, previously developed by IITA and widely grown in Nigeria and other African countries such as the Republic of Benin, Togo, Gabon, and Cameroon, were also produced for the first time and included in the trial. All these varieties were compared with two best varieties by the collaborators.

The trial was sent in March of 1982 to 24 locations in 17 countries of Africa in both forest and savanna areas. By the end of the year, data had been reported and compiled from 10 of these locations in six countries – Republic of Benin, Cameroon, Ghana, Kenya, Liberia, and Nigeria. A summary of results is shown in Table 16. Performance of the streak resistant varieties was as good as improved non-streak resistant varieties under normal conditions and is expected to be much better under streak pressure.



New late-maturing streak resistant varieties will be included in the 1983 EVT-LSR International Trial. Some of them were established based on late arriving results from the international full-sib family trial conducted in 1981 in six countries of Africa. Others are a product of a backcross conversion for streak resistance of selected varieties from CIMMYT's international program. These varieties were selected based on their good performance in trials conducted in Africa, but they were susceptible to maize streak virus. This project is part of the IITA/International Maize and Wheat Improvement Center (CIMMYT) cooperation in Africa. Toward the end of 1983, a similar Experimental Variety Trial of early-maturing streak resistant varieties will also be available.

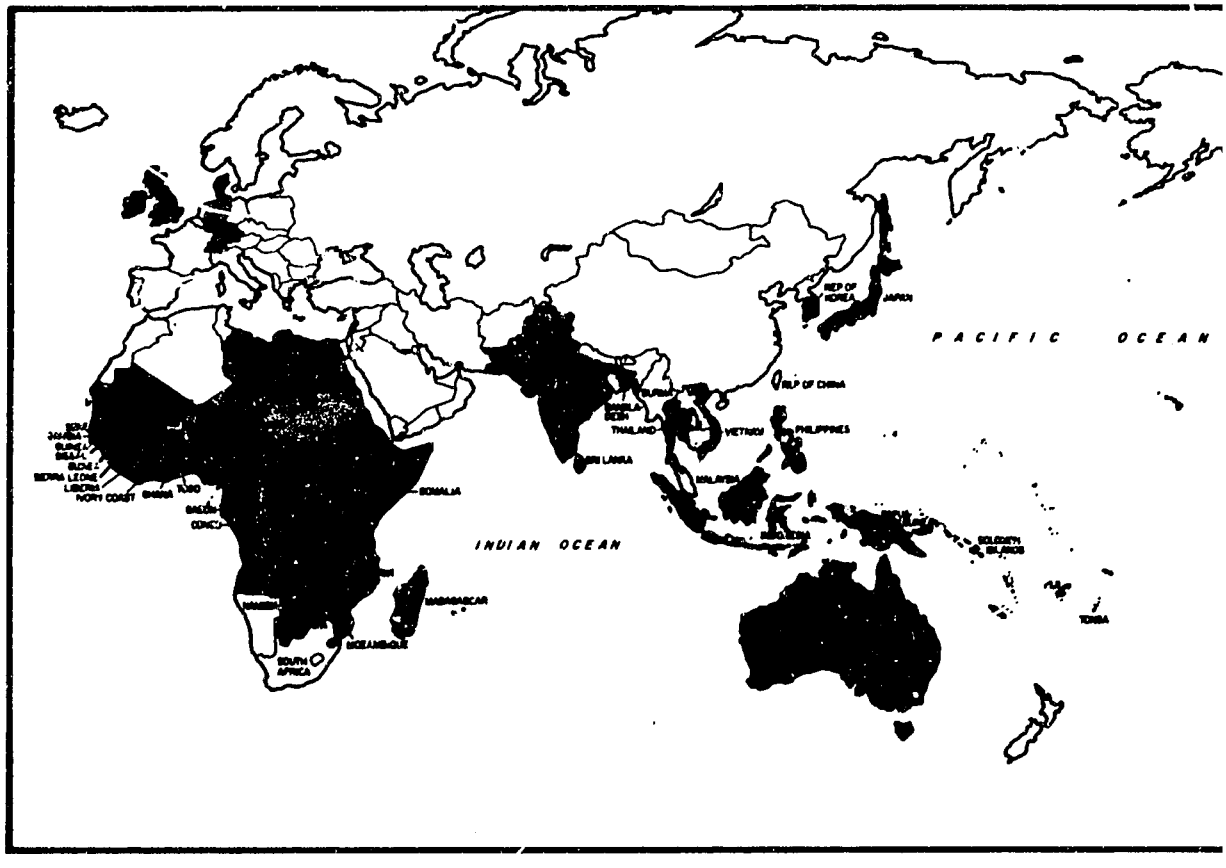
TABLE 16. Average yield[1] and some agronomic characteristics[2] of maize in 1982 EVT-LSR trial in 10 locations (six countries) in Africa.

Variety[3]	Average yield (t/ha)	Days to 50% silking	Ear height (m)	Plant height (m)	Plant Root lodging (%)	Plant Stalk lodging (%)
Ikenne LSRW	4.5	62	1.2	2.3	4.9	5.2
Ferke LSRW	4.3	62	1.2	2.2	5.2	6.2
Sekou LSRW	4.7	61	1.2	2.2	6.2	5.8
Ikenne LSRY	4.5	61	1.1	2.2	4.9	5.0
Ferke LSRY	4.4	61	1.1	2.3	5.5	5.7
Farako-ba LSRY	4.4	61	1.2	2.3	2.2	4.0
Mokwa TZB	4.9	62	1.2	2.3	3.9	4.0
Gusau TZB	5.3	61	1.1	2.2	4.3	3.8
Onne TZPB	4.8	61	1.3	2.4	4.4	4.6
Suakoko TZPB	5.2	61	1.3	2.3	4.2	4.8
Check I[4]	4.4	62	1.2	2.2	3.4	4.9
Check II[4]	4.2	61	1.3	2.4	6.2	3.0

[1] *Statistically significant differences between varieties were found in 8 out of the 10 trials. C.V. range was 12–32%.*
[2] *Average of data available from five locations.*
[3] *All varieties except the checks are based on the results of 1981 progeny tests.*
[4] *Different checks at each location.*

Sharing Research and Technology Expertise with Staff of National Programs and University Students

Although IITA is not a university, it does have a solid commitment to accept a number of post-graduate students who want to work on the research portion of their degrees under the supervision of a senior scientist at the Institute and have the approval of their universities to do so. During 1982, 34 Masters degree candidates from 10 countries and 30 Ph.D. (doctoral)



A doctoral (Ph.D.) candidate from the University of Science and Technology at Kumasi, Ghana, works on his thesis research in virology under the direction of an IITA senior scientist. He is one of 30 engaged in Ph.D. thesis research during 1982 at IITA.

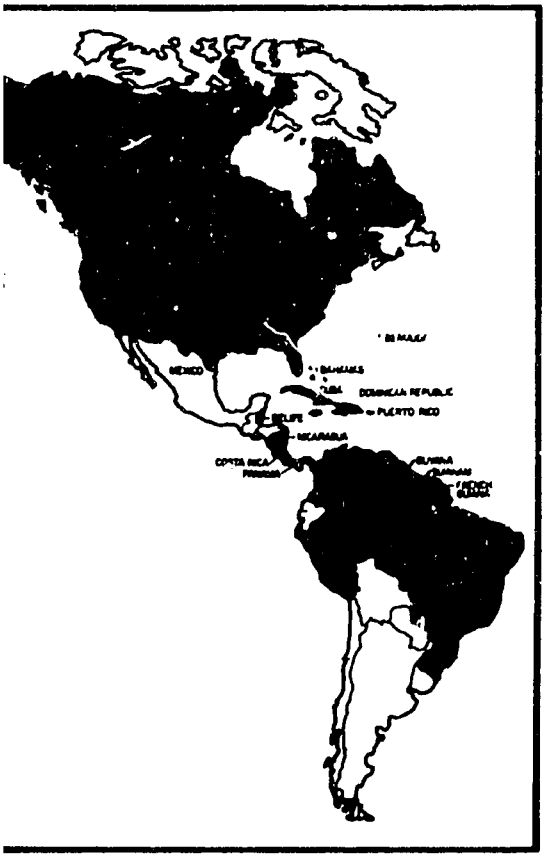


FIGURE 19.
More than 2,500 persons from 79 countries around the world have received research and technology training at IITA over the past 12 years.

candidates from 12 countries were engaged in such research. Since this program started in 1970, the numbers have totalled 144 and 87, respectively. Although the majority came from Africa, others represented Asia, Australasia, South and Central America, North America, Europe, and the Pacific region (Table 17 and Figure 19).

Undergraduates are not forgotten. Up to 20 of them from African universities are selected each year to get research experience at IITA for three or four months during their final long vacation period.

Non-degree training at the Institute is more flexible, and since 1970 over 200 staff members of departments or ministries of agriculture, international agencies, and other organizations have gained additional technological knowledge or skills tailored to their individual needs. By far the largest number of training participants – 1,859 – have been involved in group courses for various lengths of time up to 16 weeks. Although most of these courses are conducted on the IITA campus, courses have also been held in Cameroon, Nigeria, Sierra Leone, and Upper Volta. In addition, IITA scientists have assisted with courses in Brazil and Liberia.

IITA considers these training programs a "two-way street." Not only do they result in an ever increasing flow of competent research workers and staff members who put research results into practical use at national and local levels, but they add to the research capacity of the scientific staff of the Institute. Another advantage is that IITA can keep more closely in touch with agricultural problems of the humid and subhumid tropics through those who have been trained and return to work in their home countries. Over the years, the number is sizeable – more than 2,500 persons from 79 countries around the world.

Training participants in group courses get instruction not only in classrooms and laboratories but also in the field. Most courses are conducted in both English and French.

TABLE 17.
Number of persons receiving research and technology training at IITA from 1970 through 1982 and the continents or regions they represented.

Continent or region	No. of countries	University Master's candidates	University Ph.D. candidates	Participants in group courses (On site)	(Off site)	Others
Africa	41	85	64	1483	216	383
Asia	11	5	2	55	–	11
Australasia	2	1	2	4	–	1
Europe	5	47	13	5	–	5
North America	2	5	5	30	26	13
South/Central America	14	1	1	35	–	7
Pacific region	4	–	–	5	–	–
	79	144	87	1617	242	420

List of Personnel

ADMINISTRATION

E.H. Hartmans, Ph.D., director general.
B.N. Okigbo, Ph.D., deputy director general (on sabbatical leave).
L.H. Shebeski, D.Sc., deputy director general and interim director of research.
M.A. Akintonide, B.S., director of administration.
S.V.S. Shastry, Ph.D., director of research.*
J.E. Haakansson, M.B.A., director of budget and finance.
O.O. Ogundipe, M.D., medical officer.
C.A. Enahoro, administrative assistant to the director general.
K.A. Aderogba, D.P.A., principal administrative officer.
S.J. Udoh, A.M.N.I.M., chief accountant.
M.E. Olusa, assistant to the director for administration.
E.A. Fo., manager of information systems.
D.J. Sewell, dormitory and food service manager.
R.O. Shoyinka, B.S., personnel manager.
E.A. Onifade, security superintendent.
A. Yusuf, B.S., controller of stores.

CEREAL IMPROVEMENT PROGRAM

Y. Efron, Ph.D., assistant director and program leader.
K. Alluri, Ph.D., rice agronomist/breeder.
S.K. Kim, Ph.D., maize breeder.
J. Yamaguchi, Ph.D., rice physiologist.*
Kaung Zan, Ph.D., IRRI liaison scientist.
M. Bjarnason, Ph.D., CIMMYT maize breeder.
J. Arrivets, M.S., IRAT liaison scientist.
F.H. Khadr, Ph.D., maize breeder IITA/CEC, Zaria.
H.N. Pham, Ph.D., CIMMYT, maize breeder.
V.T. John, Ph.D., rice pathologist.
Z.T. Dabrowski, Ph.D., maize entomologist.
A.O. Abifarin, Ph.D., IITA liaison scientist, WARDA, Liberia.
V.L. Asnani, Ph.D., SAFGRAD, project leader, Upper Volta.
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T.G. Hart, Ph.D., chief of party, NCRE, Cameroon.
E.A. Atayi, Ph.D., agricultural economist and deputy chief of party, NCRE, Cameroon.
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A.C. Roy, Ph.D., rice agronomist, NCRE, Cameroon.
J. Chung, Ph.D., maize breeder, NCRE, Cameroon.
H. Talleyrand, Ph.D., agronomist NCRE, Cameroon.
Om.P. Dangi, Ph.D., sorghum and millet breeder, NCRE, Cameroon.
D. McHugh, extension agronomist NCRE, Cameroon.
M.S. Alam, Ph.D., rice entomologist.
L. Everett, Ph.D., maize breeder.
J. Gibbons, Ph.D., rice breeder.
J.M. Fajemisin, Ph.D., maize pathologist/breeder (visiting scientist), National Cereals Research Institute, Nigeria.
D. Makonnen, Ph.D., maize breeder (visiting scientist), Addis Ababa University, Ethiopia.

FARMING SYSTEMS PROGRAM

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C. Garman, M.S., agricultural engineer.
N.C. Navasero, B.S., associate agricultural engineer.
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G.F. Wilson, Ph.D., agronomist.
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M. Ashraf, Ph.D., agricultural economist.
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A.S.R. Juo, Ph.D., soil scientist (chemistry).
B.T. Kang, Ph.D., soil scientist (fertility).
R. Lal, Ph.D., soil scientist (physics).

K. Mulongoy, Ph.D., microbiologist.
I.O. Akobundu, Ph.D., weed scientist.
P.S.O. Okoli, Ph.D., agronomist.
D.S. Ngambeki, Ph.D., agricultural economist.
Y. Arora, Ph.D., soil scientist (chemistry).*
B.S. Ghuman, Ph.D., soil scientist (physics).*
O.A. Opara-Nadi, Ph.D., soil scientist (physics).
T. Kosaki, Ph.D., soil scientist (soil evaluation).
J.A. Poku, Ph.D., weed scientist.
H.O. Maduakor, Ph.D., soil scientist.*
G. Cesarini, Ph.D., socio-economist (visiting scientist).*
M.A. Gowman, visiting weed scientist (FAO/ICI).
P.L.G. Vlek, Ph.D., visiting soil scientist (IFDC).*
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S.K. Mughogho, Ph.D., soil scientist (fertility), (IITA/IFDC/IFAD).
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R. Balasubramanian, Ph.D., soil fertility specialist (MIDAS, Ghana/IITA/USAID).
J.O. Braide, Ph.D., agronomist (MIDAS, Ghana/IITA/USAID).
N.V. Nguu, Ph.D., agronomist, (Cameroon/IITA/World Bank).
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J. Van der Heide, Ir. soil scientist.*
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F. Nweke, Ph.D., associate economist.
D. Vuylsteke, Ir., plant physiologist (plantains).
N. Hulugalle, Ph.D., soil scientist.
E. Baryeh, Ph.D., agricultural engineer.

GRAIN LEGUME IMPROVEMENT PROGRAM

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L.E. Jackai, Ph.D., entomologist.
S. Asanuma, Ph.D., microbiologist.
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B.B. Singh, Ph.D., plant breeder.
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F.E. Brockman, Ph.D., agronomist and project leader, Programme National Manioc (PRONAM), Zaire.
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A.M. Varela, B.Sc., entomologist, Paraguay.
M. Veloso, physical plant services officer, PRONAM, Zaire.
J.A. Whyte, Ph.D., plant breeder, CNRCIP, Cameroon.
F. Schulthess, Ing., entomologist, FAO associate expert.
E.M. Chukwuma, research associate.

TRAINING PROGRAM

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C. Puttevils, Lic., translater/interpreter.
D.W. Sirinayake, training officer.
A.P. Uriyo, Ph.D., training officer and agronomist.

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F.O. Ogunyemi, F.C.C.A., accountant.

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R.E. Rathbone, M.S., editor.*
N.C. Russell, M.A., editor.
F.M. Gatmaitan, Jr., senior graphic designer.

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P.D. Austin, B.S., officer in charge, Onne.

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M. Davids, Ir., associate expert, FAO.

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S.B. Akande, assistant cataloger (on study leave).

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A. Amrani, heavy equipment service officer.
A.C. Butler, buildings and site service officer.
O.O.A. Fawole, automotive service officer.
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J. Lukowski, electrical service officer.
D. J. Amaratunge, refrigeration/air conditioning service officer.
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G. Thottappilly, Ph.D., virologist.
J.W.M. van Lent, Ir., virologist.
H. Huttinga, Dr. Ir., visiting scientist.

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*Left during the year.

Airview of a portion of IITA's main experimental farm at Ibadan, Nigeria. Research is also done in two other ecological zones of Nigeria and in other countries in cooperation with national, regional, and international centers.