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Copies of this publication may be obtained from

Distribution Unit, IITA

ISBN 978 131 186 X

Printed in Nigeria by IITA and Modern Design & Associates Ltd.

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Abstract

The International Institute of Agriculture (IITA) is among the major suppliers of genetic materials to national agricultural research and extension systems in West and Central Africa for the development of improved maize varieties. This paper presents the results of a survey of the impact of germplasm from IITA on maize production and food security in 11 countries, which together contain over 90% of the area cultivated to maize in West and Central Africa. Between 1965 and 1998, the public sectors of these countries released a total of 186 varieties while the private sectors released 86 varieties. In the 1990s, IITA was the major source of maize germplasm used by these countries. Increased maize production from improved varieties was 2.6 million tonnes of grain in 1998, which could provide 2200 kcal per person per day to about 9.3 million people for one year. A total of 490 scientists were trained by IITA in maize research between 1970 and 1998.

Key words: maize, impact, IITA, West and Central Africa

Introduction

Maize is a major cereal crop in West and Central Africa, currently accounting for a little over 20% of domestic food production in Africa. Its importance has increased as it has replaced other food staples, particularly sorghum and millet (Smith et al. 1994), and it has also become a major source of cash for smallholder farmers (Smith et al. 1997). Trends in maize production indicate a steady growth, mostly due to the expansion of cultivated area, but also the result of improved maize yields. In 1989–1991, the average maize yield in Africa of 1.2 tonnes per hectare was twice that estimated for the 1950s, before improved varieties were generally available (Byerlee and Heisey 1997). In West and Central Africa in the last 20 years widespread adoption of improved maize varieties in the savannas means that maize is no longer a backyard crop but a major cereal grown for both cash and food (Eckebil 1994; Fajemisin 1994; Smith et al. 1997).

The International Institute of Tropical Agriculture (IITA) has a regional mandate for maize research in West and Central Africa. IITA works in partnership with national research and extension services to develop and disseminate improved maize technologies that meet the requirements of their major clients, small-scale farmers. There is no doubt that IITA and the other Future Harvest centers in the Consultative Group on International Agricultural Research (CGIAR) have contributed greatly to increased maize production in West and Central Africa. This is the first systematic study to assess the impact of IITA's work in maize genetic improvement on production in West and Central Africa.

Maize improvement at IITA

Early work at IITA focused on the development of high-yielding open-pollinated maize varieties with resistance to the prevailing major diseases in the humid forest and moist savannas of West and Central Africa.

The research accomplishments of IITA to combat the widespread outbreak of maize streak virus (MSV) disease in the 1970s received the King Baudouin award in 1986. Over the last 20 years, IITA has continued to supply the national maize research programs in West and Central Africa with MSV-resistant maize germplasm.

IITA-developed germplasm with resistance to the maize diseases streak, blight, rust, and leaf spot has been used directly in some countries, including Burundi, Ethiopia, Kenya, and Mozambique. At the same time, IITA has transferred technologies such as screening and breeding techniques in order to enhance the capacity of national and regional partners to develop higher yielding and stable varieties.

Early- and extra-early maturing varieties were developed in regional trials that have enabled maize production to expand into the Sudan savannas where the short rainy season had prevented maize cultivation, and to be used in double cropping systems in areas with a long rainy season.

A hybrid maize program launched in 1979 led to the development and release of first generation inbred lines and hybrids in 1983. A spillover effect of this release was the formation of seed companies to market the hybrid maize. In 1993, each of the three seed companies operating in Nigeria officially announced IITA's open-pollinated and hybrid maize varieties in their seed catalogs.

Downy mildew disease of maize, caused by the fungal pathogen *Peronosclerospora sorghi*, was widely reported in Africa in the 1970s and has become a serious threat to maize production in parts of Nigeria, the Democratic Republic of Congo, Mozambique, and Uganda (Kling et al. 1994). Development of downy mildew-resistant varieties has been a major priority in the breeding program at IITA since the early 1980s. Working with national researchers, a number of widely adopted downy mildew-resistant varieties have been developed and released by IITA.

Striga, a parasitic weed that severely affects yields of maize and other crops, infests almost 21 million hectares of land in Africa. Combating *Striga* has been one of the focal issues for the IITA maize research team since the mid-1980s. Major achievements have been made in breeding both for tolerance to *Striga* and for reduced emergence of the parasite. Efforts are now under way to identify the mechanisms of resistance in these new varieties and inbred lines. The Rockefeller Foundation has provided funds for a collaborative project between IITA, the Internartional Maize and Wheat Improvement Center (CIMMYT), and the Kenyan national program to map the genes for resistance to *Striga* in IITA germplasm. The research is ongoing and scientists expect to have a map of one population ready in 2000. This should enable them to initiate marker-assisted backcrossing of the resistance genes into diverse, adapted populations. On-farm trials of *Striga*-resistant maize varieties and other methods for integrated control are currently being conducted by national research scientists and extension workers in many countries of West and Central Africa. The main objective is to promote the adoption of *Striga*-resistant varieties in rotation with selected legumes that also help control the weed.

High-yielding, improved varieties are sometimes not adopted by farmers because they may be susceptible to storage weevils or may lack the characteristics desired by end-users for local food preparation. IITA has worked closely with scientists in Benin Republic to understand the mechanisms of weevil resistance and to develop varieties acceptable to farmers and consumers. A food technologist is also involved in the development of diversified maize products, to create new markets for maize products. Recently, breeding efforts have been initiated to enhance the micronutrient content of maize varieties, to combat the widespread diseases iron deficiency anemia and corneal blindness caused by vitamin A deficiency. Another major human health concern is the problem of aflatoxin contamination in stored maize, which IITA is also addressing.

IITA works with the West and Central Africa Collaborative Maize Research Network (WECAMAN) to coordinate international trials of improved maize germplasm that is distributed to national programs on request. In addition, several tonnes of breeders' seed are distributed each year in bulk samples of 1–5 kg for multiplication by national programs. IITA scientists are actively involved in the regional networks and in a number of training activities to enhance the capacity of national scientists to develop their own technologies and to promote adoption of those technologies by farmers. Another important activity supported by WECAMAN is the promotion of community seed production schemes to meet farmers' demand for high quality seed.

In addition to its breeding program, IITA maintains in its genebank about 500 local accessions of maize collected from different countries in West and Central Africa. These accessions have been extensively used to develop drought-tolerant and *Striga*-resistant populations.

The impact study

The study was designed to assess the impact of IITA's work in maize genetic improvement on maize production in West and Central Africa. The specific objectives of the study were to:

- document the extent of use of maize germplasm from IITA by the breeding programs of countries in West and Central Africa for basic research and variety development
- assess the spread of maize varieties developed at IITA, and estimate changes in maize production due to these maize varieties
- assess the benefits of this research on the economy and food security of the region
- document the contribution of IITA's training program to human capital development for maize research in West and Central Africa

The study targeted 11 countries, eight in West Africa and three in Central Africa, which together contain over 90% of the area cultivated to maize in West and Central Africa (Table 1). A survey questionnaire was completed by the leaders of national breeding programs on maize. Information requested included details of maize varieties released in the country during the period 1965–98, parent

Table 1. Countries surveyed in the impact study, and number of maize varieties released between 1965 and 1998

Country	Number of varieties released	
	Public sector	Private sector
West Africa	139	81
Benin	16	0
Burkina Faso	25	20
Ghana	17	14
Guinea	12	0
Mali	9	0
Nigeria	29	23
Senegal	22	16
Togo	9	8
Central Africa	47	0
Cameroon	13	0
Chad	14	0
D.R. of Congo	20	0
Total	186	81

materials, area planted, and details of training through IITA. Where respondents had difficulty providing data, literature data or expert opinion was used, or data available were averaged and applied to all countries.

Release of improved maize varieties

Both the public sector and an emerging private sector were involved in the development and distribution of new improved maize varieties in West and Central Africa. From 1965 to 1998, the public maize research programs of the countries surveyed released a total of 186 maize varieties. Private companies released 81 maize varieties in the countries surveyed in West Africa; there were no private sector releases in the Central African countries (Table 1). The public sectors (including IITA) play a key role in the development of the private sectors because about 98% of genetic materials used by them to develop their own varieties were from the public sectors.

The number of varieties released has increased steadily since the early 1970s, probably reflecting the work of IITA and the other Future Harvest centers (Fig. 1). IITA has had the mandate for maize research in West and Central Africa since 1980. Before then, national programs in the surveyed countries released an average of 0.83 varieties every year; this figure rose to 5.19 varieties per year after 1980.

The released varieties had three main genetic sources: IITA and CIMMYT breeding programs, and local varieties. CIMMYT was the major source in the 1970s and 1980s, with IITA becoming the main source in the 1990s (Table 2). Together, IITA

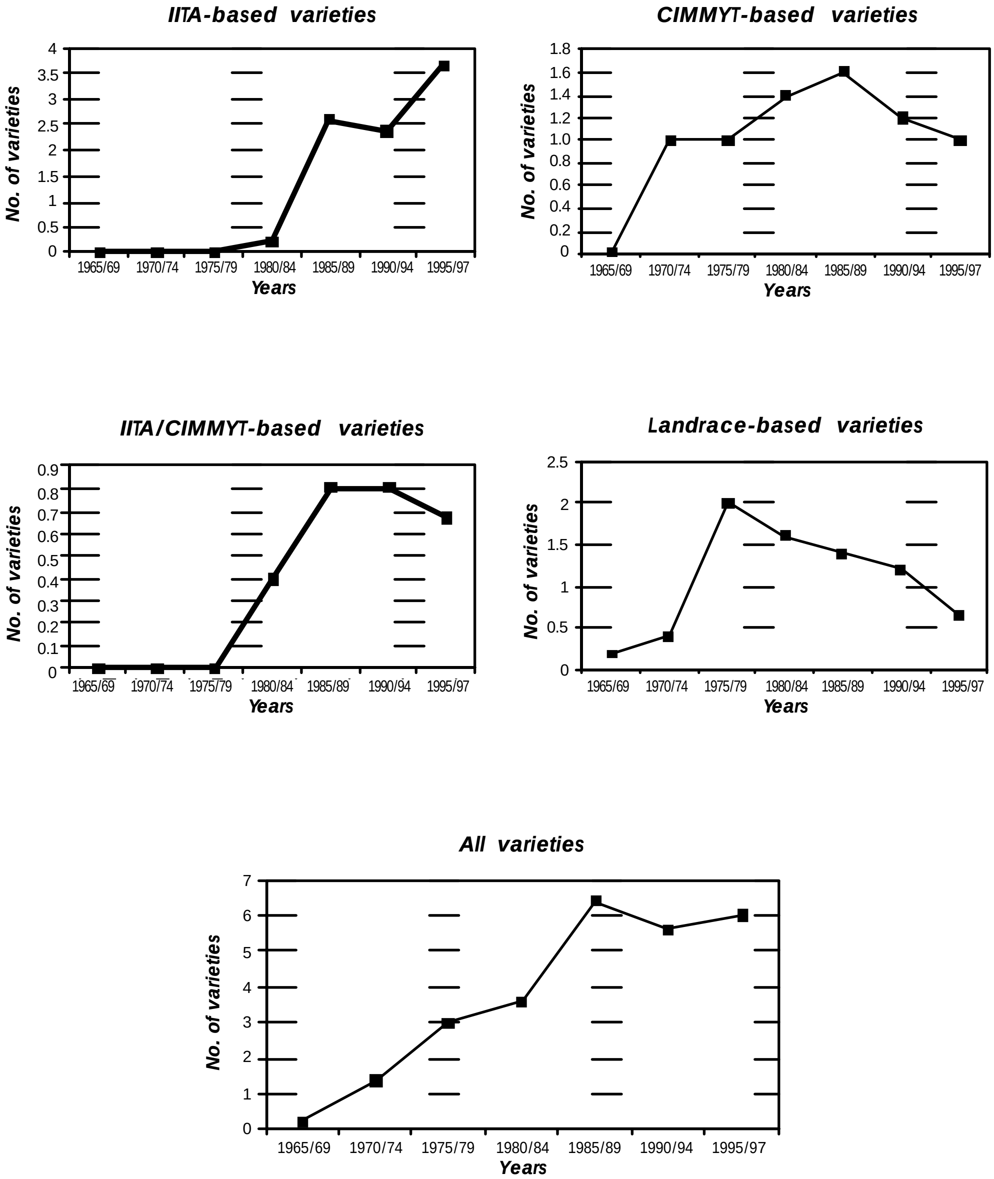

Figure 1. Release of maize varieties in West and Central Africa, 1965–1997.

and CIMMYT supplied nearly 95% of the germplasm in the 1970s, and 60% in the 1990s.

Most of the IITA-supplied germplasm needed little or no further improvement or adaptation before use (Table 3). This strategy aims to support weak national breeding programs by supplying nearly finished products.

The IITA-supplied germplasm possessed one or more desirable traits, such as resistance to biotic constraints (viruses, insect pests, downy mildew, and *Striga*),

Table 2. Source of germplasm incorporated in maize varieties released in survey countries (%)

Source	1965–69	1970–79	1980–89	1990–97
IITA	0	15.0	11.0	49.2
CIMMYT	0	72.9	48.2	10.9
Local varieties	50	3.6	12.7	15.7
Others	50	8.6	28.2	24.2

Table 3. Use of maize germplasm from IITA in the varieties released by national programs in the survey countries (% of varieties)

Category	1970–79	1980–89	1990–98	All
1	0	20	23	22
2	50	40	25	27
3	50	40	52	51

1 = basic germplasm (substantial improvement done after being received from IITA).

2 = selection from IITA trials, with some improvement for local adaptation.

3 = direct use of IITA material, no additional improvement done except seed multiplication.

different maturity groups (late, early, and extra-early), grain color (yellow and white), or grain texture (dent and flint), as well as high and stable yields.

Capacity building

IITA has contributed significantly to capacity building in the national systems for maize research in West and Central Africa. A total of 490 scientists were trained at IITA on maize research between 1970 and 1998 (Table 4), including 30 PhD and MSc students. Assuming these former IITA students now work in their national systems, IITA trainees represented about 36% of senior researchers and 14% of intermediate level researchers working in maize research and seed production in the countries surveyed (Table 5).

The number of national scientists remains very low compared to the area planted to maize in the study area. The ratio of senior researchers to hectares planted to maize was 1:106 800 in 1998. This highlights the need to strengthen local and regional capacities for maize research in West and Central Africa.

Food security

The increase in production was calculated from the area planted to improved varieties in each country in 1998 and the yield advantage. The area planted to improved varieties was found through farm surveys. The yield advantage was calculated as the difference in farmers' fields between the average yields of improved and local varieties (or improved varieties older than 5 years). Potential yields of improved varieties from either on-station or on-farm research would be higher. However, the measurement of yield advantages did not take into

Table 4. Number of scientists from the survey countries trained at IITA in maize research

	1970–79	1980–89	1990–98	Total
PhD				
Men	3	4	10	17
Women	0	0	3	3
Total				20
MSc				
Men	2	4	3	9
Women	0	1	0	1
Total				10
Research training associates				
Men	7	8	1	16
Women	0	1	0	1
Total				17
Visiting research scholars				
Men	7	6	1	14
Women	0	0	0	0
Total				14
Group trainees				
Men	25	273	107	405
Women	0	9	15	24
Total				429
All				
Men	44	295	122	461
Women	0	11	18	29
Total	44	306	140	490

Table 5. Personnel working in maize research in the survey countries in 1997–98

	Public sector (10 countries)	Private sector (3 countries)
Senior researchers and administrators	52	25
Intermediate-level researchers and administrators	61	26
Technicians and other support personnel	117	87
Farm and casual laborers	272	271
Total	502	409

consideration the number of years or cycles that were required to develop improved varieties. The increase in production was converted into energy, allowing for 15% waste, using figures from FAO food composition tables (FAO 2000).

On average, about 37% of the total area (8.2 million hectares) were planted with improved maize varieties (Table 6). These improved varieties resulted in a yield advantage of 45.3% over local varieties. The increased production of maize grain

Table 6. Estimated economic benefits from the use of improved maize varieties, 1998

	Area planted		Average yield		Increased production	GEB*/ha of improved	No. of beneficiaries	
	Total (10^3 ha)	Improved varieties (%)	Local varieties (t/ha)	Advantage (%)	(10^3 t)	varieties ($US)	Total	% 1996 popn
Benin	513	25	1.2	50	230	102	293,851	5.28
Burkina Faso	113	46	1.5	53	41	160	275,108	2.55
Ghana	550	53	1.5	33	146	109	550,783	3.09
Guinea	86	23	1.1	50	11	85	40,342	0.54
Mali	275	23	1.5	67	63	120	238,830	2.15
Nigeria	4,255	40	1.2	83	1,702	209	6,431,780	5.59
Senegal	139	90	1.1	24	32	46	121,637	1.43
Togo	382	1.3	1	100	5	155	19,386	0.46
Cameroon	374	28	1.8	17	31	48	118,810	0.88
D.R. of Congo	1,437	31	0.8	83	312	151	1,179,590	2.52
Chad	65	70	1.1	24	12	36	44,774	0.69
Total	8,188	37	1.3	45	2,585	162	9,314,890	3.77

*GEB = gross economic benefit.

was 2.6 million tonnes per year. This is equivalent to the required daily energy for about 9.3 million people, or nearly 4% of the total population in the countries included in this study, which is above the 3% yearly population growth rate for Africa. In money terms, improved maize varieties gave gross returns of about US$162 per hectare of land planted to improved maize varieties.

The area planted with improved varieties of maize varied greatly between countries, from 89% in Senegal to 1.3% in Togo. The yield advantage also varied, from 17% in Cameroon to 100% in Togo. The gross economic benefit ranged from US$36 per hectare in Chad to US$200 per hectare in Nigeria; and the percentage of the population to gain food security varied from 0.5% in Togo to 5.6% in Nigeria.

Conclusions

An average of 17 maize varieties were released per country by the public and private sectors of the survey countries between 1965 and 1998. IITA and CIMMYT contributed significantly to increasing the number of varieties released by the national programs, and were the main sources of germplasm. IITA also contributed substantially to capacity building for maize research in sub-Saharan Africa and to the development of private seed companies. Increased production in 1998 from the use of improved varieties was about 2.6 million tonnes, which could feed 9.3 million people. CG centers such as IITA can still contribute to an increased rate of adoption of improved varieties in West and Central Africa.

Acknowledgments

IITA and the CGIAR Impact Assessment and Evaluation Group (IAEG) sponsored this study. Data collection was completed by the leaders of maize programs in the study countries: Benin Republic (C.G. Yallou), Burkina Faso (J. Sanou), Cameroon (C.G. Zonkeng), Chad (M. Dabi), Democratic Republic of Congo (M. Mbeya), Ghana (K. Obeng-Antwi), Guinea (S. Camara), Mali (N'tji Coulibaly), Nigeria (B.A. Ogunbodele), Senegal (A. Ndiaye), and Togo (E.Y. Mawule). J.M. Fajemisin and B. Badu-Apraku coordinated data collection in some countries of West Africa. R. Evenson, the CGIAR IAEG principal investigator for the CGIAR germplasm study, provided timely advice.

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