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Eradication Strategy for Maize Downy Mildew

Proceedings of an African
Conference and Workshop

K. F. Cardwell

EDITOR

Proceedings of the Maize Downy Mildew Eradication Campaign Conference and Workshop, 22–24 February 1994, Ibadan, Nigeria

Copublishers:

International Institute of Tropical Agriculture (IITA)
Food and Agriculture Organization of the United Nations (FAO)
Federal Department of Agriculture, Nigeria

ISBN 978-131-097-9

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International Institute of Tropical Agriculture

Oyo Road, PMB 5320
Ibadan, Nigeria

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Printed by Intec Printers Ltd., Ibadan, Nigeria

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"Crazy top" symptoms of downy mildew

Acknowledgments

The support of the International Institute of Tropical Agriculture in the organization of the conference and workshop are gratefully acknowledged. The untiring assistance of Dr V. Adenle and Mrs C.F. McDonald deserve special acknowledgment. The assistance of Dr R. Iken and Dr R. B. Singh of the Food and Agriculture Organization of the United Nations (FAO) is also acknowledged.

These proceedings were produced by the IITA Publications Unit. Thanks are due particularly to K. Atkinson, T. Owoeye, and Y. Olatunbosun for their editorial advice and preparation of the text for publication. The joint meetings and publication of the proceedings were funded, in large part, from project no. GLO/92/T02 of the FAO with the Nigerian government. The Nigerian Federal Department of Agriculture, particularly A.O. Edache and the special Downy Mildew Task Force chaired by T.O. Adenola, have led the organization of the campaign and implementation of its action program, which included holding of the conference and workshop.

Contents

Acknowledgements v
Preface ix

ADDRESSES

Chairman's Address 3
N.O. Adedipe

Welcome Address 4
Lukas Brader

Keynote Address 5
Mallam Adamu Ciroma

Opening Address 7
Captain Adetoye Sode, NN

An Address Launching a Book Entitled *Maize Improvement, Production and Utilization in Nigeria* 9
Maurice A. Zard

Closing Address 10
C.O. Lufadeju

TECHNICAL PAPERS

The Nature of the Downy Mildew Disease of Maize Caused by *Peronosclerospora sorghi*: a Technical Overview 15
K.F. Cardwell

Breeding Maize for Downy Mildew Resistance 26
S.K. Kim, J.G. Kling, J.E. Iken, K.F. Cardwell, A.O. Adenola, and V. Adenle

The Role of the National Seed Service in Strategies of Maize Downy Mildew Control in Nigeria 34
I. Usman

Strategies for Maize Downy Mildew Control: Efforts of Private Seed Companies 41
M.D. Gupta

Strategies for Downy Mildew Control: Ciba's Approach 45
P.N. Ikemefuna

The Experience of Nigerian Maize Farmers 49
M.M. Omole

Coping with Maize Downy Mildew: the Experience of Farmers 52
Bayo Ajayi

Summary of State-by-State Report of Downy Mildew Incidence in Nigeria 54
O.A. Adenola

COUNTRY REPORTS

The Status of Downy Mildew in the Republic of Benin 61
Chakirou Lawani

The Status of Downy Mildew in Uganda 64
George Bigirwa

The Status of Downy Mildew in Zaire 67
Mukendi N'kashama

STATE AND INSTITUTIONAL REPORTS

Ondo State 73

Osun State 75

Oyo State 77

Kogi State 79

Edo State 82

Kwara State 83

Seed Production and Distribution: the Experience of Private Seed Companies 85
E.A. Obinyan

Seed Production and Distribution: the Experience of Agricultural Development Projects 92
N.B. Mjindadi and O.O. Oyebanji

Features of World Bank Support for Nigeria's Seed Sector 97
J. Yayock

A One-State Model for Implementation of a Maize Downy Mildew Eradication Strategy: A World Bank Plan 100
N.S. Maini and L.O. Fajana

Agricultural Development Program's Strategy to Control Downy Mildew Disease in Ondo State 103
G.O. Fasuyi

Alternative Strategies in the Distribution of Seed Treatment Chemicals 106
U. Kipfer

PROCEEDINGS SUMMARIES
Conference and Workshop Summary 115
Group Session Summaries 116
Executive Summary—Workshop Resolutions 121

ANNEXES
Annex 1. FAO/Nigeria TCP Proposal for Control of Maize Downy Mildew in Nigeria 127
Annex 2. Projected DMR Seed Requirements/Project Year (tonnes) 130
Annex 3. List of Capital and Expendable Materials and Personnel Required for Breeder Seed Production and Maintenance 131
Annex 4. State Representation for the Campaign on the Control of Downy Mildew 132
Annex 5. Abbreviations and Acronyms 133
Annex 6. List of Contributors 135

Preface

For the past 18 years, and especially since 1991, the downy mildew disease of maize has been gaining ground in Nigeria, threatening approximately 1 million hectares of planted maize crops in a spreading pattern. The Nigerian government organized a campaign in 1993 to control the spread of the downy mildew pathogen and the consequent crop losses. This publication is the proceedings of the one-day conference and ensuing two-day workshop which launched the control effort.

The conference was organized to focus attention on the campaign roles and responsibilities of international and national agencies which took part at the outset. To highlight the importance of the problem, the farmers themselves gave accounts of how they had lost entire maize crops to downy mildew.

The workshop featured presentations by staff of the commercial and extension sections of agricultural development projects of the affected states. Representatives of private and public seed producers, industry, and agricultural chemical suppliers presented the logistical problems that they had encountered in confronting the downy mildew problem in the field. The participants divided into working groups which inventoried the infrastructure that was in place in Nigeria to conduct a control campaign. They identified the gaps and assessed the needs of the various agencies and businesses which must play a part if a control campaign is to succeed. Participants from other countries where downy mildew threatens maize production discussed potential control strategies for their countries using the Nigerian experience as a model.

To prevent crop losses from such diseases as downy mildew, concerted action must be planned from the level of government policy all the way to the farmer. In the following pages, the conference and workshop have described the range of information which must be available for that to happen.

K.F. Cardwell
Maize Pathologist
IITA

ADDRESSES

Chairman's Address

N.O. Adedipe
Vice Chancellor, University of Agriculture, Abeokuta

It gives me very great pleasure to be here this morning to honor the invitation to chair the opening ceremony of this very important and timely conference and workshop on designing an eradication campaign for the control of maize downy mildew. I thank the organizers of the conference for the invitation.

Maize has become the predominant cereal crop in Nigeria in the last 5–6 years, particularly in terms of the ecological zones covered in its production. The increased production of maize has resulted from extension programs of the state agricultural development projects; from improved adapted maize varieties, particularly the TZB series; from the spread of area of cultivation to the moist savanna; and from increased utilization of production inputs. The lowland humid forest zone, characterized by high rainfall and humidity, presents problems of high incidence of pests and diseases, with food security and economic implications.

Downy mildew, a devastating fungal disease, appears to have the potential to spread with the expansion of maize cultivation. Symptoms of the disease include stunting, chlorotic stripping, narrowing of leaves, phyllody of floral parts, and barrenness. The causal organism is thought to be a complex *Peronosclerospora* spp. Plants infected early suffer 100% loss of yield and incidences in epidemic proportions have been reported in Ondo and Oyo states in the last three years.

There are fears that the disease may soon become epidemic in the neighboring states of Edo, Lagos, and Ogun if adequate control measures are not put in place.

In evolving an eradication strategy, this conference intends to expand awareness among government and state agencies, donors, and the private sector about the problem and to foster an interchange of ideas that would enhance the plan of eradication.

Some of the options available in the development of an eradication strategy are: the use of the excellent genetic resistance available in the germplasm collection of the International Institute of Tropical Agriculture (IITA) and the Institute of Agricultural Research and Training (IAR&T) in Ibadan; seed dressing with appropriate chemicals; and some postemergence application of chemicals. Luckily, some resistant varieties of both open-pollinated and hybrid varieties of maize are now available to farmers to combat the menace of downy mildew. However, we are all aware of the notoriety of fungi to evolve new strains that can overcome existing types of genetic resistance.

I hope that by the end of this conference and workshop, workable strategies would have evolved in the campaign to eradicate downy mildew of maize from the lowland humid forest zone of West Africa, where maize production is a major component of farming systems.

In so hoping, we commend the efforts of the organizers—the Food and Agriculture Organization of the United Nations (FAO), the Federal Ministry of Agriculture, and IITA—for hosting this all-important event.

Thank you all for attending this opening ceremony.

Welcome Address

Lukas Brader
Director General, International Institute of Tropical Agriculture

It is with great pleasure that I welcome you to IITA and to this conference and the ensuing workshop on the control of maize downy mildew.

It is almost five years since FAO first contacted IITA with the objective of collaboration on activities in technology implementation. As it happened, that was also the time that a special task force from the Nigerian Federal Department of Agriculture contacted IITA to participate in finding a solution to the problem of the downy mildew disease of maize. IITA was in the unique position to connect the players from the different teams and to coordinate this important meeting.

Scientists from IITA have been working on downy mildew disease for over 15 years, being one of the major problems in improving maize production in West Africa. Now the key elements of improved agricultural technology to control this disease are finally ready to be released.

I am pleased to see the range of people here that are ready to work together to solve this problem. There are representatives from all sectors; government, NGOs, private industry, and the public sector; research scientists and farmers; agencies, donors, and extension agents. It is indeed a satisfying role for IITA to be able to facilitate a gathering of this type.

Even though IITA is a research institute, we do not see research as a goal in itself. It only becomes useful when results are approved at farm level. As the national programs of Africa develop and strengthen, our role also becomes one of partnership in collating research results. We serve to facilitate both regional and interregional agriculture and agricultural resources.

This conference center should be like fertile ground to healthy seed. All of the components for productive yield are here; the right people, the appropriate technologies, and the spirit to work together. There is no doubt that we are dealing with an extremely important problem that can seriously affect, if not totally, the benefit to be gained from maize production in Nigeria and other parts of West Africa.

Downy mildew is spreading, killing maize plants. However, I am also optimistic that this conference can come up with a campaign that can stop the spread of, and hopefully eliminate, the disease.

A number of very promising solutions are available; so, we are anxious to see your battle plans and, more importantly, to see them implemented in an effective manner.

I wish you success in your deliberations over the next few days and, again, I say welcome to IITA.

Keynote Address

Mallam Adamu Ciroma
The Hon. Minister of Agriculture and Natural Resources

It gives me great pleasure to be here on this important occasion to address this international workshop on the eradication of the downy mildew disease of maize in the West-African sub-region.

As you may be aware, maize has almost become the most important cereal crop in Nigeria. Grown on an estimated 2.5 million hectares of land and with annual production of not less than 3.0 million tonnes, the position of this crop in the Nigerian economy can be fully appreciated. Over the years, production has spread from the rain forest zones to the derived savanna regions of the country. Domestic utilization of maize as a major food crop and an industrial crop is growing rapidly. Indeed, maize has become a major food item often referred to as the "hunger breaker" being the first crop to appear after the dry season. Industrial utilization of maize increased very rapidly following the import substitution policy adopted under the structural adjustment program.

The occurrence and spread of many diseases of maize, particularly downy mildew, pose considerable danger to our national effort to accelerate the production of this vital crop. Records show that downy mildew disease was first reported in 1969 in Samaru, near Zaria, Kaduna State and later, in 1975 at Kabba, Kogi State, and Owo in Ondo State. In 1991, heavy infestations of the disease were reported in ten states of the Federation namely; Benue, Borno, Edo, Kaduna, Kogi, Kwara, Ondo, Osun, Oyo, and Yobe. In the forest and transitional zones of the country, an estimated area of 75,000 square kilometers is presently affected. It is certain, then, that if the disease is not controlled, it will spread to more areas of the country with the resultant reduction in grain production and loss of farmers' incomes.

This workshop is timely and I commend the organizers immensely for their initiative. Following the outbreak of the disease in 1991, my Ministry commissioned a survey team made up of experienced scientists and specialists to make a full-scale report on the outbreak, including its economic implications. The team was required to establish the extent of the outbreak, determine control methods, and propose recommendations for short, and long-term solutions to the problem. The survey confirmed the disease incidence in ten states of the Federation with a degree of infection ranging from 2% to 100%. Millet and sorghum crops were also reportedly affected in some cases. The survey estimated a national average yield loss of 10% for maize. Some of the major short-term solutions proposed by the survey team which my Ministry adopted included the use of fungicides, as well as locally available resistant varieties. The medium- and long-term strategies include intensification of continuous research on varietal selection, manipulation of production factors, and publicity focused on farmers' education as it relates to the disease, as well as training of farmers and extension workers. In implementing the survey team's recommendations, my Ministry purchased and distributed seed-dressing chemicals worth 5 million naira to the affected states for their farmers to use. Funds were also made available to the National Seed Service (NSS) to enable them to embark on massive multiplication of downy mildew-resistant (DMR) varieties of maize for distribution to farmers. The control of agricultural pests and diseases, I should stress, is always a running battle, and for this reason my Ministry will continue to monitor the disease situation and sustain the control effort.

As part of our overall crop pest and disease strategy, the Plant Quarantine Service is to introduce appropriate internal quarantine measures. Under the National Seed and Plant Quarantine Project Agreement entered into between Nigeria and the World Bank, the two agencies are being assisted with a loan of US $14 million to strengthen their services and modernize their operations.

I would like to place on record my appreciation of the cordial relationship that exists between IITA and my Ministry. With the recent transfer of the national research institutes to my Ministry, I expect renewed vigor in collaboration between our national research systems and IITA in the training of Nigerian agricultural personnel, including extension workers. I acknowledge similar roles in our sister African countries. IITA pioneered research on hybrid maize in Nigeria. The country is already deriving considerable benefits from this research and that on several other crops, notably cassava and cowpea. The strategic place of soybean in human nutrition and livestock feeds makes it imperative for IITA to focus greater resources on soybean research. The malnutrition problem in Africa is too well known for elaboration. The present low levels of yield of soybean varieties available in Nigeria do not encourage investment in soybean production.

The commitment of the present military administration to the development of agriculture in the country cannot be doubted. The 1994 budgetary allocation to agriculture and fiscal policies relating to the sector are bold efforts aimed at the attainment of our goal of national food security. This year's budget also marks a milestone in our efforts to accelerate the production of industrial crops. Government has set aside the sum of 200 million naira for the accelerated production of an industrial crops program. The arable crops under the program include soybean, cotton, and groundnuts. The tree crops covered are cashew, cocoa, gum arabic, oil palm, and rubber. The project is designed to enhance production of these target crops to meet the domestic demand and for export.

In conclusion, let me itemize what my Ministry expects from this important workshop. This workshop should:

1. Set in motion strategies for developing maize varieties that have a higher degree of resistance to downy mildew disease than what we presently have.
2. Evolve strategies to develop high-yielding hybrid maize which adapts to wider ecologies (forest, savanna, midaltitudes etc.).
3. Evolve strategies aimed at developing hybrids and open-pollinated varieties that are highly adaptable to the acid soils of the country.
4. Evolve strategies to develop hybrids and open-pollinated varieties of short duration, suitable for the dry regions of the country.
5. Evolve strategies for the use of pesticides in combating maize diseases, especially downy mildew.

With the array of scientists assembled here, I believe you are equal to the task. I wish you fruitful deliberations and safe return to your respective destinations.

Opening Address

Captain Adetoye Sode, NN
Military Administrator, Oyo State, Federal Government of Nigeria

It is a unique opportunity to be invited to deliver the opening address at this all-important workshop on a topical problem—downy mildew disease of maize. I was gladdened to note that eminent scientists of international repute are concerned with the total eradication of the most devastating fungal disease of maize.

As you are well aware, agriculture is the predominant occupation of the people of Oyo State and they produce substantial quantities of grain. In view of this, Oyo State is very much concerned about the threat posed to its grain production potential by this devastating disease.

The disease has spread like wildfire since its entry into the state in 1992 from neighboring Kwara and Osun states, and devastated over 50,000 hectares of maize plots. It caused an estimated loss of over N65 million in 1992. The figure for 1993 will definitely be higher in view of the large areas put to maize production in the 1993 season.

Downy mildew disease was initially strange to the farmers. At the onset of the disease they mistook the symptomatic yellow foliage coloration they observed to be nutrient stress. They consequently rushed to apply fertilizer in the hope that the plants could be salvaged. The farmers eventually abandoned the plots when the plants did not recover. This administration cannot allow this trend to continue especially if we must achieve the much desired goal of food self-sufficiency.

At this juncture, let me acknowledge, with gratitude, all past efforts of both federal and state governments as well as research institutes to keep the disease in check with the use of resistant varieties and seed-treatment chemicals. In particular, I thank the Federal Government through the Honorable Minister of Agriculture for the kind assistance in the form of Apron Plus® and DMR foundation seeds which was recently allocated to Oyo State. I should, however, report that, because of the limited supply of chemicals, the anticipated yield of certified seeds would be a drop in the ocean. I therefore, would like to request that Apron Plus® and DMR foundation seeds be supplied to all the affected states in general but Oyo State in particular. I must emphasize that a lasting solution to the menace of the disease lies in its eradication rather than mere control. Eradication, when finally achieved, should be followed by proper monitoring to prevent reoccurrence in the spirit of the old saying that prevention is better than, and even cheaper than, cure.

I must commend the organizers of this workshop for their choice of time and venue. The workshop, coming just before the planting season, will prepare the ground for necessary trials for the eradication program. The combined use of the downy mildew-resistant (DMR) certified seeds and the seed-dressing chemical Apron Plus® has at best scratched the surface of the problem because there are not enough certified seeds or chemicals to supply all the farmers.

Let me assure you that this administration is fully poised to support you in your struggles to evolve methods and materials to eradicate the disease.

The State Government through the Oyo State Agricultural Development Program (OYSADEP) has, in collaboration with various research institutes and federal agencies within and outside the state, harnessed all available resources to assist our farmers. The Seed Unit of

OYSADEP has multiplied some quantities of DMR foundation maize seed for distribution in the coming season to farmers within the state. This will be matched with an effective public awareness campaign on the symptoms of the disease, possible preventive measures, and its economic importance.

Honorable Minister of Agriculture represented by the Director of Agriculture, and other distinguished participants, I warmly welcome you to this workshop. I sincerely hope that you will not only have most rewarding deliberations which will lead to quick eradication of this dreaded downy mildew disease, but that you will all enjoy your stay in Ibadan.

Distinguished ladies and gentlemen, I, on behalf of the Military Administrator of Oyo State, now have the pleasure to declare this workshop open.

An Address Launching a Book Entitled *Maize Improvement, Production, and Utilization in Nigeria*

Maurice A. Zard

When I was asked to launch a book about maize today, I wondered what a layman like myself could say in a gathering of academics and researchers such as we have here today. I was consoled by the fact that no questions would be asked about starch characteristics or chemical composition, about which I am generally ignorant. Nevertheless, I must point out that as one of the zonal vice presidents of the Maize Association of Nigeria and a practising fish and poultry farmer who consumes over 3,500 tonnes of maize every year, I know enough to be extremely interested in the fate and progress of maize cultivation in Nigeria.

It is encouraging to note that at a time of critical national economic recovery, the Maize Association continues to direct its energy and resources to such activities that would improve the quantity and quality of maize. I am certain that Nigeria can indeed produce enough maize both for internal consumption and export. One is therefore distressed to hear about plans to import maize into this country. I see your efforts as a clear signal to government that what we need to do is to tap our various resources and direct our energies towards self-sufficiency not only in maize production but also in agricultural production in general.

The contributions of IITA towards maize improvement in this country are immense and commendable. One can only hope that the rumors we hear all over the place are not true, that IITA plans to abandon work on maize improvement in the forest zones of the country. What those of us involved in maize utilization would prefer, is continued efforts at developing hybrids that are suitable and adaptable to the forest ecology. Maize is without doubt a very important crop even in the forest zones of Nigeria.

Your Excellency, all protocol observed, the book on maize improvement, production and utilization which I have been asked to launch today, contains valuable information on various aspects of maize production. It indeed summarizes the journey so far in maize research and production. I recommend the book to you all and also hope that you will join me as I launch it with a token sum.

I thank you all for listening and wish you happy deliberations.

Closing Address

C.O. Lufadeju
Director General, Ministry of Agriculture and Natural Resources, Osun State

I feel greatly honored to deliver the closing address at this important conference/workshop. As you are aware, maize is one of the most important staple foods in the country with an annual production of over two million tonnes. In Osun State some 58,253 hectares of land were planted to maize in 1993, giving an estimated yield of about 87,000 tonnes. The importance of maize in the economic well-being of livestock and Nigerian farmers therefore cannot be over-emphasized. Its role in key industries is tremendous. However this thriving maize industry is being seriously threatened by downy mildew (DM) and may be completely ruined by the disease if not effectively checked.

This disease was first reported on maize in Samaru, Kaduna State in 1969 and later in Ondo State in 1975. Since then it has spread to northern Benue State, and most of Kwara, Kogi, and Ondo states. The disease was first cited in Osun State on a farm near Ijeda in Ife/Ijesha zone in 1990, and by 1991 it had virtually spread to all parts of the state. Control measures were quickly put in place through the combined efforts of IITA, IAR&T, and NCRI scientists in collaboration with the research and extension arms of the state agricultural development program (ADP). I wish to register the sincere appreciation of the Government and people of Osun State to these various agencies for their efforts which resulted in the curtailment of the ravaging effects of this disease in the state. The two major control measures used were resistant varieties and treatment of seed with Apron Plus®.

This workshop has provided the forum for assessing the economic practicability of these two major control strategies, their adoption rate by farmers, and the constraints faced in the diffusion of the technology which should lead to the mapping out of strategies that will ensure the quick eradication of the disease within the shortest time possible and at minimum cost to both government and adopters (farmers). The workshop must also have afforded participants the opportunity to rub minds on ways of checking the spread of this disease to areas not yet affected in Nigeria's humid south and other neighboring countries as diseases are no respecters of socio-political boundaries.

The cost of buying DMR seeds and the seed-dressing chemical (Apron Plus®) is definitely an additional burden to the farmer. Most small-scale farmers lack the necessary capital to purchase inputs at the beginning of the season and therefore may not be able to adopt the control measures recommended. To forestall this unpleasant situation, governments of the states where the disease is endemic are implored to provide credit facilities to farmers either directly or through community banks and/or branches of the Nigerian Agricultural and Cooperative Bank (NACB) in their states.

I am also reliably informed that the current resistant varieties are not a hundred percent resistant to the disease. The white varieties have between 70 and 85% resistance while the yellow one (SUWAN 1), has between 90 and 95% resistance. Since the use of resistant varieties is the most cost effective and environmentally desirable method of control, I wish to implore scientists

to breed varieties (both white and yellow) that have high percentages of resistance. This will reduce the overdependence on the use of chemicals as a control measure.

I am pleased to note that considerable time has been devoted to formulating an action plan to fight this disease, both in the short and the long run. The battle between crop pathogens and scientists is a tedious one, but I am confident that you are up to the task and I want to assure you of my government's support for your efforts to combat this devastating disease.

I cannot end this address without acknowledging the kind gesture of the Federal Government through the Federal Department of Agriculture for the provision of DMR maize seeds and Apron Plus® for the use of farmers in the states affected by this disease.

I want to thank the organizers of this very important conference/workshop—IITA, FAO, and FDA, not only for its accurate timing, since another cropping season is about to start, but also for its scope. With these short remarks, I have the honor and privilege to declare this workshop closed.

TECHNICAL PAPERS

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The Nature of the Downy Mildew Disease of Maize Caused by *Peronosclerospora sorghi*: a Technical Overview

K.F. Cardwell

Introduction

Downy mildew of maize caused by *Peronosclerospora sorghi* can be one of the most destructive diseases of this crop in the world (Frederiksen and Renfro 1977). Yet the life cycle of the organism that causes the disease has several aspects which make it relatively easy to control. In many parts of the world where maize is grown, the downy mildew diseases have been controlled and these control measures are appropriate and available for use in Africa, even by the smallest landholder.

In most African countries where downy mildew has become a serious problem on maize, the constraints to the control of the disease are not the lack of control measures, but the logistics of supply and distribution of the technologies. This conference today, and the workshop tomorrow, are designed to address the issues of how to disseminate downy mildew control information and technologies. We will discuss the technical details about the disease itself; the technical and logistical details of resistant variety production; the problems of cost, distribution and safety of fungicide utilization; and the policy support needed at the governmental level to facilitate the elimination of this disease.

Nigeria is very much in the focus of this conference, because a severe endemic downy mildew problem on maize has developed in a large part of this country (Fig. 1). The disease is spreading from the infected areas and is threatening neighboring states and countries. Though much of the discussion during the next few days will be about Nigeria, most, if not all, of the discussion will be pertinent to other parts of Africa.

The first order of business is to review some of the details about where the disease is a problem, when it is most severe, and how it becomes a serious threat to maize production.

The nature of the problem

Figures for 1991 show yield losses to maize downy mildew (DM) in Nigeria totalling N343,500,000 (Adenola 1991). Kwara State alone lost 40% of its production to DM that year (Table 1). When a plant becomes systemically infected it will not produce an ear. The tassel and ear become deformed, making "crazy tops" and "leafy ears". So if 80% of the plants in a farmer's field are infected, he or she will have an 80% loss.

The causal agent

The etiology of a disease is the identification of the cause of it. The downy mildew disease of both maize and sorghum has the same etiology, as it is caused on both crops by the fungus named

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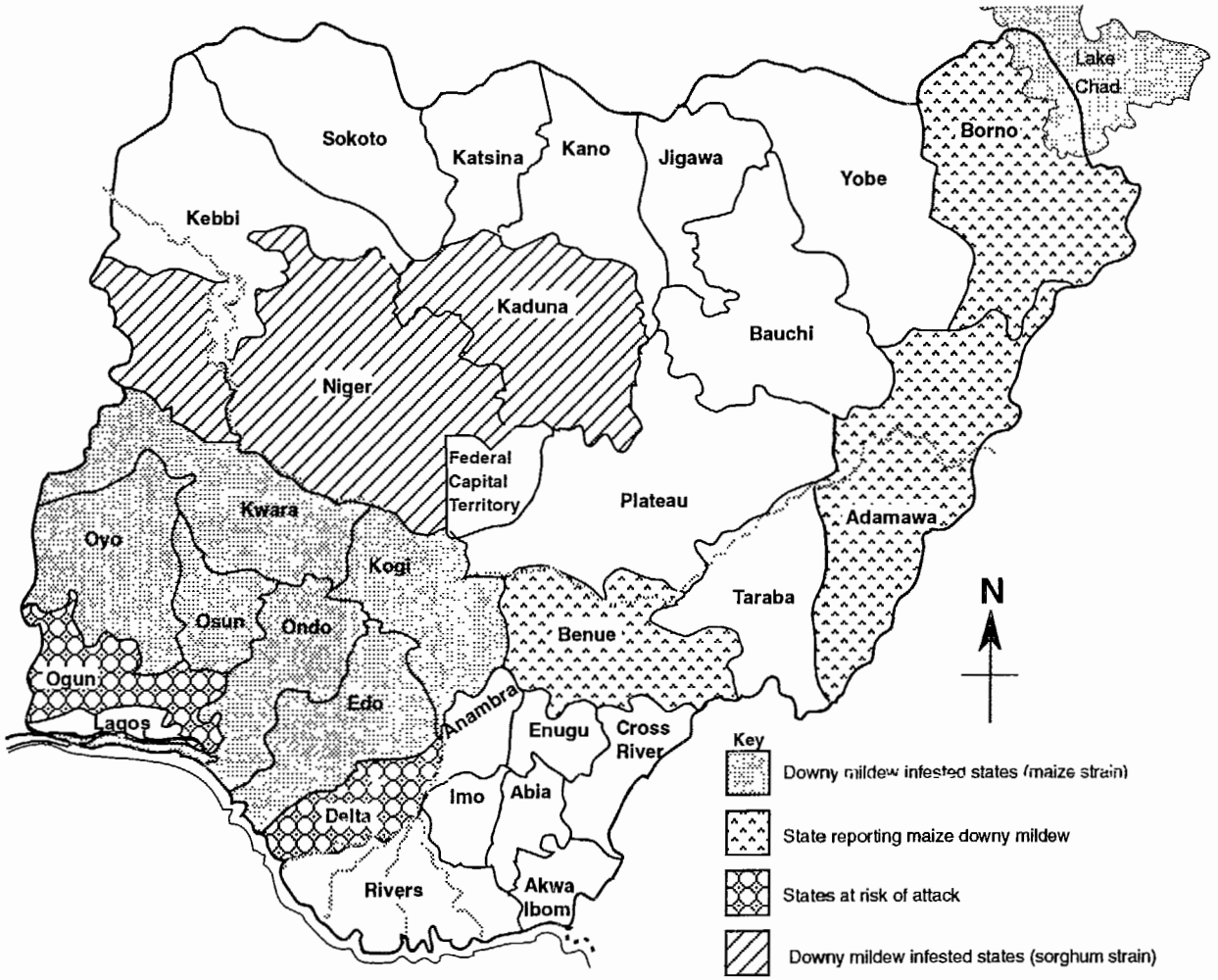

Figure 1. Maize Downy Mildew Affected States

Table 1. Estimated losses in downy mildew affected states in 1991.

State	Area cropped (ha)	Output (tonnes)	Yield (t/ha)	Estimated % loss	Losses (tonnes)	Estimated Cost (at N2,500/t) (Million N)
Ondo	58,000	97,000	1.67	40	39,964	99.91
Oyo	78,763	110,268	1.40	30	34,073	85.18
Bendel	106,000	159,000	1.50	4	6,550	16.38
Benue	106,848	128,217	1.20	4	5,282	13.21
Kwara	163,069	114,149	0.70	40	47,028	117.57
Borno	151,700	137,700	0.91	2	2,836	7.09
Kaduna	400,380	800,760	2.00	0.2	1,649	4.02
Total	1,064,760	1,547,094			137,382	343.36

Adenola (1991)

Peronosclerospora sorghi (Weston & Uppal) Shaw. There are two strains, a sorghum strain and a maize strain, although under the microscope the strains of the fungus look the same. The maize strain infects maize only, while the sorghum strain can affect both maize and sorghum (Fig. 2). Another difference between the two strains is that the sorghum strain produces an overseasoning structure known as an oospore. This spore has a covering that dries and turns hard and impenetrable so that it can survive for months in the soil. The maize strain does not seem to produce oospores, but survives by producing short-lived conidiospores in cycle after cycle of reproduction.

In Nigeria, it is thought that both strains of downy mildew are present (Anaso et al. 1987, Olanya and Fajemisin 1994). Near Zaria, Kaduna State, in northern Nigeria, downy mildew has been reported on sorghum since 1962 (Harris 1962) and on maize since 1970 (King and Webster 1970). The plants in this area are infected each season primarily from oospores in the soil. Occasionally, infected maize plants are seen, but generally the incidence is low.

Near Owo, Ondo State, in the south, the first reports of downy mildew on maize appeared in 1975 (IITA 1975, Fajemisin 1980). The disease in the south does not seem to infect sorghum, even when susceptible varieties are exposed to downy mildew spores from infected maize (Olanya et al. 1994). The epidemics in the south are caused by constant production of wind-borne conidiospores. We have been able to catch and identify DM conidiospores in specially designed spore traps throughout the year. These epidemics on maize can be devastating, causing up to 100% losses.

In addition to Nigeria, there are several other countries in Africa where the maize strain of downy mildew has been reported. A report of a maize strain of downy mildew came from Zaire during the mid-seventies (R. Kenneth pers. comm.), though it was unclear whether sorghum was ever exposed as maize was cited as being the predominant crop. The report includes mention of losses of up to 85% in 1975 in the Gandanjika area. Surveys in Rwanda and Zambia in 1991–1992 found downy mildew on sorghum but not on maize, while Zimbabwe has both maize and sorghum downy mildew (C. Bock pers. comm.). There are national program reports of downy mildew on maize from Mozambique and Uganda.

Epidemiology

Epidemiology is the study of the development and spread of disease causing organisms, and the conditions under which they occur. *Peronosclerospora sorghi* requires cool conditions (median 20–21 C), and RH between 74–96% to sporulate. At above 90% RH, sporulation occurs irrespective of temperature, but cool temperatures become critical when the RH is lower than 90% (Williams 1984). Moisture on the leaf's surface is necessary for sporulation and infection to occur. Dew point can occur when ambient RH is lower than 90% if the temperature drops sufficiently, thus it is possible to have moisture on the leaf's surface, and sporulation and infection, even during the dry season when the relative humidity is low but the air temperatures are also low (Cardwell et al. 1994). Under the proper ambient conditions, and after cessation of light, sporulation will commence in 7 to 8 hours.

Once the spores begin to mature, usually at about 0300 hrs, they begin to dislodge and drift in moist air currents. These spores are very delicate and cannot stand drying conditions. Therefore, they must land on a susceptible plant within a short time or they die. In laboratory conditions, in room temperature water, DM conidiospores begin to germinate within 20 minutes

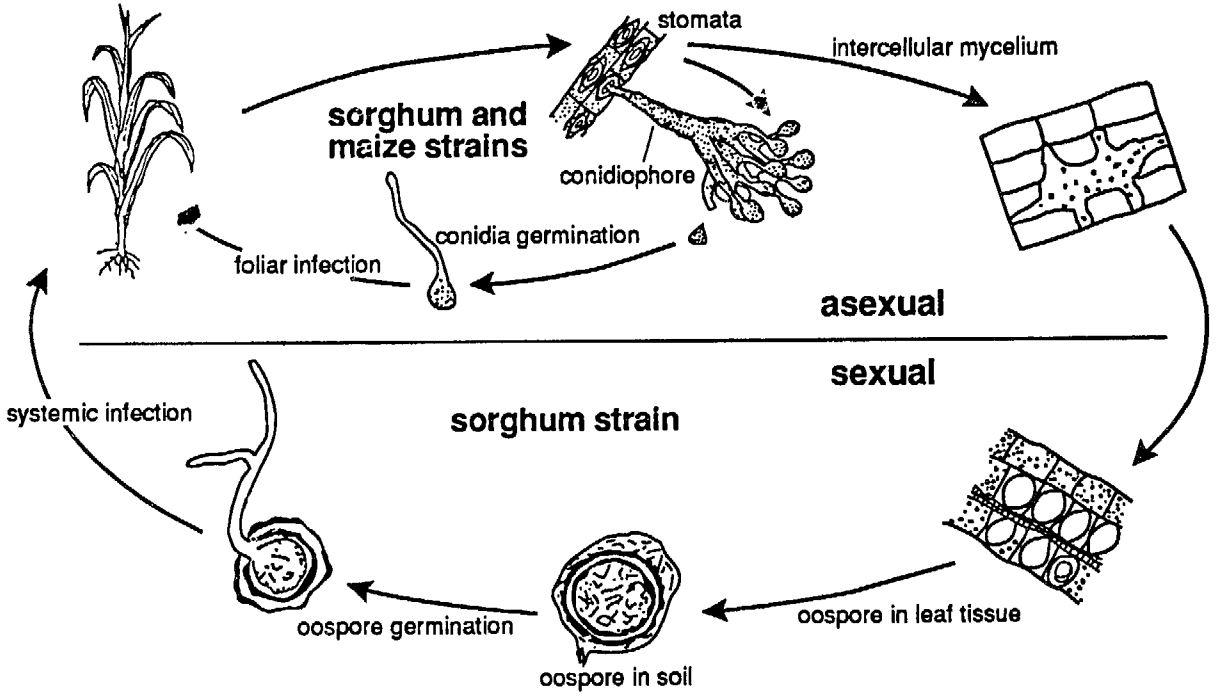

Figure 2. Maize and Sorghum Strains of Downy Mildew

of detachment (Cardwell et al. 1994). Nevertheless, it is likely that these spores can be carried long distances in moisture-laden winds that occur around rainstorms.

For an infection to occur, apart from moisture on the surface of the leaf, the most important condition is whether the spore has landed on a receptive host plant. The plant stomata should be open as the fungus grows into the plant mostly through open stomata. The plant must be young, no more than 30 days old, and of a susceptible type.

The only way that the maize strain can survive over the dry season is if there are continuous plantings of susceptible varieties so that young receptive hosts are always available. It is common practice for farmers who have access to a piece of low land with water in it to plant maize during the dry season. These fadama plantings normally have very low amounts of downy mildew, usually only 5–10% infection, and the farmer can sell green maize at the end of the dry season for a good profit. Scientists believe that the disease persists in these fadamas and that they are the source of the downy mildew epidemic for the following year.

Once the rains begin, the relative humidity increases and maize is planted outside of the fadamas; spores carried by the wind from the few infected plants in the fadamas fall on newly emerged, susceptible young plants to cause infection (Fig. 3). Under ideal conditions, secondary infection occurs within 10 days, i.e., it takes only 10 days from the time the fungus infects a plant until it begins to produce spores on that plant. Then that plant begins infecting other plants both near it and in other fields. In other words, it becomes contagious. An epidemic can then begin, with exponential increases in the numbers of infected plants such that plantings which occur one month after the first rains may suffer up to 50–80% infection levels.

Control options

With the knowledge of the life cycle of the downy mildew pathogen and the cycle of the disease in the region which is infected with the maize strain, it is possible to formulate a strategy that could actually eradicate the disease from the area. The following conditions are required to keep an epidemic of maize downy mildew going:

1. It is necessary to have susceptible young plants growing at all times of the year for the epidemic to continue from year to year (the current practice by many small-scale farmers is to make sequential plantings, at least once a month, and this is helping the fungus to survive).
2. The plants have to be of susceptible varieties and/or unprotected by a fungicide to become infected.
3. Infected plants, left in the field, become contagious to the susceptible plants around them.
4. Heavily infected fields, abandoned by farmers, become the source of infection for at least 60 days for fields near by and also many kilometers away.

It is obvious that resistant varieties are needed, fungicides can be helpful, and farmer awareness and government policy could be combined to reduce the downy mildew disease of maize from a serious problem to one that is not serious. What will it take to do so on the scale of infected area like that found in Nigeria?

DMR seed production

Downy mildew-resistant (DMR) varieties are available (Kling et al. 1994) but the amount of seed that is needed for the infected zone in Nigeria is considerable. The Nigerian Federal Department of Agriculture Downy Mildew Task Force estimated that around 6,000 tonnes will be required

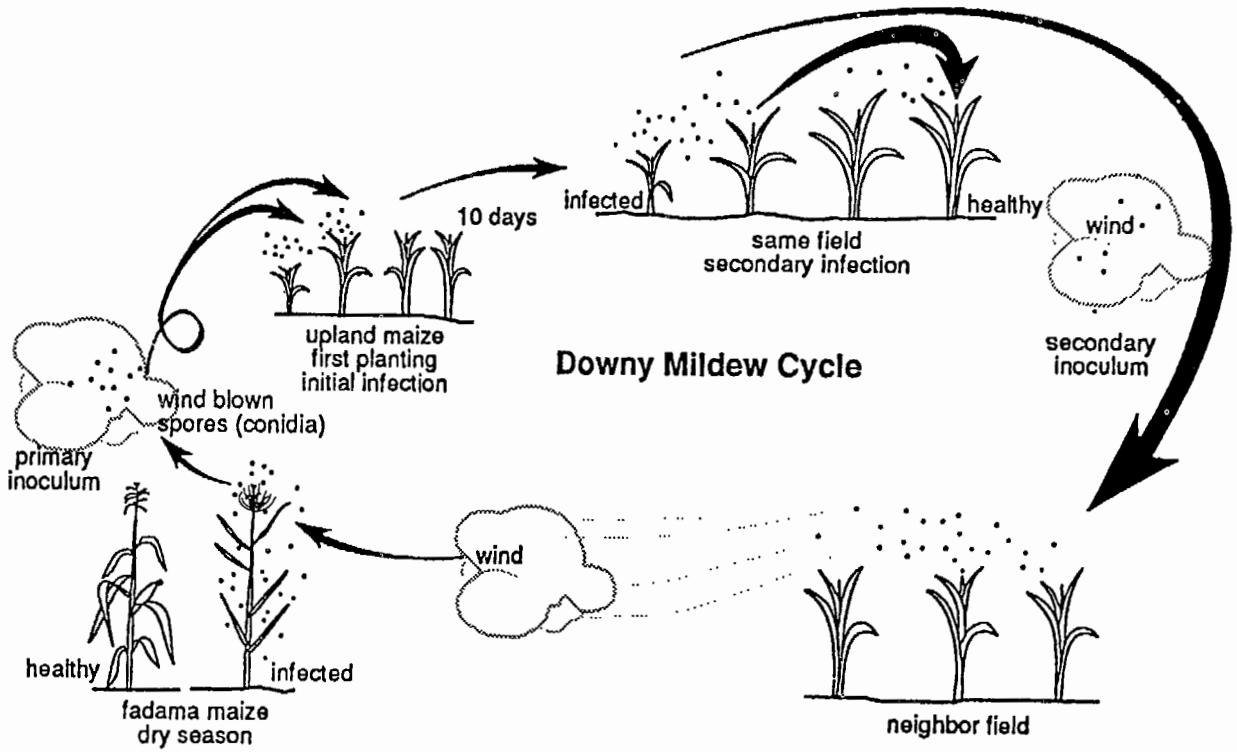

Figure 3. Life Cycle of Downy Mildew

by 1998 for the states of Nigeria in which downy mildew is endemic (Table 2). Current DMR seed production levels up to 1993, by both private and public producers in Nigeria, are only around 600 tonnes. The cost to produce the amount of DMR seed that is needed is in the hundreds of millions of naira. To meet the demand by farmers for this seed, it will be necessary to develop a policy for the support of seed production and to set the cost of this seed within the economic thresholds of the farm sector in the DM affected states. It will also be necessary to mount a publicity campaign to create more demand by the farmers, to promote the awareness of the importance of DMR seed, and to increase the willingness to buy improved seed.

Table 2. Estimated requirements for downy mildew-resistant certified seed needed in Nigeria and projected cost of production and delivery.

Year	1994	1995	1996	1997	1998
Quantity of DMR Seed ('000 tonnes)	1.2	2.4	3.6	4.8	6.0
Seed Cost (N'000,000)	24	48	72	96	120
Haulage Cost at 2.5% Seed Cost (N'000,000)	0.6	1.2	1.8	2.4	3.0
Handling Cost at 1% Seed Cost (N'000,000)	0.24	0.48	0.72	0.96	1.2
Total Cost of Seed (N'000,000)	24	49	74	99	124

Calculated at N20/kg Seed Cost

The logistics of producing certified seed from breeder seed must also be taken into consideration (Table 3). Who will produce breeder seed? Who will pay for it? It is on record that IITA cannot continue to be heavily involved in supporting the maize crop of southern Nigeria. Which national program should be strengthened to take on this role? Who will produce foundation seed? We are not just talking about a one time production, but continuous full scale production for many years.

This workshop is a forum for working out the details to these and other logistical problems. We must look for ways to extend and implement the various downy mildew-control methods that are available.

Downy mildew eradication

Given the information that we have about the life cycle of the fungus and the conditions under which infection occurs, it is easy to see that the fungus has some weak points that can be exploited for its control. Let us explore the options for controlling the downy mildew disease of maize and look at other campaigns that have been waged to control this crop disease.

Historically, DM eradication campaigns have had mixed results. In the early 1970s there was an outbreak of downy mildew on maize in Taiwan (Chang 1972). Scientists worked to discover the causes of the disease and then government stepped in to promote the control strategy that the scientists had recommended. They too had a situation where there was continuous cropping of susceptible hosts. Yet they had no resistant varieties or fungicides that worked. They recommended **a two year cessation of all maize planting.** With strict government control, the eradication campaign worked. Today maize is being cultivated in Taiwan and downy mildew is no longer a problem. This control strategy was severe, but has paid off economically.

On the other hand, in Thailand, maize downy mildew has been a problem since the mid-seventies. Some resistant varieties and chemical seed dressing were available. Now the seed dressing has become ineffective, and maize is often heavily damaged when susceptible varieties are used (N. Vandermarel pers. comm.).

Table 3. Estimated requirement and estimated cost of production of foundation and breeder seed to meet current and projected demand.

	1994	1995	1996	1997	1998
Foundation Seed					
Quantity of DMR foundation seed(tonnes)	30	60	90	120	150
Estimated cost at N25/kg (N'000)	750	1,500	2,250	3,000	3,750
Handling cost at 10% (N'000)	75	150	225	300	375
Total cost of seed (N'000)	825	1,650	2,475	3,300	4,125
	1994	1995	1996	1997	1998
Breeder Seed					
Quantity of DMR breeder Seed (kg)	750	1,500	2,250	3,000	3,750
Research (N'000)	75	150	225	300	375

Options for Nigeria

There are various options for controlling DM in Nigeria. Let us look at the areas that could work technically, and then focus on the options that are most likely to be implemented.

- In Nigeria there are resistant varieties available, which are continuing to be improved.
- Commercial chemical products, specifically Apron Plus®, are still effective and available.

- It should become general public knowledge that to plant sequential plantings of susceptible, untreated seed, and to plant susceptible, untreated maize in fadamas during the dry season perpetuate the problem. Plant only resistant or treated seed in the fadamas, or do not plant maize.
- If infected plants are left in the field, they will continue to sporulate and the epidemic will continue. Rogue and destroy infected plants.
- In addition to wind, the movement of infected plant materials (such as green ears) from one area to another can also spread the disease.

Government action
- Regulation: prohibit maize in the fadamas—unlikely.
- Internal quarantine: avoid movement of disease carrying materials—difficult and unlikely.
- Input price supports: assistance with seed-dressing chemical and/or improved seed—possible.
- Extension: mass media campaign—very possible.

Farmer action
- Plant early and only once in the year—unlikely.
- Rogue DM infected plants—possible.
- Destroy heavily infected fields—likely.

Integrated action requiring government, farmers, & extensionists
- Multiply and plant DMR seed—likely.
- Use appropriate fungicidal seed dressing—likely.
- Use resistant seed and fungicidal dressing—likely for large-scale farms.
- Use only DMR seed with fungicide seed dressing in fadamas—should be mandatory.

What needs to be done
- Organize and sensitize farmers to control options.
- Increase availability and usage of DMR seed.
- Make chemically-treated seed available to all farmers.

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Breeding Maize for Downy Mildew Resistance

S.K. Kim, J.G. Kling, J.E. Iken, K.F. Cardwell, A.O. Adenola, and V. Adenle

ABSTRACT

Downy mildew (DM) threatens maize production in Nigeria, Zaire, Mozambique, and Uganda. DM is the most damaging disease of maize in the south, central, and western parts of Nigeria. It is spreading and threatening to move into a neighboring country, the Republic of Benin. Scientists at IITA have developed maize varieties (open-pollinated and hybrid) with resistance to DM. Present downy mildew-resistant (DMR) varieties show approximately 10 to 30% DM incidence. Efforts are made to reduce DM incidence in DMR varieties down to 10%. In the DM affected areas, farmers must only plant DMR varieties or seed which has been treated with an effective fungicide. If the recommended management practices are adopted, downy mildew in Nigeria and other countries can be effectively controlled. Production of DMR varieties is the most economic, environmentally safe, and sustainable way to control this disease.

Introduction

Downy mildew has been identified as one of the most serious constraints to maize production in the forest ecology. Studies to facilitate inoculum production and to develop simple, fast, and reliable techniques for screening for resistance have been jointly conducted by maize breeders and pathologists. The prime objective of the breeding is to accumulate durable resistance genes that would ensure stability of the host plant resistance and promote increased maize production in endemic areas (Efron et al. 1989, Fajemisin et al. 1985, Kim et al. 1990).

Most of the improved maize varieties grown in Nigeria are highly susceptible to DM (Kim et al. 1990). Genes for resistance have been identified in maize germplasm from Thailand and the Philippines where DM is a serious, endemic maize disease. Host plant resistance screening was carried out at Owo (Ondo State ADP) during 1990. The Federal College of Agriculture in Akure (Ondo State) has been the major center for screening for DM resistance since 1991. Genes for DM resistance have also been incorporated into streak resistant (SR) varieties (Efron et al. 1989, Fajemisin et al. 1985, Kim et al. 1990).

This paper summarizes the response of local maize varieties to DM. A progress report on DM resistance breeding is presented as well as recommendations on how to minimize losses in maize from DM infection.

Screening methods

Techniques for artificial infestation of DM have played a vital role in determining the progress of DM resistance breeding. A nighttime infestation technique developed in Thailand was used until 1991, which often permitted 20–30% of the plants to escape infection. In 1992, a new seedling inoculation method was developed and applied for the first time (K. Cardwell et al. unpublished). In this method a mixture of seeds of three susceptible maize cultivars are

germinated in flats in the laboratory. After 76 hours, infected leaves are placed over the seedlings and allowed to sporulate overnight inside a controlled temperature cabinet. Seedlings are then transplanted to the field and test rows are planted ten days later. An average disease incidence of 85% (1992) and close to 90% (1993) in susceptible test rows was obtained. A new incubation technique adopted recently has reduced escape rates to about 5%. With this new method, we can screen segregating materials of maize throughout the year.

Response of local maize collections to downy mildew

The Maize Association of Nigeria (MAAN) with the assistance of State Agricultural Development Projects (ADPs) collected maize samples from farmers in four states—Edo, Niger, Ondo, and Oyo, (before the establishment of new states) in 1992, and 15 states in 1993. Individual seed samples were planted in Akure under artificial downy mildew infestation. Results from four states in 1992 showed that the majority of materials (60.7% of the samples) showed high susceptibility to DM and only 14.5% showed resistance. The remaining 24.5% of the materials were segregating (Table 1). Approximately 65% of the materials from Ondo State, the hot spot of DM infection were resistant and/or segregating. Segregation was due to cross-fertilization by local susceptible varieties. Special efforts have been made by national programs (ADPs, NSS, NAFPP, NCRI/IAR&T) and IITA to recommend DMR varieties for Ondo State. In Oyo State, where DM only recently became established, only 10% of the materials showed resistance.

As a part of a Maize Adoption Study of MAAN and IITA, additional collections of local maize were made in 1992 and 1993. A total of 256 samples from 15 states covering most of southern Nigeria were screened at Akure in 1993. An average of 66.5% of the materials were susceptible, 13.1% were resistant, and 20.4% were segregating (Table 2). All of the collections from four non-DM infected states (Anambra, Cross-River, Imo, and Rivers) were susceptible. Three states (Edo, Ondo, and Oyo) had an average of 35% resistant materials. Since DM can cause up to 100% yield reduction in susceptible varieties, a special effort should be made to distribute DMR varieties to all DM-affected states.

Table 1. Response of local maize collections from four southern states under artificial downy mildew infestation at Akure, 1992.

State	No. Samples	Percentage of samples showing		
		Resistance	Segregation	Susceptibility
Edo	43	20.9	28.0	51.2
Niger	48	0	16.8	83.3
Ondo	49	28.6	26.6	45.0
Oyo	30	10.0	26.7	63.3
Mean		14.9	24.5	60.7

Table 2. Response of local maize collections from 15 southern states under artificial downy mildew infestation at Akure, 1993.

State	No. Samples	Percentage of samples showing		
		Resistance	Segregation	Susceptibility
Abia	13	23.1	30.8	46.2
Akwa-Ibom	8	0	12.5	87.5
Anambra	11	0	0	100.0
Cr. River	7	0	0	100.0
Delta	7	0	28.6	71.4
Edo	17	35.3	17.6	47.1
Enugu	18	16.7	38.9	44.4
Imo	9	0	0	100.0
Kwara	43	16.3	23.3	60.5
Lagos	10	0	40.0	60.0
Ogun	19	15.8	31.6	52.6
Ondo	38	36.8	23.7	39.5
Osun	25	16.0	32.0	52.0
Oyo	22	36.0	27.3	36.4
Rivers	9	0	0	100.0
Mean	(256)	13.1	20.4	66.5

Breeding efforts

IITA's maize breeding efforts for West and Central Africa, particularly for the forest and traditional ecologies in Nigeria, have focused on the development of maize varieties resistant to both DM and maize streak virus. To assess the current status of DM resistance in elite maize varieties from IITA, twenty varieties including susceptible checks were tested under artificial infestation of downy mildew at Akure in 1991 and 1992. Among them, three DMR varieties, Suwan 1-SR (late, yellow, flint), Suwan 2-SR (intermediate, yellow, flint), and Across 89 DMR-ESRW (early, white, flint/dent) showed the highest levels of resistance (Table 4). The first two varieties were developed in Thailand and were converted to have resistance to maize streak virus at IITA. Thailand has the longest history of breeding for DM resistance. Two late-maturing varieties, DMR-LSRW (white) and DMR-LSRY (yellow) still show about 20%DM incidence. With the new infestation technique available, we expect to bring the level of resistance in existing DMR varieties up to an acceptable level within the next five years. The long-term approach for downy mildew- resistance breeding at IITA is to incorporate DM-resistance genes into four broad-based, reciprocal composites which form the foundation of the population improvement program. These are TZE Comp 3 (early, flint), TZE Comp 4 (early, dent), TZL Comp 3 (late,

flint), and TZL Comp. 4 (late, dent). All open-pollinated varieties and hybrids derived from these composites would then have acceptable levels of DM resistance. Details of the breeding work on these and other DMR populations from 1989 to 1993 are summarized in Table 3.

Table 3. Response of families of open-pollinated maize populations tested under artificial downy mildew infestation at Akure, Nigeria (1989–1993).

Year/Season[a]		Material	No. of families	Reps	Mean %DM	Susc.check[b] %DM
1989	A	EV8443-DMRSR BC2SI	127	2	19.0	53.1
		EV8443-DMRSR BC3	148	2	32.8	57.4
1989	B	DMR-LSRW S1	227	2	0.4	6.0
		DMR-LSRY S1	188	2	0.4	6.0
		DMR-ESRW S1	262	2	1.0	16.3
		Pop. 28-DMRSR S1	238	2	0.3	9.0
		DMR Levels Trial	16	5	–	–
1990	A	Pop 28-DMRSR S1	79	1	1.94	20.5
		Pop 22-DMRSR BC4 S1	182	1	6.48	29.5
1991	A	TZE Comp 4-DMRSR BC1 S1	300	2	41.4	66
		TZE Comp 3C1 S1	1125	2	11.2	52.0
		DMR levels	15	6	28.9	67.0
1991	B	DMR levels	15	6	8.7	26.4
1992	A	TZL Comp 4 C0 S2	450	2	63.3	85
		TZE Comp 3 C1 S1	900	2	22.2	86
		DMR levels	20	8	39.8	84.3
	C	TZL Comp 4 C0 S2	351	2	–	–
1993	A	Pop 31-DMRSR S1	225	2	35.1	94
		Pop 22-DMRSR S1	265	2	38.8	90
		Acr 90 DMR-LSRW S1	200	2	12.4	89
		Acr 9028-DMRSR S1	200	2	15.4	85

[a] A, B and C indicate first, second, and third (dry) season respectively.
[b] Susceptible check is Pool 16-SR

Table 4. Response of downy mildew resistance level trials of elite maize materials under artificial downy mildew infestation in Akure, Nigeria (1991 and 1992).

Variety	Downy mildew incidence (%) 1991	1992
Suwan 1-SR BC5	9.2	5.2
Suwan 2-SR BC4	9.4	11.2
Acr 89 DMR-ESRW	11.3	13.7
DMR-ESRW	17.5	20.5
DMR-LSRY	22.0	21.8
8644-27	10.1	22.3
DMR-ESRY	14.6	29.8
TZE Comp 3 C1	28.3	30.1
Acr 9028-DMRSR	–	32.0
Pop 22-DMESR	20.7	32.1
Pop 31-DMRSR	21.5	33.4
TZ 9043-DMRSR	40.7	39.8
TZ 8843-DMRSR	35.6	40.0
TZL Comp 3 CO	29.5	41.2
8644-31	30.8	43.0
TZL Comp 4 CO	51.8	65.7
Funtua 88 TZSR-W-1	70.6	73.9
8321-18	–	74.0
EV8443-SR	–	82.0
Acr 88 Pool 16-SR	67.0	84.3
Mean	28.9	39.8
LSD (0.05)	13.1	12.4
Prob. of F	0.000	0.000
CV%	35.8	31.4

Relatively small-scale efforts to incorporate DM resistance into hybrid varieties have been carried out at Akure. Approximately 75 to 100 different crosses involving DMR lines were tested under artificial infestation with DM. The major outcome of the research was the development of a DMR hybrid, 8644-27 (with the commercial name of Oba Super 2 by Pioneer Seeds). One of the two parent lines is KU1414, a DMR inbred from Thailand. The F1 itself shows about 20% DM incidence (Tables 4 and 5). By 1992, we had converted the other parent of this hybrid, TZ1 18, to have DM resistance, and KU1414 to have streak resistance. Now both parents confer resistance to DM, maize streak virus, and ear rots, all important biotic constraints for maize production in the south of Nigeria. The result of another trial (K92230, Table 5) confirmed the resistance of 8644-27 (12% incidence) in comparison to the susceptible hybrid, 8321-18. Pioneer markets these hybrids as Oba Super 2 and Oba Super 1, respectively, and treats the seed with

Apron Plus® fungicide (Table 5). The combination of resistance and seed treatment provided complete protection for Oba Super 2, demonstrating the efficacy of this package in preventing DM infection. Crosses between KU1414 from Thailand and MIT2, an inbred line from the Phillipines, showed very high levels of resistance without any seed treatment (Trial K9224, Table 5). Incorporation of new sources of resistance into the breeding program can thus enhance the levels of DM resistance and increase the durability of the resistance.

Table 5. Response of DM, ear rots, and grain yields of DMR maize hybrids under artificial downy mildew infestation in Akure, Nigeria 1992.

Variety	DM infested (%)	DM resis. (1-9)	Ear rots (1-9)	Grain yield t/ha	%yield trial mean
Trial: K9211					
8644-27	27	2.0	2.8	4.2	168
9055-42	26	2.8	2.8	4.3	159
9211- 3	20	2.8	3.5	4.2	156
EV43DMR-SR	55	3.7	2.5	3.7	138
DMRLSR-W	26	2.0	4.3	3.7	138
LSD 0.05	–	1.4	1.8	1.3	–
C.V.%	–	19.1	35.9	33.7	–
Trial: K9223					
Oba Super 2 + Apron	0	1.0	3.3	3.4	167
Oba Super 1 + Apron	2	1.3	3.3	3.3	158
8644-27	12	2.0	4.0	3.0	146
DMRLSR-W	13	2.3	3.3	2.8	136
8321-W	54	5.3	2.0	2.6	124
DMRLSR-Y	15	2.7	4.0	1.9	90
LSD 0.05	–	1.9	1.2	1.2	–
C.V.%	–	25.7	25.4	36.7	–
Trial: K9224 (DMR diallel crosses)					
KU 1414 x MIT2	3	2.0	–	5.8	181
TZi 3 x KU1414	4	3.0	–	5.4	161
TZi25 x TZi 15	89	7.7	–	1.1	33
TZi 25 x TZi 12	93	9.0	–	0.7	20
LSD 0.05	–	1.9	2.1	–	–
C.V. %	–	26.1	38.5	–	–

Rating scale of 1 to 9: 1 = highly resistant, 9 = highly susceptible (based on severity).
Grain yield (t/ha): grain yield at 15% moisture.
% yield trial means were calculated using the mean yield of each trial which had more entries than the selected entries presented here.

Why is downy mildew spreading?

As shown in the results of the screening of the local maize collections against DM disease (Tables 1 and 2), more than 60% of materials grown in the DM-affected states are susceptible. Material grown in non-DM states are almost entirely susceptible. Farmers in the DM-endemic states must grow DMR varieties to prevent the continued spread of the disease. Farmers in the forest zone cannot produce high quality DMR seeds due to unfavorable environmental conditions. Most farmers rush to local markets before planting to buy grain, most of which is brought from the north by traders and is susceptible to downy mildew.

Aside from the use of susceptible varieties, the cultural practices that are used for maize in the DM- affected areas are leading to further increase and spread of the disease. It was shown in 1991–1993 in hydromorphic valleys (fadamas) in Ondo State that maize can grow throughout the dry season with a low incidence of downy mildew. Thus, the farmers that grow susceptible maize in fadamas during the dry season are bridging the dry season for the disease. Then when the rains start, farmers begin to plant. Usually the first plantings are not very infected, but all subsequent plantings become more and more infected. In the main downy mildew zone, farmers are planting maize almost year round. That means that there are always young DM-infected plants in the vicinity of newly planted maize fields.

Recommendations for control of downy mildew

1. Grow only DMR varieties. Seeds are available from seed companies and ADPs. Buy high quality seeds from registered and reputable seed companies (Pioneer, UAC, and UTC). Oba Super 2 (Pioneer) with chemical treatment showed zero infection (Table 5). Seeds at the local market come mostly from northern Nigeria and are susceptible.
2. The most resistant variety which does not require chemical treatment is Suwan 1-SR. Other highly resistant varieties are 8644-27 DMR-SR (hybrid related to Oba Super 2), Suwan 2-SR, and Across 89 DMR-ESRW.
3. Multiply only new cycles of those DMR varieties. Any plants showing DM infection must be removed. Pollen from one susceptible plant can contaminate and reduce the levels of resistance in the variety.
4. Early planting can escape DM infection. This method does not work for the second season due to the increase in DM inoculum during the first season.
5. Treat seeds with a chemical, Apron Plus®, if your variety shows more than 20% incidence. The chemical treatment will control DM only for one cropping season.
6. State and federal extension agencies must increase their efforts to demonstrate the effectiveness of DMR varieties in the DM-endemic areas. Without the proper demonstrations and campaigns, farmers will not understand the nature of DM and how to keep it from spreading.

Special precaution for risk areas and conclusions

In areas where farmers grow green (fresh) maize during the dry season or very early in the first season, normal or late planted maize is especially at risk to DM infection. Therefore, it is important to grow only DMR and/or fungicide-treated seeds for early green maize production. Any states in Nigeria and neighboring countries have potential for DM epidemics. With the

development of DMR varieties, the spread of downy mildew in countries where the disease is endemic can be effectively contained. Availability of seed of adapted, resistant varieties will greatly reduce the frustration of farmers who have been forced to plant susceptible varieties.

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The Role of the National Seed Service in Strategies of Maize Downy Mildew Control in Nigeria

I. Usman

Introduction

Maize (*Zea mays*) is one of the most commonly grown cereals in Nigeria. Its annual production in Nigeria is estimated to be about 3 million tonnes. It is commercially grown as a sole crop and, in other instances it is intercropped with cassava, cowpea, root crops, and other crops.

Its use as a major food item, pharmaceutical preparation, livestock feed, and other agro-based industries raw materials has further enhanced its importance as both a food and as an industrial crop.

In recent years, cultivation and yield of maize in Nigeria has been seriously threatened by the occurrence and spread of the devastating disease, maize downy mildew. According to a survey carried out in 1991 by a task force of the Federal Department of Agriculture (FDA), about 75,000 km^2 of land was affected by the disease.

Background of downy mildew (DM) Disease in Nigeria

Downy mildew disease of maize is caused by the fungus *Peronosclerospora* spp. It was first reported on maize in Samaru, Zaria in 1969, and in Kabba, Kogi State and Owo, Ondo State in 1975.

Oyekan et al. (1989) reported the spread of the disease to other parts of the country, especially in five states—Bendel, Benue, Kaduna, Kwara, and Ondo. In a recent survey, Adenola et al. (1991) reported its spread to seven states. They reported that the disease had attained epidemic proportions in Kwara, Ondo, and Oyo states. The annual loss in maize yield in 1991 due to the disease was estimated to be 47,028 tonnes, 39,964 tonnes, and 34,073 tonnes in Kwara, Ondo, and Oyo states respectively.

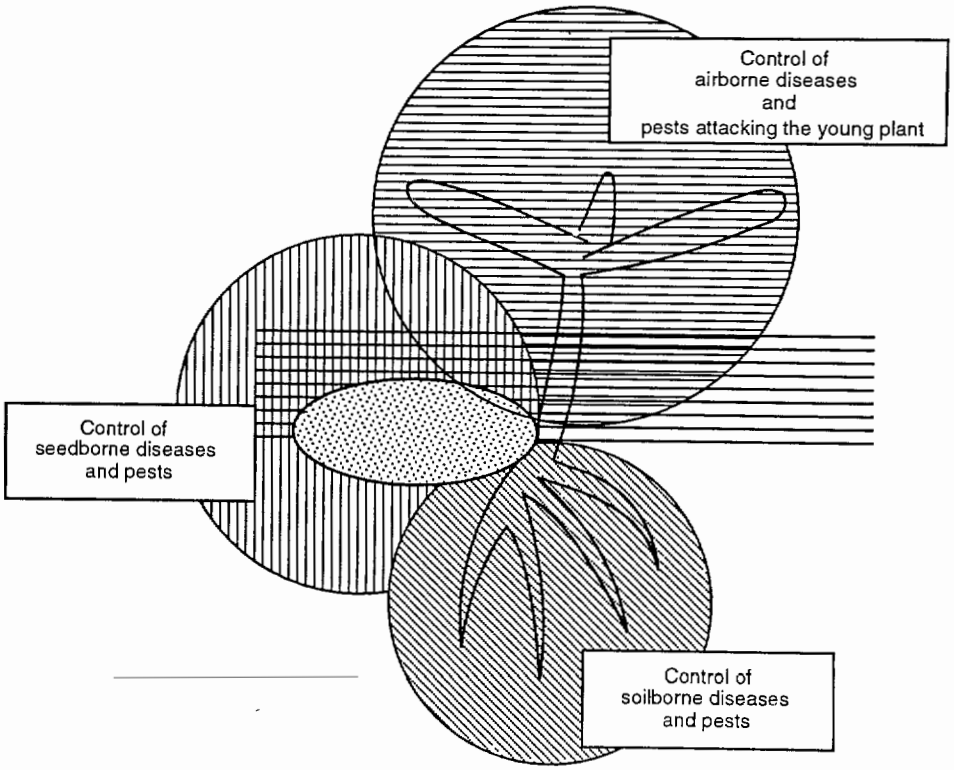
Rationale for control

Since the 1991 survey reporting an epidemic of the disease in Kwara, Ondo, and Oyo states, disease-monitoring tours in some of the affected states have shown that the disease is spreading to new areas in two directions, i.e., from the South to the North and from the South-West towards the Republic of Benin. Consequently, if decisive and effective measures are not taken, the entire maize crop in the country may be lost to downy mildew disease, with international repercussions.

The National Seed Service

Improved seeds offer not only one of the cheapest and basic potential means of increasing yield per unit area, but are also one of the critical determinants of benefits that can be derived from other agro-inputs such as fertilizer, herbicides, insecticides, and irrigation water. Indeed, all over the

Target areas for Seed Treatment



Target Areas for Seed Treatment

world, the use of improved seeds has been the most cost-effective means of achieving self-sufficiency in crop production.

The National Seed Service (NSS) was established in 1975 as a specialized project of the FDA with the key goal of providing high quality improved seed and seedlings to Nigerian farmers.

At first, NSS was assisted by the Food and Agriculture Organization (FAO) through a project: Improvement in Seed Production and Quality Control (NIR 72/075), funded by UNDP. This was followed by the second phase in 1981–1985 funded exclusively by the Nigerian Federal Government under the Unilateral Trust Fund Management, UTF/NIR/04. Foundation seed production was strengthened during this second phase. The third phase (1987/89) was in the form of financial and technical assistance from UNDP/FAO on improvement of quality seed. These three FAO/UNDP-funded projects formed a sound foundation for the development of seed programs in Nigeria.

The expansion of the seed program was assited by the World Bank through a project called the National Seed and Quarantine Project (NSQP). The main objective of NSQP was to support the national goal of increasing agricultural production and distribution of good quality superior varieties of seed to Nigerian farmers.

The project has produced foundation seeds of maize, rice, sorghum, cowpea, and soybean. A total of 265.5, 391.1, and 520 tonnes of improved seeds were produced in 1991, 1992, and 1993 respectively.

Improved seeds are known to be carriers of the genetic potential for high yields and disease resistance, so the use of improved seeds to control downy mildew cannot be overemphasized.

Government role in DM control

Subsequent to the DM outbreak in 1991, the Federal Government set up a monitoring committee, including the NSS, to monitor the disease and to advise the government on the extent of the outbreak and the economic value of the disease, and recommend control measures. As a follow-up to the report submitted by the committee, the Federal Government in July 1992, through the National Seed Service, distributed a total of about 154 tonnes of Apron Plus®-treated maize varieties to 14 affected states (see Table 2). A total of 80.586 tonnes of these seeds were downy mildew-resistant varieties.

The National Seed Program has appreciated the gravity of this disease and this has also been proportionately reflected in the production of DM-resistant maize varieties in its Seed Production Program. For instance, out of a total of 56.2 tonnes of maize foundation seeds sold to ADPs and other agricultural agencies in 1992, 18.43 tonnes were downy mildew-resistant varieties such as Suwan1, DMRLSR-W, and DMRESR-W.

In spite of the assistance in the provision of DM-resistant foundation seed to the affected states, some states are not giving the disease the seriousness it deserves. The 1993 figures for the amount of foundation seed procured by some of the affected states are shown below.

Table 1. Agencies that collected DMRSR–W and Suwan 1 varieties (July 1991).

Agency	Location	Variety	Quantity collected (kg)	Expected yield (t)
NSS	Ilorin	DMRSR-W	105	4.2
NSS	Zaria	DMRSR-W	55	2.2
NPQS	Ibadan		20	0.8
OYSADEP	Shaki	DMRSR-W	180	7.2
National Rice/Maize Program	Ibadan	DMRSR-W	30	1.2
Mr Bewaji	Oshogbo	DMRSR-W	200	8.0
NSS	Ikorodu	DMRSR-W	40	1.6
NSS	Ibadan	DMRSR-W	12	0.48
NSS	Umudike	DMRSR-W	30	1.2
Ogun State ADP	Abeokuta	DMRSR-W	100	4.0
Ag. State ADP	Zaria	DMRSR-W	50	2.0
Farinde	Shaki	DMRSR-W	40	1.6
Agro-Rice Industries	Ihialla	DMRSR-W	50	2.0
Otunla Farms	Oyo State	DMRSR-W	150	6.0
OYSADEP	Oyo State	Suwan 1	1,057	42.28
Total			2,119	84.76

About 17.6 tonnes of DM-resistant varieties were carried over unsold from 1993 to 1994. Revalidation tests were carried out in order to use this seed for the 1994 foundation seed distribution to states and other agencies.

Assistance with seed-dressing chemicals

In 1993, about 4.3 tonnes of Apron Plus® were procured by the Federal Government. The seed-dressing chemical was distributed to the affected states and neighboring states free of charge. This is a price support system to ensure that treated seeds sold to farmers were affordable, and that the cost of seed treatment was not added to the sale price of seed. For instance Ondo was given 850 kg of Apron Plus®.

Other agencies that benefitted from the seed-dressing chemicals include the National Rice/Maize Center (through its services to Maize Association farmers and on-farm demonstration trials), and the National Seed Service (NSS).

Table 2. Quantities of Downy Mildew Improved Seed Distributed to Affected States (In 1992).

States	Nega Maize IV *	Nega Maize V *	TZPBSR-W Treated **	DMRESR-Y **	DMRSR-W **	SUWAN-G **	TZSR-Y **	Total (tonnes)	Infestation levels in 1992 %	Remarks
Kwara	10	-	6	4	-	-	-	20	31.2%	All seeds allocated
Ondo	10	-	6.8	3.2	-	-	-	20	29.0%	All seeds allocated
Osun	-	8	7	-	2	-	-	17	15.0%	All seeds allocated
Oyo	-	8	9	-	-	-	-	17	10.0%	All seeds allocated
Benue	4	-	8	-	-	-	-	12	4.0%	All seeds allocated
Kogi	-	3	7	-	-	2	-	12	3.0%	All seeds allocated
Edo	-	2	8	-	-	2	-	12	2.5%	All seeds allocated
Delta	1	2	9	-	-	-	-	12	2.5%	All seeds allocated
Borno	-	-	7	-	-	-	-	7	2.06%	All seeds allocated
Kaduna	-	-	5	-	-	-	-	5	Approximately 1%	All seeds allocated
Ogun	-	-	2.6	-	0.4	2	-	5	1%	All seeds allocated
Lagos	-	-	2.6	-	0.4	2	-	5	1%	All seeds allocated
Adamawa	-	2	3.0	-	-	-	-	5	1%	All seeds allocated
Niger	-	-	3.0	-	-	-	2	5	1%	All seeds allocated.
Total Tonnes	25	25	84	7.2	2.8	8	2	154		

Note: * Seeds Lots treated with Fernas — 50 tonnes

** Seeds Lots treated with Apron Plus® 50 - DS 104 tonnes — 104 tonnes

Total — 154 tonnes

Table 3. Maize DMR Seed Sales to Affected Agricultural Development Projects.

State	Variety (kg)			Total (kg)
	DMRESR-W	DMRLSR-W	SUWAN -1	
Oyo	75	75	100	250
Osun	–	–	50	50
Ogun	250	100	250	600
Kogi	500	100	–	600
Total	825	275	400	1,500

1994 National Seed Service approach (specific)

1. **Seed Production.** The NSS in its current seed procurement exercise is aiming to have 40% of its total maize seed as downy mildew-resistant cultivars. The NSS hopes that the affected state governments will wake up to their responsiblities, particularly with the present campaign being organized by the workshop on eradication of the disease.

2. **DMR Seed Campaign.** Through the collaboration already forged with the National Agricultural Extension and Liaison Services (NAERLS), the NSS intends to mount an effective campaign through electronic and print media. This will include publication of information leaflets in the dialects of the affected states, the organization of field days, and the establishment of demonstration sites in selected locations to increase awareness among farmers. The active participation of the National Rice/Maize Center, IAR&T, and IITA in this program is well recognized.

1994 NSS approach (general)

- Effective monitoring of seed production by contract growers in the affected states. Adopt appropriate cultural practice necessary to control the disease.
- Some proportion of the 60% non-DMR seed could still be treated with Apron Plus® to meet increased demand.
- Improved seeds (DMR) to be combined with fertilizer and chemical as a package.
- Collaboration with appropriate agencies (government and non-government organizations) to effectively control the disease.

Conclusion

The active participation of all concerned—research institutes (IITA and IAR&T), seed agencies (NSS, ADPs, private seed companies), extension workers, and farmers—is needed to combat the devastating effect of maize downy mildew disease in Nigeria. State governments, through the

ADPs, need to be more alert to their responsibilites by supporting the DM control program financially and materially.

Finally, more research needs to be done, particularly on the genetic improvement of existing cultivars to increase the level of resistance, and on the epidemiology of the disease to find out the resting phase of the southern strain of the pathogen.

Certainly, the role and contribution of IITA so far is very remarkable and commendable. It is pertinent to mention that on 14 April 1989, IITA gave the National Seed Program and two ADPs (Kwara and Ondo) a sizeable quantity of downy mildew-resistant varieties to combat the disease. On behalf of the Nigerian farmers, I say "thank you" to IITA.

Let me, however, add that the laudable efforts made so far would be wasteful and meaningless if IITA did not continue its research on maize in the humid forest zone.

Strategies for Maize Downy Mildew Control: Efforts of Private Seed Companies

M. D. Gupta

Introduction

On behalf of all private seed companies, I would like to record our sincere thanks to IITA, FAO, and FDA for inviting us to participate in this conference/workshop addressing the control of downy mildew of maize.

Traditionally, agriculture has been the mainstay of the Nigerian economy. Maize production and productivity have increased significantly in the last few decades, and maize has become the most important cereal crop being used for food, feed, and industrial purposes. It is cultivated throughout the country on an estimated million hectares of which more than 80–85% falls within the northern savanna zone. Maize is of great importance to private seed companies because it was the IITA hybrid maize which led to the formation of the first seed company—Agricultural Seeds Limited (Agseed)—a decade ago. Hybrid maize is one of the major benefits the science of genetics has given the world of agriculture.

Tropical maize and maize downy mildew

Generally, maize yield in the tropics is lower than that of the temperate zones because of the evolution of tropical maize. For centuries, subsistence tropical farmers have selected vigorous plants with leafy growth and heavy husk cover which retain most of the carbohydrates in the stem to provide resistance to diseases and insects common in warm humid climates.

On the other hand, in modern temperate zones, varieties have been bred for cultivation under well-protected conditions. As a result, these types produce more carbohydrates in the grain than tropical maize and less in the leaves, husk, and stalk. Even the same tropical maize yields much more in the savanna than in the forest regions under identical management. IITA physiologists have established that the lower yield in forest zones is attributed to (a) the limited supply of sunshine especially during grain filling, (b) lodging caused by taller, thinner stalks and higher placed ears, and (c) increased attacks by diseases, stem borers, and stalk and ear rots.

It is also established that the modern varieties out-yield the local varieties only under high plant population because the per plant yield of improved varieties may not be higher than the local ones.

The fungal disease, downy mildew, caused by *Peronosclerospora sorghi*, is one of the several biotic stresses to threaten maize cultivation in southwestern Nigeria. In 1975, IITA reported the existence of the disease in a seed multiplication plot near Owo. It is estimated that the disease is spreading westward towards the Republic of Benin at a rate of about 50 km per year. Currently it has spread to seven southwestern states of Nigeria where about 200,000 ha of maize is grown. It has also been seen on maize in Côte d'Ivoire, Zaire, Sudan, Somalia, and countries of Southern Africa. Thailand and the Philippines have good genetic sources of resistance to this fungus. Interestingly, the strain of fungus which infects maize in southern Nigeria does not easily

infect sorghum; this same strain is reported to be very virulent on maize in Zaire and Thailand. Another strain of this fungus infects sorghum in northern Nigeria. Fortunately, the strain in southern Nigeria does not appear to be seedborne, and so, it must establish itself on maize seedlings not older than four weeks to cause the disease.

Seed and private seed companies in Nigeria

The seed is the single most important input in all plant-based agricultural systems. The seed determines the upper limit of yield potential and therefore ultimate productivity of other inputs. While a seed is the carrier of genetic potential of crop plants, other inputs simply build the environment. Over the past fifty years, it has been established that 50% of the productivity gains in agriculture have come from improved seeds. The other 50% is from improvement in management including correct timing, appropriate use of fertilizer, crop protection measures, and equipment. Consequently, there can be no agriculture without seed. Unfortunately, in Nigeria, agriculture in general and seed in particular have not been accorded their rightful position. However, the present government is trying to redress this situation by giving due importance to seed.

In the mid 1980s, the global seed business was estimated to be worth over US $ 50 billion, of which two-thirds was in the private sector. Another survey in 1988 showed that the value of commercial seed sold in all the developing countries was US $ 3.8 billion which is hardly 10–12% of global sales. In these countries, more than 80% of seed used is farmer-saved seed.

In Nigeria, some progress was made during the last ten years due to the efforts of national and international institutions, universities, state agencies, river basin authorities, and eight private seed companies. Seed sales through these organizations had an estimated value of up to US $ 3–4 million. Nevertheless, against an estimated seed requirement of over 300,000 tonnes in 1993, only 2,000–3,000 tonnes was sold. For such an important crop as maize not more than 500 tonnes hybrid seed was sold (1.25% planted area of maize). Seed production by the public sector is on the decline. The socioeconomic conditions have not been favorable to those in the private seed sector. Out of eight private companies established during last ten years, at least 5 are now closed. Pioneer, UAC, and UTC are the only organized seed companies now in operation. The Government is helping to establish a few small producer-distributors at village level.

For the success of a seed company, there should be strong public and/or private research to develop superior varieties and to maintain parent seed; good seed production, processing, and storage facilities; and seed promotion and marketing structures.

Fortunately, reasonably good research and production facilities have been put in place. Lacking are the awareness of certified seed among farmers, and the seed distribution channels. Ultimately, the companies have to encourage the use of private dealers/distributors but due to low demand for seed, the risk of losing viability of unsold seeds and low profit margins, they are not effective. Therefore, government agencies, especially state agricultural development projects (ADPS) are requested to help in the distribution of seed temporarily. Unavailability of fertilizer is another hurdle that needs to be overcome.

Downy mildew control and role of seed companies

There are three classical approaches to integrated pest management:
1. Use of genetic resistance
2. Use of fungicide
3. Cultural control practices.

The private seed companies are directly involved in the research, production, and distribution of the seeds of the cultivars resistant to downy mildew. They also dress their seeds with fungicides. Indirectly they educate the farmers on the use of cultural practices such as early planting, destroying infected plant debris, crop rotation, etc.

Downy mildew-resistant varieties and hybrids

Use of resistant varieties and hybrids is the safest, cheapest, and most effective means of downy mildew control. IITA and national scientists have developed several hybrid and open-pollinated varieties with very high levels of resistance/tolerance. These varieties are currently being produced and distributed in the forest zone. The IITA yellow hybrid 8644-24 is being marketed by Pioneer Seeds under the name Oba Super 2. At least 20 tonnes of this hybrid were sold in the downy mildew endemic area last season. Another Pioneer proprietory white hybrid resistant to downy mildew, Pioneer 3236 (YOG64), was also introduced in 1993. Pioneer has produced more than 300 tonnes of these hybrids for sale in 1994. For the characterisitics of the varieties see Table 1. A new proprietory yellow hybrid YIE78 ranked first in two years of national trials will be produced in one or two years.

Table 1. Characteristics of downy mildew-resistant hybrids being marketed by Pioneer.

Character	Oba Super 2 (8644-27)	Pioneer 3236
Grain color	Yellow	White
Grain texture	Flint	Semi-Flint
Plant height (cm)	215	205
Days to maturity	115	110
Adoptation	Forest/Savanna	Savanna/Forest
Reaction to:		
Downy Mildew	Tolerant	Tolerant
Streak virus	Tolerant	Tolerant
Rust & blight	Tolerant	Tolerant
Resistance to lodging	Tolerant	Mod. Resistance
Average yield (t/ha)	3.5-4.0	4.0-4-5
Yield potential (t/ha)	6.0-7.0	7.0-8.0

The IITA open-pollinated varieties, DMR-ESR and DMR-LSR, are being produced by UAC seeds. The PANAR hybrids will be produced by UAC once they are licensed. UTC is

producing the only IITA hybrids adapted to the midaltitude zone. So far the gene(s) imparting downy mildew resistance in maize is stable and has not been overcome by the pathogen. But the widespread deployment of only one genetic source might cause the pathogen to develop a new virulent race(s).

Recently the government decided that maize hybrids should be produced only by private seed companies whereas the open-pollinated (OP) varieties can be produced by private as well as public institutions such as the state ADPs. Good hybrids under all management conditions yield at least 20% more than the best OP variety. Thus it is more economical for farmers to plant hybrids even though they have to buy hybrid seed every year but this fact has not been recognized especially in the southern part of Nigeria.

However, considering the widespread use of improved seed under present circumstances, the private companies can also produce OP seed. Private companies cannot match the price of OP seed produced and sold by government agencies if they enjoy some kind of subsidy. Usually seed produced by private companies is of better quality, so any subsidy to public seed production has an adverse effect on the growth of private seed companies. The existing companies can produce the needed quantity and better quality seed of all crops including foundation seed, if they are assured of sales preferably via confirmed orders from public agencies.

The role of the public sector should be to regulate the seed quality at all levels, regulate seed trade practice, promote the use of improved seed including hybrid maize, provide other inputs namely fertilizer, provide seed supply-demand data, and do the basic research.

Fungicides

The use of the fungicide metalaxyl has been found to be very effective for the control of downy mildew. The fungicide formulation Apron Plus® also gives a very high degree of protection. About 10g Apron Plus® is recommended to dress 1 kg of maize seed.

As a regular practice, private companies dress their maize seed intended for distribution in the forest zone. Pioneer Seeds does not charge the southern farmers for Apron Plus® treatment as an incentive for them to adapt hybrids, but the high cost of this chemical prohibits Pioneer Seeds from using the recommended doses. Therefore government is requested to provide Apron Plus®, preferably free of charge or at a subsidized rate, to private companies for treating seed meant for the seven downy mildew-infested states. Apron Plus® is systemic in nature, and it is most likely that the excessive use of Apron Plus® will make the fungus develop resistance to this chemical.

Appeal to government

For the eradication campaign to be successful and for the maximum use of the resources of seed companies, it is requested that government:

- procure and distribute the downy mildew-resistant hybrids and OP seed produced by private companies.
- make fertilizer available to private companies for their research and production as well as to farmers buying improved seed as the sale of fertilizer with seed will greatly enhance seed sales and increase productivity.
- encourage private companies by the total removal of subsidy from publicly produced seed.
- effectively create awareness of improved seed among small farmers.

Strategies For Downy Mildew Control: Ciba's Approach

P. N. Ikemefuna

Introduction

In every agricultural ecosystem around the world, crops are attacked by various types of pests and diseases. These include insects, fungi, broad-leaved weeds and grasses, and nematodes. The agrochemical industry has developed specific product solutions and application methods to control these biological problems. All of these products and methods have advantages and disadvantages.

In this presentation, therefore, I will try to highlight the importance and usefulness of seed treatment with chemicals. I will also explain how a seed-dressing chemical (Apron Plus®) was developed and successfully introduced into the Nigerian market for the control of downy mildew, and other insect pests and diseases.

Many pest problems are directly linked with the seed and can be spread from one area to the other through the distribution of the seed. Soil insects are present wherever crops are grown and can attack the young seedlings even before they emerge from the soil.

The most appropriate technology to control these pests is one which involves placing the chemicals directly onto the seed (see Figure 1).

The benefits of seed treatment are manifold.

For the seed producer:

- Improved seed quality and better performance in the field
- Increased competitiveness
- Better plant establishment and yield security
- Protection against seed, soil, and airborne disease
- High emergence
- Convenient, quick, and safe crop management
- Labor saving

For the environment:

- Product is placed directly on the seed
- Small quantities of product required per hectare
- Does not affect beneficial soil fauna and flora

For the consumer:

- Residues in harvested grains are below the limits of detection
- Abundant supply of maize means lower cost to consumer

Various methods have been developed for the application of the chemicals. The various application methods have also to satisfy the various users' needs. A small-scale farmer has neither the same quantities of seed to treat nor the same equipment available as a big private seed producing company which is highly specialized in its field of activity. With this in mind, it becomes evident that the various seed-dressing chemicals available in the world markets, have to be formulated in different ways to match the application method used.

The following are the most common seed treatment formulations:

	Liquid Formulations	Application
1.	FS—Flowable Concentrate for seed treatment	As a suspension
2.	LS—Solution for seed treatment	As a solution (a.i is dissolved),
3.	ES—Emulsion for seed treatment	As an emulsion (oil in water),
4.	CS—Capsule suspension	Suspension of a micro-encapsulated active ingredient
	Powder Formulations	
5.	DS—Powder for dry seed treatment	Direct on the seed
	WS—Water dispersible powder for slurry	As a slurry which is prepared by first suspending the powder in water.

In the late 1970s, the first outbreaks of downy mildew on maize were noted in Kabba, Kwara State. Downy mildew of maize, caused by *Peronosclerospora sorghi* can cause losses in grain yields on maize of up to 95%. In the following years this disease spread more and more into the southwest of Nigeria and today is also present in Edo, Kaduna, Kogi, Niger, Ogun, Ondo, Osun, and Oyo states, covering a total area of about 150,000–200,000 ha.

Control strategies by Ciba

The first trials to control maize downy mildew in Nigeria were carried out with Apron 35 SD at Kabba in 1981, 1982, and 1983. The results from these trials clearly showed that Apron 35 SD, used as a seed treatment, was highly effective in controlling downy mildew of maize (see Table 1).

Table 1. Effect of different doses of Apron 35 SD on seed germination, downy mildew incidence, and grain yield of maize in 1981 and 1982.

Fungicide dosage (g a.i/kg seed)	Seed germination		Downy mildew incidence		Grain yield (kg/ha)	
	1981	1982	1981	1982	1981	1982
Thioral 1.00	80.4 a	88.1 a	91.3 a	85.1 a	633 c	1093 b
Thioral 1.50	78.3 a	86.1 a	80.0 b	89.7 a	748 c	863 b
Apron 35 SD 0.7	86.7 a	85.3 a	00.0 c	00.0 b	5,290 a	5,049 a
Apron 35 SD 1.4	81.3 a	82.6 a	00.0 c	00.0 b	4,911 b	5,060 a
Check (untreated)	82.0 a	90.6 a	95.3 a	88.8 a	368 c	943 c

Means followed by the same letter are not significantly different (p = .05).
Source: Dr A. Anaso—IAR Cropping Scheme

At this point, it became necessary to look beyond the control of Peronosporales into ergots, smuts, damping-off diseases, and soil-seedling pests. Consequently, in 1985, Apron Duet came up with a single packet containing two satchets—one of 8.0 g of furathiocarb, and the other, 3.5 g of metalaxyl plus 3.5 g of Captan. A first year trial revealed two major facts:

1. Illiterate farmers were traditionally used to one satchet for seed treatment and did not understand what to do with two satchets.
2. Captan was not effective in controlling smuts in sorghum and millet; and since this was a serious problem, it was immediately replaced with carboxin. All ingredients were combined, and the new mixture was called Apron Plus®. In terms of downy mildew control, Apron Plus® has clearly demonstrated its superiority to other chemicals.

Market introduction

The market introduction of Apron Plus® happened in three phases:

1. Further product development involving multi-state trials by research institutes together with on-farm demonstrations at various large-scale farms in the country. The phase began in 1986.
2. During the second phase test marketing of the product was carried out at the World Bank-financed agricultural development projects (ADPs) in the downy mildew-endemic states of Kwara, Niger, Osun, and Oyo. The results of the product development and the test-marketing phases were so impressive that agricultural consultants and advisers on their own started to recommend Apron Plus® to farmers and ADPs in Nigeria.
3. In the commercialization phase the sales were made nationwide and targeted to key crops such as maize, rice, sorghum, millet, and cotton. The selling efforts were supported by advertisements in newspapers and magazines, on billboards, posters, and product leaflets as well as direct promotion with distributors and end-users.

Despite the fact that Apron Plus® is more expensive per hectare than other products, the amount sold showed a steady, but progressive growth in the following years (Table 2).

Training

In order to support the control activities of downy mildew, training workshops are organized on a regular basis for various types of customers. These include agricultural development projects (extension officers), and large-scale farmers.

The training focuses on an integrated approach to the control of downy mildew, i.e., on the use of resistant varieties and certified seeds, on the treatment of the seed with Apron plus®, and on cultural practices such as roguing.

Collaboration

During 1990–1992 Ciba had a special agreement with the now defunct Agseed Nig. Ltd. This was to ensure that only seeds treated with Apron Plus® were sold to farmers in the downy mildew-endemic states. For this matter, and to support the idea of chemical seed treatment in order to avoid downy mildew attacks, special advertising campaigns were organized. With the help of leaflets emphasizing the benefits of chemical seed treatment and the use of hybrid seed varieties the message was carried to the farmers.

Table 2. Apron Plus® imports into Nigeria since 1987.

State ADPs	Year	Quantity (kg)
Bauchi	1989	2,800
Katsina	1989	1,300
Plateau	1990	3,000
Oyo	1990	12,000
Cross River	1990	500
Borno	1991	500
Benue	1991	3,000
Kwara	1991	500
Ondo	1991	6,000
Gongola	1991	300
Anambra	1992	8,000
Ondo	1992	6,000
Plateau	1992	4,000
Osun	1993	8,000
Kogi	1993	4,100
Total		60,000
Swiss Nigerian Chemical Company, Ltd		
	1987	7,000
	1988	3,500
	1989	3,000
	1990	8,900
	1991	0
	1992	0
	1993	2,000
Total		24,400

The Experience of Nigerian Maize Farmers

M.M. Omole

Introduction

The earliest documentation on the status of downy mildew is in the Holy Bible, in the book of Leviticus. Mildew was described as leprosy and dangerous. Any person infected by mildew/ leprosy was declared unclean and would be isolated until they were healed. Downy mildew on maize is caused by the spore-producing pathogen *Peronosclerospora* spp. It causes dramatic losses of maize in Africa, Asia, and America.

Our experience

Our company experienced devastating losses to downy mildew in 1991. Earlier that year, we decided to plant hybrid maize which was said to be high yielding. A total of 1,250 kg of hybrid maize seed bought from an accredited source in Ibadan was planted in Kaduna, Ikenne, and Lokoja. The seeds were dressed with a pinkish seed-dressing material. I did not normally buy dressed seed for planting, so on this occasion I was sure that my seeds were adequately protected. I usually planted in stages, so about 64 hectares were ploughed twice and harrowed once. A mixture of Gramozone and Primextra was sprayed two days after planting. The total amount spent on soil preparation to completion of planting of the 1st phase was about N192,000. All the maize germinated well to start with and flourished till they were about three to five weeks old. Then suddenly, we started to notice yellowish-white maize stands here and there. I first instructed that the affected stands be removed from their different loci in the plantation. But we noticed that more and more stands were becoming affected day by day, so I decided to carry out random sampling and examination of the 64 hectares. By the time the sampling was completed, it was confirmed that the whole farm was infected to a point of no return. I could hardly believe what I saw. I wondered how such could happen on a farm managed by me with all my experience. The infection was due to the dreaded downy mildew disease. From my academic knowledge of the disease, I knew that it could not be reversed once it had manifested on the plants; but because I was thinking of the cost that was involved, I started to look for a solution. I sprayed the affected and non-affected plots with Ridomil and Bordeaux mixture to no avail. I then took the only option of solving the problem which was to replough and replant the whole plantation. This time the seed was open-pollinated and bought from the National Seed Service (NSS), Ibadan. I made sure that the seeds were treated with the recommended seed-dressing material Apron Plus® 50 DS. A.G. Leventis and NSS later gave us some kilograms of well-treated, free-issue maize seed for planting.

The loss had, however, already been sustained. At the end of that season, the maize farm lost N274,505 gross.

Measures taken

I personally felt very concerned about the spread of the disease within my immediate surroundings because the maize plantations all around were full of yellowish-white or greenish-white young stands or twisted leaves on some older plants that resembled a witches' broom. Some had "crazy tops" that is, a proliferation of tassels or a mixture of tassels and miniature cobs. In most cases the affected stands carried no cobs on the stems. They were barren. The outbreak of the disease on most farms was very widespread. I talked to the farmers on the need to uproot or rogue the affected stands on their farms. Some were very reluctant with the hope that they would accept the yield no matter how small. However none of those visited a month later claimed to have harvested any cobs from the stems. The situation was bad!

Agricultural organizations later embarked on an awareness campaign on the incidence of the downy mildew disease (DM) on maize throughout Oyo State and made suggestions for preventive measures. I also took it upon myself to educate the farmers on the problem, and to convince them on the tried and tested method of dressing seeds with Apron Plus® 50 DS. In fact, some treated seeds were sold to farmers against the following season and most of them came back to our office to confirm positive results and express appreciation.

Most farmers have now employed the seed-dressing method and, subsequently, the spread of the disease has been controlled in our area.

Conclusion

Our experiences in 1991 have shown that:

- Sources of seeds for planting should be properly monitored and production of seeds for distribution should be handled only by honest and experienced growers.
- Downy mildew can be effectively controlled through seed dressing using the appropriately tested and certified chemicals.
- There should be random sampling and testing of treated seeds in order to determine the effective coverage and concentration of the chemicals in the treated seeds.
- Scientists/toxiologists should devise simple methods of carrying out such tests and teach the farmers/growers how to do this to avoid underdosage or use of inappropriate dressing materials.
- The possible spread of the disease should be publicized early in the given year on radio and television so that farmers can be on their guard to prevent attack.
- Any infested field should be destroyed and replanted with well-treated seeds.
- Foundation disease-tolerant or resistant maize varieties should be introduced for distribution: for example, downy mildew-resistant varieties (DMR) bred by pathologists and breeders should be given to accredited contract farmers/growers such as agricultural development programs (ADPs) and the National Seed Service (NSS) for multiplication and distribution to farmers.
- Farmers should be informed of the right time to plant maize to produce clean, disease-free seeds.
- Most contract growers, especially for the NSS, are not being properly monitored by the officials to ensure that good, highly viable, and clean seeds are returned after harvesting.

- The cost of hybrid seeds per kilogram is prohibitive. Something should be done to bring down the cost otherwise, farmers will continue to plant the low yield disease-carrying seeds.
- The cost of Apron Plus® 50 DS has also risen in the local markets. It is very difficult for non-registered farmers to get the chemical through ADPs. I propose that the Farmers' Congress should also be involved in the distribution of seed-dressing materials, and disease-free seeds to farmers.
- Finally, governments at both the federal and state levels should assist by increasing the levels of subsidy to farmers so that seed-dressing materials can be obtained at a considerably cheaper rate than is the case now.

Coping With Maize Downy Mildew: The Experience of Farmers

Bayo Ajayi

It gives me real pleasure to present this paper which treats a topic that has been a menace to maize production in Kwara State. I would also like to open a discussion on my own line which is not limited to downy mildew.

Maize downy mildew is a disease on maize and by definition, is a deviation from normal health, growth, or structure of maize that is sufficiently pronounced to produce a noticeable symptom or to impair quality or economic value of the produce. By my definition, disease affects not only plant growth but also includes deterioration of harvested plant products, e.g., seed, fruit, and grain. Downy mildew is a fungal disease and the causal agent is mainly airborne. The symptoms are mostly manifested on leaves and corn ears and it can be passed from generation to generation. There are numerous hosts that harbor the disease agents such as the soil and the air, so maize plants are always exposed to this pathogen. Furthermore, the tropical environment is highly suitable for its perpetuation as it comprises high humidity, high temperature, cloudy days, numerous weeds, abundant nitrogen in the soil, waterlogging, deficiency of nutrients, and other diseases which enhance the pathogenic effect of this disease.

Most of you that are academics and to some extent, those of you who went through formal training in Agriculture in higher or tertiary institutions, may see the effect of fungi and other diseases on cereals as mere confirmation of whatever information your textbooks and science journals contain. Your concern is likely to be on research or on the reduction of national agricultural production as it affects the general national economy or availability of food on your dining tables. Your attitude to disease infestation can be likened to that of a doctor to his patients. But for farmers, such effects can seem like the "end of the world" since farming is a business as well as a way of life; that is, the risk of pest infestation could determine between survival and death. No amount of compensation can replace the satisfaction a farmer derives from seeing his crops growing the way he likes them to grow.

This is not to say that farmers are indifferent to international and national efforts to combat hindrances to crop development and protection. We are aware of and feel the impact of different campaigns to promote production of crops through improved cropping methods, breeding improved varieties, control of diseases, provision of adequate inputs, credit facilities, etc.

The effects of downy mildew on my farms, over the years, may seem to be tolerable but could be significant. This is because I have made it a rule of thumb to dress my seeds with fungicides especially Apron Plus® and Mancosan®. A few farmers in my locality do the same. However, when one adds the cost of these chemicals to a loss of about 1% of produce, the effect is significant, especially on a large farm like mine—about 40–50 hectares at a time.

I, personally, have benefitted from assistance programs, services, and from vital information from different agricultural institutions. I have also benefitted from participation in various seminars/workshops and agricultural shows both in Nigeria and abroad. Notable among these places are: IITA, Federal and state ministries of agriculture, ADPs, IAR&T, NALDA, and RMRDC.

However, I would like to appeal to other agro-allied bodies to lay more emphasis on the total package delivered and after sales service to farmers. You will all agree that any abnormality in crops during any stage of growth which minimizes or maximizes harvest is of significance. To lay emphasis on one disease alone is to mince words; it is like saying that the disease of the eyes is less important than that of the ears; or saying that the fingers should have been affected instead of the toes. What I am trying to point out here is that all institutions and their sponsors involved with eradication or mitigation of the effects of crop losses should pool their efforts towards providing a total package of recommendation, and provision of adequate extension services and farm inputs. From the moment they are sown through the ripening of the grain to storage and final consumption, crops are exposed to many different fungi, bacteria, viruses, pollutants/poisons, and the effects of farmers' inability to interpret information, obtain inputs, and obtain financial support that can result in considerable harvest losses, economic losses, and even danger to life.

Finally, it is sad to hear that IITA wants to discontinue research on maize in the forest ecology. This will not be to the benefit of Nigerian farmers. One would expect IITA to redouble its efforts in this noble task instead of pulling out. Farmers will dialogue to resist this unwelcome development. They will advocate for more funding to research institutes for the enhancement of high technology in production.

Summary of State-by-State Report of Downy Mildew Incidence in Nigeria

O. A. Adenola

Introduction

Downy mildew disease has been observed in Nigeria for ^' nost two decades now and ever since, it has been spreading from one location to the other. The downy mildew strain that affects only maize was first identified on the Kabba/Owo axis of the forest zone in 1975. For many years its effects remained localized around this center of discovery. Thus, the Nigerian experience as regards the disease's rate of spread, is that it may be passive for a number of years in one location but may move very fast in other locations. The rate of spread in the last two years from Ondo into Osun and Oyo states has been very alarming. This is contrary to its earlier pattern of being passive in Ondo/Kwara states for over a decade without any appreciable spread.

Even though control work was started a long time ago through the development of resistant maize varieties, downy mildew continues to destroy maize crops. The disease that initially covered a small area of the forest zone now covers a substantial part of Nigeria's land mass. To date, it has been identified in Benue, Delta, Edo, Kogi, Kwara, Ondo, Oyo, and Osun states. Even though the movement seems to be generally in a southwestly direction it is not totally uni-directional. If the postulation that the disease is windborne is true and if it continues its present route it will soon get to the Republic of Benin.

During one of our monitoring trips to Ondo State, it was discovered that the incidence of downy mildew decreased progressively as one moved nearer the location of the Ondo State Agricultural Development Project (ADP) (Ekiti Akoko). This confirms that some degree of resistance has been incorporated into some of our maize varieties, and that the ADP in Ondo State is having success in the dissemination of downy mildew-resistant (DMR) materials. When these varieties are used, the incidence of the disease is reduced according to the level of resistance. If every state had used DMR varieties, the disease might not have spread to Oyo State.

It is on the basis of this fact that we decided to collect data from every state in respect of downy mildew disease vis-a-vis the production and use of resistant maize varieties by farmers in the state as well as the use of chemically treated seed. Copies of a questionnaire were sent to all the states that were already, or thought to be potential victims of the disease. The information contained in the returned questionnaire is presented in the following table.

Observations and implications

1. The disease is spreading into new areas every year but its spread has been faster in the last 2 years.
2. The area covered by the disease is expanding therefore doing more damage to the maize industry in the country.
3. The number of farm families suffering from the devastating effect of downy mildew has risen to over one million in only 7 states. This means that many homes may not be able to afford 3 square meals any longer. We have observed fields that have experienced 100% loss as a

result of downy mildew. Incidentally farmers of some of such fields are present at this workshop.

4. The farmers that have not experienced the disease do not know about it and do not take experts seriously when advised until their farms are affected.
5. The use of resistant materials and/or chemicals can check the spread of the disease substantially.
6. Farmers now source their seed from many sources as opposed to the traditional method of saving the seed from one season to the other.
7. Some ADPs do not dress the seed sold to farmers with Apron Plus®. Rather farmers dress the seed themselves.
8. There is a growing desire by farmers to use chemicals to dress their seed as can be seen in the figures for Osun and Oyo states, but the cost is a big constraint.
9. Finally, it is clear that the extension agent to farmer ratio is still high. This ratio should be reduced to 1:800 as soon as possible to enhance the success of the campaigns. Interstate cooperation is needed to achieve fast and comprehensive control.

Statewide Status of Downy Mildew of Maize: February 1993

Parameter	States							
	Kwara	Oyo	Osun	Ogun	Kogi	Ondo	Delta	Total
1. Estimated land area under maize	102,224 ha	260,000 ha (1992)	58,253 ha	–	150,000 ha	90,000 ha	3,740 ha	664,217
2. Estimated no of farmers	184,787	344,230	239,051	250,000	172,000	150,000	180,000	1,520,068
3. Maize type grown	OP (White)	OP (Y/W)	OP(W/Y) Hybrid	OP (W/Y)	OP (W/Y) Hybrid Low	OP (W/Y)	OP (W/Y)	
4. Maize seasons observed	2	2	2	2	2	2	2	
5. Private seed source								
i. Farmer seed	Yes	Yes	Yes	5%	Yes	Yes	Yes	
ii. In-state ADP	Yes	Yes	Yes	80%	Yes	Yes	Yes	
iii. Out of state	Yes	Yes	Yes	5%	Yes	Yes	Yes	
iv. Private seed company	No	No	Yes	5%	No	No	No	
6. What proportion of farmers buy seeds and hectares planted								
i. Once each year	40% (40,890)	60% (156,000)	40% (23,300)	85%	20% (30,000)	30% (27,000)	1% (374)	277,567
ii. Occasionally	80% (81,779)	30% (78,000)	30% (17,476)	10%	50% (75,000)	50% (45,000)	-	(297,255)
iii Never	10–20%	10%	30%	5%	30%	60%	99%	
7. Private seed companies	Nil	3	3	–	–	–	–	–
8. Seed processing plants	1	6	Nil	1	–	1	–	–

Parameter		States							
		Kwara	Oyo	Osun	Ogun	Kogi	Ondo	Delta	Total
9.	Degree of DM infestation	High	High	High 1992 Low 1993	– –	–		High	Low
10.	Estimated area under DM resistant seed	65% 66,445.6 ha	0.06% 150 ha	60% (34,95/ha)	30% –	40% (60,000 ha)	35% (31,500 ha)	-	
11.	Quantity of DMR seed produced by ADP in 1992/1993	105.71mt –	1.6mt 5.6mt	70.6mt 92.5mt	5.22mt –	40mt 50mt	70mt –	– –	293.13mt
12.	Proportion of DMR seeds by contract growers	95%	66.4%	85% 1992	97% 1993	90%	80%	64 %	–
13.	Produced directly ADP	5%	33.6%	15%	3% 1992	10% 1993	20%	31%	–
14.	Quantity of Apron Plus commissioned by ADP in 1992	422kg 252.6kg	1027kg 3220kg	1048.7kg 4000kg	25 kg 19.5kg	– 138.3kg	110kg 119.9kg	29.95kg 86.33kg	

Parameter	States							
	Kwara	Oyo	Osun	Ogun	Kogi	Ondo	Delta	Total
15. Quantity sold to farmers 1992	269.7kg	1027kg	1048.7kg	–	–	–	29.95kg	
1993	113.7kg	3720kg	2452.7kg	–	138.3kg	119.9kg	86.33kg	
16. Quantity used to dress ADP produced seeds 1992	Nil	Nil	Nil	Nil	Nil	110kg	Nil	
1993	Nil	Nil	Nil	Nil	138.3kg	119.9kg	Nil	
17. Proportion of farmers that used seed dressing						–		
1992	60%	30%	50%	–	–	5%	–	
1993	40%	75%	80%	–	–	5%	–	
18. Extension agents	126-170	269	207	126	142	138	165	
19. Extension agent/farmer	1:1,126	1:2,000	1:2,000	1:2,000	1:2,000	1:2,000	1:2,000	1:1,532
20. Proportion of farmers reached by an extension agent	10%	95%	85%	60%	–	80%	73%	67%
21. No. of SPATS/ agent	80	80	180	150	80	80	80	

* 1 sachet = 10g

COUNTRY REPORTS

The Status of Downy Mildew in the Republic of Benin

Chakirou Lawani

Maize production in Benin

Maize is mainly used for human consumption and it is the staple food for a large proportion of the Benin population, especially in the southern and central regions. Maize represents the main food grown in terms of area cultivated (480,000 ha versus 131,515 ha for sorghum, and 122,309 for cassava in 1992). Maize is grown throughout the country although the best producing areas lie in the southern part of the country (provinces of Oueme, Atlantique, Mono, and Zou), constituting about 80–85% of cultivated area. The major part of this zone (about 25% of the area of Benin) has a sub-equatorial climate characterized by two rainy seasons (April to July, and October to November) and two dry seasons (August to September, and December to March). The relative humidity is often very high and temperature generally fluctuates around 30–35°C. Maize production is expanding in Benin and the crop is now grown in every province.

The following improved varieties are distributed through extension services and are used by farmers: Pirs Aback, POZA RICA, POSTA, TZB, TZBSR, TZESR, and DMR. In order to give momentum to its policy of seed production, the Government of Benin created eight farms in different regions to produce and distribute improved seeds to farmers. Up till now, Benin has benefitted from a three-year seed project which has been extended for one year, twice. The adoption of improved varieties is slow (10–25%) and is hindered by the following:

- Scarce and costly fertilizer
- Susceptibility of improved varieties to storage pests because of poor husk cover.

The different types of fertilizers used are NPK 14-14-15, triple superphosphate (47% phosphate), ammonium sulphate, and urea (46% nitrogen). Rates of application vary according to the type of fertilizer used and the type of soil; the following rates are often applied per hectare: 150 kg NPK and 50 kg urea, or 100 kg ammonium sulphate and 50 kg urea.

In the south of Benin, maize can be grown as a sole crop, but it can also be found as part of mixed cropping due to lack of land. The mixed cropping patterns found are: maize-cassava, maize-groundnut, maize-cowpea, maize-sesame-cassava, maize-sorghum-cowpea, maize-cassava-cowpea.

In the south of the country, the average size of a farm does not generally exceed 1 hectare. Luckily, Benin's maize producing areas do not yet suffer from downy mildew, although the disease has been reported in various Nigerian states close to the Republic of Benin. The main constraints are the weather conditions (temperature generally about 30–35°C and relative humidity often exceeding 70%) in the maize producing areas which would contribute to the spread of downy mildew if it were to hit the area. The presence of the disease along our borders represents an imminent threat to maize production in Benin. The potential impact of the disease would be very great with very important harvest losses due to the fact that many farmers grow maize as a sole crop after groundnut *(Arachis hypogen)* or sweet potato *(Ipomea batata)* established just after the first rains of the rainy season.

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The Benin Seed Project

The aim of the seed project was to help the Benin government set up the basic structure needed to implement a national seed plan. This aim has not been achieved due to various drawbacks such as poor site selection, farm management problems, conditions of production, and the absence of a true national policy on seeds.

The seed industry is currently structured as follows:

Breeder seed production is conducted at the food crops research station level from adequate germplasm and in accordance with farmers and consumers' needs. The three food crop stations (Ina, Niaouli, and Bohicon) currently benefit from an FAO Technical Cooperation Program (PCT/BEN/8952 "Collection and Conservation of Stock and Breeder Seeds from Food Crops").

Foundation seed production occurs at two seed farms among the seven existing ones (Agbotagbon, and Alafiarou). These two will become the production and packaging unit (UPC) for foundation seed, and for packaging seed produced by farmers in charge of multiplication throughout the country and by economic agents interested in the matter.

Industrial treatment of seeds occurs at the independent seed packaging and processing factory of the Centre for Regional Action and Rural Development (CARDER), Borgou in Parakou.

Control of seed quality for certification purposes by the National Laboratory for Seeds and Seedlings Analysis and Certification established within the Directory of Products Control and Packaging (DCCP) in Cotonou.

The foregoing shows the official organizational structure of improved seed production and certification. This organization also accounts for disease-resistant varieties. Seed distribution is mainly ensured by CARDERs.

The potential for the adoption of new varieties would be very high if only there were no constraints such as:

- Low income for farmers who cannot afford improved seeds.
- The requirements related to the introduction of improved varieties (fertilizers, water, etc.).
- The problems of storage of harvested produce related to the intrinsic qualities of the introduced varieties.

The extension services department of each CARDER is in charge of distribution. This department is adequately equipped to perform its duties, though for all objectives to be achieved, technical, financial, and other indispensable means need to be put at their disposal. The distribution approach must also be studied thoroughly in order to better define it and to adapt it to the farmers' environment so as to overcome possible reluctance. Unfortunately, since the end of the Program for the Restructuring of Agricultural Service (PRSA), the number of extension workers has reduced sharply.

The acceptance of the idea of purchasing improved seeds must come after an awareness campaign directed to the peasants at the grassroot level which identifies the problem and describes the very serious consequences for maize cropping. As soon as the farmers have understood the problem, their reluctance to the new technology will be overcome and the chances for the success of the operation will be increased. The cost of seeds may still be an obstacle. In general, any chemical seed treatment is performed by rural development bodies (mainly the CARDERs) before seed sale. In some cases, the farmers themselves ensure seed provision through self-managed production and one notices that very few farmers treat their seed due to lack of financial means or the unavailability of the product for the treatment or because they use so-called "traditional seed protection" products.

The prevailing agricultural research infrastructure (varietal introduction) includes various stages, namely:

1. Screening with a view to identifying the best varieties in terms of performance, for a specific purpose (as part of joint efforts between the National Institute of Agricultural Research of Benin and the Plant Protection Department).
2. Seed multiplication on-farm.
3. Pre-extension trials through relevant CARDER structures (Research and Development Division).
4. Multiplication on seed farms upon request from the CARDER.
5. Extension activities on farmers' fields mainly conducted by the extension staff.

Several economic and decision-making factors are likely to determine the success or failure of the promotion of mildew control methods:

1. The price of the seed has to be as low as possible for it to be accepted by a large number of farmers, and should be a fully mastered resistance transfer technology.
2. The dissemination channel should be supported by clearly designed projects with specific farmer-oriented objectives.
3. There should be technical collaboration with national plant protection services and agricultural research services.
4. A proper awareness campaign at the farm level.

In Benin, no special project is committed to the protection of maize crops besides the Benin and German Project for the Reinforcement of the Plant Protection Service. This project is involved in work on the protection of food crops against pests in general with the objective of minimizing field and storage losses due to pests and diseases affecting the major food crops through the implementation of economically and ecologically sound plant protection measures.

To obtain the external support required for an efficient transfer of mildew control technologies, a project has to be developed for the sub-region in the spirit of this international workshop with country components to be executed by the national plant protection and agricultural research services. Funding sources should be identified for seed development (research) release and extension activities.

To conclude this presentation, I would like to draw the attention of this assembly to the fact that this disease is suspected on sorghum in the far north of Benin. The case has been reported but in-depth investigations are yet to be carried out.

The Status of Downy Mildew in Uganda

George Bigirwa

Introduction

Agriculture is by far the most important sector of the Ugandan economy, accounting for over two-thirds of the nation's gross domestic product (GDP). It provides about 80% of employment, and constitutes 90% of the export earnings. Food crops dominate agriculture representing 80% of the value of monetary and non-monetary agriculture (MOA/MFAD 1990).

Maize is believed to have been introduced into Uganda in 1861 but did not become established until the twentieth century (Norman et al. 1984). In the last two or so decades, maize in Uganda was only eaten as a meal by immigrant tribes; the Luo and Maragoli from Kenya, Nubians from the Sudan, and migrants from Rwanda (Jameson 1970). Presently maize ranks as one of the major staple food crops widely grown and consumed by all tribes in Uganda. The amount of maize used as food in Uganda is estimated to be 59% (Bantayehu and Brhane 1991). This sharp increase is attributed to declining production of bananas and cassava.

For the past six years the government of Uganda has placed emphasis on the production of non-traditional export crops so as to diversify export earnings. Presently maize is the only cereal exported from Uganda. Both production and hectarage have increased significantly. For instance, in 1981 about 260,000 hectares were planted while in 1989 it shot up to 556,000 hectares. The current aggregate supply is estimated to be 644,000 tonnes against a yield of 1.5 t/ha without using fertilizers. Farmers in the country are able to grow most crops, maize inclusive, twice a year. In swampy areas maize is grown almost all year round.

Among the factors which limit maize production are pests and diseases such as maize streak virus, northern leaf blight *(Exserohilum turcicum)*, common smut *(Ustilago maydis)*, and of late, downy mildew. The most common type of downy mildew of maize is that caused by *Peronosclerospora sorghi*. The origin of downy mildew in Uganda is not clearly known. However, Doggett (1970) reported that the disease appears to have a long history in East Africa where it was causing economic losses on sorghum but not on maize. The story has now changed and maize is being severely affected. Isolated cases of maize downy mildew were first observed in 1989. From 1991 cases became widespread such that incidence and severity have been increasing yearly. The disease is now affecting maize in about 20% of the maize-growing regions. Losses of about 15–20% are estimated. The disease is now found affecting maize in Iganga, Kasese, and Mpigi districts. In Masindi it is affecting both maize and sorghum. The disease has also been reported in other districts such as Lira, Apach, Paliisa, Mubende, and Mbale. If the situation continues, the maize success story in Uganda is likely to be history. Use of undressed seed especially by farmers who plant seed from their previous harvest, rotation of maize with host crops, continuous cropping of maize in the same field, failure to destroy infected crop debris, and failure to rogue and destroy infected plants as they appear in the field are possibly the main causes of the increased incidence and spread. The recent susceptibility of maize to the disease cannot be clearly explained. However one may attribute it to the varietal resistance breakdown and changing weather patterns. In the light of the grave nature of the disease, the

losses it is causing, and the rate at which it is spreading in other countries we must pay urgent attention to it in Uganda.

The possible areas to focus on are.

- A country-wide survey to map out the affected area.
- The rate of incidence, severity, and possible yield losses.
- The strains present and mode of spread.
- The need to sensitize and educate farmers and extension agents about the disease and its control.

Many farmers are aware of the dangers of diseases and the benefits of using improved varieties of seed. With the help of the extension agents, a good number of farmers have put aside their conservative attitude of clinging to their traditional technology and have adopted innovations. For instance, the response to the new open-pollinated maize variety, Longe 1, is very positive and there is also tremendous pressure and demand for hybrids. Through on-farm research where farmers are directly involved, the potential for acceptance of resistant varieties is enormous. New varieties will continue to be accepted as long as seed quality is good in terms of germinability, yield potential is equal to or more than that of their local varieties, maturity period is about $3^1/_2 - 4$ months, and resistance levels to the common diseases in their localities are good. Conditions of service of the extension agents have been improved so reaching and advising farmers irrespective of sex will be easy.

Farmer control of some pests and diseases using chemicals has been in practice for a long time in Uganda especially for crops such as cotton and other high-value crops such as vegetables and banana. The most important thing is to conduct courses aimed at teaching farmers the associated dangers, and proper usage, handling, and storage of pesticides. For farmers who produce their own seed this would be welcome.

Agricultural research in Uganda used to be under the Ministry of Agriculture, Animal Industry and Fisheries, but as from January 1994 it became semi-autonomous under the National Agricultural Research Organization (NARO). Six research institutes fall under this organization, each with a specific mandate. Maize research is under the Namulonge Agricultural and Animal Production Research Institute (NAARI). Two substations fall under this institute; Kigumba in the mid-west and Kalengyere in the south. In addition, there are several multilocational testing centers spread all over the country. There are strong links between researchers, extension staff, and farmers. Interaction is made possible through courses/seminars, field days, and on-farm participatory research.

The financial standing of the country is bad, as most of the activities are being run on grants obtained from such donor agencies as the World Bank, IDRC, the Rockefeller Foundation, IFAD, and EEC. The economic considerations that may determine the success of promoting technologies for controlling maize downy mildew are to do with availability of funds to conduct research, to develop and test resistant varieties, and to disseminate information to farmers. Cooperation with international institutes such as IITA and FAO, which have the capability, would greatly assist in solving this problem before it gets out of hand.

The national maize research program received financial support from USAID from 1988 to 1993. Emphasis was being put on technology transfer. With the phasing out of this project, it may be difficult to promote downy mildew control technologies. The external support that would be needed to assist in the successful transfer of downy mildew control technologies include:

- Collaborative ventures with scientists and institutes such as IITA where work on the disease is being fully addressed.

• Funds to initiate the project, e.g., setting up and maintenance of trials, educating the parties involved through courses and operational costs.
• Means of transportation (vehicles).
• Continuous interaction and exchange of information.

Finally, I would like to end by thanking the organizers of this workshop. For Uganda it has indeed been a timely and welcome venture because it came at a time when we were assembling ideas to begin addressing this problem. With this kind of cooperation being initiated, it is my sincere hope that downy mildew can be effectively controlled.

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The Status of Downy Mildew in Zaire

Mukendi N'Kashama

Introduction

Maize *(Zea mays)* is the second most important crop in Zaire after cassava. It is grown mostly by small farmers in the countryside. They sometimes use it as a staple food, but often sell it to traders in the main centers of consumption, inhabited mostly by wage earners (PNM 73–74).

The ecological adaptability of this food crop means that it can be grown in very varied soil and climatic conditions at between 500 and 2,500 m above sea level. It is thus somewhat paradoxical to note that the yields produced by farmers are constantly decreasing. Two reasons are generally cited to explain this situation: biotic and abiotic factors. We shall note only two of these which are of primary importance:

1. The lack of varieties resistant to the most important diseases such as mildew, with a genetic potential for high yield.
2. The use of inappropriate farming practices which do not allow the variety to fully express its yield potential. This means that high yields per unit area cannot be attained. We would cite, for example, inappropriate planting dates and the non-use of fertilizer.

Frey (1979) and Russel (1986) state that the significant increase in maize production in the developed countries is partly due to the use of genetically improved seed and partly to improved farming practices.

Farmers in Zaire therefore need stable varieties which are resistant to the main fungal and viral diseases, such as mildew and mosaic, and have a high potential yield. Good farming practices which improve productivity need to be developed along with varietal improvements. This can be done through breeding and improvement by multidisciplinary teams composed of breeders (plant improvement specialists), pathologists (crop protection specialists), agronomists, and socioeconomists.

Over the years, the National Maize Program (PNM) has worked more on improving yield and practically ignored resistance to the various diseases of maize. Consequently the area cultivated with PNM-improved varieties is not very representative. Some maize diseases are, however, of great economic importance and affect maize productivity every year throughout the country (Binsika 1979, and Shanower 1991).

The importance of maize downy mildew in Zaire

Maize downy mildew is caused by the pathogen *Peronosclerospora sorghi* (Weston and Uppal). It is the most important disease of maize in the northwest of Shaba province and throughout Kasai province. The symptoms of mildew appear everywhere in these areas when maize is planted late in the first cropping season, and on almost all maize planted in the second season (Binsika 1978). The PNM has developed a series of high-yielding, open-pollinated varieties. Unfortunately all these varieties are highly susceptible to mildew.

Production losses to the disease vary between 10 and 100% when the attack occurs at silking. In order to avoid losses due to *Peronosclerospora* spp., PNM recommended early planting of

maize in the first cropping season (from September to January), and legumes in the second season (from January to May). PNM has, of course, tested the effect of fungicides such as Ridomil® on mildew. Although the results were very good, the high cost of these chemicals means that they are currently beyond the possibilities of the Zairois farmer. (Mukendi 1983, unpublished).

There is no doubt that the use of resistant varieties is the most effective way of combating mildew and other diseases. Several sources of resistance have been identified and used in breeding and improvement programs against mildew at IITA and in Asia (Thailand) (Kim et al. 1981). Since 1984, PNM has tested and adopted the IITA experimental variety DMR-SR-W and Y. Although this variety showed some tolerance to mildew, it is about 40% susceptible in conditions of heavy infection, particularly in the second season, and its potential yield is relatively low compared to that of the local varieties. No local source of resistance has been identified.

Zaire has both a national program in charge of work on maize and a national seed service which supervises the industrial production of certified seed throughout the country. Certified seed of all food crops is produced on seed farms which have received help from the World Bank and the FAO, under the supervision of the National Seed Service (SENASEM). It should be noted that the seed produced by SENASEM are of varieties developed or tested and approved by the national research program, such as PNM, PNL (National Legumes Program), and PRONAM (National Cassava Program). No exotic varieties can be produced or multiplied in Zaire before being tested by the national program with the mandate for research on the relevant crop.

New varieties are put into extension by the national research programs and the National Extension Service. Once the farmers and other users have adopted a newly introduced variety, the foundation seed is given to SENASEM for multiplication and marketing.

Maize downy mildew is the biggest constraint to maize production in the administrative regions of Eastern and Western Kasai. This means that all maize farmers in the region are aware of the importance of using resistant varieties. Many farmers constantly ask us how to combat this problem. Unfortunately for them and for us, because of the social and political problems of the last three years, we have not been able to give them a satisfactory answer in that it is impossible to use chemicals (fungicides) because of the low purchasing power of the Zairois people in general and the farmers in particular.

The National Extension Service, the National Seed Service, and the national research programs have well-qualified scientific and technical staff, but they do not have the logistic back-up (vehicles, equipment, and other supplies) they need.

Zaire was one of the first sub-Saharan countries of Africa which, with the help of international bodies and institutes, set up national research, and extension and improved seed production programs. However, since the virus of democratization has found refuge in our countries, most of the infrastructure built with the help of foreign donors has been destroyed by acts of vandalism. The scientific and technical staff find themselves without offices, laboratories, and often housing. However, Ngandajika Station in Western Kasai, where mildew is the main disease and causes significant losses, still has some buildings, greenhouses, laboratories, offices, and houses which require extensive repairs. PNM has qualified staff at the station who are waiting for funds to become available. Given the economic and financial crisis in Zaire at the moment, there is no likelihood that the government will be able to fund any agricultural projects. This is not only because the government is not able to pay for the running of agricultural projects,

but also because foreign and international organizations and institutions have stopped funding development projects in Zaire because of the social, political, and economic crisis in the country.

The farmers of Zaire as well as the agricultural scientists and technicians are thus left without any logistic, financial, or material means at all. This is why we are requesting the assistance of international organizations and other donors of good will to help the thousands of Zairois farmers whose very survival depends on the distribution, multiplication, and use of varieties resistant to mildew and other pests.

Conclusion

The distribution of resistant varieties in the south of Zaire would make not only the maize farmers of mildew-endemic regions happy, but also all the people of the Kasai region in the center-south of Zaire who depend on this staple food.

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STATE AND INSTITUTIONAL REPORTS

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Ondo State

Introduction

The outbreak of downy mildew disease of maize in Ondo State can be traced back to the early 1970s when over 70% of the maize planted in Owo Local Government was noticeably attacked by the disease leading to a great reduction in yield. The disease later assumed epidemic proportions and spread to other parts of the state.

When the outbreak of the devastating disease was officially reported, maize breeders from the National Cereals Research Institute (NCRI) and the International Institute of Tropical Agriculture (IITA), Ibadan swooped into action by breeding resistant varieties such as DMRESR(W), DMRLSR(Y), and DMRLSR(W). The extension work station, Owo, and the Federal College of Agriculture, Akure were used as some of the experimental sites.

On 14 April 1989, a special allocation of 4 tonnes of downy mildew and streak-resistant maize varieties (white and yellow) was presented to the Ondo and Kwara state ADPs. Out of this consignment, Ondo State ADP received 2.5 tonnes of DMRESR-Y and 0.5 tonnes of DMLSR-W.

During the 1989 cropping season, the consignment was planted in seed farms under direct effort and the outgrowers scheme for further multiplication and distribution to farmers in the state.

The National Seed Service has been kind enough to supplement the requirement for planting materials both for direct effort and the outgrowers scheme annually since the inception of the state ADP. It is worth noting that the Federal Government in its Downy Mildew-Resistant Maize Relief Program allocated 20 tonnes of treated DMRESR-Y and DMESR-W maize seeds to Ondo State in the 1993 cropping season.

The targets and achievements in terms of hectares and tonnes of downy mildew-resistant varieties of seeds produced under direct effort and the outgrowers scheme in the state since the inception of the project in 1989 to date are given in tables 1 and 2.

In 1992, another downy mildew-resistant variety of maize called SUWAN was introduced into the state through NCRI. This variety has replaced the two earlier downy mildew-resistant varieties due to its comparative advantage in yield.

For the 1993 cropping season, 25 tonnes of DMRESR-Y and W, and SUWAN were distributed to outgrower farmers in the state.

The Ondo State Agriculture Input Services Company collected 10 tonnes of the three varieties mentioned above from Ondo State ADP for distribution to various farmers.

In 1994, a target of 70 ha was earmarked for direct multiplication farms (4 ha) and outgrower farmers (66 ha). At present a total of 80 tonnes of DMR maize varieties DMRESR (W) and (Y), DMRLSR (W) and (Y), and SUWAN are available for sale in Ondo State ADP. However, despite all efforts to eradicate or reduce this virulent disease, it persists because:

- Most resource-poor farmers (PRF) still believe that a small quantity of their old stock has to be kept.

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Table 1. Targets and achievements (ha) in production of downy mildew resistant maize in Ondo State.

Production	1989		1990		1991		1992		1993	
	Targ.	Ach.	Targ.	Ach.	Targ.	Ach.	Ach.	Targ.	Targ.	Ach
Direct effort	120	71.5	80	48.7	20	24	30	24	20	–
Outgrower	40	46	56	56	67	77	100	148	100	1
Total	160	117.5	136	104.7	87	101	130	172	120	1

Table 2. Quantity of DMSR varieties of maize produced (tonnes) 1989–1993.

Production	1989	1990	1991	1992	1993
Direct effort	–	37.5	45	30	30
Outgrowers scheme	133.00	90.2	120	165	170
Other farmers					
Total	133.00	127.65	165	195	200

• Many of these resource-poor farmers find it difficult to spend ten naira (N10.00) on a kilogram of improved maize.
• The local downy mildew susceptible varieties of maize taste better and are less chaffy than the improved varieties.
• Some farmers claim that they use the local land-races as calendars to count days as against the improved seeds that keep up to 4 months before maturity.

However, the farmers have been informed through radio, television, and contact farmers that there are early and late varieties of improved maize varieties that are resistant to downy mildew.

Conclusion

It is pertinent to commend the efforts of the maize breeding scientists in the international and national agricultural institutions in combating the downy mildew disease of maize. The disease will be much reduced if not completely wiped out, if at least 1–3 kg of resistant and early maturing maize varieties can be given free to the resource-poor farmers who are mainly subsistence farmers.

Osun State

Introduction

The first report of the incidence of downy mildew (DM) was made in July 1990 on a farmer's field around Ijeda in the Ife/Ijeda zone of Osun State. By August 1990, the disease was confirmed on a maize farm at Osogbo. Staff of the old OYSADEP and scientists from IAR&T went to document the disease for record purposes, and listed strategies to combat it. The disease spread like bushfire and, before the end of the cropping season, it had spread to Osogbo, Ede, Iwo, and most of Ife-Ijesa zone.

Efforts in 1991

Small plot adoption technique (SPAT) plots of DMR maize were set up in the endemic areas to demonstrate to farmers that certain maize seeds can escape the disease.

On-farm adaptive research (OFAR) trials were set up to test the efficacy of Apron Plus® in protecting maize plants when used at the recommended rates.

Field days

Field days were organized to educate the farmers on ways to combat the deadly disease. This was done on a block basis in the endemic zones of Ife-Ijesa, Osogbo, and part of the former Ibadan zone of the then OYSADEP.

Multiplication of resistant varieties

In 1991, 10 ha of DMR varieties were cultivated from where about 15 tonnes were harvested and this was injected into the endemic areas in the 1992 planting season.

Efforts in 1992

The use of Apron Plus® was encouraged. In 1992, 1,048.65 kg of Apron Plus® (104,865 sachets) was sold to farmers in Osun State. This was sufficient to treat 209,730 kg of seeds, which could plant 8,389.20 ha of farmland.

Planting of DMR varieties

Apart from the 10 tonnes produced in 1991, the Federal Government supplied 17 tonnes of DMR maize varieties or other varieties treated with Apron Plus®. This was distributed free to farmers for planting as a late crop in 1992, and more than 800 farmers benefitted statewide. During a diagnostic survey of the farming system of Osun State in 1992, incidences of DM were encountered mainly on farms where the farmers claimed that Apron Plus® was costly or where farmers had used their own seed or had bought their seed from the market. This was before the Federal Government's aid of 17 t of DMR seeds or seeds treated with Apron Plus®. A survey conducted by OSADEP in 1993 revealed that 97% of the farmers given the DMR seeds actually planted them and kept the new seeds for planting in 1993. About 63% also claimed that they had given their farmer friends DMR seeds. Field surveys also show that an average of 6% of the farms had DM disease in various degrees of severity.

1993 report

The estimated area under maize cultivation was 58,253 ha (both early and late crops). The incidence of the disease was mild in 1993 compared with 1992. Between 60 and 65% of the area under maize cultivation was with DM seeds. In 1993, 4,000 kg of Apron Plus® was commissioned, and 2,452.65 kg were sold to farmers. The awareness of the efficacy of Apron Plus® has grown considerably. About 5 tonnes of foundation seeds stage II were produced on the seed farm, while about 70 tonnes of certified seeds of DMR maize were cultivated by outgrowers in 1993. Osun State ADP also indented for 8,000 kg of Apron Plus® against the 1994 season and at least 75 tonnes of DMR maize will be available for farmers this season.

Proposal for 1994

1. Foundation seeds: 2 ha by the program to give a yield of 3 tonnes.
2. Outgrowers: 60 ha to give a yield of 90 tonnes.
3. Apron Plus®: 8,000 tonnes indented.

Oyo State

Introduction

Maize is one of the most important grain crops in Oyo State, others being sorghum, soybean, and pigeon pea. Of all these grain crops, maize is number one in terms of area under cultivation and utilization for food by the local populace. In 1991, for example, about 138,000 ha of maize was planted in Oyo State. Maize is popular in the diet of the people and it is also an important component in livestock feed. Industrially, maize is now being utilized in the manufacture of beer, and industrial gum.

Importance of DM in Oyo State

Oyo State was first ravaged by downy mildew (DM) in 1991 when the disease, which was not known by farmers, caught almost everyone unawares. Crop enumeration in that year showed that about 138,000 ha were planted to maize, about 30% of which was devastated by the disease. In Ogbomosho zone, about 6,450 ha were damaged, in Ibadan 7, 000 ha, and in Oyo zone 3,467 ha. It can be conclusively said that the disease is now ravaging maize fields in three out of four agricultural zones—Ibadan, Oyo, and Ogbomosho, while Shaki was the only zone that was free up to the end of the 1993 season.

Control of DM in Oyo State

Oyo State ADP (OYSADEP) has, between 1991 and 1993, taken measures to control the disease by means of seed dressing and the introduction of DM-resistant maize varieties. The former approach (seed dressing) was used extensively at first because of the non-availability of adequate quantities of DM resistant seeds. In 1992, for example, the quantity of Apron Plus® sold to farmers in the program area was 1,027 kg, while in 1993, the figures rose to 3,720 kg. This was due to the increased level of awareness on the part of farmers as a result of the vigorous enlightenment campaign on the control of the disease mounted by the extension services department of the program.

OYSADEP did not depend on seed dressing alone in its efforts to control DM disease in the state. The quantity of DM-resistant maize seed produced by the program in 1992 was 1,580 kg but this rose to 5,550 kg in 1993.

These two technologies are available to the farmers in Oyo State and by now the level of awareness on the part of the farmers, as far as these technologies are concerned, is very high.

Special considerations for promotion of technologies

Some of the special considerations for promoting the two technologies—seed dressing with Apron Plus® and use of DM-resistant seed—include the following:

- Both Apron Plus® and DM-resistant seed should be available in adequate quantities. This will enhance the acceptability of the technologies by farmers.

- Subsidy on Apron Plus® and DM-resistant seed should be borne by either the State or the Federal Government, or both. If the current prices of both technologies are reduced, it will increase their level of adoption by the resource-poor farmers of the state.
- Training farmers on awareness and control of the disease. Initially most people confused the symptoms of the disease with those of nutrient deficiency. Consequently, in trying to control the disease, farmers erroneously applied inorganic fertilizers to the maize plants affected by the disease. Training is therefore needed for farmers in both the affected and non-affected areas.
- Publicity campaigns. More vigorous campaigns on radio, television, and in the print media should be mounted to create more awareness about the disease and its control.
- Dressing of seed before sale to farmers. This measure will ensure that all seed purchased for planting will not be used for other purposes.
- While research is looking into the complaints of farmers on the chaffiness and low yield of the DM-resistant varieties, the Women in Agriculture Department of the State ADP should enlighten farmers on the use of chaff such as for feeding livestock.
- In the long term, the emphasis of ADPs should be on outgrowers' production of seeds with a view to transferring seed production technology to farmers who produce at cheaper prices. This will ensure affordable prices of seed to farmers.

Constraints to adoption of DM control methods

The major constraint to the adoption of DM control methods in Oyo State is the high price of Apron Plus® and DM-resistant seeds. Field reports that reach OYSADEP through the Extension Services Department confirm that farmers usually complain of high prices of these inputs. Apron Plus® is seen as an additional cost to farmers in their bid to produce maize. Also, since the DM-resistant seed is more costly than maize grains sold in the open market, a resource-poor farmer may be tempted to purchase and make use of such highly vulnerable seed for planting.

Kogi State

Introduction

Maize is one of the most important food crops in Kogi State. Fresh maize on the cob, roasted or boiled, is very popular among people of all ages. Maize is mainly consumed as flour, and *akamu*. Industrially, maize serves as a primary material for starch production and its other derivatives. Maize is also assuming an important role in the brewing industry. Furthermore, the position of maize in livestock/poultry feed production cannot be overemphasized.

In Kogi State, maize production ranks about highest among the major crops. A conservative estimate of crop production reveals that maize covers about 150,000 ha while yam, cassava, cowpea, rice, and guinea corn and millet cover 130,000, 95,000, 45,000, 95,000, 30,000 ha respectively in the state.

There are about 172,000 farming families in Kogi State and it can be safely stated that all of them plant maize, although the majority do so at subsistence level. Color preference for maize varies in the state but on the whole, both white and yellow are in high demand. Maize is planted twice a year where the rains are established early (between end of April and May). The estimated yield derivable from the early crop could be put at about 75,000 tonnes from about 50,000 hectares. More than 50% of this early maize produce is usually eaten green (boiled or roasted on cobs). In view of the rainfall pattern and drying problems, a larger proportion of maize is planted between June and July. Estimated land area for this late planting in Kogi State is about 100,000 ha with about 100,000 tonnes as expected yield.

Seed sources

Maize farmers get their seeds from their own produce, the state agricultural development program (ADP), or neighboring states. The impact of private seed companies is still very low. Only about 20% of farmers buy seeds every year, while about 50% buy seeds occasionally, and about 30% rarely buy seeds. The implication of this is that, except when there are serious problems, most farmers don't bother to buy improved seeds. Those who do buy believe that they need not buy in subsequent years because they can always take seeds from their produce.

Presently, about 40% of the total land area planted to maize in Kogi State is expected to be planted with downy-mildew resistant varieties. Disease incidence is noted to be relatively low in the eastern parts of the state. Farmers in that region still largely use TZSR and other local varieties. A common complaint of farmers who use the downy mildew-resistant varieties is that they are relatively smaller seeded and also lower yielding than other varieties such as TZSR. One only hopes that researchers will seriously look into this with a view to finding a solution.

In spite of the importance of this crop and efforts put into increasing its production, the relative annual production has not significantly increased. Among the factors militating against increased production is downy mildew disease and fertilizer scarcity.

Extent of downy mildew disease on maize

Downy mildew disease of maize in Nigeria is caused by the fungus *Peronosclerospora sorghi* (Weston). The pathogen belongs to the oomycetes class and therefore is an obligate parasite. Downy mildew disease was first reported on maize in Samaru, Zaria in 1969 (King 1970). It was later observed in Owo in Ondo State in 1975 (IITA Annual Report 1975). At about the same period, the disease was noticed in Kabba (Kogi State). Since then the disease has remained in that area and has spread to parts of Kwara and Edo states (Oyekan et al. 1989).

The disease thrives under high humidity (about 90%), low temperature (about 20–25°C), and rainfall. Sporulation, dissemination, and crop infection are also favored by the same weather conditions. Turbulent rains and storms as well as run-off water also help in the dissemination.

It is generally known by farmers that early crops of maize usually escape downy mildew disease, whereas maize crops planted in June and July are usually severely attacked. Yield losses reported in Kogi State due to downy mildew disease are directly proportional to the percent of infection. In fact, total yield loss is common on many farms.

The Role of the Kogi Agricultural Development Program

Seed multiplication. Kogi Agricultural Development Program (ADP) multiplies not less than 40 tonnes per year of downy mildew-resistant varieties (early or late, yellow or white) through outgrowers. However, the problem of delayed buy-back has always hindered the efforts of the seed multiplication program. As such, more than 60% of what is produced is sold in open markets.

Provision of Apron Plus®. Realizing that dressing maize seeds with Apron Plus® helps to protect the crop from downy mildew disease, Kogi ADP is encouraging farmers to dress their maize seed before planting. To this end, about 16,000 10g satchets of Apron Plus® were sold to farmers in 1993. This was grossly inadequate to meet farmers' demand. Arrangements are being made to buy much larger quantities for the current farming season.

Extension services. There are 142 extension agents (EAs) currently serving in the Kogi ADP. This gives an EA/farmer ratio of 1:1,200. Each extension agent handles 80 SPATs per year. With this, Kogi ADP is just able to reach about 75% of the farming populace in the state. It is hoped that before too long, the other extension agents will be engaged.

To complement interpersonal activities between farmers and the ADP, Kogi Agricultural Development Program (ADP) is using the electronic media to publicize the use of Apron Plus® and resistant varieties of maize. Last year, a field day was conducted at Olle in Kabba/Bunu LGA on a SPAT plot using a resistant variety in a farm where susceptible varieties were planted. The SPAT clearly spoke for itself and virtually all the farmers in attendance decided to use resistant varieties in subsequent years.

Conclusion

Even though the level of downy mildew disease incidence is currently low in the eastern parts of the state, efforts are being made by the Kogi ADP to get farmers to start to use resistant varieties. The possibility of the outbreak of the disease in the East is very high because of close interaction of people from the western and eastern parts of the state.

In view of the devastating effects of downy mildew and the paramount importance of maize in the diet of the people, one would like to request the Federal Government to step boldly into the issue of making resistant varieties of maize and Apron Plus® more readily available and cheaper to farmers.

Also, knowing that our farmers prefer to select seeds from their own produce, varieties that can retain their resistance for generations should be made available to farmers.

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Edo State

Maize is the most widely grown and consumed cereal in Edo State. It is grown all over the state but predominantly in the northern part of the state. It is produced both at the subsistence and commercial levels. Finance is the most limiting factor in its production, but this problem is often compounded by lack of fertilizer, land preparation equipment, and the land tenure system. It is produced twice a year.

Before the creation of Edo State in 1991, downy mildew disease was endemic in two local government areas with borders next to Ondo State, i.e., Owan and Akoko Edo. With the inclusion of Sobe (formerly Ondo State) in Edo State, downy mildew disease assumed epidemic proportions.

Attempts to sell downy mildew-resistant maize varieties in 1989 were not successful. Farmers found the yield low and perhaps not properly adapted to the mostly derived savanna vegetation of the northern part of the state.

Farmers in the endemic areas depend mostly on the Ondo State ADP for their maize and treatment with Fenesan D to combat the disease. Since these two local governments areas are the main cereal producing areas, in 1994 the ADP will develop $1^1/_2$ hectares of directly produced DMR seeds and 5 hectares from outgrowers efforts. The intensive campaign for the use of DMR seeds will be intensified and more vigorous efforts will be made to procure and distribute fertilizer and Fenesan D. The Edo State ADP looks to other agencies to help combat the disease before it spreads to other local government areas.

Kwara State

Introduction

Maize downy mildew disease had been known to exist for many years in Okene/Kabba area of the former Kwara State, but it was confined to this area. However, in 1991, and within a season, the disease suddenly spread as far as Ilorin and Moro local government areas—a distance of more than 300 km.

Importance of maize in Kwara State's agricultural economy

Maize is one of the most important staple foods in Kwara State. As a major cereal crop widely grown throughout the state, it is one of the major sources of income for farmers.

The estimated area of production is 102,274 hectares. There are two main crops per season. The early maize is planted with the first rain and generally harvested green, and the late maize, planted July/August, is allowed to turn brown, then harvested, and shelled. The yield is approximately one tonne/ha on farms.

Apart from direct consumption in various dishes, the state Livestock Feed Company and local poultry businesses use it in making livestock feed, while the Okin Biscuit Company at Offa uses it as one of their raw materials to produce biscuits.

Importance of maize downy mildew in the state

Out of the 12 local government areas in the state, 9 have already been affected. The disease in the meantime appears to have stopped its advancement into the unaffected areas.

Where infection has occurred there have been cases of total crop failure, but generally, the range of loss is usually between 60 and 80% with susceptible varieties. But even with resistant varieties losses could be as high as 30–40% without seed dressing.

Technologies that can be used by farmers to control downy mildew in the state and their constraints

Early planting. This can make the crop escape the disease, but as earlier noted, the crop is grown throughout the season and even in fadama areas during the dry season. The early crop is harvested green and consumed partly because it is usually the first crop in the season, and partly because drying is difficult because of high humidity and rainfall during maturity period. It is the late crop that is dried, shelled and sold in bulk, and/or stored. It is therefore difficult for the farmers to only grow the early crop.

Seed treatment. Up till now, this is the most effective method of control using Apron Plus®. The problem is its high cost. In KWADP, a satchet of the chemical cost N5 in 1991 but rose to N15 in 1993. With a 2 kg satchet of seeds and with a kg of seed costing N10, the farmer will end up paying about N18/kg for dressed seed. Even then we cannot be sure that the cost will not rise

in future. For resource-poor farmers, affordability becomes the issue, and the temptation of using undressed farm seed is great.

Resistant varieties. This would have been the easiest method for promotion, and adoption. It is even the most effective but the level of susceptibility (about 40%) on the field is too high. The yield on farmers' fields at normal periods is already low enough (one tonne/ha) therefore to lose 30–40% of this, if this method is used alone, is suicidal.

Special considerations for promotion of the technology package

Gender. Most women growers are small holders therefore seed packages should be in 1–5 kg sizes. Furthermore, the seed should preferably be already dressed so that they will not be used as grains.

Sustainability. The price of Apron Plus® should be both affordable, and if possible, completely resistant varieties should be bred.

Constraints to the adoption of the available downy mildew Control Methods

These have been highlighted but the problem of distribution in Kwara State should be added. There is generally only one sale point of seed and chemicals in each local government area. Ideally, farmers should not have to travel more than 5 km to buy these inputs, but the overhead cost of this would be unsustainable.

Constraints experienced by farmers in maize production

- High cost and unavailability of fertilizer.
- High cost of herbicides and seed-dressing chemical.
- Finding labour and hiring equipment for cultivation (tractor services) is now a real problem both in terms of the exhorbitant cost and availability.
- Simple and efficient planters to reduce labour costs and chemical hazzards are needed.
- Where there are sizable holders shelling can be problematic.
- Lack of storage facilities.
- Problem of haulage from farm to market because of lack of good rural feeder roads and high cost of transportation.

Conclusion

The epidemiology of the disease in the state needs to be fully understood. For instance, why did the disease which had for years been confined to a given area suddenly explode? Finding the correct answer to this may help us prevent a reoccurrence.

Seed Production and Distribution: The Experience of Private Seed Companies

E.A. Obinyan

Introduction

The production of food and the protection of food sources through advancements in agricultural technology for the developing countries of sub-Saharan Africa is the focus of such organizations as FAO and IITA. The downy mildew of maize eradication campaign in the six states of the middle belt region of Nigeria is therefore timely. In all plant-based agricultural systems, seed is the most important input as it determines the upper limit of yield potential and therefore, the ultimate efficacy of other inputs such as fertilizer and agrochemicals. Seeds are the carriers of genetic potential of crop plants. It is estimated that 50% of the productivity gains in plant–based agriculture in the last 50 years have been achieved through the use of improved seed technology.

Spencer (1990) classified the improved seed technology within the type II and type III agricultural technology, which results in considerable improvement in productivity. Type II (e.g., hybrid) requiring considerable purchased input (fertilizer, pesticides, equipment), provided the drive for the green revolution in Asia. Type III (e.g., crop varieties resistant to pests and diseases) are changes within regions. Quantum leaps in agricultural production certainly result from type II technology. However, it is sad that, whichever type of technology is chosen, successful commercial production and distribution of improved seed to farmers, particularly in economies like Nigerias, have not been achieved.

Private seed companies and the Nigerian seed industry

In Nigeria, the impetus and groundwork for the development of the private sector seed industry was due to the efforts of the National Seed Service (NSS), the National Accelerated Food Production Program (NAFPP), IITA, ICRISAT, IAR/ABU, IAR & T, universities, and some private companies.

The hybrid maize development project was initiated in IITA with the collaboration of some national programs in 1982. The introduction of hybrid maize triggered the formation of the first Nigerian private seed company—Agricultural Seed Limited (a subsidiary of Leventis Plc) in 1984. This was closely followed by Parental Line Seed Limited, Otta (1985), and various others (Table 1). In addition, many contract growers have been employed by the National Seed Service.

Most private seed enterprises have ceased operations for many reasons. Some are:

1. Lack of seed extension and the negative notion of extension agents about hybrids and good quality seeds, resulting in the loss of confidence in improved seeds amongst peasant farmers.
2. Marketing of seeds of substandard quality.
3. The collapse of large-scale commercial farms which were the main users of high quality seeds and hybrids.
4. Private sector inability to compete with the subsidized seed prices of the government seeds.
5. High interest rates, being an industry with slow rate of returns on investment.

Table 1. Status of Private Seed Companies in Nigeria since 1984.

Name	Head Office Location	Year of Estab.	Activities	Current Status
Agric. Seeds Ltd (Agseed)	Zaria	1984	Research, production and marketing of hybrid and OP maize and varieties of cowpea, soybean and rice.	Ceased operation in 1992 and sold assets to Pioneer Hi-bred Nig. Ltd.
Parental Line Seeds Ltd (Temperance Seeds Ltd)	Otta, Abeokuta	1985	Production & marketing of maize, hybrids and OP seeds. in 1990.	Phased out and taken over by Pioneer Hi-bred.
Nigeria Grain Prod. Company	Kaduna	1986	Production & marketing of maize, rice, and cowpea seeds.	Closed in 1990. Owned by Federal Govt.
Total Agric. Ltd	Otokoto (Oyo State)	1987	Production & marketing of maize, rice, and cowpea seeds.	Closed down in 1990.
Greenland Farm Nig. Ltd	Egbe, Kwara	1987	Production & marketing of maize, rice, and cowpea seeds.	Closed down in 1991.
UTSEEDS	Jos	1988	High altitude wheat and maize seeds	Operational
Pioneer Hi-bred Nig. Ltd	Lagos/Zaria	1990	Production & marketing of maize, sorghum and sunflower hybrids and varieties of rice, cowpea' soybeans, cotton, etc.	Reviewed their operations in favor of discontinuing operations in Nigeria.
UAC Seeds (formally part UAC Agro Industries)	Zaria	1989	Research, production and marketing of maize, sorghum, and vegetable hybrids. Varieties: rice, maize (OP) cowpea, and sorghum.	Has technical support from of Pannar Seed (PTY) Ltd, South Africa. The largest seed company in Africa.

6. Lack of expertise and proper management required for hi-tech industry.
7. Lack of legislation to protect privately bred materials, which could prove beneficial to the seed industry.
8. High expectations from the promoters that the seed business is a money spinning venture, leading to frustration.

Seed demand and supply in Nigeria

Information on the demand and supply of seed in Nigeria is inaccurate. However, the information available shows a wide gap between seed demand and supply when compared with the total seed requirement (Tables 2 and 3).

Table 2. Seed needed to meet gross requirement of selected staple food crops ('000 tonnes)

Crops	1990	1995	2000	2005
Millet	56	68	82	101
Sorghum	37	46	58	72
Maize	25	33	44	58
Rice	25	38	59	90
Cowpea	70	95	117	143
Yam	990	1192	1436	1730
Cassava	1662	2028	2530	3147

Source: Federal Ministry of Agriculture, Water Resources and Rural Development, Report. A perspective plan for agricultural development in Nigeria, 1990–2005 pp 16.

Table 3. Production targets (1994–2000) (kg).

Crop	1994	1996	1998	2000
Maize OP	4000	6000	8000	10000
Maize Hybrid	4000	6000	8000	10000
Rice	4000	6000	8000	10000
Sorghum (OP)	600	1400	2200	3000
Sorghum (Hybrid)	N.A	200	500	1500
Millet	200	400	600	800
Cowpea	800	1200	1600	2000

Source: NSPQ (World Bank Assisted): Strategies for the National Seed Sub-sector Development Plan.

A comparison between tables 2 and 3 shows that a large gap still exists between requirement and production targets. Also, it is a fact that far less production is achieved than the targeted goals.

Private sector seed production

A basic requirement for seed production stability is an estimation of effective demand. The effective demand is further influenced by the reputation of the seed company, the effectiveness of a promotional campaign, the efficiency of arrangements for distribution, the seed prices, and availability of complimentary inputs, among others.

However, seed production by seed companies has been based, more or less, on estimates of projected demand. Consequently, all private seed companies in Nigeria market less than 2000 tonnes annually.

Seed production is currently through the use of a selected outgrower system, and particularly for hybrids, the outgrowers are under contract. The key elements specified in the production contracts are:

- Supply of foundation seed to the grower,
- Hectares to be planted by the seed grower,
- Timing and isolation required,
- Buy-back price by the seed company, and
- Minimum seed quality standard that must be produced by the grower.

This is undertaken under regular supervision by the private seed company. The whole process requires a considerable level of technical know-how, both on the part of the grower, and the seed companies, which influences the quality of the seed produced.

The success of the production process therefore depends on processes from the breeding point until the seeds are finally packed for distribution to farmers. Currently, most private seed companies produce publicly bred maize (from IITA, e.g. 8921-18; 8605 -1; etc.), rice (from IITA and NCRI), cowpea (from IAR and OAU), and soybeans from IITA.

Seed marketing and distribution

Marketing is defined by Unilever as "The management process responsible for identifying, anticipating, and satisfying consumers requirements profitably, and the ability to continue satisfying them in the face of competitive efforts to fulfil those needs and wants differently or better."

The cardinal objective of satisfying consumer needs profitably can be stimulated by various activities including, but not restricted to, product creation, advertisement and promotion, sales, and distribution. These can be summarized, in a set of variables known as a marketing mix. These are:

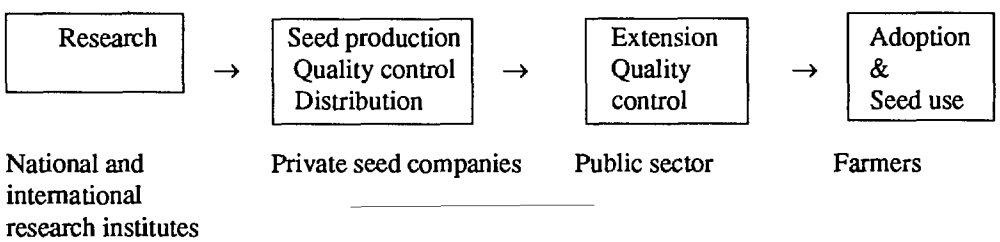
Product: Quality, packaging, size, services, warranties.
Price : List price, discounts, payment periods, credit terms.
Promotion: Advertising, personal selling, sales promotion, publicity.
Distribution (Place): Channels of distribution, coverage, location, inventory storage, transport, etc.

The application of the marketing concept as represented by the private seed companies is of paramount importance in the spread of improved seed technology.

Improved seed represents the outcome of a sequential series of decisions and activities, which begins with the initial manipulation of germplasm and the identification of a suitable variety or hybrid (research). It continues through the multiplication and processing (production), and distribution of seeds to farmers for purchase and use. Other major functions which determine the ability of the seed industry to respond to the needs of farmers and changing market requirements, include varietal development and release, quality control, processing, storage, and transportation.

In the above process, the role of the private and public sectors is complimentary and the proportion of the shared responsibilities depends on the state of the macro-economy and the stage of development in the seed industry (see Figure 1).

Figure 1. Chain of collaboration for an effective seed industry



Analysis of the technical and economic characteristics of the seed industry indicates a need for a complimentary role between the public and private sector while production, processing, and distribution of many types of seed must be profitable for the private sector. Provided that improved germplasm or varieties are available for the existing or stimulated demand for commercial seed, very little economic rationale exists for direct public sector involvement in seed production and distribution. However, it has an important role to play in supporting basic and applied research, promoting adoption of improved seeds through extension, implementing quality control, legislating standards, and compensating for externalities. The Nigerian private sector experience has been at best, a mixture of discouraging conflicting roles and signals.

The role of private seed companies in eradicating maize downy mildew disease

From the above analysis, it is clear that private sector seed companies have a key role to play in the eradication of downy mildew disease of maize, which is the key focus of this conference and workshop. The strategies for the control and eradication of this disease in the transitional zone of Nigeria, are twofold:

1. The production and distribution of downy mildew-resistant (DMR), open-pollinated and hybrid maize seed by private seed companies.
2. Chemical control through the joint efforts of the agrochemical companies and private seed companies (i.e., using seed dressing and other plant protection postemergence chemicals).

Seed companies have key roles to play in these strategies.

Since 1991 UAC Seeds has produced downy mildew-resistant open-pollinated seed for distribution to farmers in the downy mildew endemic zone in Nigeria (see Table 4).

Table 4. DMR maize seed produced by UAC since 1991.

Year	Mega-maize 4 DMRE-SR(W) (tonnes)	Mega-maize 5 DMRSR(W) (tonnes)	Hybrid dressed with Apron Plus® (tonnes)	Remarks
1991	10	20	10	–
1992	50	60	05	100 t to NSS
1993	20	29	05	–
1994	22	40	05	Based on request

In 1992, UAC sold 100 tonnes of OP maize seed at a price of 70% of the cost of production to the National Seed Service for distribution to farmers as our contribution to the control of the disease.

At a current production cost of about N19,800 per tonne, including distribution cost, it is evident that agencies, research institutes, the National Seed Service, and private seed companies will require enormous resources.

The public sector can effectively facilitate and encourage the proper use of these seeds by farmers.

An article on page 3 of the Nigeria Maize News Vol. 1 (1), July–September 1991 says "The outbreak of downy mildew in Oyo and Ondo states, indeed any part of Nigeria is an irony. WHY? Because this is one maize disease in which research is far ahead of the problem..."

The answer to the above is the missing link in the chain in Figure 1. I wish to posit that if the funds injected into the ADPs seed multiplication units had been committed to the purchase of downy mildew resistant seeds, dressed with the appropriate seed-dressing chemicals, and distributed to farmers through the ADPs, whose responsibility is to ensure, through appropriate extension guide that these seeds are planted by the farmers, the result would have been different.

Recommendations

1. The ADPs seed multiplication unit should be turned into Seed Extension Units with a clear mandate and resources to ensure the proper use of improved seeds by farmers under their mandate.
2. The creation of a fund with contributions from FAO and the Federal Government to be administered by the Downy Mildew Eradication Committee.

At this juncture, I wish to recommend the setting up of a Downy Mildew Eradication Committee to immediately address the issue of eradicating downy mildew. This committee would be comprised of representatives from:

- The Federal Department of Agriculture
- The Food and Agriculture Organization of the United Nations (or other funding agencies)
- Private companies
- Research institutes (international and national)
- The Maize Association of Nigeria
- The agrochemical companies.

The alternative is that some day, we may find that downy mildew has wiped out all our maize in Nigeria.

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Seed Production and Distribution: the Experience of Agricultural Development Projects

N.B. Mjindadi and O.O. Oyebanji

Introduction

Good quality seed is a vital basic input and plays a key role in crop productivity. The agricultural research system in the country has developed valuable crop varieties which are adapted to the different agroecological zones (suiting different environmental situations) to meet various objectives. The recently approved national agricultural research projects, funded by the World Bank, will further improve varietal development work and related technologies (World Bank 1990, NSS 1989). Already, strong links have been established between research institutes and agricultural development projects (ADPs) in the country for on-farm testing of crop varieties and disseminating technology through extension (Joshua 1988). A sound seed production and distribution system backed by a good research and extension base will greatly enhance productivity in the country. The National Seed and Quarantine Project, which has become loan effective, will go a long way in meeting the above objectives. The National Seed Service (NSS) and ADPs are the key actors in this system (Cheema et al. 1992).

Historical perspectives

ADPs were originally established to accelerate food crop production and to increase the income of small-scale farmers. The first enclave projects were established in Funtua and Gombe in 1975 followed by Ayangba, Lafia, Bida, Ilorin, Oyo North, and Ekiti-Akoko at different dates from 1978–1982. The success of the enclave projects encouraged the Federal Government to approve the establishment of statewide ADPs in Bauchi, Kaduna, Kano, and Sokoto states between 1981 and 1984. There are now 31 ADPs in the country (Abuja inclusive) serving as implementation arms of the state ministries of agriculture, which are the policymaking bodies.

Each ADP has a short life span within which to spread new technologies to farmers. One technology which has to be spread rapidly to improve food production is the use of improved seed. From the establishment of the ADPs, the demand for improved seeds by farmers has increased dramatically due to the impact of ADP extension services. The NSS, also created in 1975, and with a mandate to produce foundation and certified seeds as well as arrange for seed certification, was finding it increasingly difficult to satisfy the farmers' demand for the provision of good quality seeds of all recommended varieties of crops in the country. For these reasons, it became imperative for the projects to complement the efforts of NSS in seed production. As a result, the projects started to produce their own improved seed and to multiply on their seed farms any improved seed they could obtain from either NSS, research institutes, or emerging private seed organizations. The ADP seed farms served as avenues for ensuring consistent supplies of foundation seed of dependable quality to the outgrowers for the production of certified seeds.

Apart from the NSS, other seed-producing agencies are research institutes, directorates of food, road and rural infrastructure (DFRRIs), ADPs, private seed firms, and individuals.

In order to bring the seed agencies together for the improvement of seed production in the country, a national seed production and distribution workshop was jointly organized in February 1988 by FACU and NSS with the following objectives:

1. To review the seed production activities of various seed producing agencies in the country.
2. To streamline the seed production and quality control activities in the country.
3. To develop strategies and make recommendations that would enhance the productivity of improved seed and give easy access to the source of the improved seed for farmers.

Some of the recommendations of the 1988 workshop regarding the roles and responsibility of NSS and ADPs are listed below (see Kolawole and Adeniyi 1988).

National Seed Service (NSS)

1. Coordinate seed production activities in Nigeria.
2. Receive available quantities of breeder seed from research institutes/universities.
3. Produce foundation seed stage I (FS-I).
4. Supply FS-I to agricultural development project seed units bearing in mind ecological adaptation of the crop.
5. Register and monitor public and private seed companies.
6. Provide technical support, assistance, and advisory services to states.

Agricultural Development Projects (ADPs)

1. Receive FS-I from NSS.
2. Produce foundation seed stage II (FS-II).
3. Organize certified seed production.
4. Develop outgrowers network.

The recommendations of the 1988 workshop formed the basis of the established working relationship between NSS and ADPs/FACU in seed production and distribution.

Available improved crop varieties

A number of improved varieties of crop plants have been developed over the years by the research institutes and universities in the country combining high yield potential, resistance to major diseases and pests and the desired growth duration to fit into the cropping system. Though an exhaustive list of these varieties cannot be given here, we can mention some of the outstanding varieties such as the TZSR series of maize resistant to streak, hybrid maize, the DMRSR series of maize resistant to both streak and downy mildew, short duration rice varieties such as ITA 257, ITA 150, and IRST 170 for upland, ITA 212, 222, 306, and FARO 29 for lowland, IFE Brown, IFE Bimpe, TVX 32366 in cowpea, TMS 30555, and 30572 in cassava which, if grown on a large scale, may revolutionize agriculture in the country. The unavailability and short supply of quality seed and planting materials have limited the adoption and spread of these varieties.

Seed production mechanism of the ADPs

The seed production unit of the ADPs is a component of the Technical Services Division charged with the responsibility of producing seeds of improved varieties of crop plants adapted to their respective area of operation (Kolawole 1988). This is to complement the efforts of the private sector in meeting farmers demand for high-quality seed.

Initially the focus of the ADPs was direct production of certified seeds and this was carried out in the seed farms established in each of the operational zones within the state. However, the performance in direct certified seed production was not quite satisfactory due to the high cost of production and poor cost recovery. This led to the recommendation of a shift in emphasis from direct seed production to FS-II production, while the certified seeds were to be produced through the outgrower scheme. All the ADPs are gradually phasing out certified seed production in favor of the outgrowers scheme and thereby concentrating on FS-II production.

Foundation seed production

NSS is the major supplier of FS-I to ADPs. The seed unit of each ADP has at least 50 ha of permanent seed production where FS-II is grown and inspected at appropriate times on the field by ADP seed inspectors and NSS quality control officers.

Certified seed production

The certified seed production by the ADPs is expected to be through outgrowers although some are still engaged in limited production of certified seeds. The ADPs select and register the outgrowers before the commencement of the growing season. The compact area approach is recommended rather than the dispersed system (which is adopted by most ADPs), as it is more economical in the selection of outgrowers and leads to effective monitoring, supervision, technical guidance, and quality control in seed production.

In order to encourage the outgrowers, the ADPs provide incentives in terms of supply of inputs such as seed, fertilizer, chemicals, and land preparation facilities on credit at the time of seed procurement.

From the experiences so far in the implementation of the outgrower scheme for the production of certified seeds, the success of the system is largely dependent on the selection of a trusted cadre of outgrowers.

The criteria being advocated for outgrower selection are:

1. The grower should be an enlightened farmer ready to learn and adopt improved practices of high quality seed production, able to develop facilities at his farm, and able to bear losses due to rejection of seed. The farmer should also have long-term interests in seed production activities.
2. The farm should be located in a compact area with access to facilities, technical guidance, supervision, field inspection, and transportation of seed.

Seed certification and internal control

The inspection visits for seed certification of ADP and outgrower farms are not adequate and need to be improved. However, NSS has recently been making efforts to address this problem through the appointment of qualified staff in each state for seed certification. The number of visits at the appropriate time is being stepped up. Transportation for inspection visits is either provided by NSS or the ADP. Regular training of ADP seed inspectors and quality control officers will help upgrade their knowledge and skills in seed certification. The ADPs have an internal quality control system to produce and prepare good quality seed for certification.

Seed processing

Many states do not have seed processing plants and sell manually processed seed to farmers which increases the cost and production of sub-standard seed. In order to solve this problem, NSS

has been mandated to provide facilities at its plant to the ADPs at nominal charges for processing of ADP outgrower seed. Some ADPs have processing plants of high capacity which are underutilized. Such ADPs have been advised to provide services to adjoining state ADPs for a fee. For example, the plant at Ado-Ekiti in Ondo State can be used by Edo and Kogi ADPs, plants at Damaturu in Yobe State can be used by Borno State ADPs, and the plant at Gombe in Bauchi ADP can be used by Adamawa ADP until those ADPs/NSS have their own facilities.

Seed testing

The primary objective of seed testing is to get information on the value of seed for its germination/emergence capacity, purity, and other characteristics to avoid the risk of failure. Any seed lot sold to farmers must bear information about germination capability. Seed-testing laboratories have an important role to play in this. Many state ADPs engaged in seed multiplication do not have a seed-testing laboratory to support the program. However, NSS has and is establishing seed-testing laboratories at different places in the country to provide seed-testing services to ADPs, as well as for their own use.

Some ADPs have realized the importance of seed testing, and have made provisions in their budget for establishing seed testing laboratories and NSS has been asked to assist such ADPs in setting up laboratories and in training their staff.

Seed distribution: procurement and pricing

The seed production unit of the ADPs usually purchases unprocessed seeds from outgrowers which are later processed, treated, and bagged. The processed seeds are passed to the commercial services division/input supply unit of the ADP for sale to farmers. However, the ADPs are facing problems of seed procurement from outgrowers for various reasons which include:

1. Lack of adequate funds earmarked for purchase of seed from outgrowers.
2. Delayed payment of outgrowers resulting in seed being sold as grain in the market.
3. Tendency on the part of the outgrower to hold seed in the event of low price of seed.
4. Outgrowers owing large amounts of money to ADPs for inputs provided and the tendency on their part to avoid sale to ADPs.

These problems stated above are being addressed through the following steps:

1. ADPs are being mandated to provide adequate amounts of money for a revolving fund to buy the required quantity of good quality seed. ADPs are being encouraged to maintain a separate account for this fund.
2. Timely release of funds for the purchase of seed to avoid seed being sold as grain.
3. Pricing by NSS/ADP should be announced early enough to allow for full cost recovery and a reasonable margin of profit for the grower.
4. The ADPs are being advised to ensure that the purchase price of seed from outgrowers is higher than the prevailing market price for grains. Cost of production of various types of seed has to be worked out in price. For example, the cost of production of lowland varieties of rice is higher than that of upland rice and so the price has to be fixed accordingly.
5. ADPs with assistance from NSS can fix the price of certified seed for sale to farmers every year.

Seed marketing

It has been observed that there is a need for a clear-cut policy on marketing to avoid duplication among agencies/organizations. Marketing responsibilities for various types of seed should be:

- Research institutes for breeder seed
- NSS for FS-I
- ADP for FS-II
- ADPs for certified seed.

To ensure wider availability of good quality seed in rural areas, ADPs are being encouraged to develop a network of private retailers who could market seed around their areas.

Summary and conclusion

The importance of improved seed is now generally recognized by Nigerian farmers. It is one of the most effective means for increasing crop yield/ha, for making farming more profitable, and for accelerating the attainment of national self-sufficiency in food production and agroindustrial development (Joshua 1988). The improved seed gets to the farmer through the ADP extension outfit, while the ADPs in turn collect the improved seeds from NSS for multiplication. A sound seed production and distribution system plays a pivotal role in agricultural productivity. The National Seed Service and the agricultural development projects (ADPs) are the key actors towards achieving this goal. In order to maintain a strong link between the apex units (NSS and FACU) for effective seed production and distribution by the ADPs, the following arrangements are in place:

1. Involvement of FACU and ADPs in various seed committees.
2. Involvement of NSS in annual thematic supervision of ADPs organized by FACU to provide technical support to ADPs as regards seed drying, seed testing services, printing of seed manuals, and training of ADP staff.

The eradication of maize downy mildew could be achieved through the production and effective distribution of improved varieties of maize seeds tolerant to the disease. The established seed production and distribution network of the ADPs supported by the extension system will assist in the eradication of maize downy mildew disease.

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Features of World Bank Support for Nigeria's Seed Sector

J. Yayock

Introduction

From an economic viewpoint, seed remains the most important agricultural input for crop production outside fertilizer. In recognition of the importance of seed, the Federal Government of Nigeria sought and obtained the support of the World Bank to develop the sector. In realization of the direct relationship between, on the one hand, a viable seed industry and, on the other hand, the first line of defence against the introduction of exotic pests, diseases, and noxious weeds, the World Bank support was designed to include the Plant Quarantine Service. This gave birth to the National Seed and Plant Quarantine (NSPQ) Project. For the purpose of this brief presentation, I will deliberately focus on the seed component of the project.

Constraints of the seed sector

At the appraisal of the NSPQ Project in 1989, the following were reported to be the key constraints facing the seed sector;

1. The absence of clearly defined, cost-effective, and sustainable objectives and a national strategy for the sub-sector, resulting in piecemeal attempts at development of a seed program.
2. Weak public sector institutions, with poorly defined roles and responsibilities, resulting in duplication and assignment of conflicting functions to participating organizations.
3. Lack of an appropriate environment for private sector development which inhibits competitive market growth.
4. Pursuance of ad hoc seed pricing policy without due consideration to costs of production and marketing which adversely affect the viability of public and private sector operations.
5. A weak national system for the development, registration, and release of new crop varieties.
6. Absence of vital national seed legislation to provide a framework for the future development of the industry and to provide legal backing to certification and quality control operations.
7. Inadequate staff and ill-equipped seed certification and quality control operations.
8. Absence of reliable information on the effective demand for good quality seed.
9. Inadequate allocation of funds for human resource development through national or international institutions for both the public and private sector agencies.
10. Inadequate funding of public sector agencies and cumbersome financial procedures for the release of funds.

Features of the NSPQ project

Financing plan. The financing plan for the NSPQ Project is for the World Bank to contribute $14 million which represents 68% of the total project cost of $20.6 million. The FGN, PQS, and NSS are expected to provide the balance in the proportions 24, 6, and 2%, respectively. The project is for 5 years beginning January 1991. The funding arrangement requires that for every $100 spent, the FGN and its agencies first put up their $32 equivalent as a counterpart contribution, before the World Bank releases its share of $68.

The seed component. The seed component of the project was conceived and designed to address the following major issues.

1. To define the medium-term seed sector policy framework.
2. To facilitate the enactment of seed legislation.
3. To introduce a national seed pricing policy.
4. To initiate institutional development—including the establishment of a national seed council (NSC), and rationalization of roles and responsibilities of such public sector agencies as the NSS, and ADPs.
5. To strengthen the seed certification service.
6. To encourage private sector production of a large part of foundation, and *all* certified seed.
   * Reforming pricing policy so there is freedom to establish seed prices.
   * Leasing existing processing facilities of ADPs.
   * Making publicly produced breeder and foundation seed accessible.
   * Allowing freedom to develop research capability.
   * Assisting "pioneer" seed entrepreneurs in establishing small-scale seed enterprises.
7. The intention of the Project is also to support the upgrading and rehabilitation of facilities for breeder seed production and storage by research institutes, as well as the processing and storage facilities for foundation seed by NSS.
8. To strengthen crop variety testing, registration, and release programs through the introduction of streamlined operating procedures and the provision of equipment for field trials.

Role of NSS. Specific to the rationalization of institutional roles, the NSS is expected to continue to play a key and leading role in the seed sector with particular focus on the following:

- The promotion of the seed industry.
- Coordination of breeder and foundation seed production.
- Regulatory functions for seed quality maintenance.
- Human resource development.

The private sector. Let me end my brief remarks on the main features of the NSPQ Project by referring to the recognition given to the private sector which holds the key to a successful Nigerian seed industry. The specific actions expected to be initiated in the context of the NSPQ Project to create appropriate incentives and a conducive environment for the private sector development include the following:

1. Changes in the pricing policy for the public sector agencies aimed at full-cost recovery of foundation and certified seeds in a phased manner in order to remove a key constraint to greater participation by the private sector.
2. Public sector seed production agencies should limit their involvement to publicly bred open-pollinated varieties as a means of encouraging the development and/or introduction of new hybrids by the private sector.

3. Through their membership of the National Seed Council, the private seed sector would be able to directly participate in the formulation of seed policies.
4. The private sector should have access to breeder seed and foundation seed. The allocation policy of publicly bred varieties must be clear enough to enable the establishment of independent research capability.
5. The private seed enterprises should be able to import breeding materials to develop their own varieties.

Mid-Term review. Finally, it is rather fortunate that this workshop and particularly the discussion on the development of a sustainable and viable seed sector is coming at a time when the NSPQ Project is about to undergo a mid-term review. It is my expectation that both the FGN and the World Bank would benefit from comments which might prove useful in redesigning the Project for implementation in the next two years.

A One-State Model for Implementation of a Maize Downy Mildew Eradication Strategy: A World Bank Plan

N.S. Maini and L.O. Fajana

Introduction

Considerable work has been carried out and discussed to find a lasting solution to downy mildew disease of maize. In particular, the efforts of the Federal Government of Nigeria in the areas of developing resistant varieties, purchasing large quantities of seed of resistant varieties for farmers in the endemic area, procuring Apron Plus® for seed treatment, and providing special grants, all aimed at eradication of this virulent disease, are highly commendable.

Due to the ad hoc nature of earlier approaches towards eradication of this disease, there was little success. It is, therefore, obvious that a well-planned and articulated program, tying up all logistics required to put the spread of the disease under check, is the only way out. The major problem areas include:

1. Communication gaps between research, extension workers, and farmers.
2. Lack of awareness with regard to (a) effectiveness of resistant variety/hybrid and (b) efficacy of chemical treatment.
3. Accessibility of seed of resistant cultivars and seed treatment chemicals by farmers.

Objectives of the plan

The main objective of the plan is to eradicate maize downy mildew in the endemic areas of southern Nigeria. Bearing in mind that the disease is known to be moving at the rate of about 100 km per year, the broader objective will be the prevention of the outbreak of the disease along the maize-producing areas across the humid forest and coastlands of West Africa and beyond.

Suggested strategies/approach

Sale of seed at subsidized rates does not always produce the desired result especially where a self-sustaining program is required. Government policies as well as those of the World Bank have, in the recent past, tended to favor a self-sustaining approach to problems. However, it is necessary for government to provide a conducive environment for a self-sustaining program to operate and manifest itself.

The envisaged strategy focuses sharply on the agricultural development project (ADP) system for the success of this program. The National Seed Service, seed companies, chemical companies, and other related bodies would provide their support on a no profit, no loss basis. In other words, the participants in this pilot scheme are expected to only break-even or just manage to recover their costs. Expectations of huge profits at this pilot phase would be harmful to the planned scheme. The following strategies are presented for consideration.

1. Massive on-farm adaptive research (OFAR) trials, using five treatments per trial are recommended which include:

- Treated resistant maize variety
- Treated resistant hybrid maize variety
- Untreated resistant maize variety
- Treated high-yielding susceptible maize variety
- Susceptible, untreated control.

One trial set is suggested per village extension agent (VEA). Cost of trial establishment is to be borne by NSS, ADPs, and the private sector through organized contributions. One field day per local government area (LGA) is to be organized.

2. Production of large quantities of certified seed of resistant varieties and distribution to farmers in the endemic area. ADPs are to collect foundation seed from the National Seed Service and arrange to multiply them using their contract growers, small/medium seed enterprises, and private seed companies so as to make available large quantities of resistant varieties within 2 years. World Bank/FACU should provide adequate funds for the procurement of seed by ADPs.

3. The strategy of substantial seed production considered feasible could be to identify one Contact farmer in each community. This farmer should be assisted in the multiplication of an area of 1–2 ha sufficient to cater for the seed requirement of the community estimated to be about 100–120 ha under maize. The Contact farmer should be assisted by the ADP to procure seed, fertilizer, and chemicals at the right time. The technical know-how would be provided by the seed development officers of the NSS. At the time of harvesting, a field day would be organized and training conducted in the selection of maize cobs suitable for seed purposes. In order to further encourage the Contact farmer to treat the seed selected by him for local distribution in his community, he may be provided with a low-cost seed treater under the scheme "Treat Your Own Seed Before Sowing". Such treaters (1,000) would be mass produced by NSS with the help of local blacksmiths. This would eliminate transportation and handling costs and make seeds of resistant cultivars easily available to farmers at an affordable price.

The incentives required for the Contact farmers are to link the distribution of fertilizers and chemicals at the right time. The chemical companies may provide the Apron Plus® at the bulk-packing price. The only support which the Federal Government/World Bank could consider is to provide the low-cost treaters, not for the Contact farmer but for the benefit of small farmers in the community.

4. To further encourage the use of seeds of resistant maize cultivars and seed treatment, farmers using cultivars/hybrids resistant to downy mildew should qualify for allocation of fertilizer so that the disease is totally wiped out. This approach will discourage most farmers from using susceptible maize cultivars untreated with chemicals.

A pilot scheme to eradicate the downy mildew disease is being proposed to the World Bank during the mid-term review. Under this proposal, the NSS would work out the possibility of supporting the downy mildew-eradication program on a pilot basis in Ondo State. The NSS would provide the technical and financial support to supplement the efforts of Ondo ADP. It is estimated that total land area for maize production in the state is about 10,000 ha and the proposed scheme should eradicate the disease within two years. Results obtained from this scheme will go a long way to demonstrate the efficiency of the resistant cultivars/seed treatment being advocated in this presentation.

Conclusion

Eradication of downy mildew disease of maize is a complex problem that requires a combination of approaches to combat its menace. All efforts, plans, and programs aimed at controlling the disease should be closely coordinated. Research scientists, extension officers, and the private sector must close the communication gap that has hitherto prevented the flow of information within the system.

Government support alone will not be sufficient to combat the disease, so the private sector must rise to the challenge and provide additional support for total control. Moreover, since the disease is threatening to pose an international problem, it would be advisable if the FAO could assist in the control of the disease in the same way as the locust is being controlled.

Agricultural Development Program's Strategy to Control Downy Mildew Disease in Ondo State

G.O. Fasuyi

Introduction

Maize is an important staple food as well as an essential raw material for several agro-allied industries in Nigeria; over 2 million tonnes is produced annually. It has been reported that over 60% of maize produced in Nigeria is from the high rainforest zone. With the introduction of the structural adjustment program (SAP) in 1986, maize gained an even higher status in terms of production and utilization as it has become a primary raw material for most agro-allied industries as a result of backward integration and local sourcing for raw materials by most industries in Nigeria. Consequently, it is now being produced on a large scale in both the southern and northern parts of the country.

There are several biological constraints affecting maize production in Nigeria. One of these is downy mildew disease. Downy mildew was first observed in Owo, Ondo State in 1975 (IITA Annual Report 1975). Since then, the disease has spread to other parts of the state, and is now endemic. Many maize farms have been wiped out by this disease and affected farmers thrown out of business with huge financial losses (Table 1).

During the 1991 growing season alone, the prevalence, rapid spread, and virulence of the disease reduced the yield of maize by up to 85% in Ondo State. Reports indicated that the disease had spread to many states including Edo, Niger, Osun, and Oyo states and is now threatening to wipe out all advances made in maize production in Nigeria. This would jeopardize efforts to attain self-sufficiency in maize production, thus crippling agro-allied industries utilizing maize as a major raw material.

Strategy of Ondo ADP to control the disease

Although the ADP in Ondo State has not carried out any basic research on the control of downy mildew disease, the following approaches have been successfully used to reduce the incidence of the disease.

Use of downy mildew-resistant varieties of maize

The ADP, through its direct seed farm and outgrower seed multiplication program, has produced 133, 127.65, 165, 195, and 200 tonnes of downy mildew-resistant (DMR) varieties of maize in 1989, 1990, 1991, 1992, and 1993 respectively (Table 2).

Table 1. Downy mildew occurence and incidence in Ondo State of Nigeria in 1991, 1992, and 1993.

Ondo State (towns)	Disease incidence (%)		
	1991	1992	1993
Ita-Ogbolu	25–70	15–55	10–40
Ikere	60–80	30–60	20–50
Ado - Ekiti	20–60	15–50	15–45
Ifaki - Ekiti	50–80	25–70	20–60
Aiyegbaju	20–80	40–70	25–55
Ilupeju	70	60	55
Omuo	50–90	30–70	30–60
Ikare	80–95	50–75	35–65
Oka	60–80	40–65	20–55
Ifira	70–85	55–75	30–65
Arigidi	55–70	40–65	40–60
Owo	95	80	75
Akure	70	60	50
Ipele	90	75	60
Aramoko	70	55	30
Orin	85	70	50
Ondo	50–60	30–50	20–35

Source: ADP Research Unit

Table 2. Quantity of DMSR Varieties of Maize Produced from 1989–1993 by Ondo State ADP (tonnes).

Production	1989	1990	1991	1992	1993
Direct	100	37.45	45.0	30	30
Outgrowers'scheme	33	90.2	120.0	165	170
Total	133	127.65	165	195	200

Most of the seeds were sold to farmers in the state at subsidized prices through the various farm services centers located all over the state. The sales are closely supervised by the Agricultural Inputs Supply Company (AISC) which is a sister organization to the ADP. Many farmers are now not only aware of DMR seeds, but also use them. This practice has greatly reduced the incidence of the disease in the state. Part of the seed produced is also sold to sister ADPs in the zone where the incidence of downy mildew disease has been reported.

Use of chemicals

Fungicides (chemicals) that can control the disease have also been introduced to the farmers by the ADP. At this time the only product available is Apron Plus® 50 DS (Ciba Geigy Ltd.) which is applied as seed dust at the rate of 1 10g sachet to 1 kg of maize.

Educational programs

Concerted efforts have been made to educate the farmers and the public at large on the incidence and control of the disease. Weekly radio and television programs are run in February and March every year. Short courses have also been run for farmers and extension agents on the control of the disease. A one-day workshop was held in August 1990 at Akure by IAR &T in collaboration with IITA and Ondo State ADP. The workshop which involved farmers, extension agents, and scientists took participants to downy mildew-infested maize fields to enable them to appreciate the damage done by downy mildew.

Other efforts

- In 1989, the International Institute of Tropical Agriculture released 2.5 tonnes of DMR ESR-Y and 0.5 tonnes of DMRLSR-W to Ondo State for its seed multiplication program.
- In 1992, the NSS/NAFPP released 2 tonnes of DMR varieties packed in 1 kg satchets. These seeds were given to the farmers free of charge to help popularize the use of resistant varieties in the control of the disease.
- The Federal Government of Nigeria allocated 20 tonnes of treated DMRESR-Y and DMRESR-W maize seeds to the state during the 1993 cropping season.
- Ondo State through its On-Farm Adaptive Research (OFAR), which is a joint effort between research, extension, and farmers, is currently pushing a demonstration trial on the superiority of DMR varieties over local varieties.

In conclusion, the incidence of this disease has been greatly reduced in the state as a result of the various measures adopted to combat it. However, we wish to state that concerted efforts should still be made by the Federal Government of Nigeria towards the production of resistant varieties of maize and their distribution to farmers at highly subsidized prices through the ADPs in the affected states.

The extension arm of the ADPs should also direct more efforts towards educating the farmers on the use of resistant varieties of maize.

Reference

IITA (International Institute of Tropical Agriculture). 1976. Annual Report 1975–1976. IITA, Ibadan, Nigeria.

Alternative Strategies in the Distribution of Seed Treatment Chemicals

U. Kipfer

Introduction

The objective of this workshop is to design or to develop a campaign to control maize downy mildew. In order to achieve this goal in time, we need to know where maize is grown, where it is planted, and the extent of the biological problem.

From our own marketing research, we know that the total planted maize area in Nigeria is ±1,000,000 ha. By far the largest portion of the maize is grown in the northern parts of the country. More than 70% of the maize produced in Nigeria is produced in the Guinea Savanna zone. The rest of the maize area is split more or less fifty/fifty between the western and eastern zones of the country.

The endemic disease area needing seed treatment is estimated to be 450,000 ha. The biological problems are: downy mildew, smut diseases, and soil insects.

Seven states are represented here and are to be covered by this campaign. When downy mildew alone is considered then it is assumed that close to 100% of this area is, or shortly will be, infected by the disease.

According to the agricultural development project (ADP) data the total planted area in the downy mildew endemic states is 660,000 ha. Of this area ± 270,000 ha can be planted with improved seed varieties supplied through ADPs, the National Seed Service (NSS), and private seed companies.

Recommended seed rates vary depending on the cropping scheme used. For intercropping, the rates fluctuate between 15 and 20 kg/ha depending on the crop the maize is grown with. For maize grown as a sole crop the seed rate is 25–30 kg/ha. Based on these indications, I believe it is appropriate to use a medium seed rate of 20 kg/ha which means that 13,300 tonnes of maize seed are required for the project states (Edo, Kogi, Kwara, Ogun, Ondo, Osun, and Oyo).

When thinking about distribution of seed-treatment chemicals, the sites of seed production and multiplication have to be considered. In Nigeria maize seed production can be found at three different levels:

1. Private seed companies such as Pioneer, UAC, and UTC.
2. Government agencies like NSS and the various ADPs.
3. Small-scale farmers.

Approximately 5–10% of all maize seed is produced and marketed by the private seed companies, another 15–20% by NSS and ADPs, and the bulk, 75–80%, is produced by small-scale farmers. If these percentages are translated into tonnes of seed and focused onto the southwestern area of Nigeria, i.e, the downy mildew-endemic states, then this means that ± 600 t are produced by the private seed companies, 2,700 t by the government agencies and the remaining 10,000 t by small-scale farmers. These figures alone may not be of much significance unless one is considering how these quantities can be treated with seed-dressing chemicals and how they will be distributed.

Before looking at the possible strategies, some thought has to be given to how the seed is distributed from the producer to the end-user. Private seed companies have two ways of distributing their product. They either sell the seed to a distributor who in turn sells it to the end-user, the farmer, or they sell directly to the end-user when it is a medium or large-scale farm. Government organizations, on the other hand, market their maize seed mainly directly to farmers and in the case of the National Seed Service, through the ADPs. (See Figure 1.).

Strategies

Seed treatment at seed company level

We have seen that 5–10% of the maize seed required in the downy mildew-endemic states is provided by private seed companies. These ±600 tonnes should ideally be treated in bulk as this would allow for cost savings for various reasons:

1. Seed-dressing chemicals can be purchased in bigger-sized packages which will lead to a cheaper price per unit.
2. Larger quantities can be treated within a shorter period of time and this would have a positive impact on labor costs.

For such large-scale operations different types of seed treatment equipment are available. In figures 2 and 3 the specifications for two commercial units available are shown. The cost of acquisition and operation of such equipment can be seen in Table 1, considering a naira to dollar ratio of 25:1. In selecting seed treatment equipment, the following aspects should be considered:

Equipment	Features
*Seed Types & Capacity	Tonnes Hours/Maximum/Minimum
*Versatility	Seed Types/Formulations
*Calibration	Easy + Accurate
*Uniform Seed Coating	One/Two Products
*Filter System	Clean
*Container + Pump System	Convenient
*Easy to Clean and Service	

For the farmer who buys his seed through this channel there are many benefits as he gets good quality seed at a reasonable price which is already treated with the seed-dressing chemicals needed for his specific situation. The farmer does not need to bother about where to buy the product or how to treat the seed. Furthermore, the risk of contamination is eliminated as the farmer does not handle the chemical. In terms of distribution of the seed-dressing chemical, large-scale centralized seed treatment is the most effective as the product only has to reach one customer or, in this particular case, three seed companies against thousands of individuals. In practice the maize goes wherever the seed-dressing chemical goes.

Seed companies have to make sure that all the seed being sold in the southwestern states is treated with Apron Plus® 50 DS as this is the only product for the time being to efficiently control downy mildew. The labels of the bags containing the seed for these areas should also be marked with the name of the dressing product.

Seed treatment at government agency level

As seed producers, both the NSS and the ADPs should have their own seed-treatment facilities. The seed which is produced by these government agencies is meant for the small-scale maize grower who plants less than two hectares of the crop. Earlier we noted that these two governmental bodies are producing and marketing ± 450 tonnes of seed for the seven states where downy mildew is endemic. In order to ensure that the seed sold by them is treated with Apron Plus® 50 DS two alternative strategies are suggested.

Table 1. Seed treatment equipment capital expenditure and operating costs.

1. **Capital Expenditure**	
Amazone Trans-mix	± $12,000
Gustafson	US$ 25,000.
2. **Operating Costs** (For Amazone Trans-mix to treat 1'000 kg)	
Seed-dressing chemical	
(Apron Plus® 50 Ds: 10g/kg)	N17,960
Maize Seed	N6,000
"	25
"	25
"	20
"	50
Total	N24,080

1. Every ADP, including their respective zonal offices, should be equipped with at least one Amazone Trans-mix. The number of machines per station is of course dependant on the amount of seed that usually passes through them. One machine can treat between two and three tonnes each working day. The seven states—Edo, Kogi, Kwara, Ogun, Ondo, Osun, and Oyo—each have ± 25 zonal offices, which would translate into 25 seed treaters. Based on the price indication (Table 1), a capital expenditure of around $110,000 would be involved.
For the National Seed Service the same method would apply.
2. If the strategy mentioned above is not viable for one reason or the other then we suggest that both ADPs and NSS include enough 10 g satchets of Apron Plus® in each bag of maize seed sold. In the case of the National Seed Service which sells their seed mainly in 50 kg bags, 50 satchets of Apron Plus® have to be included and sold together with the seed maize. The ADPs, which mainly use 5 kg bags for marketing their seed, would have to include 5 satchets of the seed-dressing chemical.

The advantages of the first alternative over the second one in terms of distribution of the seed-dressing chemical are:

1. Better zonal distribution of treated seed.
2. Better coverage of distributed maize seed with Apron Plus®.
3. Higher quality of application of the chemicals as professional equipment is used.

Seed treatment at farmer level

Most of the maize seed is produced by the small-scale farmer. This means that this large quantity, 10,000 t of seed, never enters any official distribution system. If this campaign for the control of maize downy mildew is to be successful, special solutions have to be found on how to reach these farmers and convince them of the necessity to have their home grown maize seed treated with Apron Plus®.

We are faced with three major challenges:

1. Distribution of the seed-dressing chemical, i.e., how to get Apron Plus® to the farmer.
2. How to convince farmers to purchase the chemical and to apply it.
3. Follow-up in order to make sure that the seed has actually been treated.

For the distribution of the seed-dressing chemical the extension services of the agricultural development projects have to participate. ADPs have to make sure that the product is brought as close to the farmer as possible. For this a network has to be established whereby all interested distributors in the state are involved. ADPs with their village extension officers and commercial branches choose a pro-active approach and push their distributors to purchase the product from the ADPs or take it on consignment.

The quantities of maize seed used by the small-scale farmer are on the low side. We believe that on average, ± 20 kg have to be treated. Therefore the 10 g satchet of Apron Plus® should be used. Although this package size is slightly more expensive than the 1 kg pack, it still makes very good economic sense especially when potential losses suffered through maize downy mildew attacks are taken into consideration. In this sector, the application of the chemical is left entirely with the farmer. As for the application equipment, emphasis should be laid on such locally available materials as gourds, plastic bags, and concrete mixers. Seed treatment machines like the Amazone Trans-mix would not be very viable as the quantities to be treated by each individual farmer would be too small.

Another opportunity to distribute Apron Plus® would be to use seed-treatment teams. The idea behind this strategy is to establish small groups (teams) consisting of an agro-technician and an assistant equipped with a 4-wheel-drive pick-up truck and one Amazone Trans-mix applicator. Costs for operating a mobile seed-treatment team are shown in Table 2. These seed-treatment teams would move from village to village in order to treat the maize seed of interested farmers. The product, Apron Plus® would be carried along and sold to the respective farmers on the spot. The main focus of these teams should be on the small to medium-scale farmers which grow at least two hectares of maize. Leader farmers would have to be identified. Such leader farmers could also be used in training workshops and field-days or other promotion activities in order to help to promote the idea of seed treatment.

Initially, we suggest that this idea be tried out in pilot projects in Ondo and Oyo states. The advantages of this strategy are that the farmer does not have to look for the product himself, because it is brought to him. Also professionally treated seed would have a better distribution of the chemical on each seed, which in turn will guarantee higher efficacy. However, these seed-

treatment teams might have a disadvantage in the sense that they would have to be supervised very carefully and very seriously. Such supervision would not be free.

The problem is not only the distribution of the seed-treatment chemical but also how to convince the farmer to buy and apply it. Several opportunities exist here.

1. Conducting awareness campaigns on the radio. Surveys have shown that most farmers have easy access to this medium. The campaigns should contain information about the biological problem itself, the causes, and its associated dangers. The farmers also have to be informed of the solutions to solve the problem, where they are available, at what cost, and what financial benefit they will derive from applying Apron Plus® 50DS.
2. Training village extension agents and, through them, training farmers.
3. Conducting field days.
4. Conducting on-farm demonstrations in strategic locations in the respective states.
5. Selecting of lead farmers.

Even when this has been successfully carried out, there is no guarantee that all the maize has been really treated. Therefore, we have to find a way to check what actually has been done and what result has been achieved in the field. For this follow-up we suggest that:

1. Extension officers of ADPs regularly control the fields during the planting season as well as after emergence of the crop. For this a simple to handle reporting system would have to be developed.
2. At the end of the growing season an end of year survey should be carried out.

Privatization of seed production and distribution

About 25% of all maize seed in Nigeria is produced by either the private sector or governmental organizations. By laying the full responsibility for seed production on private seed companies, the production as well as the distribution of the seed could be organized in a much more efficient way. Private companies tend to behave more commercially and are more competitive than any government body anywhere in the world. The more competition private companies face the more innovative they become and the more they take care of the users' needs. All of this should have a positive impact on the availability of better adapted maize varieties.

Such a strategy would also ease the distribution of the seed-dressing chemicals as all the seed could be treated at one or two strategic locations in the country and in bulk.

Conclusions and recommendations

1. In order to achieve the set objectives of this downy mildew-eradication project, 100% of the seed that is not resistant to downy mildew should be treated with Apron Plus®.
2. The seed should be treated at its various levels of production, i.e, at the level of the private seed companies, at government level, and at farmer level.
3. The seed produced by private companies and governmental agencies should be treated in bulk with the aid of the Amazone Trans-mix seed treater or any other similar type of equipment.
4. At farmer level, a network should be established through which Apron Plus® can be distributed to the small-scale farmer. This network should be supported by promotion campaigns on the radio, training, and field days.
5. For medium-sized farmers with a planted area of at least two hectares of maize, seed-treatment teams should be created to commercially assist in seed treatment.

The most important point during the discussion of the program and when establishing the action plans is that the three different levels of production are kept in mind and that something should be done for each one of them if the campaign is to be a success.

Figure 1. Distribution channels of maize seed in Nigeria.

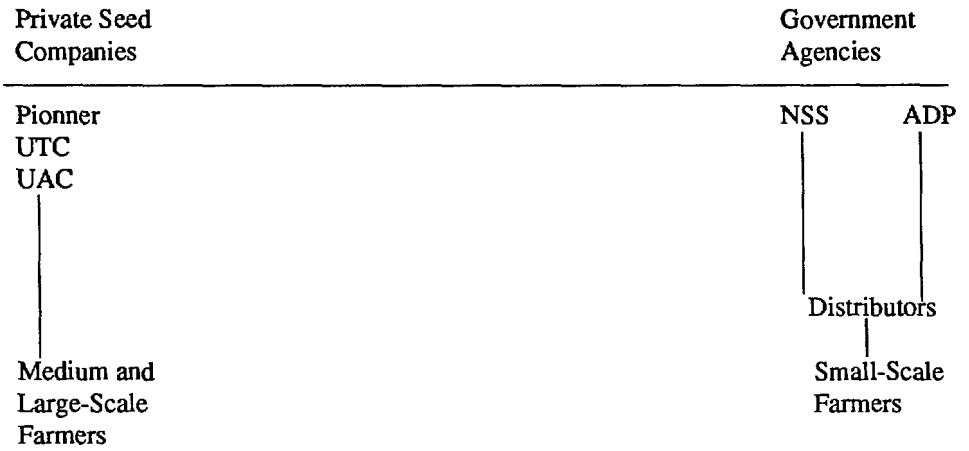

Table 2. Cost of equipping and running a mobile seed-treatment team.

Equipment	**Cost (US$)**
1. 4-wheel-drive pick-up	25,000
2. Spare parts kit	5,000
3. Amazone Trans-mix	3,500
4. Portable generator set (4 KVA; 380 V)	5,000
Total	38,500
Operation	**(N)**
1. Maintenance + Fuel	20,000
2. Outstation allowance for staff	10,000
Total	30,000

The operating costs for the seed treatment (Table 1) have to be added to the total of the running costs as outlined above.

PROCEEDINGS SUMMARIES

Previous Page Blank

Conference and Workshop Summary

Maize is becoming an increasingly important cereal in Nigeria with an annual production of about 3 million tonnes. An estimated one third of this is grown in the humid forest zone. One of the most important constraints to maize production in this area at present is the downy mildew disease. The disease causes between 30 and 100% losses in maize yield every year in the affected states, with an estimated total loss in 1992 of 3.5 million Naira.

This disease, caused by a fungal pathogen, *Peronosclerospora sorghi*, has been in Nigeria since 1969 when it was found on sorghum in Samaru and in later years found on maize in Kabba, Kogi State. It was reported on maize in Owo, Ondo State in 1975. Until 1989 this disease was localized but then it started moving westward at a rate of 100 km per year. By 1992 it had spread into Oyo state and assumed major national recognition because of the losses it was causing. 'At the current rate, the disease will spread to the Republic of Benin by 1995.

Results from research work at IITA and IAR&T on downy mildew-resistant varieties, seed treatment, and other agronomic methods of control need to be publicized. It is for this reason that IITA/FAO/FDA held a three day conference/workshop on the downy mildew disease of maize. Over one hundred and fifty participants from the National Seed Service (NSS), ADPs of the endemic and endangered states, farmers, private companies, donor and international agricultural organizations (FAO, UNDP, World Bank), and international visitors attended the conference. The history of the disease in Nigeria, the epidemiology, and control options available for the formulation of effective control and eradication of this devastating disease were reviewed.

The following two-day workshop was filled with situation overviews from Nigeria, Uganda, and Benin, situation reports of the ADPs in the endemic states, farmers' experiences, and efforts of seed and chemical companies. The workshop participants were involved in plenary discussions on issues such as how to develop sustainable production of downy mildew-resistant seed, the pros and cons of using hybrids, and the pros, cons and logistics of chemical seed-dressing technology. The plenary session papers and discussions are being bound into proceedings.

Two project proposals were developed during the workshop.
A TCP proposal was developed with FAO for a two-year campaign (see Annex 1). A UNDP project proposal was written for a sub-regional downy mildew control campaign that will include Nigeria, the Republic of Benin and Uganda.

Working groups hammered out and voted on resolutions for immediate national action on the control of the downy mildew epidemic. The following is a summary of the resolutions which is the consensus of the working groups. Details of working group deliberations can be found in Group Session Summaries I–III.

Previous Page Blank

Group Session Summaries

Group Session I Summary—6 working groups of 8 people each—proposals, summaries, and resolutions on:
Formulation of scenarios for sustainable maize seed production for downy mildew control; highlighting the role of Federal Government, National Seed Service, the ADP's, the private sector, and research institutes.

Chair: Mr Rambocus, World Bank, Lagos. Rapporteur: Dr Cardwell.

Proposals	Number
Federal government	
Ensure that DMR seed is available	1
Fund research	1
Fund breeder seed production	3
Fund seed maintenance (seed storage systems)	3
Formulate coherent seed policy	2
Ensure & fund ADP requirements	2
Ensure pricing and purchase of seed	2
Subsidize seed cost (2 year term)	1
State governments	
Ensure adequate supplies of agricultural inputs for seed producers and seed consumers	1
National seed service (NSS)	
Produce foundation seed I and II	1
Produce foundation seed I and II (short term)	1
Produce foundation seed I	3
Produce foundation seed II	1
Produce certified seed	1
Monitor 'outgrower' seed production	1
Conduct seed certification	2
Enforce seed certification (regulatory role)	4
Ensure agricultural inputs (fertilizer) for all sectors	1
Monitor nationwide seed production and distribution	1
Agricultural Development Projects (ADPs)	
Produce foundation seed II	2
Produce certified seed	5
Produce certified seed (short term)	1
Monitor 'outgrower' seed production	2
Distribute certified seed (extension role)	5

Participate in distribution of private sector seed	2
Procure and distribute agricultural inputs	2
Coordinate & manage campaign strategies	2
Increase sales points for seed and agricultural inputs	1
Private seed companies	
Produce hybrid seed	4
Produce foundation seed I and II (short & long term)	4
Produce certified seed (short & long term)	2
Procure and distribute agricultural inputs	1
Research and field testing of DMR materials	3
Support research institution activities	1
Distribute own seed	6
Farmers	
Seed growers (contracted)	4
Seed users	2
Seed marketers	1
Research institutions (IITA & IAR&T)	
Produce breeder seed	5
Produce foundation seed	1

Summary top ranked proposed activities of seed production sector

Federal Government	
Fund breeder seed production	3
Fund seed maintenance (seed storage systems)	3
Formulate coherent seed policy	2
Ensure & fund ADP requirements	2
Ensure pricing and purchase of seed	2
National Seed Service (NSS)	
Produce foundation seed I	3
Conduct seed certification	2
Enforce seed certification (regulatory role)	4
Agricultural development projects (ADPs)	
Produce foundation seed II	2
Produce certified seed	5
Monitor "outgrower" seed production	2
Distribute certified seed (extension role)	5
Participate in distribution of private sector seed	2
Procure and distribute agricultural inputs	2
Private seed companies	

Produce hybrid seed	4
Produce foundation seed I and II (short & long term)	4
Produce certified seed (short & long term)	2
Research and field testing of DMR materials	3
Distribute own seed	6
Farmers	
Seed growers (contracted)	4
Research institutions (IITA & IAR&T)	
Produce breeder seed	5

Group Session Summary II—7 working groups of 8 people each—proposals, summaries, and resolutions on:

1. How to improve on the current system of distribution of seed-dressing chemicals.

2. How to monitor farmer utilization of seed-dressing chemicals.

3. How to improve safety for farmer utilization of seed-dressing chemicals for downy mildew control.

Chair: Prof Mjindadi, FACU. Rapporteur: Mrs McDonald, IITA

Proposals

The Federal Government of Nigeria	
Through FEPA, standardize pesticide registration	2
Withdraw from distribution of chemicals	1
Provide guaranteed loans for procurement by authorized dealers	1
Legislate to protect farmers from:	
overpricing and counterfeit products	3
Use Standards Org. Nig. to monitor purity	3
Monitor seed companies through the NSS	2
Support ($) research for alternative control options	2
Support ($) village level training activities	1
NSS	
Seed dress all foundation seed that goes to growers	1
Ensure that all certified seed is properly treated before sale	4
Make seed dressing a certification regulation	4
Insert sachets into reserved stocks of seed	1
Develop and provide safety manuals for proper utilization, storage, and disposal of pesticides (with FAO/IITA)	1

ADPs

Treat all ADP produced and contracted seed with Apron Plus® (develop seed treatment equipment)	7
Encourage farmers groups in distribution of chemical	1
Encourage distribution through Farm Service Centers	1
Extend seed-dressing technology to farm coops	1
Maintain directory of retailers	1
Package treated seed in small quantities so even very small-scale farmers will have access	1
Engage in campaign and training activities	7
Monitor farmer usage of Apron Plus®	5
Provide plastic bags or gloves with all sachets of Apron Plus®	4

Private sector

All privately produced seed must be treated before sale (Full recommended dosage of 10 g Apron Plus®/ kg of seed)	7
Clearly label treated seed as poisonous	7
Chemical companies to identify distribution agents	5
Chemical companies to inform ADP's of all distributors and quantity of yearly allocation	1
Chemical companies to conduct training courses	3

Summary of top ranked proposed activities of seed treatment sector

Federal Government

Through FEPA, standardize pesticide registration	2
Legislate to protect farmers from: price gouging and counterfeit products	3
Use Standards Org. Nig. to monitor purity	3
Monitor seed companies through the NSS	2
Support ($) research for alternative control options	2

NSS

Ensure that all certified seed is properly treated before sale	4
Make seed dressing a certification regulation	4

ADPs

Treat all ADP produced and contracted seed with Apron Plus® (develop seed treatment equipment)	7
Engage in campaign and training activities	7
Monitor farmer usage of Apron Plus®	5
Provide plastic bags or gloves with all sachets of AP	4

Private sector

All privately produced seed must be treated before sale	7
(Full recommended dosage of 10g Apron Plus®/ kg of seed)	
Clearly label treated seed as poisonous	7
Chemical companies to identify distribution agents	5
Chemical companies to conduct training courses	3

Farmers

Purchase and grow only treated seed	5
Buy chemical and treat own seed	2
Use plastic bags or gloves to protect hands	7

Group Session III—2 working groups of 10 people each

Chair: Dr K.F. Cardwell, IITA. Rapporteur: Ms J. Udoh, IITA

Group 1—Action Program for ADP extension agents for 1994 DM control campaign. **List positions and personnel who will be involved in two large field days. Arrange dates for field days in each state. Include a plan for reaching farmers of both genders and of different languages.**

Names of key ADP personnel can be found in annex 4.

Group 2—Action Program for ADP and private seed producers for meeting 1994 seed requirements. **According to state hectarage, determine seed requirements, how many production contracts are expected, and what proportion of seed production can be met by private sector. Discuss methods for how to include private sector in current ADP seed distribution network.**

It was estimated that approximately 900 ha of seed production is required to meet demand in the 6 endemic states for 1994. (Calculated at 3 tonnes production/ha to cover a projected requirement for 277,000 ha). The ADPs would contract to produce 300 ha total or 50 ha/state. The ADP seed unit then requested 7500 sachets Apron Plus®, 1,500 L herbicide, and 750 kg foundation seed of DMRLSRW and Suwan 1.

This leaves a net requirement of 600 ha under certified seed production to the private sector. The private sector has already produced and dressed about 300 tonnes of seed, but the ADP representatives were unable to give commitment to buy or commission this seed due to the disparity in cost:

ADP price/tonne = N10,000 OP variety
Private sector price/tonne = N39,000 Hybrid
Private sector price/tonne = N22,500 OP variety

Executive Summary—Workshop Resolutions

Resolutions of the IITA/FAO/FDA international workshop on the control of the downy mildew disease of maize in Nigeria:

1. The Federal Government of Nigeria (FGN) is requested to initiate and implement the following activities that are deemed by this group to be essential to the success of this campaign:

a. Support the development of a national capacity to produce and maintain high quality stocks of breeder seed.

b. Formulate a coherent policy for the function and success of a productive and sustainable seed sector.

c. Develop a market base in which seed producers are ensured of timely purchase of their product.

2. The FGN and affected state governments are strongly urged to link the sale of improved downy mildew-resistant (DMR) seed to availability of fertilizer, such that for every kg of breeder or foundation seed that goes into production of certified seed, and every kg of certified DMR seed that is bought by a farmer for planting, the seed is sold with the requisite minimum requirement of fertilizer to ensure the ideal agronomic development of the crop.

3. Stable DMR seed production and availability is the most urgent requirement for the downy mildew control campaign to succeed. The participants of the workshop have identified the necessity to transfer certified seed production, on a gradual basis, from the public to the private sector. The main obstacle to this goal, and to the goal of a sustainable seed industry, is the current disparity between the price of seed produced via the public sector and via the private sector. Thus the FGN is requested to assist in the following ways:

a. On a temporary basis (over the next 2–3 years) absorb the difference in seed price such that private sector seed can be sold competitively alongside of ADP produced seed.

b. At the same time and on a temporary basis (over the next 2–3 years), establish pricing guidelines which will gradually move all seed producers toward competition on the basis of cost of production.

4. With respect to Apron Plus® seed dressing and other pesticides, the FGN is requested to initiate and implement the following activities that are deemed by this group to be essential to the success of this campaign:

a. Legislate registration of agricultural pesticides (through FEPA).

b. Legislate farmer protection from overpricing, product impurity, and improper labelling of treated seed.

c. Support research for alternative control strategies.

5. The National Seed Service (NSS) is requested to produce sufficient DMR foundation seed to meet the downy mildew control campaign projections for coverage of endemic and endangered areas of the Republic (see Annex 2).

6. The FGN through the NSS is urgently requested to formulate a clear and enforceable policy for seed certification requirements; and beginning in 1994 to conduct localized monitoring, quality testing, and certification of contract growers seed quality.

7. The NSS is requested to make proper seed dressing a requirement for certification of seed and monitor that all certified seed is treated with the commercially recommended dosage of Apron Plus® by private and public seed producers.

8. The management of the agricultural development projects (ADPs) is requested to strengthen the following activities of the ADPs that are located within the states that are identified as endemic or endangered by maize downy mildew.

a. Contract and monitor the production of certified seed to meet the projections put forward by the downy mildew campaign (see Annex 2) until such time as this activity can adequately be met by the private sector.

b. Liaise with private sector to determine quantities of certified seed that will be needed in each state each year and plan for production.

c. Procure and distribute the necessary agricultural inputs to meet the basic agronomic production requirements of each farmer client.

d. Maintain a current data base of seed and agricultural products that pass through project offices.

9. The ADPs are urged to actively promote the extension and distribution of all certified DMR seed throughout all zones to the farm service centers in the target states.

10. With respect to the use of seed-dressing chemicals, the management of the agricultural development projects (ADPs) is requested to strengthen the following activities of the ADPs that are located within the states that are identified as endemic or endangered by maize downy mildew.

a. Treat all ADP produced and contracted seed with the commercially recommended dose of Apron Plus® (develop seed-treatment equipment) and clearly label that the seed is poisonous.

b. Engage in campaign and seed-dressing training activities and monitor farmer usage of Apron Plus®.

c. Encourage farmers to use gloves or a plastic bag on their hands when they are handling treated seed.

11. The general managers of private seed companies in Nigeria are requested to:

a. Collaborate with the Federal government, through the NSS, and the state ADPs to ascertain production shortfalls for DMR materials, and to assist in meeting the shortages in DMR seed production requirements with the view to ultimately relieving the public sector of responsibility of such activity.

b. Actively continue in the development, production, and distribution of high quality improved DMR hybrid and OP varieties.

c. Continue to procure and distribute appropriate agricultural inputs linked with seed sales.

d. Engage in and support research activities such as testing of new DMR materials and maintenance of breeder seed.

12. The general managers of the private seed companies in Nigeria are requested to treat all maize seed with correct dosages of Apron Plus® and properly label the bags with cautions not to eat the contents.

13. The general managers of private chemical companies are requested to:

a. Take an active role in developing a network of distribution outlets in association with the ADPs.

b. Actively participate in training and extension activities.

14. The agricultural research institutes (particularly IAR&T) should determine the requirements for, and procure support for the specific activities of improving levels of resistance to downy mildew, and improving and maintaining high quality stocks of breeder seed for deployment to the private and public seed sectors of Nigeria (see Annex 3).

15. The maize farmers of Nigeria are called upon to recognize the danger of downy mildew disease to all private and industrial consumers of the grain. The public cost to control the downy mildew disease of maize is high, and will be higher. We call upon the leaders of farmers' organizations to impress upon fellow producers that the costs incurred today to stop this problem will ensure a more productive future for all involved. Downy mildew disease is not going to go away without some cost to everyone involved in the agricultural sector. It is up to every farmer to learn how to produce a clean crop and how to avoid infecting his or her neighbors crops due to carelessness. Please work with your local governments, ADP extensionists, and fellow farmers to spread the message.

16. Maize farmers in Nigeria are called upon to recognize the benefit of using seed-dressing chemicals on all maize seed to avoid infection of their maize with downy mildew. Lead farmers should work with other farmers so that they will know how to use seed dressing, and realize that it is poisonous and that treated grain should not be eaten. When planting treated seed, protection in the form of a plastic bag or gloves should be worn over the hand. The glove or bag, and all sachet refuse should be burned after use.

ANNEXES

Previous Page Blank

Annex 1

FAO/Nigeria TCP Proposal for Control of Maize Downy Mildew in Nigeria

Agency: FAO/FDA/IITA
Duration: 18 months

Background
Maize is the most commonly grown cereal in Nigeria with annual production of 3 million tonnes for use as a major food item, as livestock feed, and other manufactured uses. In recent years production has been threatened by the spread of the disease downy mildew caused by the fungus *Peronosclerospora sorghi.* In 1991, about 250,000 sq. km was affected in 6 states. The strain of the fungus is particularly virulent and a component control system has to be in place and functioning for effective control.

Research by the International Institute of Tropical Agriculture (IITA) and the Nigerian Government has shown that a combination of resistant varieties and seed treatment is effective in controlling the disease. At a workshop held at IITA and sponsored by FAO and UNDP under TSS-1 arrangements, a substantial technical assistance program was drawn up for submission to UNDP and other agencies for financial support.

However the same meeting also reported the ongoing spread of the disease at the frontal rate of about 100 km per year. Interim measures need to be immediately implemented for the 1994 growing season before the infestation becomes countrywide and spreads into the neighboring country, the Republic of Benin .

Problem to be addressed
Although the chemical treatment and resistant variety combination is widely accepted as an effective control method, the workshop reported that problems of farmers adopting the procedure were common. This was due to the lack of clear extension literature and pamphlets and motivated extension personnel in the ADPs and the National Seed Service. Unless farmers are informed of the benefits of the available control measures, targets for the production and utilization of DM-resistant seed stocks and utilization of seed dressing will not be met. In addition to commercial inputs, farmers need to be reached with information about cultural practices which will reduce the spread of the disease.

Benefits of the work
By providing publicity materials and training key extension personnel, farmers will be informed of the benefits of using the effective control measures and will therefore produce more maize for seed crops for basic food and industrial consumers. Additionally, if the control measures are widely adopted, the disease spread into states and neighboring countries not currently affected, will be halted.

Government priorities
The government is clearly committed to improvement of the seed industry in general through a World Bank program to the value of US$ 14 million. A number of facilities and personnel for

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this program will be associated with the World Bank project. The Government also supports IITA in implementing its research in the field.

Workplan and activities

The Government will provide the staff of the National Rice/Maize Center, National Research Institutes, NSS and ADPs for the training and will provide sites at the demonstration areas for planting etc. The Government will also provide a member of its staff to act as the National Campaign Coordinator.

Provisional budget

Training workshop for 20 Agric Development Program staff (in 10 states) for 3 days (2 workshops)	$ 40,000
Training facilities for 10 workshops	5,000
Local resource persons	10,000
Travel costs for resource persons	6,000
Vehicle, station wagon	25,000
Farmers field day/training demonstration (10 states)	75,000
Publicity campaign: radio and television, posters, billboards, technical bulletins and leaflets	40,000
	201,000
Communication consultant 1m/m	10,000
Marketing consultant 3m/m	30,000
Total	$ 241,000

Note: The Nigerian Federal Department of Agriculture (FDA) has promised $10,000/annum for coordination of the campaign.

Terms of reference (communication consultant)

1. In consultation with national staff plan a publicity campaign for the adoption of control methods of maize downy mildew.
2. Advise on layout of posters and other materials for the general public, farmers etc.
3. Advise on suitability of other media methods as appropriate.

Terms of reference (marketing consultant)

1. Assess demand for downy mildew-resistant seed states.
2. Work with communications consultant on strategies to increase demand for resistant seed.

3. Develop a scheme for marketing channels to be sent to the FDA for implementation.
4. Conduct a market analysis to determine the likely effect of increases in the price of maize seed.

Achievements of the project

By the end of the project the following will be in place:

- A baseline for economic impact assessment for the campaign.
- A series of publicity material in a number of different media for all levels of people involved in maize production.
- In 10 states extension staff trained in communicating the benefit of DM control methods to others.
- In 10 states farmers and extensionists informed of effective DM control methods by field demonstrations.
- A mechanism for fully launching communication activities for the sub-regional DM control program.

Annex 2

Projected DMR Seed Requirements/Project Year (tonnes)

	1994	1995	1996	1997	1998
Certified	6,929.00 (897.60)	7,136.87	7,351.00	7,571.51	7,798.66
Foundation	57.57 (42.50)	59.48	61.26	64.99	–
Breeder Seed	481.25kg (85.00kg)	495.69kg	510.56kg	525.88kg	541.66kg

( ) = Estimated Actual production
Based on 277,000 ha requirement for 6 States (1994 estimate).
Assuming: 3 tonnes/ha yield by seed producer, 5% annual increase in demand

Annex 3

List of Capital and Expendable Materials and Personnel Required for Breeder Seed Production and Maintenance (Approximately 500kg/yr of DMR seed)

Capital Expenses	
Irrigation	$ 100,00
Tractors & implements	50,000
Cool storage room	50,000
Dryer	50,000
Vehicle	20,000
General equipment	10,000
Sub-total	$ 280,000
Expendable Inputs	
Expendable inputs ($10/kg)	$ 5,000/yr
(Fertilizer, herbicide, pesticides)	
Hand pollination	
(Pollination bags)	5,000/yr
Miscellaneous	3,000/yr
Sub-total yearly	$ 11,000
Personnel	
Technicians (10)	N 50,000/EA/yr
One breeder	

State Representation for the Campaign on the Control of Downy Mildew

Designation	Ondo	Oyo	Osun	Edo	Kwara	Kogi	Delta
Extension	Mr A. A. Eleyinmi	Mr S.A. Adegebo	Mr I. O. Onigbogi	Mr R. O. Obasohan	Mr M. O. Olaoye	Mr O.B. Olumo	Mr B. A. Okobanoh
WIA	Miss Nike Afolabi	Mrs Tola Ojeniyi	Mrs E. F. Ojo	M. O. Ewansiha	Mrs Adeyemi	Mrs Adeniyi	Mrs Sakpoba
Seed Unit	Mr E. O. Akindele	Mr. Ogungbade	Mr J. K. Fabiyi	R. O. Aviomoh	Mr. J. O. Aina	M. O. Adewumi	C. Nwaodua
Commercial	Laide Buraimoh	Mr Adewoyin	Mr Odebunmi	D. O. Iyo-Ewuare	Mr J.B. Adeyemi	Mr J.B. Agbaje	Mr. R. Okafor
Communication support	Mr M. N. Akinniyi	Mr Oyebamiji	Mr Anwo	S. O. Yalekhue	Mrs Salami	Mr J. B. Omotehinwa	A. Aghanenu
Field day local	Owo Ikole	Ibadan Ogbomoso	Osogbo Ilesa	Owan Akoko Edo	Omuaran Ilorin	Ole Aiyetoro	Delta North Delta Central
Target dates	June July	June August	May(late) September	July August	June August	August September	June August

Those to be involved in the campaign

EAS, BEAs, BESs, Communication Staff, Farmers (male and female), NAERCS' Staff, Mass Media staff, NACDA Staff, Headquarters Staff Extension, Commercial, and Technical Services), CGAs Officials, Representatives of Women's groups, NSS Staff and MANR Commissioner and his entourage.

Language: Local language and English

Gender Issues: WIA Agents (BEAs) usually reach the women in groups and individually (i.e. CFs). Use of WGSP (Women Group Skill Plots) to disseminate the technology.

Annex 5

Abbreviations and Acronyms

ABU	Ahmadu Bello University
ADP	agricultural development project/program
AISC	Agricultural Inputs Supply Company
CARDER	Center for Regional Action and Rural Development (Benin)
DCCP	Directory of Products Center and Packaging (Benin)
DFFRI	Directorate of Food, Roads and Rural Infrastructure
DM	downy mildew
DMR	downy mildew resistant
EA	extension agent
EEC	European Economic Community
FAO	Food and Agriculture Organization of the United Nations
FACU	Federal Agricultural Coordinating Unit
FMAWR&RD	Federal Ministry of Agriculture, Water Resources and Rural Development
FDA	Federal Department of Agriculture
FGN	Federal Government of Nigeria
GDP	gross domestic product
ha	hectares
IAR	Institute of Agricultural Research
IAR&T	Institute of Agricultural Research & Training
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDRC	International Development Research Center
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture
LGA	Local Government Area
MAAN	Maize Association of Nigeria
MOA	Ministry of Agriculture (Ghana)
MSV	maize streak virus
mt	metric tons
NAARI	Namulonge Agricultural & Animal Production Research Institute (Uganda)
NACB	Nigerian Agricultural and Cooperative Bank
NAELRS	National Agricultural Extension & Liason Services
NAFPP	National Accelerated Food Production Program
NARO	National Agricultural Research Organization (Uganda)
NARS	national agricultural research systems
NCRI	National Cereals Research Institute
NGO	nongovernmental organization

NSPQ	National Seed and Plant Quarantine Project
NSS	National Seed Service
OAU	Organization of African Unity
OFAR	on-farm adaptive research
OP	open-pollinated
OŞADEP	Osun State ADP
OYSADEP	Oyo State ADP
PNM	National Seed Service (Zaire)
PQS	Plant Quarantine Service
PRSA	Program for the Restructuring of Agricultural Service (Benin)
RMRDC	Raw Materials Research and Development Council
SENASEM	National Seed Service (Zaire)
SNCCL	Swiss Nigerian Chemical Company Ltd
SPAT	small plot adoption technique
USAID	United States Agency for International Development
UAC	United African Company
UTC	United Trading Company
VEA	village extension agent
WIA	Women in Agriculture

Annex 6

List of Contributors

N.O. Adedipe	Vice Chancellor, University of Agriculture, Abeokuta
V. Adenle	International Institute of Tropical Agriculture (IITA)
O.A. Adenola	Director, Maize and Rice Research Association
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R.A. Aviomoh	Chief Seed Officer, Edo State
George Bigirwa	Maize Pathologist, Namulonge Agricultural & Animal Production Research Institute, Uganda
Lukas Brader	Director General, IITA
K.F. Cardwell	International Institute of Tropical Agriculture (IITA)
The Hon. Mallam Adamu Ciroma	Minister of Agriculture & Natural Resources
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E.A. Obinyan	UAC Nigeria Plc
M.M. Omole	International Breweries (Agro-Allied) Ltd
O.O. Oyebanji	FACU, Abuja
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