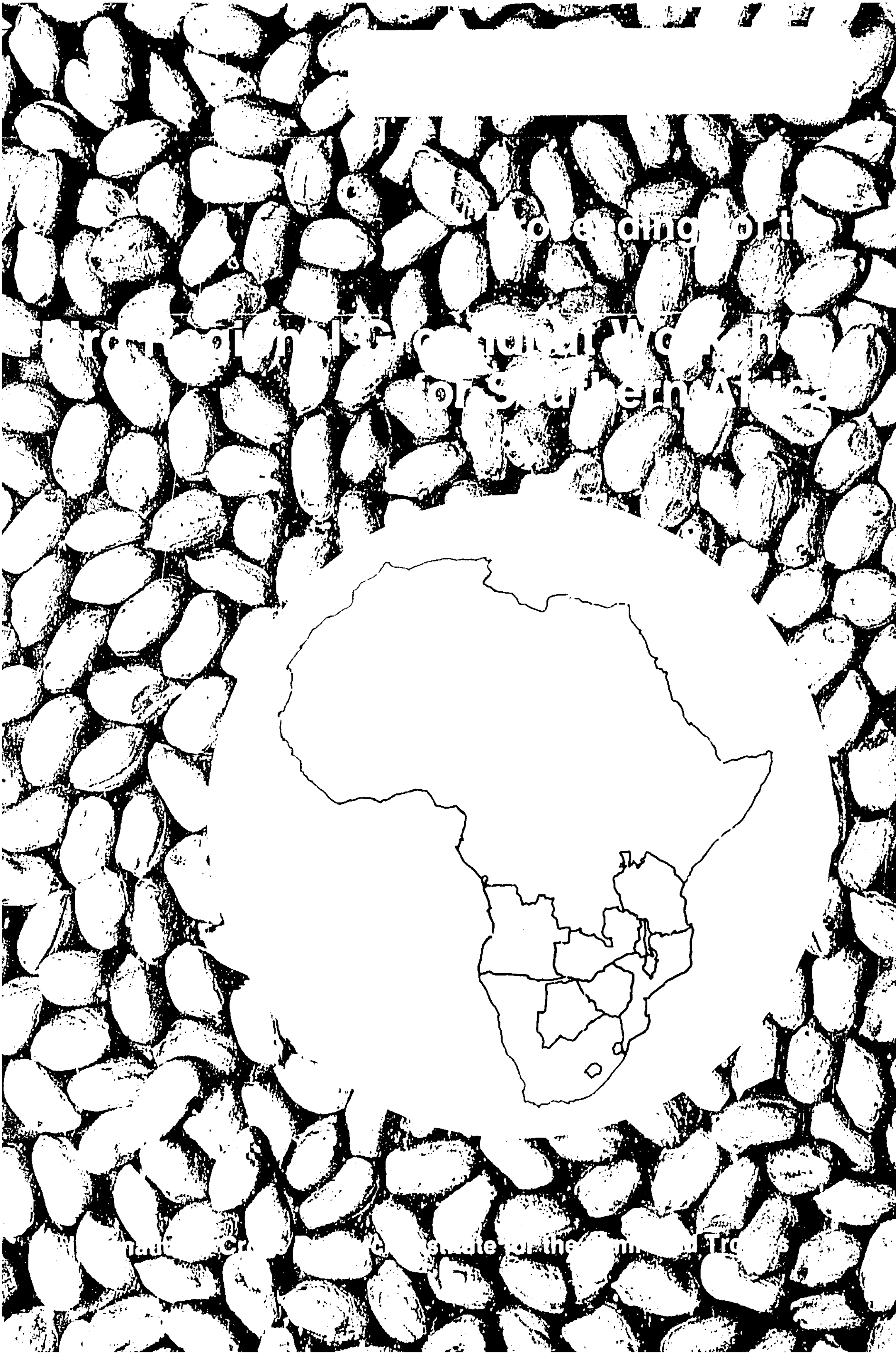

Abstract

Citation: ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1989. Proceedings of the Third Regional Groundnut Workshop, 13-18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P 502 324, India: ICRISAT.

Twenty-four of 26 national program scientists actively engaged in groundnut improvement in the Southern African Development Coordination Conference (SADCC) region participated in the Regional Workshop; Angola being the only country in the region not represented. Also participating were groundnut scientists from Zaire and Mauritius and scientists from ICRISAT Center (India), SADCC/ICRISAT Regional Groundnut Improvement Program (Malawi), and the ICRISAT Sahelian Center (Niger). Papers reviewed groundnut research on breeding, entomology, and agronomy; early leaf spot disease of groundnut; and new methods for detection of aflatoxin contamination. The recommendations arising from the meeting afford a valuable guideline for regional project activities.

Résumé

Référence : ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1989. Comptes rendus du Troisième colloque régional sur l'arachide, 13-18 mars 1988, Lilongwe, Malawi. Patancheru, A.P. 502 324, Inde : ICRISAT.

Vingt-quatre parmi les 26 chercheurs des programmes nationaux oeuvrant sur l'amélioration de l'arachide dans la région de la Conférence de coordination du développement de l'Afrique australe (SADCC) ont participé à ce colloque régional; l'Angola étant le seul pays de la région qui n'a pas été représenté. Y ont également participé les chercheurs de l'arachide provenant du Zaire et de l'Ile Maurice ainsi que ceux du Centre ICRISAT (Inde), du Programme régional SADCC/ICRISAT d'amélioration de l'arachide (Malawi) et du Centre sahélien de l'ICRISAT (Niger). Les communications ont fait le point sur la recherche dans les domaines de : sélection, entomologie et agronomie de l'arachide; cercosporiose précoce; et nouvelles méthodes de détection de la contamination par les aflatoxines. Les recommandations issues de la réunion offrent une ligne directrice précieuse pour les activités de recherche régionales.

Sumário

Citação: ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1989. Proceedings of the Third Regional Groundnut Workshop, 13-18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P. 502 324, India, ICRISAT.

Participaram na reunião regional, vinte quatro dos vinte seis cientistas dos programas nationais ativamente trabalhando no melhoramento do amendiom na região da Conferência da coordinação do Desenvol vimento no sul da Africa (SADCC); Angola sendo o unico pais da região não representado. Participaram tambem cientistas de Zaire, de Mauritius, do centro de ICRISAT (India), do programa regional do melhoramento do amendiom de SADCC/ICRISAT (Malawi), e do centro de ICRISAT em Sahel (Niger), todas eles trabalhando com o amendiom. Foram aprendados resumos das pesquisas da procriação, da entomologia, e da agronomia do amendiom; e metodos novos da descoberta da contaminação de "aflatoxin". Na reunião foram fornecidas recomendaçoês valiosas para as orientaçoês das atividades dos projetos regionais.

Proceedings of the Third Regional Groundnut Workshop for Southern Africa

13–18 March 1988
Lilongwe, Malawi

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics,
Patancheru, Andhra Pradesh 502 324, India

1989

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Welcome Address and Overview of ICRISAT

L.D. Swindale[1]

The Honorable Minister of Finance, Your Excellency the Ambassador of the Federal Republic of Germany, Your Worship the Mayor, distinguished administrators, participants, and guests:

It is with great pleasure that I welcome you to the Third Regional Groundnut Workshop for Southern Africa being held in the capital city of our host country, Malawi. ICRISAT is most appreciative of the support it has received from the Government of Malawi and we hope to be able to respond with continued and increased input into the improvement of groundnut production in the SADCC countries of the southern Africa region. I would like to take this opportunity to consider ICRISAT's mandate, to review briefly the progress made in recent years, and to project our plans for the next 5 years. This should help in putting our involvement within your Region into a wider perspective.

The central theme of ICRISAT's mandate is to focus on improving the quality of life for the nearly 800 million people living in the semi-arid tropics (SAT). Most of these people are involved in agriculture and live in the developing countries of the world. To improve their conditions it is necessary to improve the efficiency of rainfed agriculture of the SAT. It was with this end in view that the Consultative Group on International Agricultural Research (CGIAR) created in 1972 the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) sited near Hyderabad, India. ICRISAT is mandated

1. to conduct research by itself and in collaboration with other appropriate agencies;
2. to function as a Center for exchange of information, techniques, materials, and ideas relating to SAT agriculture;
3. by means of training programs, to increase the numbers and improve the quality of scientific and technical manpower available to solve the problems of SAT agriculture;
4. to identify constraints to agricultural development within the SAT, and to work effectively towards their resolution;
5. to serve the national research and development systems by promoting technical cooperation among them by means of networks by the transfer of appropriate technology available from various sources, and by fostering systems that match the capacity and competence of the diverse national systems;
6. and finally, by increased agricultural productivity, to alleviate the problems relating to hunger and malnutrition of the people of the SAT, while not jeopardizing the long-term sustainability of the environment.

There are three facets to ICRISAT's mandate: (a) the improvement of the five important SAT food crops sorghum, pearl millet, chickpea, pigeonpea, and groundnut; (b) research on resource management to develop cropping systems with long-term sustainability that will ensure both ecological conservation and optimization of productivity; and (c) cooperation in research and training with national research systems in developing countries. The setting up of networks and regional programs combines all three facets.

In crop improvement, we intend to use all available technological options. Facilities are currently being set up at ICRISAT Center to enable us to exploit several of the recently developed biotechnological advances, but the major concentration will continue to rely upon proven plant-breeding methods. One approach to crop improvement lies in the alteration of plant architecture or physiological functioning that can lead to rapid improvement. Another approach is to pyramid genes for resistance to biotic and abiotic stresses so that the new varieties can withstand environmental stresses and show high stability. This has been effective in low-input systems, but benefits depend upon the prevalence and severity of stresses in a given environment.

1. Director General, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). (The address was read by Dr K.R. Bock, Team Leader and Principal Plant Pathologist, SADCC/ICRISAT Regional Groundnut Improvement Program, on behalf of Dr Swindale.)

Yet another approach is to develop variety-specific or environment-specific agrotechniques that permit the realization of a greater part of the yield potential of a crop variety. It is a sound strategy to pursue concurrently research on varietal improvement and varietal management. Using these approaches, considerable advances have been made in improving yields and stability of yield in all the five ICRISAT mandate crops. Within the last 2 years some 30 varieties or hybrids bred by ICRISAT scientists have been released to farmers in countries of Africa, Asia, Oceania, and Latin America. Examples are the sorghum hybrid ICSH 153 (CSH 11) and the millet hybrids ICMH 451 and ICMH 501 released for cultivation in all rainfed regions of India; the kabuli-type chickpea ILC 3279 from the ICRISAT/ICARDA collaborative program that has been released in Syria and Tunisia; two short-duration desi chickpeas released in Ethiopia; the pigeonpea ICPL 87 released in India; and the groundnut ICGS 11 also released in India.

Research on resource management has entailed a conjunctive treatment of the resources, constraints, and opportunities available to farming enterprises, and includes all crops used in the systems and not only the five ICRISAT mandate crops. This approach has required the establishment of collaborative linkages with other institutions, both within and outside the CGIAR system. Technological options have to be evaluated from the standpoints of economic viability, social impact, and environmental conservation, with long-term sustainability being essential for any proposed system. Research in agroforestry has only recently begun, and should expand and become an important aspect of ICRISAT's work in Africa and Asia.

A great deal of effort has gone into the development of cooperation with national research institutions in developing countries. ICRISAT is a world center for the collection, maintenance, and exchange of germplasm of its five mandate crops and of their wild relatives. It is also a clearinghouse for information and techniques that can contribute to improvement in crop production in the SAT. ICRISAT has a strong training function, organizing special courses, conferences, symposia, and workshops. It coordinates research networks and endeavors to initiate and sustain regional research.

Difficulties in transfer of technology from the Asian SAT, where ICRISAT Center is located, to the African SAT regions have stimulated the regionalization of ICRISAT's research activities. The Southern African Regional Program and the Sahelian Center that serves West Africa are now well established. Regional sorghum programs for West and East Africa are in the process of being developed. Kabuli-type chickpeas are being developed in collaboration with ICARDA, and a legumes network for East and Central Africa is under consideration. The Cooperative Cereals Research Network (CCRN) and the Asian Grain Legumes Network (AGLN) operating from ICRISAT Center, are developing rapidly, and formal linkages have been made with several countries. Effective collaborative research projects are in operation and some of these involve not only ICRISAT and the specific national research institutions but have other international, regional, and donor group participation.

The Southern African Development Coordination Conference (SADCC)/ICRISAT Regional Groundnut Improvement Program for Southern Africa was made possible in the first instance by the International Development Research Centre (IDRC) funding the project for the first 4 years (1982-86) and by the Government of Malawi agreeing to host the project and making facilities available at the Chitedze Research Station. During 1986, the status of the Program was changed to an ICRISAT Core Program. Over the last 6 years the Regional Program has made impressive progress. A collection of important germplasm lines has been established and utilized in breeding for resistance to biotic and abiotic stresses and for high yield and quality in cultivars adapted to the region. A very effective field-screening technique has been developed to test germplasm accessions and breeding lines for resistance to groundnut rosette virus disease. A variety evaluation network has been established in the region to test material developed at Chitedze and a number of genotypes have performed well in different countries. The cultivar ICGMS 42 is now in prerelease trials in Zambia. Workshops and Scientists' Group Meetings held in the region have been well attended, and have fulfilled their purpose by bringing together the groundnut research workers of the region and ICRISAT Regional Program and Center scientists to discuss their work and problems and strengthen cooperation within the region. The considerable success achieved has resulted in the Southern African Centre for Cooperation in Agricultural Research (SACCAR) Board and the Council of Ministers approving the expansion of the SADCC/ICRISAT Regional Groundnut Improvement Program, and in August 1987 the Government of Malawi signed the necessary agreement for the continued operation of the project at Chitedze. With ICRISAT core funds and with a grant provided by the Federal Republic of Germany, new buildings and research facilities were planned and are now nearing completion. It is hoped to expand the existing ICRISAT research staff of virologist/pathologist and breeder by adding another pathologist and an agronomist. A second breeder, and possibly an entomologist, may also be recruited. The advice of the participants at this meeting on research priority areas and staff requirements would be greatly appreciated and will influence the composition and activities of the expanded Program.

I have been much impressed by the success of your Groundnut Network and by the excellent spirit of cooperation that has been manifest. Your advice and assistance is critical in making the Regional Program truly relevant to your regional needs, and I hope that from your interactions during this Workshop many new ideas and suggestions will emerge that will lead to even more successful collaboration in research and training in the future.

SACCAR Representative's Address

D.M. Wanchinga[1]

The Honorable Minister of Finance, Your Worship the Mayor of Lilongwe, Your Excellency the Ambassador of the Federal Republic of Germany, the Principal Secretary (Ministry of Agriculture), participants, ladies, and gentlemen:

It is indeed a great privilege for me to deliver this short address on behalf of the SADCC member States and, in particular, on behalf of the Southern African Centre for Cooperation in Agricultural Research (SACCAR).

Cooperative agricultural research in SADCC countries started off on the directive of Heads of State and Government in April 1980, when they met in Lusaka to adopt a program of cooperation among the majority-ruled States of southern Africa.

Botswana was allocated the function of coordinating agricultural research and training among the SADCC countries.

SACCAR was formed in 1984 as a management entity of collaborative regional agricultural research programs. SACCAR, therefore, carries out this function on behalf of the Government of Botswana. SACCAR's activities are governed by a Board composed of Directors of Agricultural Research or Chief Agricultural Research Officers in SADCC member States. The Board is chaired by Botswana.

There are now about 11 regional research programs that are either ongoing or planned.

The Regional Grain Legume Improvement Programme is one such program. Under this broad program, there are three projects, i.e.:

- The Bean Improvement Project, which is executed by Centro Internacional de Agricultura Tropical (CIAT), and has its headquarters in Arusha, Tanzania; a substation is planned here in Malawi.
- The Cowpea Improvement Project, which is to be executed by the International Institute of Tropical Agriculture (IITA) and is to be based in Mozambique.
- The SADCC/ICRISAT Groundnut Improvement Program, based here in Malawi.

The Groundnut Improvement Program and the Sorghum and Millet Improvement Program, which is the earliest SADCC Regional Program, are both executed by ICRISAT.

As Her Excellency will point out, the Federal Republic of Germany has pledged support in the first phase of this Program as a SADCC Regional Program. This Program is planned to last about 15 years. We are grateful for the support of cooperating partners. SACCAR will continue to support the SADCC/ICRISAT Regional Groundnut Improvement Program by soliciting donor support for it, and direct support to individual scientists through SACCAR's own program of research and travel grant awards and in providing backup information on agricultural research resources of the region. In return, SACCAR is hopeful that participating member States will work closely with the regional program to benefit fully from its program of action aimed at germplasm development, technology transfer, and in the development of the regional human resource base for groundnut research and related problems.

And the value of these Programs is in enhancing food security, generating rural employment, and reducing overdependence on countries outside the region.

We, at SACCAR, shall look forward to receiving resolutions of this Workshop. Finally, I would like to thank our cooperating partners who have made our Regional Program possible; ICRISAT, which has agreed to execute our two Regional Programs; and finally, the Government of Malawi for hosting the Groundnut Regional Program and for the great support it has continued to render to SACCAR's programs and other SADCC institutions.

Thank you.

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1. Manpower and Training Officer, Southern African Centre for Cooperation in Agricultural Research (SACCAR), Post Bag 00108, Gaborone, Botswana.

Opening Address

L.J. Chimango[1]

Mr Chairman, Your Excellency the Ambassador of the Federal Republic of Germany, representatives of the Southern African Centre for Cooperation in Agricultural Research, Your Worship the Mayor, Mr District Chairman of the Party, distinguished participants, ladies, and gentlemen:

I am honored and most privileged to have the opportunity this afternoon to officiate at this inaugural session of the Third Regional Groundnut Workshop for Southern Africa.

I am privileged to do so for and on behalf of His Excellency the Life President, Ngwazi Dr Kamuzu Banda, who I am sure you all know is also the Minister of Agriculture. Permit me, therefore, to thank His Excellency the Life President for appointing me to open this very important Workshop on his behalf.

I am thus afforded the opportunity to extend to each and every one of you a warm welcome. We feel most honored that you chose Malawi, once again, as the venue of the Workshop. It is an honor for us to meet some of Africa's, if not the world's, leading groundnut scientists. You are most welcome here. Please, therefore, feel at home. You are free to go anywhere you like and to talk to anyone you like. Should time permit, you should feel free to extend your stay. At any rate do not make this your last visit to Malawi.

I am told that over 40 participants representing the national groundnut research programs of Botswana, Lesotho, Malawi, Mozambique, Swaziland, Tanzania, Zambia, Zimbabwe, and also of Ethiopia, Mauritius, and Zaire are expected to attend this Workshop.

It is most pleasing also to hear that the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has accorded this Workshop the importance it deserves and has, therefore, sent scientists from the ICRISAT headquarters in India and from the ICRISAT Sahelian Center in Niger.

Distinguished guests, ladies, and gentlemen, allow me a little self-indulgence to talk about Malawi. I note with gratitude that the agenda for the Workshop has included field tours to farmers' fields in areas of Lilongwe and Salima Agricultural Development Divisions. There you will be able to see how the ordinary man and woman cares for his groundnut crop. The holding of this Workshop could not have been more timely.

Our growing season started rather late this year because of the late arrival of planting rains. Your professional eye will not fail to see its effects in the field.

While you may not provide instant solutions to the problems you might notice whilst on your field tour, I do expect you to put those problems in their proper perspective when you come back to Lilongwe to continue your deliberations.

Groundnut is a very important crop in Malawi. It is naturally a food crop but it is also a foreign currency earner. Ministers of Finance are excited to talk about foreign exchange. Groundnuts are internally used in the manufacture of cooking oil while other grades are exported for confectionery purposes. Groundnuts are grown, almost exclusively, by smallholder farmers in Malawi. It is most popular among women growers. When I mentioned that groundnuts are popular among the women, young and old, at least one expert around this table expressed surprise. I will, therefore, explain. Groundnut powder is used as a delicacy and added to vegetable dishes. Naturally, the best of wives want to have the reputation of being good cooks as well. Currently, groundnut powder is also being used as an ingredient to prepare the famous *Likuniphala*. As a cash crop too, it is among the women that you find the best growers. Patience and care is needed during weeding, harvesting, and shelling. Once harvested, however, it can sell easily. As a good financier, the woman knows that what she sells directly by herself will go into her pocket and be used to benefit her family. No woman can guarantee that with cash crops such as tobacco. The man quite often takes it all forgetting the sweat of the wife who helped produce it. Quite often it is the 'other' woman who benefits.

But you scientists are not allowed to indulge in social critiques. And so I must return to the theme and observe that although groundnuts are grown in all three regions of the country, more than 70% of the crop is produced on the plains of the Central Region.

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1. Minister of Finance, Government of Malawi.

It is the policy of this Government to increase production per unit area of land to encourage the production of good quality groundnuts to meet both the domestic and export market requirements.

As an export or cash crop, groundnut has been growing in importance over the last few years. It is fair to say that it is only a very deliberate pricing mechanism, which has managed to hold the production to the levels now prevailing. Given markets abroad and price incentives, this is a crop whose potential is great for the Malawian farmer.

Malawi, therefore, greatly appreciates the contribution that ICRISAT has made towards improving groundnut production in the SADCC region through its Regional Program. ICRISAT has been successful, in part because of collaboration with the national scientists of the region represented here this afternoon.

On behalf of the Government and on behalf of the people of Malawi, I would also like to extend our most sincere gratitude and appreciation to the International Development Research Centre (IDRC), Canada, for funding the initial phase of the Program at Chitedze. The 4.5 years of support from the IDRC have enabled national programs within the region and ICRISAT to develop useful regional strategies jointly aimed at increasing groundnut production in the region.

It is very pleasing to note that what was an IDRC-funded project is now subsumed into the SADCC Grain Legumes Improvement Program (GLIP) with funding from the Federal Republic of Germany. In this regard, ladies and gentlemen, we are greatly honored to have Her Excellency Dr Theodora von Rossum with us here this afternoon. I wish to take this opportunity to express our most sincere gratitude to Your Excellency for your untiring efforts and, through you, to the Government and the people of the Federal Republic of Germany for this assistance.

With this most welcome funding, ICRISAT is now having a regional building constructed at Chitedze Agricultural Research Station for its SADCC ICRISAT Regional Groundnut Improvement Program. We hope that this will be a nucleus for in-service training, among many other activities for the region. The scope of the program will be expanded since the number of scientists is expected to be increased from two to five to serve the region better.

Workshops of this nature are of course excellent fora for exchange of ideas to improve the quality of groundnut research work and groundnut production in our region. It will be recalled that at the First Regional Groundnut Workshop held here from 26 to 29 Mar 1984, scientists working on national groundnut research programs in the region, highlighted the problems of groundnut production. It was not surprising to note that the magnitude of the problems is similar. This was the first time that scientists from the various national groundnut research programs came together and learnt of the problems each of them faced in their respective countries. At the end of that Workshop, nine recommendations were made, emphasizing the need for regional cooperation through collaborative research and continued support from the Regional Program for the national programs. Furthermore, at the Second Regional Workshop held in Harare, Zimbabwe, from 10 to 14 Feb 1986 another set of nine recommendations was made.

It is hoped that at this Workshop, participants will report on the progress made thus far in trying to solve the prevailing groundnut-production problems presented at the last two Workshops.

I need not remind you, distinguished participants, that the task you have before you is not an easy one. The topics listed on the agenda for your deliberations seem appropriately selected. They are issues of major concern to our agricultural and rural development efforts. In Malawi, the Department of Agricultural Research in general, and the groundnut research team in particular, have played an important part in carrying out the task of promoting the application of science and technology to small-scale farmers to increase both productivity and production of groundnuts.

You, the distinguished participants, will also examine the advances made in groundnut research. You will examine further the strategies to be adopted, particularly in the use of agrochemicals, to combat pests and diseases. Please bear in mind that the land and the environment are our most valuable natural resources and heritage. The land demands judicious usage. We should, therefore, endeavor, at all times, to make it not only most productive but also a better place for generations to come.

I am confident that you, the eminent scientists gathered here today, will use the coming week effectively through your presentations to develop strategies aimed at generating usable technologies. We must attain high and sustainable groundnut-production levels in the region to benefit the ordinary man and woman, whom we are all committed to serve.

Let us all look forward, therefore, to a productive, stimulating, and constructive week of discussions. I hope you will have an enjoyable stay in our country and that you will be able to combine business with pleasure in Malawi, which we boast of as being the warm heart of Africa.

Your Excellency, ladies, and gentlemen, I have the pleasure to declare this Workshop officially open.

Thank you very much.

Address of the German Ambassador

T. von Rossum[1]

The Honorable Minister of Finance, Your Worship the Mayor of Lilongwe, the Principal Secretary (Ministry of Agriculture), distinguished participants, ladies, and gentlemen:

It gives me great pleasure to see so many eminent researchers and scientists of the SADCC region gathered together at this very useful groundnut workshop, which supports a project cosponsored by the German government. I cannot overemphasize the importance of regional cooperation in general. The exchange of experiences and ideas is particularly useful among countries with similar conditions and options for agricultural development.

The improvement of groundnut production, both in quantity and in quality, can help the people and the economy of your countries in many ways. Groundnut serves as a food crop for direct consumption, and as the raw material for edible oil, and also constitutes a valuable export commodity, earning the much needed foreign exchange. I am especially interested in its role in nutrition; in Malawi, for example, it is a most useful and important element in child nutrition.

I have confidence that this workshop will discuss ways and means of producing more, bigger, and better groundnuts. I wish the participants much success in their deliberations and a pleasant stay in Malawi.

1. Ambassador of the Federal Republic of Germany to Malawi.

Response to the Minister's Address

M.J. Mulila[1]

The Honorable Minister of Finance, Your Excellency the German Ambassador, Your Worship the Mayor, Dr Wanchinga, Dr Bock, Principal Secretary for Ministry of Agriculture, distinguished delegates and scientists of the SADCC region, ladies, and gentlemen:

I would like to thank the Honorable Minister on behalf of the Workshop organizers and fellow participants for his graceful presence and kind words of welcome and wisdom.

His presence here, amidst his busy schedule, indicates the importance the Government of Malawi attaches to agriculture as a whole and to groundnut research in particular, both in the nation and in the SADCC region.

The SADCC ICRISAT Regional Groundnut Improvement Program has demonstrated that it does not want to exist by and of itself, but rather to work with national programs and to strengthen their abilities to benefit the farmer and consumer clients by increasing the production and quality of groundnuts.

This is the third in the series of Regional Workshops organized by the SADCC/ICRISAT Regional Groundnut Improvement Program. These Workshops have played a key role in bringing together the groundnut scientists of this region, in reviewing the progress made in the different national programs, and in assisting in further planning.

We have found that working in cooperation and collaboration has enabled faster progress than would have been the case in the absence of such a supportive and stimulating role as the one played by SADCC/ICRISAT Regional Groundnut Improvement Program.

As national program teams, we look forward to effective interaction, fruitful discussions, and clarifying priorities for future research.

Thank you.

1. Coordinator (Grain Legumes), Msekera Research Station, P.O. Box 510089, Chipata, Zambia.

Closing Remarks

D.M. Wanchinga[1]

Ladies and gentlemen:

It is once more a great privilege for me to say a few words on behalf of SACCAR, to express a word of appreciation to all of you for traveling such long distances to review current research activities on groundnut research in your respective countries, and to identify constraints and establish priorities for the Regional Groundnut Improvement Program.

In particular, I would like to thank Dr Bock and all his colleagues at the Regional Program for organizing the Workshop. I am aware that the success of such a Workshop can only be because of good planning, foresight, and untiring efforts before and during the Workshop.

I would also like to express a word of appreciation to the Management of Capital Hotel for providing us with conference facilities and for their hospitality, and also to the Government of Malawi for allowing this Workshop to take place here in an excellent scientific atmosphere.

On behalf of the participants and SACCAR, I would also like to thank ICRISAT for its financial support towards the Workshop and the program in general, and for allowing its scientists to travel long distances to come and share their experiences with us. We also thank our colleagues from Zaire and Mauritius for their participation.

We, at SACCAR, greatly value such interactions for we are aware of the opportunities afforded by these gatherings for the exchange of technical know-how, and the forging and renewal of personal contacts, which are the cornerstones of collaborative research programs. I hope that it will be an enriching experience for all of you personally and for your national programs as well.

As you are aware, the SADCC/ICRISAT Regional Groundnut Improvement Program is focused on the development of varieties adapted to the scientific, climatic, and environmental conditions of the region and suitable for use under the limiting (low-input) conditions of the small holdings; on the introduction of these varieties in suitable areas; and on their correct treatment. This focus has been made within the framework of the broader objective of achieving food security for the region and to increase rural incomes.

With the assistance of ICRISAT, I am hopeful that many, if not all, of the recommendations that will be made would be used to strengthen the Regional Program to enable it to achieve its broad objectives. I am, therefore, behind those resolutions that strengthen the program of action for germplasm development and facilitate technology transfer linkages, and I am for a balanced training program that would enable the program eventually to reach a critical mass of scientists.

We are in the process of discussing the future role of the Steering Committee of the Groundnut Program, and we hope that it will prove to be a useful planning body and will have the necessary regional representation as well as donor and SACCAR's participation.

At SACCAR, we shall continue to strive to provide the necessary support that the Program requires.

I wish you a safe journey back to your respective countries.

Thank you.

1. Manpower and Training Officer, Southern African Centre for Cooperation in Agricultural Research (SACCAR), Post Bag 00108, Gaborone, Botswana.

1

Regional Program

ICRISAT Regional Groundnut Pathology Program: A Review of Research Progress during 1985–87 with Special Reference to Groundnut Streak Necrosis Disease

K.R. Bock[1]

Abstract

The SADCC/ICRISAT Regional Groundnut Improvement Program continues to give priority to research on early leaf spot (Cercospora arachidicola) *and groundnut rosette virus disease, though work on the latter has become a routine exercise in screening material generated by the Program, particularly of short-duration gerotypes. The research on early leaf spot has involved routine germplasm screening, including the screening of interspecific derivatives; the screening of wild species of* Arachis; *studies on leaf retention as a possible indication of apparent tolerance; and the screening of intercrossed progenies of apparently tolerant lines. Progress has been slow with this refractory disease. The Program has thus far been unable to identify resistance in the cultivated groundnut. Therefore, attention has been directed to resistance in wild species; highly resistant wild species will be used in the generation of interspecific hybrids and screened in southern Africa. For the forseeable future, selecting for high yield under severe epidemic conditions provides a sound and more immediate alternative, and one that has already met with success.*

Significant progress had been made on the etiology and ecology of a virus disease of groundnut, which the Program called the groundnut streak necrosis disease. This disease assumed near-epidemic proportions in areas of low altitude in Malawi during the 1985/86 groundnut-growing season. The pathogen was identified as sunflower yellow blotch virus (SYBV). It was confirmed that the vector is Aphis gossypii, *and that the reservoir ost is a widely distributed pantropical weed,* Tridax procumbens, *and that SYBV is not seedborne in groundnut.*

Sumário

Programa Regional de Patologia do Amendoim do ICRISAT: Uma revisão ao Progresso da Investigação durante 1985-87, com Especial Referência á Doença da Necrose Listrada do Amendoim. *O Programa Regional de Melhoramento do Amendoim do SADCC ICRISAT continua a dar prioridade à investigação sobre a mancha temporã (*Cercospora arachidicola*) e à doença do virus da roseta do amendoim, embora o trabalho sobre a última doença se tenha tornado num exercicio de rotina, avaliando-se o material gerado pelo Programa, em particular os genótipos de curta duração. A investigação sobre a mancha temporã tem envolvido a rotina de avaliação de germoplasma, incluindo a avaliação de derivados interespecíficos, a avaliação de espécies selvagens de* Arachis, *estudos sobre a retenção foliar, como uma possível indicação de*

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tolerância aparente, e a avaliação de progenies intercruzadas de linhas aparentemente tolerantes. O progresso tem sido lento com esta doença refractaria. Até o momento, o Programa tem sido incapaz de indentificar resistência no amendoim cultivado. Consequentemente, a atenção tem sido orientada para a resistência em espécies selvagens. Espécies selvagens altamente resistentes serão usadas na geracão de hibridos interespecíficos e avaliadas na Africa Austral. No futuro próximo, a seleção para alto rendimento em condições epidémicas severas, providenciará uma alternativa palpável e mais imediata e que já teve sucesso. Progresso significativo foi comseguido na etiologia e ecologia duma doença viral do amendoim, a que o Programa deu o nome de Doença da Necrose Listrada do amendoim. Esta doença assumiu proporções quase epidémicas em áreas de baixa altitude no Maláwi, durante a estação de crescimento do amendoim de 1985/86. O patógeno foi identificado como virus da mancha amarela do girassol (SYBV). Foi confirmado que o vector é o Aphis gossypii *e que o hospedeiro alternativo é largamente distribuida infestante pan-tropical,* Tridax procumbens, *e que o SYBV não é transmitido pela semente.*

Introduction

Our research priorities have remained unchanged since our last Regional Workshop at Harare in 1986, and we continue to direct our energies towards studies on early leaf spot (*Cercospora arachidicola*) and groundnut rosette disease, though the latter has largely but not entirely become more of an annual routine exercise in screening.

In February 1987, we organized a Plant Protection Group Meeting, where I reported on progress with these two refractory problems. Inevitably, I must repeat again here, at this major regional meeting, at least part of the details given a bare year ago. I, therefore, hope those among you who have already heard parts of this report will bear with me.

Early Leaf Spot (ELS)

ELS remains the primary scourge of groundnut in most areas of southern Africa. Losses in potential yield of 50% are sustained annually over wide areas.

Our specific research program on ELS has involved, over the past three seasons, routine germplasm screening, including screening of interspecific derivatives; wild *Arachis* species screening; studies on leaf retention as a possible indication of apparent tolerance; and intercrossing such apparently tolerant lines and the subsequent screening of F_2 generations.

Germplasm screening

All germplasm introductions made over the past 5 years are apparently susceptible to ELS.

We tried a method of 'bulk' screening of 11 000 ICRISAT groundnut germplasm lines, in which 5 seeds of 100 lines each were pooled to give a 'mixed bulk' of 500 seeds. We hoped first to identify bulks that contained plants with possible resistance; subsequently, we hoped to identify within each bulk those particular lines with resistance by testing each of the 100 germplasm lines separately. We found assessment of plants within the mixed lines confusing and difficult. Only two mixed bulks seemed worthy of further testing, and lines contained in these are being screened individually this season. We also screened 113 interspecific derivatives, retaining only four; these are also being reassessed.

Wild *Arachis* species

We continued with observations on the reaction of wild *Arachis* species to ELS. Thirteen accessions were tested for the 2nd successive year, only one of which, *A.* sp 30003, again showed a very high level of resistance. All nine accessions tested for the first time were susceptible.

Leaf retention

We have reported previous observations on an apparent correlation, in certain selections, between comparatively slower rates of defoliation and higher yields. We have also identified selections with similar rates of defoliation in which yield was poor to average, suggesting that rate of defoliation (or leaf-retention) and yield are not necessarily interdependent.

Table 1. Response of selected virginia, valencia, and spanish groundnut types to early leaf spot control, Chitedze, Malawi, 1986/87.

Botanical type	Identity	Seed yield ($t\ ha^{-1}$) Nonsprayed	Sprayed	Response (%)
Virginia	Mani Pintar	3.12	4.08	30.8
	ICGMS 42	3.54	5.23	47.7
	ICGM 484	3.03	4.55	50.2
	ICGM 336	3.10	4.75	53.2
	Chitembana	2.04	3.28	60.8
Valencia	ICGM 285	2.34	3.24	38.5
	ICGM 284	2.74	3.89	41.9
	ICGM 197	2.53	3.82	50.9
	ICGM 550	1.54	2.41	56.5
	ICGMS 30	1.69	2.72	60.9
Spanish	ICGM 437	2.66	3.25	22.1
	ICGM 522	2.11	3.27	54.9
	ICGM 473	1.94	3.73	92.3
	Malimba	1.86	3.60	93.5
	ICGM 721	1.85	3.62	95.7
SE		±1.049		
Trial mean (n=30)		3.05		
CV (%)		6.9		

For the second season, we measured in selected lines the yield response to control of ELS by chlorothalonil applications. We hoped, in so doing, to identify tolerance, in the expectation that tolerant lines would yield well in spite of ELS, but that their response to ELS control would be significantly less than that of susceptible lines. Results of this experiment are given in Table 1. While illustrating well-known differences in susceptibility between the three botanical groups, there is no obvious indication of a high degree of tolerance in any selection. Table 1, however, indicates clearly the success so far attendant upon selecting for yield in the absence of ELS control.

Intercrossing

High-yielding lines, some of which possess superior leaf retention, were intercrossed in 1985/86 and the F_1s grown under protection in the 1986/87 season. The F_2s have been exposed this season (1987/88) to heavy ELS pressure, and their reaction to ELS will be observed at intervals throughout the season to identify any possible additive effects. In summary, progress with research on ELS has been slow. We have thus far been unable to identify resistance in any of several thousand accessions of the cultivated groundnut, and it is possible that readily exploitable resistance in *Arachis hypogaea* that would withstand the intense pressure of epidemics in southern Africa will prove elusive. While routine screening of germplasm must and will continue, we are left with two options for control.

The use of interspecific hybridization, between *A. hypogaea* and wild *Arachis* species identified as highly resistant to ELS in southern Africa, remains to be assessed. This option is being pursued with vigor, but it is essentially a long-term to very long-term proposition.

For the forseeable future, selecting within the region for high yield under severe epidemic conditions provides a sound and immediate alternative. The results obtained by the Regional Program during the past five seasons augur well for the future.

Groundnut Rosette Disease

We induced over 99% rosette incidence in our rosette disease nursery, enabling our screening to be done with confidence.

Our priority for groundnut rosette disease is to incorporate resistance into early-maturing varieties adapted to the region. We obtained two so-called resistant early-maturing varieties (K-241 D, K-149 A) from West Africa. In the process of preliminary screening in the greenhouse, it became evident that K-149 A as sent to us was susceptible, and that K-241 D was a mixture of resistant and susceptible types. Apparently resistant plants of K-241 D were grown to maturity in the greenhouse, and the progeny included in the 1986/87 disease nursery. Only 2 plants out of the 100 exposed developed rosette. We planted progeny of these in the greenhouse during the 1987 dry season, subjecting them to repeated massive inoculations. Five plants out of 25 became infected (the reasons are not understood); the remainder were grown to maturity and the progeny have been included in our hybridization program this season.

In addition to the West African resistant line, we have generated our own early-maturing resistant lines by crossing RG 1 with early-maturing susceptibles. These are now in the F_4 generation and will be utilized in future hybridization programs.

We have concluded our studies on the inheritance of resistance. The results of the 1986/87 experiments are summarized in Table 2. They confirm adequately that resistance is indeed governed by double-recessive genes.

We also included in the rosette nursery a miscellany of other tests. In response to a request from the Mozambican national program, we screened 14 widely grown Mozambican lines; all were highly susceptible. We tested seven *Arachis* wild species. Five were highly susceptible, but two remained symptom-free throughout the season. Samples of 11 plants of *A.* sp 30003 and 12 of *A.* sp 30017 were sent to the Scottish Crop Research Institute for groundnut rosette virus (GRV) and groundnut resette assistor virus (GRAV) assay: neither virus was detected in any of the 23 samples. The apparent immunity of *A.* sp 30003 to GRV and to GRAV is of great interest, particularly as this species is also apparently very highly resistant to ELS.

Vector resistance

We also tested the ICRISAT aphid-resistant line EC 36892. This accession is susceptible to rosette, but we demonstrated that the rate of infection was significantly slower, and final incidence considerably lower (about 60%) at harvest than in the adjacent susceptible lines (100%).

Groundnut Streak Necrosis Disease

We have made significant progress with studies on the etiology of a disease previously assumed to be caused by tomato spotted wilt virus. We call this condition groundnut streak necrosis disease (GSND), after the diagnostic symptom induced in groundnut. We have shown that the causal agent of GSND is sunflower yellow blotch virus (SYBV), a virus only recently described from Kenya.

GSND was present at Chitedze in trace amounts during the 1982/83 and 1983/84 groundnut-growing seasons. In 1984/85, we recorded an incidence of 0.02%; this increased markedly during 1985/86 to 0.64%. In the same season, however, an epidemic of GSND was reported in farmers' fields in lower-lying areas of southern and central regions of Malawi. This was considered by the Department of Agricultural Research to be sufficiently alarming to warrant an immediate survey of affected areas, which subsequently indicated incidences of up to 80% in several farmers' fields in Lake Shore and other districts.

In March 1987, we conducted a survey of GSND incidence in the Lilongwe Plain and in southern and Lake Shore areas (Table 3). During this survey, *Tridax procumbens*, the dry-season reservoir host of both SYBV and its vector, *Aphis gossypii*, was found to be abundant in Lake Shore areas, and, as in Kenya, many *T. procumbens* plants showed mild yellow blotch symptoms typical of SYBV. Aphids were collected from infected *T. procumbens* and

Table 2. Incidence of groundnut rosette virus in susceptible (S), resistant (R), and susceptible × resistant progenies, rosette screening nursery, Chitedze, Malawi, 1986/87.

Progeny	Number of plants infected	Number of plants exposed	Incidence (%) Observed	Incidence (%) Expected
Susceptible parents (S)	54	54	100.00	100.00
Resistant parents (R)	0	76	0.00	0.00
S × R crosses:				
F_1	56	59	94.91	100.00
F_2	7728	8330	92.77	93.75[1]
Backcrosses:				
(S × R) × S	416	422	98.58	100.00
(S × R) × R	218	291	74.91	75.00[2]

1. Predicted ratio 1 resistant to 15 susceptible plants.
2. Predicted ratio 1 resistant to 3 susceptible plants.

Table 3. Groundnut streak necrosis disease incidence in parts of central and southern Malawi, March 1987.

Locality	Approximate altitude (m)	Incidence
Central Region, high ground, Lilongwe towards Malingunde (south-west), all 5 sites	1100	All > 1
Lilongwe towards Dedza (south), 2 sites	1100-1200	Trace
Lilongwe towards Salima (east)		
Chimutu	1100	Trace
Chankhungu	1100	Trace
Mvera	900-1000	1
Rift Valley and associated areas		
Ntcheu (south-east)	700	5-10
Malosa	800	c.40-50
Mapota	800	20
Makoka	1000	5
Ulongwe	500-600	15
Nangoma	500	15
Chantulo	500	20
Muwa	500	5
Chipoka	500	1

were used to inoculate groundnut seedlings (cv Spancross). Symptoms typical of GSND were induced in groundnut in 5-7 days. Subsequently, SYBV-infected *T. procumbens* plants with attendant *A. gossypii* were established at Chitedze. Simultaneous inoculations of sunflower and groundnut seedlings from this common source resulted in the development of typical symptoms of SYBV in sunflower, and of GSND in groundnut.

The data in Table 3 indicate that GSND incidence is low at higher altitudes in the central region of Malawi, and comparatively high in Rift Valley areas and the associated eastward-facing slopes of the Southern Highlands (Malosa). It is possible that this is a reflection of greater population densities of both SYBV-infected *T. procumbens* and *A. gossypii* in the warmer, lower-lying Rift Valley areas, but no detailed studies have as yet been made.

During the survey, it was apparent that incidence tended to be higher in late-planted fields. There is some support of this observation from Chitedze records. The experimental field at Chitedze, in which we traced the development of GSND during the season, was planted over the period 8-16 Dec 1986; incidence in this block was 0.63%. Incidence in our hybridization plot, planted 2 weeks later, was 6.89%. However, two other factors might also have influenced incidence. Spacing was wider in the hybridization plot (20 cm between plants, 90 cm between rows) than in the field block (15 cm between plants, 60 cm between rows). Perhaps more importantly, as will be seen, emergence in the hybridization plot coincided with the peak migration of *A. gossypii* during the season.

Pattern of field infection and disease progress

For the second successive season, field observations were made at 10-day intervals and all infected plants were staked. Infections again occurred at random and there was no evidence for plant to plant spread. Although new infections occurred throughout the crop cycle, peak incidence seemed to be correlated with a massive early-season migration of *A. gossypii* that occurred in early January. During four successive seasons we have never observed *A. gossypii* colonizing groundnuts, and therefore we presume that the aphids merely move through the crop and migrate further in their search for preferred hosts. A second migration was recorded during the first 2 weeks of February, but this migration does not seem to have been significantly viruliferous.

It is not known at present whether infective *A. gossypii* are derived from long-distance migrations or from locally occurring populations: *T. procumbens* occurs in the Lilongwe area and also at Chitedze, where infected plants occur.

Symptomatology

Under greenhouse conditions, first symptoms appear in about 7 days and consist often, though not invariably, of a few discrete, comparatively large (1-2 mm) bright yellow spots. The next set of leaves exhibits very numerous small yellow spots; the next set develops an intense brilliant yellow, and often show ring spots and line patterns. This is the most striking field symptom. The next set of leaves has yellow streaks that mostly follow the direction of the veins: here streak necrosis ensues. The youngest leaves are often distorted, puckered, and reduced in size, with irregular streak or marginal necrosis. Older infections may show yellow streaky patches and flecks, often in irregular lines, and restricted towards the leaflet margins, with or without streak and patch necrosis.

Chronic infections, such as those arising from inoculation at plant emergence, often result in stunted plants with small misshapen leaves with varying degrees of necrosis. These are more difficult to diagnose with certainty as they may superficially resemble thrips damage.

Effect on yield. At Chitedze, we estimated about 70% loss in yield in early-infected plants, but in Zambia the loss was reported to be 20-51% in Zambia (Zambia: Groundnut Research Team 1987).

Varietal susceptibility and response to infection

Although incidence in the hybridization plot was only 7% and numbers of plants of different lines low and variable, it enabled preliminary observations to be made on susceptibility (Table 4).

Within the limits imposed by the low numbers exposed, Table 4 indicates that all genotypes were susceptible, but also suggests possible significant differences in field susceptibility within each botanical group. Among the spanish lines, ICGMS 55; among valencias, ICGM 197; and among virginias, Swallow, Flamingo, and ICGMS 42 seem most susceptible. The rosette-resistant variety RG 1 seems to contain field resistance. Whether these are effects of aphid preference behavior or not remains to be seen.

There are also great differences in varietal response to infection. For example, reaction of ICGM 197 to SYBV is persistently very severe, with extensive streak and marginal necrosis and marked leaf distortion and puckering. The reaction of ICGMS 55 is less severe: in most plants, after initial shock symptoms, necrosis is not extensive though persistant. In cv Swallow, the symptoms are mild, with more limited necrosis and sparse yellow flecking. In cv Spancross, the symptoms are both mild and transient. The relationship of comparative severity of reaction to yield loss is being studied in the field this season.

We also tested several varieties that are widely grown in areas of our region. We found Chalimbana

Table 4. Incidence of groundnut streak necrosis disease in spanish, valencia, and virginia lines, hybridization plot, Chitedze, Malawi, 1986/87.

Spanish		Valencia		Virginia	
Genotype	Number infected/ Number exposed	Genotype	Number infected/ Number exposed	Genotype	Number infected/ Number exposed
ICGMS 55	15/90	ICGM 197	6/10	Swallow	3/10
92/6/26	3/20	ICGM 284	3/50	ICGMS 42	6/90
ICGMS 11	2/10	ICGM 177	1/10	ICGM 713	3/30
ICGMS 71	2/10	ICGM 189	1/10	Chalimbana	2/40
ICGMS 72	2/10	ICGM 550	1/10	C 346/5/8	1/20
ICGM 437	2/10	ICGM 285	1/10	97/8/2	1/20
ICGM 706	3/30	ICGMS 30	8/150	Flamingo	4/20
ICGMS 9	1/10	ICGM 554	1/10	RMP 40	3/120
ICGMS 56	1/10	Valencia R 2	1/10	Chitembana	1/50
ICGMS 57	1/10			RG 1	6/330
ICGMS 59	1/10				
ICGMS 60	1/10				
ICGMS 65	1/10				
Plover	1/10				
ICGMS 2	1/10				
ICGM 729	1/30				
Total	38/310		23/270		30/730
Incidence (%)	12.26		8.52		4.11

to be highly susceptible, but the Mozambican accessions, Bebiano Encarnado and Bebiano Branco, appeared tolerant to leaf symptoms. Whether this tolerance is also reflected in the yield remains to be seen.

Seed transmission tests

We harvested 1990 seeds from severely affected plants and grew them in the greenhouse. All plants remained healthy. We conclude that GSND is not seedborne.

Geographical distribution of SYBV in eastern Africa

SYBV is now known to occur in sunflower in Kenya, Tanzania, Malawi, and eastern Zambia, and has been recorded in groundnut (as GSND) in Tanzania, Malawi, and eastern Zambia. It has not, as yet, been reported from western districts of Zambia. It is likely that it also occurs in Mozambique. In Kenya, distribution of SYBV lies mainly east of the Rift Valley, but this does not seem to be correlated with distribution or density of the important dry-season reservoir of the virus *T. procumbens*. This situation is paralleled in Malawi, where the highest incidence of GSND occurs in lower-lying eastern areas associated with the Rift Valley. Although *T. procumbens* occurs abundantly in some areas of higher ground to the west, incidence of the virus is low, in general.

Importance of GSND at present

The symptoms induced by SYBV in groundnut are distinctive and strikingly obvious. Because of this, it seems reasonable to suppose that, in Malawi, the disease occurred only in trace amounts in the groundnut crop prior to the first reported epidemic of 1985/86. Our records suggest initial crudescence during the previous season (1984/85). During 1986/87, incidence was comparatively high in affected areas, but did not approach the 1985/86 proportions. It is therefore difficult, at this early stage, to forecast possible future progress of the disease in eastern Africa, and it is equally difficult to project an appropriate level of research commitment to further studies on the disease. It does seem appropriate, however, to intensify research on the virus in collaboration with the Scottish Crop Research Institute, and to continue with studies on virus/vector relationships and varietal reactions to infection at Chitedze.

Reference

Zambia: Groundnut Research Team. 1987. Annual Report 1986/87. Msekera Regional Research Station, Box 510089, Chipata, Zambia: Groundnut Research Team. 93 pp.

Discussion

Chiteka: What is the incidence level of late leaf spot (LLS), at Chitedze? Shifts in incidence from early leaf spot (ELS) to late leaf spot have been reported in southeastern USA for various reasons. What is the resistance level to LLS in the existing lines? Why is ELS dominant over LLS with such high pressure?

Bock: In the six seasons of ICRISAT research at Chitedze, ELS epidemics have been consistently very severe, with 50% defoliation occurring at 70-80 days after emergence. Rust and LLS never appear before mid-March and then only in trace amounts. We therefore have no evidence of shifts in dominance as reported from the USA. Several high-yielding adapted lines selected by the Program also contain resistance to LLS and rust.

Rao: Based on evidence obtained in Swaziland, ELS is favored by lower temperatures and LLS by higher temperatures.

Waliyar: The climate has a great influence on the occurrence of ELS or LLS epidemics. A change in the climatic factors will determine the predominance of one or the other.

Cole: There is predominance of ELS at higher altitudes and lower temperatures (especially night temperatures) and of LLS and rust at lower altitudes (and therefore higher overall temperatures).

Sithanantham: In your search for ELS tolerance among selected lines, by considering the yield response to chlorothalonil applicatiions, the data in Table 1 show yield response ranging from 22% to 96%. Is it possible that the sprays per se contributed to some yield increase? If so, this effect should be separated from the yield response attributable to disease control alone, to distinguish tolerance more effectively.

Bock: It is my opinion that the major response to spraying is attributable to chlorothalonil.

Rao: What do you think about the origin of GSND?

Bock: It is impossible to speculate on the origins of viruses but the evidence suggests GSND has been present in East and southern Africa for a very long time indeed.

Kannaiyan: GSND was recorded for the first time in the 1983/84 groundnut-growing season in Zambia. It was also observed on *Tridax* and sunflower very commonly in the Eastern Province. The virus and the vector survives very well on *Tridax* during the off-season. The vector must be preferring more of sunflower than groundnut as seen in the disease severity which is more in sunflower (up to 50%) than in groundnut (around 1%) both on-station and on-farm.

Sibale: Why is the distribution of GSND more in the Rift Valley than in the Central Plateau area, whereas we notice equally severe incidence of sunflower yellow blotch virus at both locations?

Bock: We do not know, but it is possible that sunflower is a more attractive host for the vector, *Aphis gossypii*, than groundnut.

Wightman: *A. gossypii* does not include groundnut plants among its preferred hosts. Sunflower is more likely to be a breeding host. It would be nice to know the distribution of the virus on sunflower.

ICRISAT Regional Groundnut Breeding Activities: A Review of Research Progress, 1985-87

G L Hildebrand[1] and S.N. Nigam[2]

Abstract

*The emphasis of the SADCC/ICRISAT Regional Groundnut Improvement Program is on supplying superior germplasm to breeding programs in the Southern African Development Coordination Conference (SADCC) region. The Program's objectives are to develop germplasm adapted to the varied agroecological requirements of the region. Major emphasis is placed on breeding for resistance to two major diseases, early leaf spot (*Cercospora arachidicola*) and groundnut rosette virus (GRV), as well as breeding for high yield, quality, and earliness. Hybridization continues, using known sources of resistance to GRV as well as genotypes having the ability to retain their leaves longer under severe early leaf spot pressure. Consistently heavy early leaf spot pressure at Chitedze and perfection of the GRV-screening technique has made it possible to carry out effective evaluations of germplasm lines and breeding populations. Breeding lines are evaluated successively in preliminary and advanced yield trials before the most promising material is finally selected for evaluation in SADCC cooperative regional trials. The Program also conducts preliminary and international trials coordinated by ICRISAT Center. Promising entries in these may be promoted to regional trials. The results of the 1985/86 and 1986/87 regional trials are reported. It is noted with satisfaction that many entries exhibit the ability to yield consistently well across locations. The performance of ICGMS 42 is particularly pleasing.*

Sumário

Programa Regional de Melhoramento do Amendoim do ICRISAT: Uma Revisão ao Progresso da Investigação, 1985-87. *O enfase do Programa Regional de Melhoramento do Amendoim do SADCC ICRISAT está no fornecimento das linhas de germoplasma superiores para os programas de melhoramento da região do SADCC (Conferência Coordenadora para o Desenvolvimento da África Austral). Os objectivos do programa são o desenvolvimento de germoplasma adaptado às necessidades das várias condições ecológicas da região. Enfase especial é colocado no melhoramento para resistência nas duas das mais importantes doenças, a mancha temporã (*Cercospora arachidicola*) e o virus da roseta do amendoim (GRV), assim como o melhoramento para alto rendimento, qualidade e precocidade. A hibridização foi continuada usando fontes conhecidas como resistentes ao GRV, assim como, genótipos com habilidade de retenção das folhas durante periodos mais longos, sob grandes pressões de mancha temporã. Constantes altas pressões de mancha temporã, em Chitedze, e o aperfeiçoamento da técnica de avaliação do GRV,*

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tornou possível fazer avaliações eficientes das linhas de germoplasma e populações melhoradas. Linhas melhoradas são sucessivamente avaliadas em ensaios de rendimento preliminares e avançados, antes que o material promissor seja finalmente seleccionado para avaliação em ensaios cooperativos regionais da SADCC. Conduzimos também ensaios preliminares e internacionais coordenados pelo Centro ICRISAT. Nestes, as entradas promissoras podem ser promovidas para os ensaios regionais. Os resultados dos ensaios regionais de 1985/86 e 1986/87 são apresentados. Notou-se com satisfação a existência de um número considerável de entradas, que têm produzido rendimentos consistentemente bons nos vários locais. O comportamento do cultivar ICGMS 42 é particularmente encorajador.

Introduction

The SADCC ICRISAT Regional Groundnut Improvement Program has continued to make progress since it was last reviewed at Harare in 1986. Our objectives have remained largely unchanged as we continue our endeavors to implement recommendations of the two previous Regional Workshops. The rainfall distribution in 1986 87 was poor with alternating spells of dry and wet weather resulting in lower yields than expected.

Germplasm Evaluation

We completed the evaluation of 345 germplasm accessions obtained from the Zambian national program and 60 newly collected germplasm accessions from Tanzania. Many of these have been entered in preliminary and advanced yield trials.

Hybridization

We completed a total of 175 crosses in 1985 86. These included crosses made for high yield and quality, and crosses made between adapted lines and lines that had given high yields and had retained their leaves well under conditions of severe early leaf spot pressure at Chitedze. We completed 100 crosses in 1986 87 including 12 between adapted Mozambican lines and high-yielding ICGMS lines made for the Mozambican national program; 18 for the Zimbabwean national program for groundnut rosette virus (GRV) and early leaf spot (*Cercospora arachidicola*) resistance; 40 for GRV resistance; 20 for high yield and adaptability; and 10 for high yield and bold seed for the Regional Program. Genotypes having the ability to retain leaves for longer duration under severe early leaf spot pressure were used in some crosses.

Breeding for Disease Resistance

We continued evaluating breeding material from our own program and from ICRISAT Center. This material included populations from crosses made for early leaf spot resistance and crosses received from ICRISAT Center involving late leaf spot (*Phaeoisariopsis personata*) and rust (*Puccinia arachidis*) resistant parents. Interspecific derivatives were also included. Many promising selections have been entered in preliminary yield trials. We selected a considerable number of symptomless plants from the rosette-screening nursery for further evaluation. Some of these belonged to the sequentially branching group. We have completed a series of GRV-inheritance studies and are satisfied that the inheritance of resistance is controlled by double-recessive genes. We have also purified a source of resistance in a sequentially branching background introduced from West Africa.

Breeding for High Yield and Quality

We evaluated populations arising from crosses between genotypes having high-yield potential and bold seed. Many crosses involving indigenous cultivars and promising ICRISAT material performed poorly. In addition, selections showing promise for yield and quality at ICRISAT Center performed poorly and had markedly reduced seed size in trials at Chitedze. It was thought this may have been because of their extreme susceptibility to early leaf spot. In 1986/87, we evaluated 15 lines in a yield trial where each entry was grown with and without fungi-

Table 1. Response of selected confectionery groundnut lines to early leaf spot control[1], Chitedze, Malawi, 1986/87.

Entry	Pod yield (t ha^{-1}) Nonsprayed	Pod yield (t ha^{-1}) Sprayed[2]	Response to spray (%)	100-seed mass(g) Nonsprayed	100-seed mass(g) Sprayed	Seed color
M 13	3.38	5.37	58.9	65	64	Tan
SP 1	3.34	6.16	84.4	51	53	Tan
Egret	3.75	6.29	63.2	51	54	Tan
HYQ(CG)S-62	3.07	6.12	104.2	58	64	Tan
HYQ(CG)S-5	2.44	5.90	141.8	47	59	Tan
Local control						
Chalimbana	2.17	4.27	96.7	79	96	Tan
SE	±0.234					
Trial mean (15 entries)	2.71	5.54		59	69	
CV (%)	8.6					

1. Split plot in randomized complete blocks, subplot size: 14.4 m^2.
2. Chlorothalonil as Daconil 2787® applied nine times (1.2 kg a.i. ha^{-1}), at 10-day intervals, beginning 42 days after sowing.

Table 2. Performance of some of the groundnut breeding populations in advanced yield trials, Chitedze, Malawi, 1985/86.

Entry	Pedigree	Time to maturity (days)	Pod yield (t ha^{-1})	Shelling percentage	100-seed mass (g)	Seed color	Mean early leaf spot score[1]
Alternate branching[2]							
ICGMS 49	84/Phoma/7-B_1(P84/6/20)-B_2	154	5.16	69	60	Red	8
ICGMS 50	84/Phoma/6-B_1(P84/6/20)-B_1	155	5.00	71	48	Red	8
ICGMS 51	84/Phoma/5-B_1(P84/6/12)-B_1	162	4.74	66	53	Tan	8
ICGMS 52	84/PP/140-B_1(CG st.20/1)-P_1	141	4.34	75	62	Tan	9
ICGMS 53	84/ISMT/31(CS 43)-B_1	155	4.13	76	46	Tan	9
Local control							
Mawanga		153	4.01	68	54	Variegated	8
SE		±2.3	±0.06				
Trial mean (64 entries)		138	3.29				
CV (%)		3.3	3.8				
Sequential branching[2]							
ICGMS 55	84/Phoma/10-B_1(ICGM 291-B_1)	123	3.82	65	48	Tan	9
ICGMS 56	84/HYQF 9-B_1(Goldin 1 × Faizpur 1-5) × (Manfredi × M 13)	124	3.02	69	30	Red	9
ICGMS 57	84/RYT/8(JH 60 × PI 259747)-B_1	123	2.86	68	37	Purple	8
ICGMS 58	87/HYQSBT/11(ICGS 51)	124	2.80	67	44	Red	8
ICGMS 59	84/RYT/5(Colorado Manfredi × DMT 200)-B_1	101	2.78	75	35	Red	9
Local control							
Malimba		109	2.13	75	28	Tan	9
SE		±1.5	±0.06				
Trial mean (64 entries)		111	2.37				
CV (%)		2.6	4.9				

1. Scored at 90 days after emergence on a 1-9 scale, where 1 = No disease, and 9 = 50-100% of foliage destroyed.
2. 8 × 8 lattice, plot size 18 m^2.

cide protection. Yield responses to fungicide protection ranged from 59% to 142%. The highest-yielding entries responded least to fungicide (Table 1).

It is apparent that although confectionery groundnut lines received from ICRISAT Center are extremely susceptible to early leaf spot and respond markedly to fungicide application, seed quality, and boldness, even under protected conditions, do not reach the same high levels at Chitedze as at ICRISAT Center.

Yield Trials: 1985/86

Preliminary yield trials

We evaluated 22 sequentially branching and 22 alternately branching breeding lines in two yield trials, including selections made for disease resistance, high yield, and quality. Some performed well and were entered in advanced trials in 1986/87.

Advanced yield trials

We evaluated 106 sequentially branching and 86 alternately branching breeding lines in five trials. Some performed well and showed potential for high yields and good quality (Table 2). We selected 23 sequentially branching and 14 alternately branching lines for inclusion in regional yield trials. In addition, 14 valencia lines were selected for regional evaluation.

Table 3. Performance of some groundnut breeding populations in two advanced yield trials, Chitedze, Malawi, 1986/87.

Entry	Pedigree	Time to maturity (days)	Pod yield (t ha^{-1})	Shelling percentage	100-seed mass (g)	Seed color	Mean early leaf spot score[1]
Alternate branching[2]							
ICGV-SM 86722	(P84/6/20)P_1-B_1	144	3.24	70	47	Red	8
ICGV-SM 86725	(Robut 33-1 × NC Ac 2821) × (USA 20 × TMV 10)F_3-B_1-B_2-B_1	123	2.52	79	56	Red	7
Local control							
Mawanga		138	2.86	72	59	Variegated	7
SE			±0.123				
Trial mean (36 entries)			2.14				
CV (%)			11.6				
Sequential branching[3]							
ICGV-SM 86053	(ICGM 291)P_1-B_1-B_2	111	2.49	69	39	Tan	8
ICGV-SM 85057	(Egret × Ah 114)	130	2.48	74	48	Tan	7
ICGV-SM 86068	(Goldin 1 × Faizpur 1-5) × (Manfredi × M 13)F_3-B_1-B_2-B_1	126	2.36	69	35	Red	8
ICGV-SM 86051	(2328)B_1-B_1-B_1	118	2.19	74	41	Red	8
Local control							
Malimba		105	1.69	77	27	Tan	8
SE			±0.056				
Trial mean (64 entries)			1.71				
CV (%)			6.6				

1. Scored at 90 days after emergence on a 1-9 scale, where 1 = No disease and 9 = 50-100% of foliage destroyed.
2. 6 × 6 lattice, plot size 14.4 m^2.
3. 8 × 8 lattice, plot size 14.4 m^2.

Yield Trials: 1986/87

Preliminary yield trials

We evaluated 46 sequentially branching and 73 alternately branching breeding lines in three trials. Many had potential for high yield and quality and have been included in the advanced trials.

Advanced yield trials

We evaluated 60 sequentially branching and 31 alternately branching breeding lines in two trials. Many of these performed well (Table .). Ten sequentially branching and 8 alternately branching lines were selected for inclusion in regional yield trials.

Regional Virginia Cultivar Trials

1985/86

The virginia cultivar trial was grown at three locations in Malawi and Zambia. At all three trial sites, ICGMS 42 maintained its significant yield superiority over local control cultivars (Table 4). Nine of these entries were retained for further evaluation.

1986/87

The virginia cultivar trial was grown at six locations in four SADCC countries. In addition, it was also grown at the ICRISAT Sahelian Center, Niger. The trial in Mozambique was severely affected by lack of

Table 4. Seed and pod yields (t ha[-1]) of entries in the SADCC Regional Groundnut Variety Trials (Virginia Type), Malawi and Zambia, 1985/86.

	Chitedze Research Station, Malawi		Msekera Regional Research Station, Zambia		Golden Valley, Zambia		Mean	
Entry	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed
ICGMS 42	3.73	2.80(1)[1]	3.22	2.30(1)	2.29	1.30(1)	3.08	2.13
ICGMS 36	2.48	1.86(6)	2.64	1.87(4)	1.82	1.10(5)	2.31	1.61
ICGMS 35	2.73	1.96(5)	2.49	1.70(5)	1.53	0.97(10)	2.25	1.54
ICGMS 38	2.47	1.83(7)	2.26	1.51(7)	1.87	1.20(2)	2.20	1.51
ICGMS 39	2.61	1.80(8)	2.20	1.37(9)	1.73	1.12(4)	2.18	1.43
ICGMS 45	2.44	1.71(10)	2.62	1.64(6)	1.56	0.91(11)	2.21	1.42
ICGMS 48	2.52	1.74(9)	2.01	1.31(10)	1.87	1.07(6)	2.13	1.37
ICGMS 46	3.17	2.44(2)	0.92	0.64(13)	1.71	0.83(13)	1.93	1.30
ICGMS 47	1.61	1.19(14)	1.96	1.42(8)	1.71	1.15(3)	1.76	1.25
ICGMS 43	2.25	1.62(11)	1.61	0.96(11)	1.67	1.02(8)	1.84	1.20
ICGMS 41	1.96	1.33(12)	1.46	0.84(12)	1.42	0.82(14)	1.61	1.00
ICGMS 37	1.72	1.27(13)	0.92	0.63(14)	1.33	0.84(12)	1.32	0.91
ICGMS 44	1.64	1.23(14)	0.88	0.63(14)	1.20	0.71(15)	1.24	0.86
ICGMS 40	1.59	1.14(15)	0.94	0.63(14)	1.11	0.68(16)	1.21	0.82
Control 1	3.33	2.43(3)	3.07	2.04(3)	1.98	0.99(9)		
	(Mani Pintar)		(Egret)		(Makulu Red)			
Control 2	3.01	2.14(4)	3.03	2.07(2)	1.98	1.07(6)		
	(Chitembana)		(Makulu Red)		(Egret)			
SE	±0.049	-[2]	±0.098	±0.069	±0.124	±0.096		
Mean	2.45	1.78	2.01	1.35	1.67	0.99		
CV (%)	4	-[2]	10	10	15	20		

1. Figures in parentheses indicate rank at individual sites.
2. Not available.

Table 5. Pod and seed yields (t ha⁻¹) of 25 entries in SADCC Regional Groundnut Variety Trials (Virginia Type), Malawi, Zambia, and Zimbabwe, 1986/87.

	Malawi				Zambia				Zimbabwe			
	Chitedze[1]		Meru		Msekera[2]		Chisamba[3]		Gwebi[4]		Mean	
Entry	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed
ICGMS 42	2.61	2.04(6)[5]	1.80	1.27(1)	2.69	1.76(1)	1.11	0.79(1)	5.49	4.10(2)	2.74	1.99
ICGM 336	2.82	2.17(3)	1.64	0.67	2.05	1.34(5)	0.67	0.35	5.99	4.46(1)	2.63	1.80
ICGM 623	2.80	2.15(4)	1.76	1.09(4)	1.86	1.21(10)	0.56	0.24	5.43	3.94(4)	2.48	1.73
ICGMS 52	2.60	1.98(8)	1.12	0.69	2.02	1.36(4)	0.89	0.45(8)	5.18	3.76(5)	2.36	1.65
ICGM 749	2.59	1.94(9)	1.20	0.62	1.80	1.05	0.78	0.31	5.49	3.98(3)	2.37	1.58
ICGM 631	2.65	2.06(5)	1.20	0.58	2.06	1.24(8)	0.50	0.20	5.25	3.67(9)	2.33	1.55
ICGMS 50	3.14	2.20(1)	1.64	0.77	1.95	0.93	0.56	0.18	5.83	3.56(10)	2.62	1.53
ICGMS 51	2.78	1.92	1.53	0.78(10)	2.08	0.91	0.83	0.46(5)	5.86	3.37(13)	2.62	1.49
ICGMS 53	2.52	1.94(10)	1.37	0.83(8)	1.71	0.96	0.44	0.18	4.91	3.56(10)	2.19	1.49
ICGMS 49	3.11	2.18(2)	1.39	0.65	2.05	0.94	0.50	0.17	5.68	3.41(12)	2.55	1.47
ICGMS 54	2.55	1.93	1.08	0.65	1.44	0.77	0.50	0.23	5.00	3.75(7)	2.11	1.47
ICGM 484	2.37	1.61	1.59	0.79(9)	2.22	1.34(5)	0.50	0.26	4.88	3.31	2.31	1.46
ICGMS 46	2.15	1.70	1.34	0.85(6)	2.12	1.20	0.89	0.51(2)	4.01	3.01	2.10	1.45
ICGM 608	2.27	1.68	1.18	0.73	1.45	0.90	0.72	0.46(6)	4.54	3.29	2.03	1.41
ICGM 614	2.53	1.89	1.13	0.62	1.89	1.16	0.50	0.25	3.92	2.94	1.99	1.37
ICGMS 38	1.31	1.00	1.40	0.93(5)	1.90	1.25(7)	0.78	0.46(6)	3.80	2.79	1.84	1.29
ICGM 633	2.29	1.70	1.18	0.44	1.72	0.99	0.78	0.29	4.10	2.87	2.01	1.26
ICGMS 36	1.85	1.38	1.46	0.62	2.19	0.99	0.73	0.48(3)	3.36	2.37	1.92	1.25
ICGMS 39	1.73	1.32	1.23	0.85(6)	1.62	1.39(2)	0.89	0.48(4)	3.30	2.42	1.75	1.22
ICGMS 48	1.46	1.06	1.38	0.83(8)	1.85	1.03	0.83	0.39(9)	3.61	2.73	1.83	1.22
ICGMS 35	1.56	1.15	0.94	0.64	1.74	1.10	0.56	3.35	3.86	2.73	1.73	1.18
ICGMS 45	1.84	1.32	1.07	0.44	1.76	1.05	0.44	0.25	3.73	2.67	1.77	1.15
ICGMS 43	1.69	1.30	1.53	1.13(2)	1.68	1.05	0.56	0.36	3.36	2.57	1.76	1.06
Control 1	2.57	2.03(7)	1.93	1.13(2)	2.16	1.23(9)	0.73	0.37(10)	5.46	3.70(8)	-[6]	-
	(Mani Pintar)		(Chalimbana)		(MGS 2)		(MGS 2)		(Egret)			
Control 2	2.34	1.66(17)	1.38	0.78(10)	2.34	1.39(3)	0.61	0.24(20)	5.18	3.76(5)	-	-
	(Mawanga)		(Mani Pintar)		(Makulu Red)		(Makulu Red)		(Flamingo)			
SE	±0.084	±0.062	±0.194	±0.123	±0.082	±0.072	±0.063	±0.046	±0.324	-		
Trial mean	2.32	1.73	1.38	0.79	1.93	1.14	0.67	0.35	4.69	3.31		
CV (%)	7	7	28	31	8	13	19	26	12	-		

1. Research Station. 2. Regional Research Station. 3. Subresearch Center. 4. Variety Testing Center. 5. Figures in parentheses indicate rank at individual sites. 6. Not available.

rainfall. ICGMS 42 was ranked high at the remaining locations and was once again significantly superior to local control cultivars at most sites (Table 5). Eight of these entries were retained for further evaluation.

We report with satisfaction that ICGMS 42 is now at the prerelease testing stage in eastern Zambia.

Regional Spanish Cultivar Trials

1985/86

Spanish cultivar trials in Maputo (Mozambique), Sebele (Botswana), Ngabu and Lupembe (Malawi), and Magoye (Zambia), were adversely affected by highly variable emergence, poor plant stands, or low shelling percentages. However, at Chitedze (Malawi), ICGMS 5, 11, 29, and 30, and at Masumba (Zambia) ICGMS 11, 12, 15, and 31, significantly outyielded the best local control entries (Table 6). Eleven of these entries were retained for further evaluation.

1986/87

Spanish cultivar trials in Sebele (Botswana), Maputo (Mozambique), Ngabu (Malawi), and Magoye (Zambia) were adversely affected by lack of rainfall. However, certain entries showed promise in some of these trials. ICGMS 56 and 58 gave consistently high yields across locations (Table 7). ICGMS 5 and 11 also performed well but ICGMS 29 and 30 were disappointing at most sites. ICGMS 30 was also ranked poorly at Niamey but performed well in Burundi. Twenty-four of these entries were retained for further evaluation.

Regional Valencia Cultivar Trials

A separate trial containing 14 valencia cultivars was grown for the first time in two SADCC countries in 1986/87. Many entries showed promise, notably ICGM 189, 197, and 286. These entries also performed well in trials in Burundi (Table 8) and Niger.

The composition of the 1987/88 trial has not been altered in view of the limited number of trial sites in 1986/87.

Table 6. Pod and seed yields (t ha^{-1}) of 36 entries in SADCC Regional Groundnut Variety Trials (Spanish Type), Malawi, Zambia, and Botswana, 1985/86.

	Malawi						Zambia				Botswana			
	Chitedze[1]		Ngabu		Lupembe		Magoye		Masumba		Sebele[1]		Mean	
Entry	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed
ICGMS 18	2.30	1.77(4)[2]	1.17	0.79(10)	2.23	0.97(8)	1.59	1.06(6)	2.76	1.98(10)	0.85	0.55(1)	1.82	1.19
ICGMS 34	2.14	1.60	1.18	0.70	2.57	1.12(2)	1.60	1.05(7)	2.83	2.05(6)	0.80	0.52(5)	1.85	1.17
ICGMS 2	2.28	1.73(8)	1.74	1.09(4)	1.85	0.88	1.70	1.08(5)	2.62	1.81	0.63	0.40	1.80	1.16
ICGMS 21	1.99	1.45	1.49	0.98(6)	2.17	0.99(6)	1.43	0.88	2.95	2.11(3)	0.88	0.54(3)	1.92	1.16
ICGMS 11	2.55	1.76(5)	1.64	0.80(9)	2.05	0.86	1.53	0.93	3.46	2.26(1)	0.75	0.32	2.00	1.15
ICGMS 1	2.04	1.57	1.52	0.91(7)	2.37	1.13(1)	1.61	1.10(3)	2.45	1.74	0.63	0.40	1.77	1.14
ICGMS 9	2.16	1.51	1.71	1.20(2)	1.83	0.88	1.33	0.87	2.83	2.00(9)	0.67	0.39	1.76	1.14
ICGMS 33	1.93	1.45	1.96	1.10(3)	2.03	0.81	1.22	0.89	2.82	2.07(5)	0.74	0.45(10)	1.78	1.13
ICGMS 5	2.70	1.94(2)	1.19	0.66	1.94	0.87	1.56	0.98	3.02	2.04(7)	0.54	0.25	1.82	1.12
ICGMS 17	2.23	1.72(9)	1.18	0.72(12)	2.05	0.94	1.50	0.93	2.67	1.88	0.95	0.50(7)	1.76	1.12
ICGMS 27	2.31	1.76(5)	1.08	0.63	2.03	1.03(4)	1.62	0.92	2.72	1.82	0.80	0.50(7)	1.76	1.11

1. Research Station. 2. Figures in parentheses indicate rank at individual sites.

Continued

Table 6. *Continued*

	Malawi						Zambia				Botswana			
	Chitedze[1]		Ngabu		Lupembe		Magoye		Masumba		Sebele[1]		Mean	
Entry	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed
ICGMS 22	2.10	1.58	1.37	0.70	2.00	0.96(9)[2]	1.41	0.94	2.61	1.89	0.81	0.53(4)	1.72	1.10
ICGMS 32	2.10	1.60	1.13	0.76	2.48	1.09(3)	1.54	0.96	2.65	1.92	0.70	0.29	1.77	1.10
ICGMS 31	2.18	1.59	0.76	0.35	1.84	0.96(10)	1.53	1.11(2)	3.11	2.20(2)	0.62	0.34	1.67	1.09
ICGMS 12	2.38	1.62	1.20	0.69	1.75	0.82	1.35	0.92	3.15	2.08(4)	0.61	0.33	1.74	1.08
ICGMS 26	2.16	1.62	1.36	0.84(8)	1.64	0.76	1.37	0.92	2.58	1.84	0.63	0.39	1.62	1.06
ICGMS 29	2.49	1.84(3)	1.02	0.64	1.79	0.79	1.36	0.90	2.51	1.79	0.63	0.37	1.63	1.06
ICGMS 14	1.70	1.28	1.82	1.06(5)	1.83	0.85	1.37	0.81	2.65	1.77	0.81	0.49(9)	1.70	1.04
ICGMS 16	2.07	1.51	1.17	0.60	1.89	0.84	1.43	0.94	2.58	1.86	0.68	0.37	1.64	1.02
ICGMS 3	1.84	1.38	1.38	0.71(13)	2.12	0.91	1.12	0.88	2.76	1.83	0.61	0.37	1.64	1.01
ICGMS 25	2.22	1.51	1.19	0.55	1.84	0.86	1.50	1.02(8)	2.77	1.83	0.50	0.26	1.67	1.00
ICGMS 28	2.24	1.61	1.09	0.68	1.72	0.71	1.36	0.83	2.51	1.80	0.67	0.37	1.60	1.00
ICGMS 30	3.41	2.35(1)	0.36	0.17(36)	1.62	0.68(35)	1.33	0.81(32)	2.67	1.81(26)	0.48	0.13(36)	1.64	0.99
ICGMS 10	1.91	1.38	1.24	0.72	2.23	0.97(7)	1.10	0.68	2.61	1.82	0.64	0.32	1.62	0.98
ICGMS 23	1.99	1.43	0.88	0.51	2.07	0.92	1.38	0.96	2.49	1.77	0.55	0.29	1.56	0.98
ICGMS 24	1.94	1.44	0.85	0.53	1.60	0.74	1.40	1.10(4)	2.48	1.77	0.53	0.29	1.47	0.98
ICGMS 13	1.83	1.24	1.38	0.76(11)	2.01	0.79	1.41	0.92	2.59	1.79	0.52	0.23	1.62	0.96
ICGMS 15	2.15	1.42	1.22	0.59	1.69	0.62	1.56	0.98	3.21	1.96	0.50	0.18	1.72	0.96
ICGMS 20	1.84	1.32	0.87	0.46	1.49	0.75	1.50	0.99(9)	2.70	1.87	0.63	0.35	1.50	0.96
ICGMS 4	2.12	1.50	1.08	0.50	1.76	0.70	1.11	0.73	2.85	2.02(8)	0.44	0.20	1.56	0.94
ICGMS 6	2.25	1.64(10)	0.50	0.26	1.83	0.77	1.19	0.84	2.22	1.54	0.52	0.26	1.42	0.88
ICGMS 19	1.42	1.01	0.96	0.54	1.38	0.68	1.42	0.98(10)	2.33	1.62	0.72	0.43	1.37	0.88
ICGMS 7	1.98	1.27	1.09	0.51	1.87	0.79	1.30	0.70	2.84	1.81	0.42	0.15	1.58	0.87
ICGMS 8	2.03	1.54	0.99	0.50	1.75	0.83	1.06	0.72	1.97	1.45	0.45	0.19	1.38	0.87
Control 1	2.19	1.62(11)	1.32	0.72(12)	2.20	0.95(11)	1.51	0.98(11)	2.66	1.92(12)	0.81	0.52(5)		
	(Malimba)		(Malimba)		(Malimba)		(Comet)		(Comet)		(Sellie)			
Control 2	2.32	1.74(7)	1.88	1.21(1)	2.18	1.00(5)	1.59	1.25(1)	2.63	1.88(16)	0.90	0.55(1)		
	(Spancross)		(JL 24)		(JL 24)		(Natal Common)		(Natal Common)		(55-437)			
SE	±0.037	-[3]	±0.123	±0.085	±0.226	±0.100	±0.121	±0.090	±0.130	±0.096				
Mean	2.15	1.56	1.22	0.70	1.94	0.87	1.41	0.93	2.70	1.88	0.66	0.36		
CV (%)	3	-[3]	20	24	23	23	17	19	10	10	21	-[3]		

1. Research Station. 2. Figures in parentheses indicate rank at individual sites. 3. Not available.

Table 7. Pod and seed yields (t ha[-1]) of 36 entries in SADCC Regional Groundnut Variety Trials (Spanish Type), Malawi, Zambia, Zimbabwe, Botswana, and Burundi, 1986/87.

	Malawi				Zambia				Zimbabwe		Mean of Malawi, Zambia, and Zimbabwe		Botswana		Burundi	
	Chitedze[1]		Lupembe		Magoye[2]		Masumba[3]		Gwebi[4]				Sebele[1]		Bujumbura	
Entry	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed
ICGMS 56	2.07	1.49(2)[5]	4.34	2.25(1)	1.09	0.42(2)	2.22	1.44(13)	3.55	2.31(5)	2.40	1.58	0.31	0.09	1.57	0.88(2)
ICGMS 63	2.42	1.74(1)	2.69	1.72(10)	0.61	0.26(23)	1.99	1.34(21)	3.40	2.46(2)	2.22	1.50	0.21	0.09	-	-
ICGMS 58	1.92	1.33(3)	3.42	1.82(7)	0.68	0.24(25)	1.83	0.95(31)	3.80	2.47(1)	2.24	1.36	0.36	0.11	0.95	0.48
ICGM 473	1.44	1.09(20)	2.70	1.74(8)	0.72	0.34(11)	2.50	1.90(1)	1.76	1.36(26)	1.82	1.29	0.28	0.08	1.23	0.73(4)
ICGMS 60	1.11	0.84(36)	2.76	1.88(6)	0.81	0.37(7)	1.97	1.34(22)	2.56	1.98(8)	1.84	1.28	0.38	0.19(6)	0.99	0.44
ICGMS 11	1.46	1.08(22)	2.18	1.36(31)	0.92	0.42(1)	2.41	1.68(3)	2.78	1.80(11)	1.95	1.27	0.39	0.18(7)	1.23	0.63
ICGMS 5	1.41	1.04(28)	2.32	1.56(15)	0.79	0.30(17)	2.32	1.60(4)	2.62	1.84(9)	1.89	1.27	0.26	0.08	1.08	0.60
ICGMS 12	1.27	0.93(34)	3.27	1.74(8)	0.90	0.37(7)	2.15	1.46(10)	2.31	1.68(14)	1.77	1.24	0.27	0.14	0.79	0.45
ICGMS 65	1.85	1.30(5)	2.32	1.38(29)	0.78	0.31(16)	1.63	0.94(32)	2.99	2.24(6)	1.91	1.23	0.27	0.13	-	-
ICGMS 13	1.20	0.30(35)	2.85	1.65(12)	0.74	0.30(19)	2.07	1.44(13)	2.62	1.84(9)	1.89	1.23	0.24	0.10	-	-
ICGMS 57	1.62	1.17(15)	2.36	1.37(30)	0.27	0.09(36)	1.94	1.18(29)	3.24	2.35(4)	1.89	1.23	0.18	0.03	1.23	0.67(8)
ICGMS 69	1.87	1.33(4)	2.24	1.48	0.73	0.32	1.90	1.30	2.31	1.74	1.81	1.23	0.25	0.12	-	-
ICGMS 61	1.70	1.28(8)	3.02	1.92(5)	0.49	0.18	2.04	1.29	1.98	1.43	1.76	1.22	0.10	0.04	-	-
ICGMS 68	1.38	0.99	3.38	2.15(2)	0.80	0.38(5)	2.00	1.42	1.60	1.16	1.73	1.22	0.32	0.19(5)	-	-
ICGMS 66	1.35	1.03	3.00	2.04(3)	0.81	0.38(6)	2.22	1.46(10)	1.60	1.12	1.80	1.21	0.30	0.17(9)	-	-
ICGMS 67	1.63	1.14	2.51	1.49	0.89	0.40(3)	1.87	1.23	2.35	1.76	1.85	1.20	0.26	0.15	-	-
ICGM 734	1.37	1.08	2.29	1.54	0.70	0.31	1.96	1.42	2.01	1.60	1.67	1.19	0.33	0.21(4)	0.78	0.61
ICGM 522	1.60	1.20	2.64	1.64	0.48	0.22	1.72	1.20	2.28	1.66	1.74	1.18	0.31	0.16	0.90	0.44
ICGMS 9	1.55	1.18	2.49	1.56	0.55	0.25	2.15	1.58(5)	1.70	1.31	1.69	1.18	0.37	0.22(3)	1.16	0.68(7)
ICGMS 21	1.47	1.12	2.39	1.70	0.85	0.30	2.15	1.46(10)	1.79	1.34	1.73	1.18	0.23	0.12	1.11	0.70(6)
ICGMS 71	1.66	1.21	2.52	1.26	0.61	0.28	2.28	1.52(7)	2.13	1.54	1.84	1.16	0.22	0.07	-	-
ICGMS 70	1.85	1.29(6)	2.42	1.49	0.60	0.22	1.80	1.16	2.31	1.62	1.80	1.16	0.24	0.15	-	-
ICGMS 1	1.62	1.25(9)	2.48	1.54	0.77	0.38(4)	2.26	1.71(2)	1.23	0.92	1.67	1.16	0.25	0.13	0.94	0.57

1. Research Station.
2. Regional Research Station.
3. Subresearch Station.
4. Variety Testing Center.
5. Figures in parentheses indicate rank at individual sites.

Continued

Table 7. *Continued.*

Entry	Malawi				Zambia				Zimbabwe		Mean of Malawi, Zambia, and Zimbabwe		Botswana		Burundi	
	Chitedze[1]		Lupembe		Magoye[2]		Masumba[3]		Gwebi[4]				Sebele[1]		Bujumbura	
	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed
ICGM 437	1.29	1.02	2.44	1.61	0.43	0.22	1.84	1.30	2.04	1.63	1.61	1.16	0.21	0.13	0.93	0.61
ICGMS 64	1.53	1.06	2.63	1.40	0.74	0.34	2.18	1.38	2.41	1.50	1.90	1.14	0.28	0.17(10)[5]	1.13	0.63(10)
ICGMS 21	1.39	1.10	2.28	1.43	0.74	0.31	1.90	1.36	1.85	1.48	1.63	1.14	0.34	0.23(2)	1.16	0.73(9)
ICGMS 2	1.69	1.22(10)	2.33	1.49	0.81	0.35(10)	2.22	1.49(8)	1.45	1.09	1.70	1.13	0.25	0.17	0.96	0.56
ICGMS 59	1.28	0.97	2.20	1.42	0.46	0.24	1.95	1.37	2.25	1.63	1.63	1.13	0.26	0.14	0.54	0.34
ICGMS 55	1.93	1.29(7)	2.22	1.18	0.35	0.10	1.65	0.39	3.43	2.14(7)	1.92	1.12	0.14	0.05	0.76	0.40
ICGMS 31	1.31	1.00	2.44	1.46	0.44	0.21	1.86	1.35	2.01	1.40	1.61	1.08	0.25	0.14	0.74	0.41
ICGMS 29	1.29	0.98	2.40	1.48	0.59	0.29	2.07	1.31	1.64	1.27	1.60	1.07	0.22	0.13	1.21	0.66(9)
ICGMS 30	1.33	0.97(33)	2.44	1.53(19)	2.56	0.17(32)	1.42	0.71(36)	2.13	1.54(13)	1.58	0.98	0.34	0.06(34)	1.90	1.05(1)
ICGMS 62	1.50	1.06	2.26	1.36	0.24	0.07	1.30	0.30	2.35	1.52	1.53	0.96	0.27	0.08	1.49	0.87(3)
ICGMS 72	1.60	1.10	1.79	1.00	0.35	0.11	1.35	0.77	1.88	1.27	1.39	0.85	0.23	0.09	-	-
Control 1	1.38	1.04(25)	2.18	1.32(33)	0.71	0.35(9)	2.16	1.55(6)	3.15	2.20(3)			0.31	0.18(8)	0.35	0.52(19)
	(Malimba)		(Malimba)		(Natal Common)		(Natal Common)		(Valencia R 2)				(Sellie)		(Malimba)	
Control 2	1.56	1.20(13)	3.36	2.04(4)	0.79	0.27(22)	2.09	1.48(9)	3.39	2.54(3)			0.40	0.25(1)	1.00	0.60(15)
	(Spancross)		(JL 24)		(Comet)		(Comet)		(Valencia R 2)				(55-437)		(Spancross)	
SE	±0.057	±0.041	±0.322	±0.166	±0.095	±0.043	±0.114	±0.086	±0.167	-[6]			-[6]	-[6]	-[6]	[6]
Mean	1.55	1.14	2.61	1.59	0.66	0.29	1.98	1.32	2.27	1.69			0.27	0.13	1.06	0.61
CV (%)	7	7	25	21	29	31	12	13	12	-[6]			42	-[6]	-[6]	-[6]

1. Research Station.
2. Regional Research Station.
3. Subresearch Station.
4. Variety Testing Center.
5. Figures in parentheses indicate rank at individual sites.
6. Not available.

Table 8. Pod and seed yields (t ha-1) of SADCC Regional Groundnut Variety Trials (Valencia Type), Malawi, Zambia, and Burundi, 1986/87.

	Chitedze Research Station, Malawi		Msekera Regional Research Station, Zambia		Bujumbura, Burundi		Mean	
Entry	Pod	Seed	Pod	Seed	Pod	Seed	Pod	Seed
ICGM 189	2.08	1.56(3)[1]	2.07	1.40(2)	1.46	0.86(11)	1.87	1.27
ICGM 286	2.00	1.52(4)	2.19	1.32(4)	1.41	0.87(10)	1.87	1.24
ICGM 284	2.36	1.75(1)	1.85	1.16(7)	1.33	0.71(16)	1.85	1.21
ICGM 197	1.94	1.40(5)	2.09	1.38(3)	1.53	0.78(14)	1.85	1.19
ICGM 285	2.20	1.58(2)	1.81	1.02(10)	1.65	0.93(7)	1.89	1.18
ICGM 281	1.70	1.19(9)	2.20	1.41(1)	1.59	0.91(8)	1.83	1.17
ICGM 177	1.91	1.39(6)	2.14	1.29(5)	1.51	0.84(12)	1.85	1.17
ICGM 525	1.91	1.37(7)	1.37	0.81(12)	2.38	1.21(2)	1.89	1.13
ICGMS 30	1.40	1.04(10)	1.41	0.88(11)	1.65	1.01(5)	1.49	0.98
ICGMS 31	1.22	0.94(12)	1.68	1.09(8)	1.39	0.74(15)	1.43	0.92
ICGM 559	1.18	0.84(15)	0.67	0.36(16)	2.74	1.43(1)	1.53	0.88
ICGM 550	1.35	0.94(13)	1.07	0.58(13)	2.07	1.03(4)	1.50	0.85
ICGM 554	1.12	0.81(16)	0.82	0.46(14)	2.31	1.10(3)	1.42	0.79
ICGM 561	1.22	0.88(14)	0.79	0.41(15)	2.02	0.99(6)	1.34	0.76
Control 1	1.65	1.24(8)	1.99	1.22(6)	1.57	0.91(8)		
	(Valencia R 2)		(Jacana)		(Spancross)			
Control 2	1.32	0.99(11)	1.62	1.03(9)	1.31	0.81(13)		
	(Malimba)		(Comet)		(Malimba)			
SE	±0.070	±0.051	±0.066	±0.45	±0.054	±0.033		
Trial mean	1.66	1.22	1.61	0.99	1.74	0.95		
CV (%)	8	8	8	9	-[2]	-[2]		

1. Figures in parentheses indicate rank at individual sites.
2. Not available.

1987/88 Program

In addition to ongoing screening and evaluation of breeding material, an enlarged testing program is being conducted this season. This includes five preliminary and two advanced trials of entries from the SADCC/ICRISAT Regional Groundnut Improvement Program, three preliminary and five international trials from ICRISAT station at Chitedze, and one preliminary trial from ICRISAT station at Ngabu.

2

Early Leaf Spot

Management of Leaf Spots of Groundnut in Zambia

J. Kannaiyan[1], R.S. Sandhu[2], H.C. Haciwa[1], and M.S. Reddy[3]

Abstract

*Early leaf spot (*Cercospora arachidicola*) and late leaf spot (*Phaeoisariopsis personata*) are the most serious diseases of groundnut in Zambia. Research between 1983 and 1987, on ways to reduce their severity, is summarized. Of the many groundnut accessions screened none were found to be distinctly resistant to the leaf spots. A few promising entries identified are however being utilized in the resistance breeding program. Meanwhile, four fungicides were evaluated in field trials over two seasons to identify effective and economic control of the leaf spots. Although all the fungicides reduced disease significantly and increased yield over control, thiophanate methyl + maneb (Labilite®) was highly cost effective and beneficial in on-farm trials. Observations over two seasons in agronomic trials indicated that severity of leaf spot attack in groundnut (cv MGS 2), planted in late December, was significantly lower than in earlier plantings (late November to early December). Leaf spot severity, however, did not differ under conditions of intercropping or in different plant-density levels.*

Sumário

Maneio das Manchas Foliares do Amendoim em Zâmbia. *A mancha temporã (*Cercospora arachidicola*) e a mancha tardia (*Phaeoisariopsis personata*) são as mais importantes doenças do amendoim em Zâmbia. A investigação, realizada entre 1983 e 1987, com o intuito de reduzir a sua severidade é sumarizada. Do grande numero de aquisições testadas, nenhuma foi encontrada que fosse distintamente resistente às manchas foliares. Algumas, poucas, entradas promissoras indentificadas estão sendo utilizadas no programa do melhoramento para a resistência. Entretanto, quatro fungicidas foram avaliadas em ensaios de campo durante duas estações, com vista a identificar um método de controlo de manchas foliares eficiente e económico. Embora todas as fungicidas tenham reduzido a doença significativamente e aumentado o rendimento em relação ao controlo, o tiofanato de metil + maneb (Labilite®) foi altamente custo efectivo e benéfico nos ensaios nos campos dos camponeses. Observações recolhidas em duas estações em ensaios agronómicos, indicaram que a severidade do ataque de manchas foliares no cultivar de amendoim MGS 2, plantado em fins de Dezembro, foi significativamente mais baixa que em sementeiras feitas mais cedo (fins de Novembro e princípios de Dezembro). Contudo, a severidade das manchas foliares não variou em consociação ou em diferentes densidades das plantas.*

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ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1989. Proceedings of the Third Regional Groundnut Workshop, 13-18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P 502 324, India: ICRISAT.

Introduction

Many diseases caused by fungi and viruses have been reported on groundnut in Zambia (Angus 1962 66; Kannaiyan 1987). Of these, early leaf spot (*Cercospora arachidicola* Hori) and late leaf spot (*Phaeisariopsis personata* (Berk & Curt.) v. Arx) are the most important and cause up to 50% yield loss (McDonald et al. 1985). Early leaf spot (ELS), which occurs in epidemic proportions every season, is most damaging. Late leaf spot (LLS) usually appears when one crop is 3 months old and its severity is low to moderate. The commonly cultivated groundnut cultivars and the local landraces are susceptible to ELS and LLS.

The most economical and effective method to control leaf spots is to use agronomically acceptable resistant cultivars. This strategy is particularly suitable for the small farmers who generally lack financial resources. Unfortunately, such cultivars are not available at present. A screening program for identifying sources of resistance and transferring such resistance to high-yielding varieties has been initiated (Kannaiyan et al. 1987).

The groundnut pathology studies (1983 87) on ELS and LLS resistance screening, on chemical control, and also on effects of and cultural measures are presented and discussed here.

Screening for Resistance

The field screening work was carried out from 1983 to 1987 at Msekera Regional Research Station (13° 39′S; 32° 37′E) in the Eastern Province, the major groundnut-growing area in Zambia. The station is at an altitude of 1016 m and receives mean annual rainfall of 1092 mm, most of which falls between December and March. ELS usually appears during the 1st fortnight of December on 3 4-week-old seedlings and the spread of the disease was enhanced by the usually frequent rains. LLS infects the crop towards the end of February and its spread depends upon late rains received in March. The natural occurrence of ELS is both severe and uniform across seasons in the susceptible cultivars Chalimbana, Makulu Red, Natal Common, and Comet. This consistently high disease severity affords ideal conditions for field screening of groundnut genotypes.

Disease severity was scored on a 1 9 scale (Subrahmanyam et al. 1982) at 10 weeks after planting and 2 weeks before harvest. Based on the disease-severity score, groundnut genotypes have been classified into four groups: resistant (1 3), tolerant (4 5), susceptible (6 7), and highly susceptible (8-9). The percentage of defoliation was also determined by counting abscissed and retained leaflets. The leaf spot observations were made in both breeding and disease-nursery trials.

Breeding trials included several replicated yield trials: Preliminary and Advanced Groundnut Variety Trials (long season, long-season confectionery, and short season); ICRISAT Regional Groundnut Variety Trials (virginia, spanish, and valencia); and germplasm observational rows (virginia, spanish, and valencia). The disease scores across four seasons are summarized in Table 1. None of the 4162 genotypes showed a consistently resistant reaction across seasons. However, several tolerant accessions were identified.

Promising genotypes thus identified were further screened in the leaf spots disease nursery. Three susceptible cultivars (Comet, Makulu Red, and Chalimbana) served as controls. Spreader rows of the highly susceptible varieties Natal Common

Table 1. Relative resistance of groundnut genotypes to leaf spots at Msekera Regional Research Station, Zambia, 1983-87.

Season	Number of entries screened	Number of entries in different reaction groups: Resistant (1 3)[1]	Tolerant (4 5)	Susceptible (6 7)	Highly susceptible (8 9)
1983 84	1189	1	39	559	590
1984 85	890	0	1	181	708
1985 86	913	0	83	482	348
1986 87	1170	0	59	547	564

1. Scored on a scale 1 9, where 1 = Most resistant, and 9 = Most susceptible.

and Comet—were planted 2 weeks before planting test lines, to ensure a uniform spread of the disease and to eliminate the possibility of escapes. Both disease severity scores and percentage of defoliation were recorded two to three times during the season. Final observations were made 2 weeks before harvest. The most promising lines advanced for further testing. The performances of 13 promising lines over three seasons are summarized in Table 2.

Of the tested entries only ICG 7888 showed reasonable tolerance to leaf spots, with a mean score of 5.7 and with 53% defoliation. This entry is also resistant to rust in Zambia (Kannaiyan and Sandhu 1985). The remaining 12 promising entries gave mean scores between 6.0 and 6.9. Some of these genotypes are now being utilized in our resistance breeding program in an attempt to develop high-yielding leaf spot tolerant cultivars, suitable for cultivation in Zambia.

Chemical Control

Developing leaf spot resistant varieties is a long-term program. Therefore, a 2-year (1984–86) field trial was conducted to assess the possibility of economically effective fungicidal control. The commonly cultivated variety Chalimbana, which is susceptible to ELS and LLS, was planted in a randomized-block design with four replications. Natal Common, a highly susceptible variety, was

Table 2. Susceptibility of selected groundnut entries to leaf spots at Msekera Regional Research Station, Zambia, 1984–87.

Entry	Origin	Group	1984/85		1985/86		1986/87		Mean	
			LSS[1]	DF[1]	LSS	DF	LSS	DF	LSS	DF
ICG 7888	Peru	Valencia	6.0	52	6.0	47	5.0	59	5.7	53
ICG 4790	Argentina	Virginia	7.0	(77)[2]	5.0	(63)	6.0	60	6.0	60
NC Ac 10247	USA	Virginia	6.0	65	5.7	56	7.0	82	6.2	68
ICG 6340	Honduras	Valencia	8.0	70	5.0	(63)	6.3	65	6.4	68
MGS 1	Zambia	Virginia	6.0	70	6.3	62	7.0	81	6.4	71
ICG 7884	Peru	Valencia	7.0	78	6.3	67	6.3	68	6.5	71
Gambia Bunch	Gambia	Virginia	6.5	73	6.3	64	6.7	78	6.5	72
NC Ac 1528	USA	Virginia	7.0	83	6.3	58	6.3	75	6.5	72
CH 73 80	Zambia	Virginia	7.0	69	6.0	55	7.0	75	6.7	66
PI 331304	Argentina	Virginia	6.8	(77)	6.3	54	7.0	79	6.7	67
ICGMS 47	Malawi	Virginia	7.0	79	6.7	59	6.3	74	6.7	71
SAC 58	South America	Virginia	7.0	(77)	6.3	61	7.0	78	6.8	70
C 13	India	Virginia	7.0	(77)	7.7	60	6.0	[illegible]	6.9	62
Controls										
Comet	USA	Spanish	9.0	87	8.7	68	9.0	70	8.9	75
Makulu Red	Bolivia	Namby-quarare	7.0	85	7.7	69	7.7	76	7.5	77
Chalimbana	South Africa	Virginia	7.0	72	7.0	64	7.3	79	7.1	72
SE			±0.1	±2.6	±0.3	±3.2	±0.3	±3.5	-	-
Mean			8.0	77	7.0	63	7.3	77	6.7	68
CV (%)			3	5	7	9	7	8	-	-

1. LSS = Leaf spot severity (1–9 scale where 1 = Most resistant, and 9 = Most susceptible); DF = Percentage of defoliation.
2. Figures in parentheses are calculated means.

planted 2 weeks earlier between plots and around the trial as spreader rows. The four fungicides evaluated were a formulation of thiophanate methyl + maneb, (70% WP Labilite® 2 g L^{-1}), benomyl (50% WP Benlate® 2 g L^{-1}), chlorothalonil (500 Bravo® 3 mL L^{-1}), and mancozeb (80% WP Dithane® M 45 2.5 g L^{-1}). Citowett® (100% alkylanyl polyglycol ether), a spreading and sticking formulation, was added at the rate of 2.5 mL (10 L)$^{-1}$ to enhance effectiveness of the fungicides. These were applied as water-based sprays, using a knapsack sprayer. Control plots were sprayed with water and Citowett®. Sprays were first applied at about 60 days after sowing (DAS) and twice thereafter at 15-20 day intervals. Only two sprays of benomyl were applied during 1985-86 to confirm its favorable cost effectiveness: disease control ratio as observed from the first season's results. Disease severity scores and percentage of defoliation were recorded before each spray and again at 2 weeks before harvest. Yield and yield components were also recorded. Economic analysis of the benefit of fungicide application was based on seed and fungicide prices in Zambian Kwacha (ZK) for each year.

The spreader rows of Natal Common provided a uniform disease pressure to all the test plots in both seasons. The damage caused by ELS was very severe, while LLS was low to moderate in severity. The two seasons' mean results are summarized in Table 3.

All fungicide treatments reduced disease severity significantly over the control. Benomyl gave an excellent control of the disease, followed by chlorothalonil, thiophanate methyl + maneb, and mancozeb: percentage of defoliation also followed this trend. The present results on the efficacy of benomyl and chlorothalonil are in confirmity with earlier findings (Raemaekers and Preston 1977; Subrahmanyam et al. 1984). The new fungicide, thiophanate methyl + maneb (Labilite®), was tested on groundnut for the first time and was as effective as chlorothalonil in controlling leaf spots, but at a lower cost.

All the fungicide treatments increased seed yields significantly. Benomyl, which controlled the disease most effectively, produced the greatest yield increase (111%) in comparison to the control. Chlorothalonil gave 87% increase in yield over the control, thiophanate methyl + maneb a 77% increase, and mancozeb a 46% increase. Several earlier workers have recommended six to eight applications of fungicides, starting from the first appearance of symptoms, at intervals of 10-14 days until 2-3 weeks before harvest (Flower and McDonald 1981; Smith and Littrell 1980; Salako 1985). The present study clearly indicates that under Zambian conditions two to three applications of any of the fungicides tested are sufficient to greatly reduce disease severity to acceptable levels and consequently to increase the seed yield. The fungicide-treated plots produced larger and healthier seeds than the control. Benomyl, chlorothalonil, and thiophanate methyl + maneb sprays resulted in an increased overall net return of about ZK 1000 ha^{-1} over the control. Thiophanate methyl

Table 3. Effects of application of fungicides on leaf spots, yield, and net benefit on groundnut (cv Chalimbana) at Msekera Regional Research Station, Zambia (means of 1984/85 and 1985/86).

Treatment[1]	Leaf spot severity (1-9)	Defoliation (%)	100-seed mass (g)	Seed yield (t ha^{-1})	Percentage over control	Net return (ZK ha^{-1})	Net benefit per ZK[2] spent on fungicide
Benomyl	3.1(a)[3]	35(a)	91(a)	2.173(a)	111	2641(a)	3.28(b)
Chlorothalonil	4.5(b)	43(b)	90(a)	1.980(b)	87	2525(a)	3.40(b)
Thiophanate methyl + maneb	5.5(c)	47(b)	85(b)	1.866(b)	77	2480(a)	4.88(a)
Mancozeb	7.5(d)	68(c)	82(bc)	1.538(c)	46	2096(b)	4.63(ab)
Control	8.5(e)	77(a)	79(c)	1.041(d)	-	1508(c)	-
SE	±0.2	±1.4	±1.5	±0.058	-	±79.4	±0.46
Mean	5.8	54	86	1.720	80	2250	4.05
CV (%)	8	7	4	10	-	10	32

1. All fungicides were applied thrice during each season, except for benomyl, which was sprayed twice in 1985-86.
2. Zambia Kwacha.
3. The figures followed by same alphabets (a,b,c,d,e) are not statistically different.

Table 4. Response of groundnut cultivars to thiophanate methyl + maneb (Labilite®) spray for control of leaf spots in farmers' fields in the Eastern Province, Zambia, 1985/86 and 1986/87.

Cultivar	1985/86[1]				1986/87[2]				Mean seed yield (t ha⁻¹)		Percentage over control
	Seed yield (t ha⁻¹)		Defoliation 20 DAS[3](%)		Seed yield (t ha⁻¹)		Defoliation 20 DAS[3](%)				
	C[4]	L[5]	C	L	C	L	C	L	C	L	
Chalimbana	1.315	1.766	46	36	1.003	1.336	44	44	1.159	1.551	34
Makulu Red	1.849	2.216	40	33	1.122	1.302	46	42	1.486	1.759	18
MGS 2	1.630	2.022	41	36	1.166	1.550	41	42	1.398	1.786	28
Egret	1.690	1.939	41	35	(1.135)*	(1.402)	(45)	(42)	1.413	1.671	18
Copperbelt Runner	1.247	1.593	47	38	(1.135)	(1.403)	(45)	(42)	1.191	1.498	26
4a 8 2	(1.546)	(1.907)	(43)	(36)	1.248	1.421	47	38	1.397	1.664	19
SE (Treatment)	±0.039		±0.6		±0.043		±1.4		-	-	-
SE (Varieties)	±0.051		±1.0		±0.050		±2.0		-	-	-
Mean	1.69		39		1131		43		1.341	1.655	24
CV (%)	24		17		22		21		-	-	-

1. Mean results from 11 farmers' trials
2. Mean results from four farmers' trials.
3. DAS = Days after spraying.
4. Control, nonsprayed.
5. Thiophanate methyl + maneb (Labilite®) one spray (2 kg ha⁻¹ in 1000 L water) at about 75 days after sowing.
6. Figures in parentheses are calculated means.

+ maneb gave the maximum net benefit of ZK 4.88 per ZK 1 spent on the fungicide.

Thiophanate methyl + maneb, because it was more economical, was tested in several on-farm trials and on several improved groundnut cultivars during 1985/86 and 1986/87 groundnut-growing seasons. In each season, the fungicide was sprayed once around 75 DAS at the rate of 2 kg of 70% WP Labilite® in 1000 L water ha⁻¹. Results are summarized in Table 4.

One application of thiophanate methyl + maneb at a critical stage of leaf spot development across cultivars resulted in good control of the disease and increased mean seed yield by 24%. The varieties differed in their yield response to disease control in proportion to their susceptibility (Subrahmanyam et al. 1983). Since the field performance of the fungicide thiophanate methyl + maneb has been consistently beneficial in both on-station and on-farm trials, it seems it can be dependably recommended to farmers for economic returns in areas of Zambia where leaf spot causes serious yield losses to groundnut.

Effect of Cultural Measures on ELS Severity

Leaf spot severity was estimated in different treatments of agronomic trials conducted at Msekera during the 1985/86 and 1986/87 groundnut-growing seasons.

On the date-of-planting trials, disease severity and percentage of defoliation were recorded on cv MGS 2 planted in late November, or in early and late December. The results are summarized in Table 5.

The data indicated that groundnuts planted in late December had significantly lower disease severity (6.5) and a lower percentage of defoliation (64%) in comparison with those planted earlier, when leaf-spot severity (8.0) and percentage of defoliation (84%) were high.

Similar observations were made in plots of a groundnut intercropping trial. There were no significant differences in leaf spot severity between sole crop groundnuts and those intercropped with maize, sorghum, pigeonpea, sunflower, or cotton. Sim-

Table 5. **Effect of time of planting on the leaf spot severity of groundnut (cv MGS 2), Msekera Regional Research Station, Zambia, 1985/86.**

Time of planting	Leaf spot severity (1-9 scale)[1]	Defoliation (%)
Late November	8.0	84
Early December	8.3	76
Late December	6.5	64
SE	±0.2	±0.8
Mean	7.6	75
CV (%)	10	5

1. Scored on a 1-9 scale, where 1 = Most resistant, and 9 = Most susceptible.

ilarly, Subrahmanyam et al. (1983) did not find differences in LLS development or severity in groundnuts when grown as an intercrop with pearl millet or sorghum. Plant density (ranging from 44000 to 222000 plants ha^{-1}) did not affect leaf spots severity in a trial that included the cultivars 4a/8/2 and Sigaro Pink 35. It appears that these cultural practices are not a method of controlling leaf spots in groundnuts.

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Discussion

Ismael: You have mentioned intercropping as a means to reduce disease infection. Has anyone measured this beneficial effect of intercropping?

Kannaiyan: I have not observed reduction in disease, particularly of ELS while comparing pure stand and intercropped groundnut. For rust, there is one report of some reduction in disease incidence.

Lutaladio: In your cultural practices to control leaf spots, you found that late planting resulted in less leaf spot severity and low percentage of defoliation. How do you correlate this with climatic factors, such as rainfall and temperature?

Kannaiyan: Late-planted groundnuts are exposed to less rains and slightly higher temperatures in March/April that are unfavorable conditions to LLS, and especially so to ELS. Because of these weather factors, the leaf spot severity and percentage of defoliation are significantly lower in late-planted groundnut than in the early-planted crop.

Some Aspects of Breeding for Resistance to Leaf Spots in Groundnuts

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Abstract

*Early leaf spot (*Cercospora arachidicola*) and late leaf spot (*Phaeoisariopsis personata*) are major diseases that reduce groundnut yields. Despite breeding efforts for many years, few groundnut cultivars have been released for their resistance to leaf spots. This paper discusses some of the problems, current methods, the progress made, and the future potential in breeding for resistance to leaf spots in groundnuts.*

Sumário

Alguns Aspectos do Melhoramento para a Resistência das Manchas Foliares no Amendoim. *A mancha temporã (*Cercospora arachidicola*) e a mancha tardia (*Phaeoisariopsis personata*) são doenças importantes na redução do rendimento do amendoim. Contráriamente aos esforços feitos no melhoramento durante muitos anos, apenas poucos cultivares foram libertados pela sua resistência às manchas foliares. Este artigo discute alguns dos problemas, métodos correntes, o progresso feito e o futuro potencial no melhoramento para a resistência às manchas foliares no amendoim.*

Introduction

Early leaf spot caused by *Cercospora arachidicola* Hori and late leaf spot caused by *Phaeoisariopsis personata* (Berk. & Curt.) v. Arx are the two major foliar diseases reducing groundnut yields wherever they are grown (Subrahmanyam et al. 1980). Predominance of either pathogen depends on the prevailing climatic conditions. In Zimbabwe, the more dominant of the two pathogens is *C. arachidicola* (Cole 1981, 1985). Web blotch caused by *Didymella arachidicola* (Chock) Taber, Pettit & Philley is also a major foliar disease in Zimbabwe especially on the long-season crops. This paper focuses on *C. arachidicola* and *P. personata*.

Late leaf spot is potentially the more devastating disease because it produces many more spores than *C. arachidicola*. However, in Zimbabwe, *P. personata* occurs in trace amounts in most groundnut-producing areas and to date has had no significant effect on groundnut yields. Yield losses because of the two leaf spots have been estimated at 15-50% under nonsprayed conditions (Smith 1984; Subrahmanyam et al. 1985). In Zimbabwe, the current costs of leaf spot control on long-duration irrigated groundnuts is estimated at Z$150 ha^{-1}. However, there was no response to spraying short-duration (sequential) types during the drier years in Zimbabwe (Hildebrand 1987). Resistant or partially resistant cultivars, if used, would reduce production costs and improve gross margins.

Shifts in the dominance of leaf spots from *C. arachidicola* to *P. personata* in southeastern USA have been reported in recent years (Jackson 1981) and could potentially occur in Zimbabwe and else-

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where in the SADCC region. This shift has been partially attributed to widespread use of cv Florunner, which is very susceptible to *P. personata* but has some resistance to strains of *C. arachidicola* in southeastern USA (Smith 1980).

Breeding for Resistance

Breeding for resistance to *C. arachidicola* and *P. personata* is a major objective in groundnut breeding programs (Nigam et al. 1980; Knauft et al. 1987). Sources of resistance to *C. arachidicola* and *P. personata* have been reported in *Arachis hypogaea* (Abdou et al. 1974; Foster et al. 1981; Subrahmanyam et al. 1983). However, the levels of resistance are low (McDonald and Raheja 1978). Partial resistance to *C. arachidicola* and *P. personata* has also been reported in groundnuts (Nevill 1981; Pixley 1985). No immune cultivars have been found in the cultivated groundnut (Gibbons 1966; Garren and Jackson 1973; Nevill 1979).

Genotypes immune to *P. personata* have however been reported among the wild species (Sowell et al. 1976; Foster et al. 1981; Gibbons 1987). Using compatible resistant *Arachis* wild species, high-yielding interspecific tetraploid lines with some resistance to *P. personata* and to rust (*Puccinia arachidis* Speg) in groundnuts have been produced at ICRISAT Center (Gibbons 1987). In the 1983/84 season, 35 stable tetraploid groundnut derivatives were planted in single nonreplicated 3-m progeny row plots at the Harare Research Station and evaluated for resistance to *C. arachidicola*. None of the 35 lines showed resistance to *C. arachidicola* but many of them retained more of their leaves for 10 or more days longer than the susceptible local controls, cvs Egret and Flamingo. Several stable tetraploid derivatives were tested for resistance to *C. arachidicola* at Chitedze in Malawi and no appreciable resistance to *C. arachidicola* was found (K.R. Bock, SADCC/ICRISAT Groundnut Improvement Program, personal communication).

Screening methods

Various methods have been used in screening for resistance to leaf spot. Various components of resistance to leaf spot that contribute to resistance have been defined. These include, lesion count per leaf, percentage of leaf necrotic area, lesion size, latent period, and amount of spore production. Slow leaf spotting has also been shown in some groundnut genotypes (Watson 1987). High levels of some components of resistance to *P. personata* in certain genotypes have been reported (Chiteka 1987). All genotypes tested were of the alternate-branching type. Specific leaves were tagged at 40–45 days after sowing (DAS) and inoculated with a standardized suspension of *P. personata* conidia. The components reported in this paper are latent period, measured as the number of days from inoculation to the first two lesions sporulating, lesion diameter in mm, measured at 35 days after inoculation, and the amount of sporulation, rated using a 1–5 scale (Subrahmanyam et al. 1983), where 1 = Little or no sporulation, and 5 = Stromata over most of lesion with profuse sporulation. Levels of resistance among some of these genotypes are shown in Table 1. Resistance to *P. personata* was also rated at 120 DAS in the field, using a 1–10 scale where 1 = Little or no disease, and 10 = Dead plants.

Latent period was negatively correlated with lesion diameter ($r = -0.620$) indicating that a longer latent period was associated with smaller lesions. Similarly, a longer latent period was associated with reduced spore production ($r = -0.811$). Lesion diameter was positively correlated with amount of spore production ($r = 0.708$); thus reduced spore production was associated with smaller lesions.

Latent period was negatively correlated with plant-appearance score ($r = -0.716$), indicating that genotypes with longer latent periods had less disease at 120 DAS. Lesion diameter and amount of spore production were positively correlated with plant appearance score. Genotypes with larger lesions and more spore production had more disease at 120 DAS. The results suggest that the plant-appearance score rating isolated genotypes with higher levels of these three components. In practice, the rating is quicker and easier to use when rating large numbers of lines.

Correlations among the components with yield per plant were low but highly significant ($P < 0.01$). This suggests that the more resistant genotypes have higher yields but other more important environmental factors affected yield in this field environment.

Table 2 shows the results of stepwise regression of plant-appearance score on components of resistance. The partial regression coefficients indicated that latent period, lesion diameter, and amount of spore production were the most important components affecting total visible late leaf spot on plants at

Table 1. Components of resistance to late leaf spot on some selected groundnut genotypes rated in the field at Dozier Boys' School, Marianna, Florida, USA, 1986.

Genotype/ Identity	Latent period (days)	Lesion diameter (mm)	Amount of sporulation[1]	Plant appearance score (1-10)[2]
UF 81206	38.1	1.8	1.2	2.0
PI 203396	27.2	2.2	1.5	3.0
Makulu Red	25.6	2.7	1.9	3.5
Egret	28.2	2.4	2.9	3.5
Southern Runner	19.4	2.7	2.2	3.5
Florunner	18.5	2.7	4.5	9.0
Mean (n=105)	20.9	2.6	3.0	4.8
LSD (0.05)[3]	6.1	0.6	1.0	2.8

1. Rated on 1-5 scale, where 1 = Little or no sporulation and 5 = Stromata over most of lesions with profuse sporulation.
2. Field score, where 1 = Little or no disease and 10 = Dead plants.
3. SE not available.

Table 2. Intercepts and B values for stepwise regression of components of resistance, amount of sporulation (SSC), latent period (LP), and lesion diameter (LD), on plant appearance score in the field at Dozier Boys' School, Marianna, Florida, USA, 1986.

Step	Regression coefficient	SE	MSS	F
Step 1: Sporulation score (SPS)				
Intercept	2.30			
SSC	0.80	±0.07	80.42	126.19***
Step 2: SPS + LP (LS_1)				
Intercept	4.50			
LP	0.073	±0.03	4.83	8.10**
SSC	0.54	±0.11	13.34	22.38***
Step 3: SPS + LS_1 + lesion diameter (LD)				
Intercept	3.09			
LP	-0.06	±0.03	3.99	6.91**
SSC	0.42	±0.13	6.29	10.89***
LD	0.54	0.26	2.44	4.23*

120 DAS. These three components accounted for 60% of the total leaf spot but the amount of spore production alone accounted for 55% of the total leaf spot observed on genotypes at 120 DAS. Other components rated on these genotypes were percentage of leaf-necrotic area and lesion count. These were less consistent in rating genotypes for resistance in different environments.

Resistant cultivars

Some groundnut cultivars with partial resistance to leaf spots have been reported. Gorbet et al. (1986) reported a cultivar (Southern Runner) with partial resistance to *P. personata* in Florida. It yields significantly better than the susceptible cv Florunner, without spraying to control *P. personata*. Its yield equals that of Florunner when sprayed to control leaf spots. However, Southern Runner takes an average of 5–7 days longer to mature than Florunner the susceptible control cultivar, which is grown widely in the southeastern USA. Partial resistance to *C. arachidicola* has been reported for the cv NC 5 in North Carolina (Johnson et al. 1986). This cultivar showed a reduced area under disease progress curve (AUDPC), lower percentage of infected leaflets, and lower percentage of defoliation than the susceptible control 'Florigiant'. Southern Runner and NC 5 belong to the virginia botanical group. Tolerance to *C. arachidicola* in the form of better leaf retention has been reported for the genotype ICGMS 30 at Chitedze in Malawi (Bock 1987). Fewer sequential type groundnut cultivars with appreciable levels of tolerance of leaf spots have been reported. Sequential types yield better than long-season alternate branching types in the lower-rainfall areas of Zimbabwe. It would be desirable to have tolerance of or resistance to leaf spots in the short-duration sequential types.

Mechanisms of Resistance

Few attempts have been made at explaining the mechanisms of resistance to *C. arachidicola* and *P. personata*. Abdou et al. (1974) stated that resistance to *P. personata* in some cultivated types was associated with the production of pectic substances ahead of the developing fungus. A knowledge of resistance mechanisms may have a bearing on screening methods in selecting for resistance.

Prognosis

The search for resistance to leaf spot is with the view to reduce yield losses caused by these leaf spot fungi. Partial resistance to leaf spots has been found mainly among alternate branching types. Although the inheritance of resistance to leaf spot has not been fully worked out, it should be possible to transfer characteristics like reduced spore production and prolonged latent period across different botanical groups. The search for resistance among sequential types has not been exhaustive. These yield more than alternate types in the more marginal areas, found often in the semi-arid tropics and in the SADCC region. More success has so far been made in transfer of resistance to *P. personata* and rust from wild species to the cultivated species but little success has so far been realized with *C. arachidicola*. Work has also shown differences in strains of *C. arachidicola* and *P. personata* from different geographical areas. Resistance should therefore be confirmed in each geographical area before parents are selected for use in crossing programs. In developing resistance programs, it is important to ensure that levels of resistance to both *C. arachidicola* and *P. personata* are low and that appropriate ratings are done at the right time to ensure identification of genotypes with resistance.

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Discussion

Nigam: Did you say that resistance to late leaf spot (LLS) in spanish and valencia types was low? As much as 90-95% sources of resistance reported from ICRISAT Center belong to the *fastigiata* group and have fairly good level of resistance to LLS and rust. Since USA mainly grows *hypogaea* types, the screening is biased in favor of these types in locating resistance.

Ismael: Of the three parameters mentioned (lesion diameter, latent period, and degree of sporulation) to measure disease resistance, which one was more heritable?

Chiteka: No studies were undertaken on this aspect. It was variable elsewhere.

Resistance to Early Leaf Spot of Groundnut

F. Waliyar[1], D. McDonald[2], S.N. Nigam[3], and P.V. Subba Rao[4]

Abstract

*Research on various aspects of early leaf spot (*Cercospora arachidicola*) disease, including evaluation methods of host resistance, is reviewed. Some recent findings from research in India by the International Crops Research Institute for the Semi-Arid Tropics are summarized. Greenhouse and laboratory resistance screening methods have been used to supplement field trials. Future strategies are outlined to identify new sources of resistance to the disease.*

Sumário

Resistência às Manchas Foliares no Amendoim. *Investigação sobre os vários aspectos da mancha temporã (*Cercospora arachidicola*), incluindo os métodos de avaliação da resistência do hospedeiro, são revistos. Alguns recentes avanços da investigação na India feita pelo ICRISAT (Instituto Internacional para a Investigação de Culturas para o Trópico Semi-Arido) são sumarizados. Métodos de estufa e laboratório para a avaliação de resistência têm sido usados, para complementar ensaios de campo. Futuras estratégias são delineadas para identificar novas fontes de resistência à doença.*

Introduction

Early leaf spot, caused by *Cercospora arachidicola* Hori, is one of the most serious diseases affecting groundnut (*Arachis hypogaea* L.) production worldwide. Leaf spots damage the plant by reducing the leaf area available for photosynthesis and by stimulating leaflet abscission leading to heavy defoliation (McDonald et al. 1985). Early leaf spot and late leaf spot [*Phaeoisariopsis personata* (Berk. & Curt.) v. Arx] together cause groundnut pod yield losses ranging from 10% to 60% in many areas of the world, the loss varying from place to place, and between seasons (Jackson and Bell 1969; McDonald et al. 1985; Cummins and Smith 1973; Ghuge et al. 1981).

More time has been devoted by plant pathologists to the management of early and late leaf spots than to any other groundnut disease problem (Jackson and Bell 1969), and considerable information is available on control with fungicides (Porter 1970; Smith and Crosby 1972; Cummins and Smith 1973; Mercer 1974; Lyle et al. 1977; Mohan and Mathur 1980; Smith and Littrell 1980; Fowler and McDonald 1981; Gorbet et al. 1982). Though fungicidal control of leaf spots is effective and economical in many developed countries, its application is limited in most developing countries by the high costs of application machinery and fungicides and by lack of

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technical skills. Indiscriminate use of fungicides for leaf spots control may result in undesirable effects such as increased severity of sclerotinia blight when chlorothalonil is used against foliar diseases (Smith 1984). It is obvious that the most effective and economical means of leaf spots control would be to grow resistant cultivars.

Screening of groundnut germplasm for resistance to the leaf spots is in progress in research institutions in several countries and genotypes with resistance to early leaf spot or to late leaf spot diseases have been identified (McDonald et al. 1985). However, there has been only limited success in identifying and utilizing resistance to early leaf spot, and the stability of the resistances so far identified has still to be established. This paper discusses various aspects of the identification and evaluation of resistance in groundnut to the early leaf spot pathogen, and summarizes some recent findings from research in India by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

Evaluation of Resistance

A wide range of criteria have been used by different workers to evaluate leaf spot resistance (Sowell et al. 1976; Melouk and Banks 1984; Gobina et al. 1983). Gobina et al. (1983) showed that 'sporulation' was an important criterion when there were no significant differences in lesion numbers, while Anderson (1985) used an index which incorporated necrotic area, latent period, and degree of sporulation. Sowell et al. (1976) evaluated resistance using defoliation and disease-index parameters. Foster et al. (1981) found the number of lesions and percentage defoliation most useful for assessing resistance to early leaf spot. Hassan and Beute (1977) showed that the defoliation ratio and the visual estimation of percentage of leaves with leaf spots were efficient and reliable evaluation criteria, especially when large numbers of entries were tested. Smith and Littrell (1980) reviewed various disease assessment methods and concluded that visual rating on a 1-10 or 1-5 scale to estimate leaf area affected by disease and/or defoliation was less time consuming than the main-stem method. At ICRISAT Center, a visual 9-point scale has been used for preliminary screening of germplasm for early leaf spot resistance, but in recent investigations 'leaf defoliation' has been found to be the most important parameter for estimation of disease resistance, as abscission can be induced in several genotypes by the presence of a single lesion.

Based on the above criteria, effective field and laboratory resistance screening techniques have been developed and used in several countries and a number of sources of resistance to early leaf spot have been reported (Table 1).

The nature of resistance

Resistance has been attributed to various morphological and anatomical characteristics of the host

Table 1. Thirty-six groundnut genotypes identified resistant (elsewhere)[1] to *Cercospora arachidicola* and their performance at ICRISAT Center.

Genotype identity	Disease reaction at ICRISAT Center	Genotype identity	Disease reaction at ICRISAT Center
NC 5	R[2]	PI 276233	-[2]
NC 3033	S[2]	PI 276235	-
AC 3139	-[2]	PI 109839	-
FESR 5-P2-P1	-	PI 162857	-
NC Ac 3139	-	PI 259679	-
Kanyoma	-	PI 350680	?[2]
Tifton 8	-	PI 259747	S
VGP 2	-	PI 270806	S
VGP 3	-	PI 259639	-
VGP 4	-	PI 468251 (BPZ 56)	-
VGP 5	-	PI 468253 (BPZ 5B)	-
VGP 6	-	PI 468293 (BPZ 96)	-
VGP 7	-	PI 468295 (BPZ 98y)	-
PI 261893	-	PI 475871 (GKPSc 224)	-
PI 306230	-	PI 476029 (SPA 417)	-
PI 270680	-	PI 476034 (SPA 422)	-
PI 196652	-	PI 196604	-
PI 306222	-	PI 196677	-

1. Abdou 1966, Anderson 1985, Foster et al. 1980, Hammons et al. 1980, Hassan and Beute 1977, Kornegay et al. 1980, Melouk and Banks 1978, Sowell et al. 1976.
2. R = Resistant; S = Susceptible; ? = Reaction variable at different locations; - = Not tested at ICRISAT Center.

plant, and to chemical constituents of leaves (Stalker 1984). Hemingway (1957) observed a positive correlation between the size of the stomatal aperture and the susceptibility of groundnuts to *C. arachidicola*, and his observations were confirmed by D'Cruz and Upadhyaya (1961). Gibbons and Bailey (1967) also observed a correlation between resistance in field-grown *Arachis* species and the sizes of their stomatal apertures. Hassan and Beute (1977) considered that while stomatal size changes occurred because of changes in growth environments, decreased stomatal aperture did not appear to be the mechanism for increased resistance in the entries studied. Mazzani et al. (1972) studied the field incidence of leaf spot diseases and concluded that genotypes with greater stomatal length were not more affected by the diseases than those with smaller stomatal lengths. Abdou (1966), working with wild *Arachis* species, found no orientation in the growth of germ tubes toward stomata in immune entries, but he did observe stomata-oriented germ-tube growth on leaf surfaces of susceptible genotypes. He also observed the formation of barriers by cell-wall swelling, thickening, and the deposition of presumed peptic substances to be a response to infection in resistant genotypes.

Miller (1953) found that resistance to leaf spots was related to high riboflavin content of seeds. This point has apparently not been investigated by other workers. A recent study of groundnut phytoalexins by Strange et al. (1985), reported the isolation of an antifungal compound called 'Medicarpin' (3-hydroxy-9 methoxypterocarpan), which accumulates to toxic proportions after infection by either *C. arachidicola* or *Phoma arachidicola*. Phytoalexins are generally believed to play important roles in host resistance (Keen 1986; Strange 1987).

Components of Resistance

An understanding of how the components of resistance operate is required to estimate their relative importance in evaluating the resistance, and to explore means of enhancing it.

The known components of resistance to the early leaf spot pathogen include: number of lesions per leaflet, lesion diameter, latent period, time to leaflet loss, and degree of sporulation. Foster et al. (1980) suggested that latent period could be useful in selection of groundnut lines resistant to early leaf spot. Ricker et al. (1985) emphasized the need to determine which components of the resistant genotypes differ quantitatively from those of susceptible genotypes and whether components are the same for all resistant genotypes. Many authors have studied multiple components of resistance in groundnut (Foster et al. 1981; Melouk and Banks 1984; Nevill 1981); but their studies did not include both field and greenhouse data on components of resistance. Nevill (1981) and Ricker et al. (1985) observed significant genotypic differences in lesion numbers. Ricker et al. (1985) concluded that the lesion number was greatly influenced by environment and therefore an unreliable means to evaluate genotypes in the greenhouse. They observed significant cultivar differences for other parameters, i.e., latent period, time until leaflet loss, and degree of sporulation. They also suggested a previously undescribed, but useful, component of resistance they named MPLS (maximum percentage of lesions sporulating) to be used in selection for resistance in groundnut.

Once the relative importance of the components contributing to the development of epidemics is known, they could possibly be fitted into a dynamic model (Zadoks 1972; Parlevliet 1975; Savary 1986) to predict the progression of epidemics and to evolve disease-management strategies accordingly. Another use for this knowledge would be to breed groundnut varieties for the component having maximum influence on reduction of epidemic buildup.

Recent Research by ICRISAT on Resistance to Early Leaf Spot Disease

At ICRISAT Center, Patancheru, India, early leaf spot is always present but its incidence and severity are usually very low, and the damage it causes is normally masked by the regular and severe epidemics of late leaf spot and rust. Success in identifying resistance to late leaf spot and rust and the incorporation of these resistances into agronomically acceptable cultivars has led to increasing priority being allocated to similar work on early leaf spot. This has necessitated arrangement for field screening facilities at a location in India where early leaf spot occurs regularly and causes severe damage. Pantnagar, in northern India, fulfils this requirement and a field resistance screening project was started there in 1987 in collaboration with the G.B. Pant University of Agriculture and Technology.

During the 1987 rainy season, replicated field trials were carried out at both ICRISAT Center and Pantnagar to screen large numbers of germplasm accessions, breeding lines, and interspecific hybrid derivatives for resistance to foliar diseases. An "infector row" or "spreader row" technique (Melouk and Banks 1984; McDonald et al. 1985) was used, test entries being sown in replicated plots with rows of a susceptible cultivar being arranged systematically throughout the trials to enhance inoculum pressure. The infector row plants were sprayed with a suspension of *C. arachidicola* conidia and sprinkler irrigation was provided as required to maintain conditions conducive to disease buildup.

Early leaf spot appeared at the usual time in Pantnagar and the epidemic built up to a level that permitted effective evaluation of the test entries for resistance to the disease. Unexpectedly, early leaf spot was unusually severe on groundnuts at ICRISAT Center in the 1987 rainy season and the usual attacks of rust and late leaf spot did not materialize, these diseases appearing only very late in the cropping season and doing little damage. Therefore, it was possible to evaluate the trial entries and nearly 3000 genotypes in other experiments on the farm for resistance to the early leaf spot disease.

Several genotypes showed moderate levels of resistance to early leaf spot at both Pantnagar and ICRISAT Center (Table 2), and will again be tested in the 1988 rainy season. Thirty-eight of the lines

Table 2. Reaction to early leaf spot of 14 selected groundnut germplasm and breeding lines for resistance to early leaf spot, Pantnagar and ICRISAT Center, rainy season 1987.

Line	Identity	Reaction to early leaf spot[1]: ICRISAT Center	Reaction to early leaf spot[1]: Pantnagar
ICG 1703	NC Ac 77127	4.7	-
ICG 2711	NC 5	4.5	4.6
ICG 6284	NC Ac 17500	5.0	-
ICG 6349	NC Ac 1121	3.6	5.0
ICG 6709	NC Ac 16163	3.6	4.3
ICG 7291	PI 262128	3.0	4.8
ICG 7406	PI 262121	3.0	5.0
ICG 7630	204 66	4.8	4.8
ICG 7878	NC Ac 10811A	5.0	-
ICG 7892	PI 393527-B	4.1	4.0
ICG 9990	US 409 (Flesh)	5.0	4.5
ICG 10040	PI 476176 (SPZ 451)	5.0	-
ICG 10946	PI 476176	5.0	-
ICGV 86690		5.0	5.0
SE[2]		±0.48	-
CV (%)[2]		7.0	-

1. Field disease scored on a 1 9 scale, where 1 = No disease, and 9 = 50 100% foliage destroyed.
2. The SE and CV (%) presented represent the values for all genotypes tested.

Table 3. Field reaction of 10 selected groundnut germplasm lines showing multiple resistance to early and late leaf spots and to rust at ICRISAT Center, rainy season 1987.

Line	Identity	Disease reaction[1]: Early leaf spot	Disease reaction[1]: Late leaf spot	Disease reaction[1]: Rust
ICG 1703	NC Ac 17127	4.7	5.0	4.7
ICG 6284	NC Ac 17500	5.0	7.0	3.3
ICG 7340	198 66 Coll. 182	5.7	5.1	2.7
ICG 9294	58-295	5.1	6.0	2.7
ICG 10010	PI 476143	5.7	5.1	4.1
ICG 10040	PI 476176	5.0	4.7	3.7
ICG 10900	PI 476033	5.3	4.7	4.1
ICG 10946	PI 476176	5.0	6.0	4.1
ICG 799	Robut 33-1	8.0	7.0	7.0
ICG 221	TMV 2	8.0	8.0	8.0
SE[2]		±0.48	±0.7	±1.1
CV (%)[2]		7.0	10.7	22.3

1. Field disease scored on a 1 9 scale, where 1 = No disease, and 9 = 50 100% foliage destroyed.
2. The SE and CV (%) presented represent the values for all genotypes.

showing resistance were sent to be tested by the SADCC ICRISAT Regional Groundnut Improvement Program, Chitedze Research Station, Lilongwe, Malawi, where early leaf spot is consistently a major disease problem.

Eight of the genotypes found to have resistance to early leaf spot are also resistant to rust and late leaf spot diseases (Table 3), and could be useful in breeding for multiple disease resistance.

Because the occurrence of early leaf spot disease at ICRISAT Center is unreliable, greenhouse and laboratory resistance screening methods have been used to supplement field trials. These studies have been carried out on potted plants (greenhouse) and on rooted detached leaves (laboratory) using techniques previously reported (Nevill 1981; Subrahmanyam et al. 1983; McDonald et al. 1985). Similar methods are being used to study components of resistance.

Looking to the future, it is evident that increased efforts are required to identify new sources of resistance to early leaf spot and to integrate these with resistances to rust and late leaf spot and other important diseases and pests into agronomically acceptable and agroecologically adapted groundnut cultivars. Stability of resistance will have to be established, and investigations are required into the possible existence of physiological races of *C. arachidicola*. Integrated disease management procedures will have to be established and the breeding of foliar diseases resistant cultivars should provide the basis for these. It will be necessary for breeders, cytogeneticists, pathologists, and physiologists from different countries to work closely together according to planned strategies to achieve success.

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Field Control of Groundnut Foliar Diseases by Fungicides in Tanzania

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Abstract

*Groundnut crops in Tanzania are affected by early leaf spot (*Cercospora arachidicola *Hori), late leaf spot (*Phaeoisariopsis personata*), and rust (*Puccinia arachidis*). While efforts continue to find fungal foliar disease resistant varieties, the author undertook a 3-year study on chemical control of the diseases as a short-term solution. Five fungicides were used. All five reduced disease severity and increased seed yield over the control. Among the five fungicides, the first choice of the study was chlorothalonil (Daconil® 2787-W 75).*

Sumário

Controlo de Campo das Manchas Foliares do Amendoim com Fungicidas na Tanzania. *O amendoim na Tanzania é afetado pela mancha temporã (*Cercospora arachidicola *Hori), pela mancha tardia (*Phaeoisariopsis personata*) e pelo ferrugem (*Puccinia arachidis*). Enquanto se continua a fazer esforços para encontrar variedades resistentes aos fungos das manchas foliares, o autor realizou um estudo de três anos, sobre o controlo químico das doenças como solução de curto prazo. Cinco fungicidas foram usadas. Qualquer dos cinco reduziu a severidade da doença e aumentou os rendimentos em relação ao controlo. Das cinco fungicidas, a primeira escolha do estudo caiu sobre o clorotalonil (Daconil® 2787-W75).*

Introduction

Early leaf spot caused by *Cercospora arachidicola* Hori, late leaf spot by (*Phaeoisariopsis personata*), and rust by *Puccinia arachidis* Speg. are the most important fungal foliar diseases of groundnut (*Arachis hypogaea* L.) in Tanzania. Rust appears at almost the same time as early leaf spot, 4 weeks after seedling emergence followed by late leaf spot 7 weeks after sowing (Raya 1987). The combination of these three diseases hasten sensescence of leaves resulting in heavy defoliation (Harrison 1972). Simons (1985) indicated that crop losses because of diseases are well over 35%. The three recommended cultivars Nyota, Red Mwitunde, and Robut 33-1 are all susceptible to these diseases. While the search continues for a resistant variety, chemical control of the diseases remains the best short-term solution. A 3-year (1985 87) study was undertaken to determine suitable fungicides to control the major fungal foliar diseases of groundnut in Tanzania.

Materials and Methods

Experiments were conducted at Naliendele Research Institute, southeast Tanzania, during the 1985, 1986, and 1987 seasons. The recommended groundnut cultivar Nyota (Spancross), susceptible to all three foliar diseases was grown in a

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randomized-block design with three replications. Six treatments (including the nonsprayed control) consisted of spray applications of chlorothalonil (Daconil® 2787-W 75), chlorothalonil (Bravo 500®), triphenylstannane (Brestan®), carbendazim (Bavistin 50 WP®), and mancozeb (Dithane M45®). The rate of application was based on manufacturers' recommendations. The fungicides were applied 40-50 days after seedling emergence when the first signs of disease incidence were observed and, thereafter, weekly until shortly before harvest, giving a total of seven sprays. Infection was natural. Severity of rust and leaf spots and defoliation was assessed using a 1-9 point scale. Seed yield and its components were also recorded.

Results and Discussion

Effect of fungicide on disease severity

In all three seasons, disease incidence was severe, scoring 8-9 on nonsprayed plots. All five fungicides significantly reduced disease intensities of both leaf spots (early and late) and rust. However, chlorothalonil (Daconil® 2787-W 75) was superior over other treatments (Table 1) followed by chlorothalonil (Bravo 500®) resulting in less defoliation during all the three seasons. Mancozeb (Dithane M45®) and triphenylstannane (Brestan®) controlled rust but not leaf spots and carbendazim (Bavistin 50 WP®) controlled leaf spots but not rust.

Effect of fungicide on groundnut yield

The reduction in disease severity by fungicide application, resulted in seed-yield increases. All the five fungicides resulted in higher seed yields than the nonsprayed control plots. Controlling foliar diseases of groundnuts thus increases seed yield by 152-365 kg ha^{-1} (Table 1). Chlorothalonil (Daconil® 2787 W-75), which resulted in the most effective disease control with least defoliation, gave the highest seed yield. The next most effective fungicide was chlorothalonil (Bravo 500®). Chlorothalonil

Table 1. Effects of fungicide sprays on severity of leaf spots, rust, and yield of groundnut (cv Nyota), Naliendele Research Institute, Tanzania, three rainy seasons 1985-87. (Plot size 16 m^2).

Fungicide (concentration)	Disease severity[1] Leaf spots 1985	Leaf spots 1986	Leaf spots 1987	Rust 1985	Rust 1986	Rust 1987	Defoliation 1985	Defoliation 1986	Defoliation 1987	Seed yield (t ha^{-1}) 1985	Seed yield 1986	Seed yield 1987
Chlorothalonil (Daconil 2787-W75®) (1.7 kg ha^{-1})	2.4	2.3 (2.85)[2]	3.0	3.8	2.0 (3.0)	3.3	2.3	1.6 (1.3)	0.0	0.979	1.068 (0.881)	0.596
Chlorothalonil (Bravo 500®) (3.6 L ha^{-1})	1.1	6.6 (3.9)	4.0	2.4	6.3 (4.9)	6.0	1.0	4.6 (2.3)	2.7	1.034	0.880 (0.782)	0.513
Triphenylstannane (Brestan®) (0.6 kg ha^{-1})	4.7	7.0 (5.6)	5.0	4.8	1.0 (4.3)	7.0	3.4	2.6 (3.3)	4.0	0.728	0.900 (0.693)	0.451
Carbendazim (Bavistin 50 WP®) (2.5 kg ha^{-1})	1.3	8.0 (4.1)	3.0	5.7	8.0 (6.6)	6.0	1.3	7.6 (4.3)	4.0	0.937	0.600 (0.675)	0.488
Mancozeb (Dithan M 45®) (2.5 kg ha^{-1})	5.1	6.6 (5.5)	5.0	2.2	3.3 (3.3)	4.0	3.3	4.6 (4.3)	4.0	0.849	0.720 (0.668)	0.436
Control (nonsprayed)	8.5	9.0 (8.8)	9.0	7.8	9.0 (8.6)	9.0	7.3	8.0 (7.9)	8.6	0.581	0.492 (0.516)	0.465

1. Scored on a 1-9 scale, where 1 = Least severe, and 9 = Most severe.
2. Figures in parantheses are means of three rainy seasons.

(Daconil® 2787 W-75) resulted in 71% increase in yield over the control, while chlorothalonil (Bravo 500®) gave a 52% increase in yield. Similar reponses to fungicide application have been reported elsewhere (Vyas et al. 1986; Kannaiyan and Haciwa 1986). Seed yield in plots sprayed with triphenylstannane (Brestan®), which gave the most effective rust control, did not differ significantly from those plots sprayed with carbendazim (Bavistin 50 WP®), which controlled leaf spots but not rust. There were no yield diferences among plots sprayed with triphenylstannane (Brestan®), carbendazim (Bavistin 50 WP®), or mancozeb (Dithane M45®)

It is recommended, because of these findings, that any one of the two formulations of chlorothalonil should be used to control foliar diseases of groundnut, with the first choice being chlorothalonil (Daconil 2787® W-75).

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Discussion

Rweyemamu: I would like to comment on your conclusion. In Tanzania, we know that more than 95% of the groundnut crop is grown by small farmers. So why recommend use of fungicides, which these farmers cannot afford?

Raya: My research findings and recommendations are for commercial farmers, although I know that there are not many of those in Tanzania.

Ismael: You recommend use of chlorothalonil (Daconil® 2787 W-75) on the basis of results obtained. Have you done any economic analysis?

Raya: Economic analysis shows that if a farmer did not use any chemical control he would stand to lose financially. In brief:

With Daconil®	No chemical (control)
T.Sh 8000.00	T.Sh 15000.00
(U.S.$ 876.00)	(U.S.$1876.00)

(Approximate loss of U.S. $1000)

Lutaladio: If the recommendations you made on the use of fungicides is not applicable to small farmers, could these recommendations be made available to big farmers or seed producers. Do you have a special reason for spraying seven times? Otherwise, is this an appropriate spraying method? It could have been interesting to find out what increase in yield could be achieved by spraying once, twice, or three times at a critical period.

Raya: The recommendation indicates that spraying should be done at 7-14 days interval for maximum effect on disease control. That gives a maximum of 6-7 sprays.

Sithananthan: What was the basis of fixing the dose rate for different fungicides? This sort of study should be followed up to fix optimum numbers of sprays required, keeping in view the cost-benefit analysis.

Ndunguru: You are recommending use of fungicides to control foliar diseases in Tanzania. In practical terms, how do you see this being implemented by the small-scale Tanzanian farmers?

Reuben: The research is still valid for the large-scale farmers who will not be adversely affected by the economics involved. It is true that small-scale farmers may encounter cost-benefit problems but further research to investigate the economical impact on small-scale farmers should be done.

Effect of Abiotic and Biotic Constraints on Groundnuts Managed by Smallholder Farmers of the Lilongwe Rural Development Project, Malawi, during the 1986/87 Season

C.T. Kisyombe[1]

Abstract

Recent price increases of groundnut-production inputs necessitated the reevaluation of chlorothalonil (Daconil®)[2] *spraying on smallholder-farmer-managed groundnuts. This chlorothalonil study involved farmers who were growing commercial Chalimbana or basic Chitembana seed in Units 7 and 28 of the Lilongwe Rural Development Project. Excellent control of early leaf spot (*Cercospora arachidicola*) and pepper spot (*Leptosphaerulina crassiasca*) was achieved with chlorothalonil applications. This reduced leaf fall, leading to increased groundnut yield and improved seed quality. Drought, towards the end of the season, limited the average yield increase to 39% in treated crops over nontreated crops, while the expected yield increase was 70%. Seven out of 11 farmers obtained yields that were average or above average. The shelling percentage was good. There was an insignificant overall groundnut haulm yield increase because of spraying. Drought conditions predisposed groundnut plants to severe damage by some insect pests, such as* Hilda patruelis. *Certain abiotic and biotic diseases that are not controlled by chlorothalonil application but contribute to the reduction in yield and quality of groundnut seeds, under the smallholder farmers' conditions, are discussed.*

Sumário

Efeito de Limitantes Abióticas e Bióticas no Amendoim Manejado por Pequenos Agricultores do Projecto de Desenvolvimento Rural de Lilongwé, Maláwi, durente a estação de 1986/87. *O recente aumento dos preços dos factores de produção para a produção de amendoim, levou á necessidade de reavaliação das pulverizações com clorotalonil (Daconil®) no amendoim manejado por pequenos agricultores. Este estudo do clorotalonil envolveu agricultores, que cultivaram comercialmente Chalimbana ou semente básica de Chitembana, nas unidades 7 e 28 do Projecto de Desenvolvimento Rural de Lilongwé. Excelente controle da mancha temporã (*Cercospora arachidicola*) e da mancha de pimenta (*Leptosphaerulina crassiaca*), foi conseguido com aplicações de clorotalonil. Estas reduziram a queda das folhas, o que levou ao aumento do rendimento e da qualidade da semente. A ocorrência da seca, no fim da estação, reduziu o aumento do rendimento médio das culturas tratadas para 39% acima das não tratadas, enquanto que o aumento do rendimento esperado era de 70%. 7 em cada 11 agricultores obtiveram rendimentos*

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2. Use of trade names does not imply endorsement or criticism by the author and the Department of Agricultural Research of the Ministry of Agriculture of the products named.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1989. Proceedings of the Third Regional Groundnut Workshop, 13-18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P. 502 324, India: ICRISAT.

ao nível da média ou acima da média. A percentagem de descasque foi boa. Houve um significativo aumento geral do rendimento de massas verde devido às pulverizações. Condições de sequia predispuseram as plantas de amendoim danos severos, causados por algumas pragas de insectos, como é o caso da Hilda patruelis. *Certas doenças abióticas e bióticas, que não são controladas por aplicações de clorotalonil, mas contribuem para a redução do rendimento e qualidade da semente do amendoim nas condições dos pequenos agricultores, são discutidas.*

Introduction

Groundnuts (*Arachis hypogaea* L.) are Malawi's fourth most important export crop after tobacco, tea, and sugar. The crop is a rich protein source and provides Malawi with more than 50% of its total edible oils. Central Malawi produces more than 70% of the nation's crop. The groundnut haulms are a rich protein source when used as hay and the most abundant cattle feed found in the Lilongwe plains.

Several factors have adverse effects on groundnut production. These include:

1. Drought or unreliable rainfall;
2. Nutrient deficiencies (phosphorus, magnesium, calcium, and nitrogen because of lack of effective *Rhizobium*);
3. Delayed sowing of groundnuts;
4. Poor management of the groundnut crop;
5. Labor-intensive stripping and hand-shelling of groundnuts that limit the smallholder farmer's production;
6. Lack of farm machinery needed for timely operations; and
7. Diseases and pests.

These are the groundnut production constraints that are discussed in this paper.

Early leaf spot *(Cercospora arachidicola)* and late leaf spot *(Phaeoisariopsis personata)* can limit the crop yield by up to 50% depending on the management (Jackson and Bell 1969; Smith and Littrell 1980). Late leaf spot together with rust (*Puccinia arachidis*) are reported to decrease the groundnut yield up to 70% (McDonald et al. 1985).

Chlorothalonil (Daconil® 2787 W-75) is a contact and systemic fungicide that is currently recommended for controlling foliar fungal diseases in groundnuts (Mercer and Kisyombe 1978). Previous data for 10 seasons at Chitedze showed that chlorothalonil (Daconil®) increased the seed yield by an average of 70% over nontreated crops. Farmers profited by more than K 1000 ha^{-1} by using chlorothalonil (Daconil®). Because of the increased prices of groundnut production inputs such as seed, labor, chlorothalonil (Daconil®), and knapsack sprayers, the economics of spraying chlorothalonil (Daconil®) on groundnuts plants was reevaluated.

Materials and Methods

A random sample was made of 11 fields, each cultivated by a separate smallholder farmer within Units 7 and 28 of the Lilongwe Rural Development Project (LRDP).

These farmers had already decided to use chlorothalonil (Daconil®) during the 1986/87 season, but would be spraying only part of a continuous groundnut field.

The minimum sample area was 0.2 ha. Fields were sampled only if they had a uniform groundnut cultivar and if there were no apparent differences in growing conditions between nonsprayed and sprayed portions of the field. The fields were entirely smallholder-farmer managed throughout the growing season.

An attempt was made to visit the smallholder farmers and inspect their groundnuts every 4 weeks from early March 1987. The visits started in the middle of the growing season because this study was initiated after the 1986/87 cropping season had already started.

Chlorothalonil (Daconil®) spraying began 5 weeks after planting (about 2 weeks after emergence). Chlorothalonil (Daconil®) was sprayed on the groundnut plants at the rate of 1.2 kg ha^{-1}, using a Solo® knapsack sprayer, for each of the first two applications. The rate was increased to 1.6 kg ha^{-1} for the fourth to the sixth applications. The spraying interval was 2 weeks.

The following data were recorded:

1. Foliar fungal diseases [early leaf spot (*C. arachidicola*), pepper spot (*Leptosphaerulina crassiasca*), rust (*Puccinia arachidis*), late leaf spot

Table 1. Mean[1] disease, pest, and physical damage to groundnuts in the Lilongwe Rural Development Project Units 7 and 28, Malawi, 28–30 Apr 1987.

Cause of damage	Site number 1	2	3	4	5	6	7	8	9	10	11
	Nontreated groundnuts										
Early leaf spot[2]	9	9	9	9	9	9	9	9	9	9	9
Pepper spot[2]	9	9	5	7	7	5	7	7	8	7	4
Rust[2]	2	2	2	2	2	2	2	2	2	2	2
Late leaf spot[2]	9	9	5	6	9	5	7	9	9	9	6
Rosette virus	42	16	18	0	0	13	9	39	1	10	0
Groundnut streak necrosis virus	0	0	0	0	0	1	0	1	0	0	2
Leaf fall[2]	9	9	6	9	9	8	9	9	8	9	8
Termites	11	0	1	3	6	0	84	15	3	2	4
Hilda	0	6	2	9	8	0	13	17	22	17	3
Jassids	Severe	Mild	Slight	Severe	Mild	Slight	Mild	Severe	Mild	Slight	Slight
Thrips	0	0	0	0	0	0	0	2	2	0	1
Leaf eater	Slight	Slight	Slight	Slight	Slight	Slight	Slight	Slight	Slight	None	Slight
Alectra	38	5	0	0	0	0	0	0	9	0	0
Drought	None	None	None	None	None	None	Mild	None	None	None	None
Magnesium deficiency	None	None	None	None	None	None	None	None	None	None	None
Stinging caterpillar	None	None	None	None	None	None	None	None	None	None	None
	Chlorothalonil-treated groundnuts										
Early leaf spot[2]	8	9	9	5	9	8	7	5	9	9	5
Pepper spot[2]	5	9	7	4	7	4	6	6	7	7	3
Rust[2]	2	2	2	2	2	5	2	2	3	3	2
Late leaf spot[2]	8	9	7	4	5	4	6	3	9	9	4
Rosette virus	0	0	2	0	6	7	9	13	1	77	5
Groundnut streak necrosis virus	0	0	0	0	0	7	0	1	4	0	0
Leaf fall[2]	5	9	6	4	6	5	3	3	9	6	3
Termites	2	3	2	0	0	0	33	2	18	4	1
Hilda	49	1	20	70	23	20	76	3	24	3	3
Jassids	Severe	Severe	Slight	Severe	Slight	Slight	Mild	Severe	Mild	Slight	Mild
Thrips	3	1	0	0	0	0	0	2	3	2	4
Leaf eater	Slight	Slight	Slight	Mild	Slight	Slight	Slight	Slight	Slight	Slight	Slight
Alectra	1	0	0	0	0	0	0	5	1	7	0
Drought	Severe	None	Slight	None	Slight	Slight	Severe	Mild	Slight	Mild	Mild
Magnesium deficiency	None	None	None	None	Slight	Slight	None	None	Slight	None	None
Stinging caterpillar	None	None	None	None	None	Slight	None	None	None	None	None

1. Mean of five records. Unless otherwise indicated, data are of counts.
2. Scored on a 1–9 scale, where 1 = No disease, and 9 = 50–100% foliage damaged.

(*Phaeoisariopsis personata*)] and leaf fall were scored on a 1-9 scale supplied by ICRISAT.

2. Counts were made of plants with virus diseases (rosette and groundnut streak necrosis), soilborne-insect damage (termite and *Hilda patruelis*), foliar insect pests (thrips), jassids, and leaf eaters, and parasitic weeds (*Alectra* spp). The following scale for visual determination of biotic constraints and certain foliar insects was used to assess the damage:

None	No damage
Slight	Minimum damage
Mild	Moderate damage
Severe	Serious damage

2. Visual scores were made of abiotic constraints, such as drought and magnesium deficiency.

Results

The 1986/87 season had well-distributed rainfall until the pod-filling stage. From then until harvest time, the crop was adversely affected by drought.

Drought damage was serious on sprayed plots at Sites 1 and 7 (Table 1). Mild drought damage was recorded on the nonsprayed groundnut at Site 7, and sprayed groundnuts at Sites 8, 10, and 11 (Table 1).

Slight magnesium deficiency was recorded on both the nonsprayed and sprayed groundnuts at Sites 5 and 7; only on sprayed groundnuts at Site 8; and only on nonsprayed groundnuts at Site 10 (Table 1).

However, soil-analysis data showed that all fields were deficient in magnesium and phosphorus.

Chlorothalonil (Daconil®) controlled early leaf spot and pepper spot, and consequently reduced leaf fall up to the middle of the season (March) at nine Sites (1, 3, 4, 5, 6, 7, 8, 10, and 11) (Table 1), and sometimes the effect of the fungicide continued until harvest except for the crop at Sites 2, 3, 5, 9, and 10. Late leaf spot became serious mainly in the nonsprayed plots towards harvest at Sites 1, 2, 5, 8, 9, and 10 (Table 1).

Rosette incidence, and termite and Hilda damage ranged from slight to severe in both nonsprayed and sprayed groundnuts in all farmers' fields (Tables 1 and 2). Termites and Hilda were the most important pests at harvest; however, there was more termite damage in the nonsprayed groundnuts than in the sprayed groundnuts at most sites (Table 2).

Groundnut streak necrosis virus (GSNV) disease was only recorded from three sites (Table 1).

The damage caused by jassids ranged from none to serious in certain fields (Sites 1, 2, 4, and 8 in Table 1).

Thrips and leaf-eater damage, where recorded, was slight (Table 1).

Table 2. Mean[1] counts of rosette, termite, Hilda, and Alectra damage to groundnuts in the Lilongwe Rural Development Project Units 7 and 28, Malawi, at harvest, 4 May to 12 Jun 1987.

	Nontreated groundnuts				Chlorothalonil (Daconil®) treated groundnuts			
Site number	Rosette virus disease	Termite	Hilda	Alectra	Rosette virus disease	Termite	Hilda	Alectra
1	0	33	23	48	0	1	39	0
2	0	12	72	1	0	1	155	0
3	14	6	46	0	2	3	58	0
4	0	40	81	0	0	1	64	0
5	0	2	62	0	0	6	105	0
6	2	4	22	0	0	0	54	0
7	0	108	100	0	0	31	104	0
8	1	6	12	0	0	7	52	0
9	1	12	20	0	15	6	102	0
10	7	1	21	0	0	6	46	0
11	6	2	36	0	0	2	20	0

1. Mean of five plots.

The parasitic weed *Alectra* sp caused serious damage in the nonsprayed groundnuts at Site 1 and probably was the major limiting factor to the yield there (Tables 1, 2, and 3).

Stinging caterpillars, which are larvae of a lepidopterous moth, caused isolated damage on sprayed groundnuts at Site 6 (Table 1).

Groundnut plant stand at harvest ranged from 47.9×10^3 plants ha^{-1} to 73.9×10^3 plants ha^{-1}. Nonsprayed groundnuts at Site 3 had the lowest plant stand while the highest plant stand was recorded in the nonsprayed groundnuts at Site 8 (Table 3).

Large yield increases in response to chlorothalonil (Daconil®) were obtained at Sites 1, 3, 4, and 9, while small yield increases were obtained at Sites 5, 6, and 11, despite the fact that the yields of nonsprayed and sprayed seeds were very high (Table 3). Sprayed groundnuts at Site 7 had lower yields than that of nonsprayed groundnuts (Table 3). The yield of seeds from both nonsprayed and sprayed groundnuts was low at Site 10, although the response to the spray program was above average (Table 3).

Seven out of 11 farmers obtained seed-yield increases that were average or above average of sprayed over nonsprayed groundnuts.

Table 3. Chalimbana and Chitembana groundnut plant stand at harvest and yield parameters from farmers' fields in the Lilongwe Rural Development Project Units 7 and 28, Malawi, 1986/87.

Site number	Chlorothalonil (Daconil®) treatment on seeds	Plant stand count at harvest (× '000 plants ha^{-1})	Mean[1] seed yield (t ha^{-1})	Increase of treated over nontreated seeds (%)	Shelling percentage	Yield of grade A seeds (t ha^{-1})	Yield of grade B seeds (t ha^{-1})	Mean[1] dry yield (t ha^{-1})	Increase in treated over nontreated haulms (%)
1	Treated	60.7	1.158	109	69	0.983	0.108	1.799	55
	Nontreated	49.8	0.555	-	70	0.446	0.081	1.160	-
2	Treated	61.6	1.056	27	67	0.905	0.106	1.286	1
	Nontreated	54.5	0.832	-	70	0.717	0.108	1.304	-
3	Treated	48.2	1.102	187	71	0.943	0.120	1.842	38
	Nontreated	47.9	0.384	-	70	0.316	0.067	1.344	-
4	Treated	57.1	1.206	74	68	1.030	0.109	1.622	24
	Nontreated	61.1	0.694	-	70	0.542	0.114	1.309	-
5	Treated	71.3	1.366	10	69	1.179	0.139	1.287	27
	Nontreated	70.3	1.243	-	67	1.085	0.090	1.767	-
6	Treated	61.9	1.581	22	69	1.327	0.165	2.780	-5
	Nontreated	68.2	1.295	-	73	1.146	0.134	2.922	-
7	Treated	65.6	0.895	22	66	0.640	0.148	1.361	-
	Nontreated	67.0	1.097	-	65	0.691	0.216	-	-
8	Treated	67.9	1.253	39	68	1.049	0.182	1.911	-
	Nontreated	73.9	0.900	-	66	0.794	0.098	-	-
9	Treated	71.0	1.088	52	70	0.953	0.093	1.393	15
	Nontreated	61.8	0.718	-	68	0.644	0.057	1.639	-
10	Treated	52.2	0.970	42	70	0.773	0.197	1.457	10
	Nontreated	55.5	0.682	-	64	0.589	0.075	1.614	-
11	Treated	61.3	1.405	39	65	1.216	0.164	3.549	52
	Nontreated	54.4	1.014	-	67	0.819	0.135	2.336	-
Mean	Treated	67.8	1.189	39	68	1.000	0.139	1.844	8
	Nontreated	66.4	0.856	-	68	0.708	0.107	1.711	-

1 Mean of five plots

The shelling percentage of groundnuts was good at all sites. High yields of the premium grade A were consistently obtained in sprayed groundnuts and high yields of lower-grade seeds (grade B) were obtained in the nonsprayed groundnuts (Table 3). Higher yields (8%) of groundnut haulms were obtained in the sprayed than in the nonsprayed plots (Table 3).

Conclusions

There was a substantial seed-yield increase in most farmers' fields where chlorothalonil (Daconil®) was properly applied to groundnuts. However, abiotic constraints such as drought and nutrient deficiencies, which are not affected by chlorothalonil (Daconil®) spray reduced the yield and quality of the crop in farmers' fields.

Uncontrolled biotic constraints, which also affected the groundnut yield, included: rosette, termites, Hilda, jassids, and *Alectra* sp. The wide range of plant stand between farmers' fields at harvest from 47.9×10^3 plants ha^{-1} to 73.9×10^3 plants ha^{-1} may have been due to this problem.

Insecticidal control of insect pests would probably alleviate the damage caused by termites, Hilda, jassids, and aphids (vector of the groundnut rosette virus). Termites and Hilda were the most serious pests of groundnuts at harvest in these farmers' fields.

GSNV disease was relatively unimportant in the trial but this disease can assume epidemic proportions at the seedling stage and consequently reduce the groundnut yield by reducing plant stand.

Late leaf spot and rust generally began to attack groundnuts late in the season and therefore the effect in reducing the yield and quality of groundnuts was negligible.

The drought seriously affected groundnuts from the pod-filling stage to harvest and, in response to spraying led to an increased seed yield of 39%, which was lower than the expected yield increase of 70%. Drought also encouraged those insect pests that cause much damage to groundnut plants under water stress. Drought also caused haulm reduction in certain farmers' fields so that the overall increase in groundnut haulm yield was only 8%.

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Discussion

Kannaiyan: The groundnut streak necrosis disease (GSND) symptoms are very clear (bright yellow spots) on your seedlings. But the diseased plants undergo modified symptoms like interveinal necrosis and curling and darkening of leaflets. The diseased seedlings remain until end of the season without recovering from it and cause up to 50% loss in seed yield.

An Economic Evaluation of Smallholder Farmers' Use of the Fungicide Chlorothalonil (Daconil® 2787 W-75)[1] on Groundnuts in Lilongwe Agricultural Development Division, Malawi

A.R.E. Mwenda[2] and T.J. Cusack[3]

Abstract

The economic benefits of spraying Chalimbana and Chitembana groundnuts with chlorothalonil (Daconil® 2787 W-75), according to current recommendations, were estimated for 11 smallholder farmers in the Lilongwe Agricultural Development Division (LADD) during the 1986/87 season. A partial budget analysis showed that only one farmer obtained an acceptable rate of return on investment in the technology and that the yield response to the technology at 1986/87 prices was, on average, insufficient to cover the cost of the technology. These 1986/87 season results were then related to other research studies with chlorothalonil (Daconil 2787® W-75) on farmers' fields and at Chitedze Research Station over 17 previous seasons, to predict the future viability of the technology at 1987/88 prices, or under other future conditions. The results show that, averaged over all commercially oriented farmers and over all years, farmers would not even be able to recover the costs of the technology at 1987/88 prices, in spite of the excellent control of foliar fungal diseases achieved by using this fungicide.

Sumário

Uma Avaliação Económica do Uso do Fungicida Clorotalonil (Daconil® 2787 W-75) do Amendoim na Divisão de Desenvolvimento Agricola de Lilongwé, Maláwi. *Os benefícios económicos da pulverização do amendoim, vars. Chalimbana e Chitembana, com Clorotalonil (Daconil® 2787 W-75), de acordo com as actuais recomendações, foram estimados para 11 pequenos agricultores, na Divisão de Desenvolvimento Agrícola de Lilongwé (LADD), durante a estação de crescimento do amendoim de 1986/87. Uma análise económica parcial mostrou que, apenas um agricultor obteve uma taxa de lucro aceitável, com o uso da técnologia e que, os rendimentos obtidos com o uso da técnologia, aos preços de 1987/88, foram, em média, insuficientes para cobrir o custo da técnologia. Os resultados desta estação, 1986/87, foram então relacionados com outros estudos feitos com Clorotalonil (Daconil® 2787 W-75), em campos de*

1. The use of the name Daconil®, which refers to a commercially available wettable-powder formulation of chlorothalonil, in this paper neither represents a criticism or discrimination of similarly effective chemicals nor does it reflect the official policy or position on the use of this chemical by the Malawi Ministry of Agriculture.

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ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1989. Proceedings of the Third Regional Groundnut Workshop, 13-18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P. 502 324, India: ICRISAT.

agricultores e na Estação de Investigação de Chitedze durante 17 anos, para predizer a futura viabilidade da técnologia aos preços de 1987/88, ou sob outras condições futuras. Os resultados mostram que, fazendo a média de todos os agricultores orientados para o mercado e de todos os anos, os agricultores não serão nem mesmo capazes de recuperar os custos da técnologia aos preços de 1987/88, mesmo tendo em conta o excelente controle das manchas foliares conseguido com o uso da fungicida.

Introduction

Effective control of *Cercospora* and other fungal diseases of groundnuts is possible by spraying the crop with fungicides.

Research trials, both on-farm and on-station, were conducted in Malawi during the 1970s to identify appropriate spraying regimes and potential benefits to farmers of using chlorothalonil (Daconil® 2787 W-75) and other fungicides. Therefore, chlorothalonil (Daconil®) has been recommended by the Department of Agricultural Research, Malawi, as an effective control for *Cercospora* and other fungal diseases of groundnuts since 1980. To promote its use, Lilongwe Agricultural Development Division (LADD) has developed smallholder credit packages for eligible farmers to purchase both the recommended sprayer and the chemical.

However, recognizing that (a) despite large investments of research resources in chlorothalonil trials which achieved positive results, uptake of the technology by smallholders remains low, and (b) prices of chlorothalonil (Daconil®) and of sprayers have recently increased substantially, the Department of Agricultural Research initiated an on-farm evaluation of the use of the technology during the 1986/87 season; the results of this evaluation form the bulk of this paper.

The evaluation was designed to answer many questions.

1. For researchers: Taking into consideration the results of previous trials, what further research should be conducted on this, or related, technologies?
2. For extensionists: Should the technology, as presently used, continue to be recommended to farmers? Should the recommendations be modified?
3. For Malawi's Agriculture Development Division (ADD) credit policy: Should the existing ADD credit packages be continued, or modified, for this technology?
4. For seed production policy: Should chlorothalonil (Daconil®) be made compulsory for seed producers as an improved management practice ensuring adequate supplies of seed?
5. For all policymakers: What production and marketing factors influencing groundnut farmers (e.g., ADMARC prices and recent increases in the price of the technology) are limiting the adoption or impact of this technology?

The overall objective was to determine if, or under what conditions, farmers would benefit from using chlorothalonil (Daconil®).

Method

Central to the study was an on-farm, completely farmer-managed, trial to determine the farm-level response to the spraying of chlorothalonil (Daconil®) during the 1986/87 season and including a partial budget analysis of the use of the technology.

A random sample of 11 fields, each cultivated by a separate farmer, was selected in LADD for Chalimbana Chitembana groundnuts. The sample frame consisted of those smallholders who had already decided to use chlorothalonil (Daconil®) during 1986/87, and would be spraying only part of a continuous groundnut field. As chlorothalonil (Daconil®) is issued in 0.4 ha packs, and a minimum acceptable nonsprayed area of the field was taken to be 0.2 ha, selected smallholders were growing at least 0.6 ha of groundnuts in the same field. Fields were acceptable only if they had a uniform groundnut cultivar and if there were no apparent differences in average growing conditions between sprayed and nonsprayed portions of the field.

Sampled smallholders, representing existing users of chlorothalonil (Daconil®), were more commercially oriented than average, having above-average farm areas, ready access to institutional credit, and higher than average levels of cash sales of farm products.

Farmers were visited each month and the following data collected:

(a) researcher measurements of pest and disease incidence, and of other cultural conditions;
(b) questionnaire data on husbandry practices, whole-farm information, farm-resource availability and use, and production and marketing costs and returns; and
(c) yield assessments using sample quadrants.

These data were used to construct partial budgets for each farmer's use of the technology during the 1986/87 season.

The results of this 1986/87 trial were then related to the results of other research work in LADD and at Chitedze Research Station over 17 previous seasons, through the partial budgets, to predict future economic viability of the technology under 1987/88 prices or under other possible conditions.

1986/87 Results

Estimated yields for all the sampled plots are summarized in Table 1. The difference in yields per hectare between the treated and nontreated plots represents the additional yield of seeds (expressed on a per hectare basis) due to the use of the technology. In LADD, farmers sell shelled groundnuts.

Yield for sprayed fields averaged 1189 kg ha^{-1} of all seeds, with a range of 895–1581 kg ha^{-1}. Yields for nonsprayed fields averaged 856 kg ha^{-1}, with a range of 384–1295 kg ha^{-1}. The response to the technology was measured as positive for 10 out of the 11 sampled farmers; average response for the 11 farmers was a positive 333 kg ha^{-1}, equivalent to an average response per farmer of 53% (Table 1).

These yield estimates were incorporated into a partial budget analysis for each farmer. The partial budget is a useful way of weighing up the farmer's gains from adopting a new practice against the

Table 1. Estimated seed yields (t ha^{-1}) from sampled plots using quadrant data, Lilongwe, Malawi, 1988.

Farmer number	Grade A seeds			Grade B seeds		
	Treated	Nontreated	Difference[1]	Treated	Nontreated	Difference[1]
1	1.327	1.146	0.181	0.165	0.134	0.031
2	0.953	0.644	0.309	0.093	0.057	0.036
3	1.049	0.794	0.255	0.182	0.098	0.084
4	0.943	0.316	0.627	0.120	0.067	0.053
5	0.773	0.589	0.184	0.197	0.075	0.122
6	1.216	0.819	0.397	0.164	0.135	0.029
7	1.179	1.085	0.094	0.139	0.090	0.049
8	0.640	0.691	0.051	0.148	0.216	0.068
9	1.030	0.542	0.488	0.109	0.114	0.005
10	0.983	0.446	0.537	0.108	0.081	0.027
11	0.905	0.717	0.188	0.106	0.108	0.002

Farmer number	Unsaleable seeds			Total seeds			Percentage of increase
	Treated	Nontreated	Difference[1]	Treated	Nontreated	Difference[1]	
1	0.089	0.015	0.074	1.581	1295	0.286	22
2	0.042	0.017	0.025	1.088	718	0.370	52
3	0.022	0.008	0.014	1.253	900	0.353	39
4	0.039	0.001	0.038	1.102	384	0.718	187
5	0.000	0.018	0.018	0.970	682	0.288	42
6	0.025	0.060	0.035	1.405	1014	0.391	39
7	0.048	0.068	0.020	1.366	1243	0.123	10
8	0.107	0.190	0.083	0.895	1097	0.202	18
9	0.067	0.038	0.031	1.206	694	0.512	74
10	0.067	0.028	0.039	1.158	555	0.603	109
11	0.045	0.007	0.038	1.056	834	0.224	27

1. Difference between treated and nontreated yields per hectare, representing the seed yield due to the technology.

farmer's losses (costs) incurred by adopting the practice. The change in practice of interest in this study is from no spraying of groundnuts to spraying of groundnuts using the fungicide chlorothalonil at the recommended rates with a Solo® sprayer. Solo® sprayers are provided by LADD on credit to farmers specifically for chlorothalonil applications, and are almost universally used for such applications by farmers. Estimated partial budgets are presented in Tables 2 and 3 for each of the sampled farmers.

Extra losses incurred by farmers in using chlorothalonil (Daconil®) are the costs of the sprayer, the cost of the chemical, the labor needed to undertake the spraying and associated operations, and the additional labor needed to strip, shell, and grade the additional volume of nuts obtained as a result of using the spray. These costs are summarized in Table 2.

The major component of production costs for this technology was the purchase of the fungicide, which was consistently placed at approximately 80% of total costs. Variations between farmers in labor costs largely reflected differences in yield response to chlorothalonil (Daconil®). The costs of the sprayer

Table 2. Partial budget data for 11 sampled farmers, and their losses (Malawi Kwacha), Lilongwe, Malawi 1986/87.

Farmer number	Extra costs					Total losses
	Sprayer	Chlorothalonil (Daconil®)	Labor for spraying	Labor for stripping	Labor for shell grading	
1	12.00	108.90	3.60	5.63	11.26	141.39
2	30.00	108.90	2.16	5.88	11.76	158.70
3	48.96	217.00	3.72	8.23	16.46	294.37
4	12.00	108.90	3.00	13.62	27.24	164.76
5	12.00	108.90	3.00	4.89	9.78	138.57
6	12.00	108.90	1.80	6.77	13.54	143.01
7	15.00	108.90	1.80	2.01	4.02	131.73
8	12.00	108.90	1.80	2.89	5.78	114.03
9	10.00	108.90	2.40	6.14	12.28	139.72
10	40.21	108.90	3.00	10.24	20.48	182.83
11	0.00	108.90	2.40	4.25	8.50	124.05

Table 3. Partial budget data[1] for 11 sampled farmers' gains and net benefits (Malawi Kwacha) in Lilongwe, Malawi 1986/87.

Farmer number	Gains		Total gains	Net benefits	Rate of return on additional investment (%)
	Saleable seeds	Hire of sprayer			
1	84.80	0.00	84.80	56.59	40
2	117.46	0.00	117.46	41.24	26
3	146.87	21.00	167.87	126.50	43
4	263.20	0.00	263.20	98.44	60
5	77.05	0.00	75.57	63.00	45
6	162.15	0.00	162.15	19.14	13
7	39.21	0.00	39.21	-92.52	-70
8	21.83	0.00	21.83	-135.86	-119
9	127.22	0.00	128.31	12.50	-9
10	200.56	0.00	200.56	17.73	10
11	77.52	0.00	77.52	-46.53	-38

1. All farmers used a single 0.4 ha package of the technology, except for farmer no. 3 who used two packages.

varied greatly from those farmers who hired sprayers, rather than buying them, to those farmers who owned their own sprayers; one owner had already paid off his credit for the sprayer, and had no repair or maintenance charges, and so incurred no expenses during the current season. The other other two farmers who owned sprayers had to repay MK 40.21 each, compared to those (majority of farmers) who hired their sprayers at an average cost per season of approximately MK 15.

The value assigned to the labor used by the farmer, the farmer's family, seasonally-hired laborers and casual laborers, is MK 0.10 h^{-1}; this is the average wage-rate paid for farm tasks in the area during this part of the year, and is considered to be representative of the opportunity cost of labor for the tasks specified.

Extra gains obtained by farmers from using the technology are summarized in Table 3. Gains from use of the technology were achieved by all farmers, except one. Average gains were approximately MK 120 per farmer. Differences in the gains between farmers were largely because of differences in yield response to the technology. The value of Grade A seeds was the dominant component of gains, averaging 90% of total gains. Seed farmers (six farmers) obtained MK 0.80 kg^{-1} for Grade A seeds, compared to MK 0.75 kg^{-1} for nonseed farmers, but this did not appear to be a significant factor explaining differences in profitability.

Subtracting the extra costs (Table 2) from the extra gains (Table 3) results in a net benefit, which each farmer obtains by using the technology (Table 3). Only 3 out of the 11 sampled farmers obtained positive net benefits as calculated in the partial budgets. Net losses per farmer averaged MK 40. How should these values be interpreted? The net benefit figure is our estimate of the value that the farmer places on use of the technology for the 1986/87 season; our calculation has weighed the cash and noncash losses and gains from using the technology.

All of the farmers' gains and losses associated with adopting the technology have not been considered in estimating net benefits; however, gains and losses other than those identified in Tables 2 and 3 are considered to be too insignificant.

The net benefit value, in itself, is of limited use; we need some measure of the importance of the value. For example, on what basis could we say that a specific net benefit will be sufficiently large to justify us recommending the practice to farmers? A most useful way to express the net benefit value is as "the rate of return to additional investment". For example, for farmer no. 6, the additional investment is MK 143 (Table 2) as these are the additional costs incurred by using the technology. The return to the use of the technology by farmer no. 6 was MK 19, which is the net benefit value presented in Table 3. The rate of return for farmer no. 6's use of the technology is therefore calculated as (19/143 ×) 13%.

The "rate of return to additional investment" is presented for all sampled farmers in Table 3. Only three farmers have positive rates of return, because only three farmers have positive net benefits from use of the technology. How should these values be interpreted? A general rule of thumb for smallholder acceptability of a new technology is that the rate of return to additional investment should exceed 40% for a season. If this criterion is applied, then in this study it is estimated that only one sampled farmer obtained acceptable rates of return on additional investment through use of the technology.

In conclusion, the yield response to the technology at 1986/87 prices has, in general, been insufficient to cover the costs of the technology, despite the excellent control of foliar fungal diseases — resulting in large yield responses — achieved by using chlorothalonil (Daconil®). Response levels may have been limited because of the relatively poor distribution of rainfall during the 1986/87 season.

Results for the Period 1970/71 to 1986/87

Experiments on the yield response to use of chlorothalonil (Daconil®) on Chalimbana groundnuts have been conducted annually since 1970/71 at Chitedze Research Station (Table 4). The response measured as a percentage of the nontreated yield (Table 4) has varied from 133% in 1975/76 to only 7% in 1983/84, with an average response of 59% over the period. The main reasons for interyear differences in yield levels and in response to the fungicide appear to be differences in the magnitude and pattern of seasonal rainfall.

In addition to the on-station work, on-farm trials were also conducted by Chitedze researchers, in collaboration with LADD, on the response to chlorothalonil (Daconil®) during the years 1975/76, 1976/77, 1978/79, 1979/80, and (for the present study) 1986/87. The results of this on-farm work is summarized in Table 5. Levels of on-farm yield were

Table 4. Yield responses to use of chlorothalonil (Daconil®) on Chalimbana groundnuts at Chitedze Research Station, Malawi, 17 seasons, 1970–87, and estimated equivalent responses in farmers' fields.

Season	Seed yield (t ha^{-1}): Chitedze Research Station: Treated	Chitedze Research Station: Nontreated	Chitedze Research Station: Response	Response to treatment on farmers' fields	Percentage increase
70/71	3.159	1.773	1.386	0.762	78
71/72	2.800	1.703	1.097	0.603	64
72/73	3.628	2.344	1.284	0.706	55
73/74	2.133	1.364	0.769	0.423	56
74/75	2.207	1.589	0.618	0.340	39
75/76*	2.797	1.200	1.599	0.879	133
76/77*	2.964	2.118	0.846	0.465	40
77/78	3.670	1.707	1.963	1.080	115
78/79*	3.609	2.510	1.099	0.604	44
79/80*	2.507	1.613	0.894	0.492	55
80/81	1.900	1.100	0.800	0.440	73
81/82	2.000	1.500	0.500	0.275	33
82/83	3.100	1.800	1.300	0.715	72
83/84	1.600	1.500	0.100	0.055	7
84/85	3.300	1.900	1.400	0.770	74
85/86	2.299	1.681	0.610	0.335	36
86/87*	2.083	1.587	0.496	0.273	31
Mean	2.692	1.705	0.987	0.562	59
Mean (*seasons)	2.792	1.806	0.986	0.543	61

Table 5. The yield response to chlorothalonil (Daconil®) on groundnut (cv Chalimbana) in farmers' fields, Lilongwe, Malawi, for five seasons, 1975/76 to 1986/87.

Season	Seed yield (t ha^{-1}): Treated	Nontreated	Response	Percentage increase	Percentage response of on-farm to on-station yields
75/76	1.286	0.654	0.632	97	40
76/77	0.819	0.619	0.200	32	24
78/79	1.872	1.122	0.750	67	68
79/80	1.749	1.032	0.717	69	80
86/87	1.139	0.815	0.324	40	65
Mean	1.373	0.848	0.525	61	55

considerably lower than levels of on-station yield; the five-season on-farm average yield for treated fields was only 137 kg seed ha^{-1} compared with 2792 kg seed ha^{-1} for on-station trials. Similarly, yields on nontreated farmers' fields averaged only 848 kg ha^{-1} compared with 1806 kg ha^{-1} in on station trials. Levels of on-farm response to the technology averaged 525 kg seed ha^{-1} compared with 986 kg seed ha^{-1} for on-station trials. Response to the technology, measured as a proportion of the nontreated yield, averaged 61% for the on-farm trials; this is the same as the proportionate response to the technology used on-station for the same five seasons (Table 4).

In planning for future use of the technology, it is necessary to predict response to the technology on farmers' fields over a range of likely environmental conditions.

The estimated response to the technology in farmers' fields is presented in Table 4. These imputed responses were derived from data in Tables 4 and 5.

1. The relationship between on-farm response and on-station response was determined for those 5 years when data were available (Table 5); the average response to the technology on farmers' fields was 55% of the on-station response.
2. The estimated on-station response presented in Table 4 was reduced by 45% to arrive at the researchers' best estimate of an equivalent average on-farm response for each of the seasons, 1970/71 to 1986/87. These generated values appear to be quite closely aligned with actual recorded figures for on-farm response for 5 years; the generated values average 543 kg ha^{-1}, whereas the actual recorded values averaged 525 kg ha^{-1}.

Assuming that future growing conditions affecting groundnut producers will be similar to past conditions, then the yield estimates for farm response presented in Table 4 can be used directly to estimate future on-farm profitability, under various pricing conditions; the results of this exercise are summarized in Table 6 for the 1987/88 season prices. Positive benefits from use of the technology are expected in less than 1 year in 4 (Table 6) and average returns per season are predicted to be -27% of the investment.

The results presented in Table 6 can be usefully expressed in graphical form; Figure 1 shows how costs and benefits vary according to the level of yield response to use of chlorothalonil (Daconil®). Both costs and returns increase as higher levels of response are achieved.

In Figure 1, the line representing gains from use of chlorothalonil (Daconil®) is calculated by multiplying the response by the unit value (MK 0.63 kg^{-1}) of seeds. For example, 1000 kg ha^{-1} response will give total gains of (1000 × 0.63) = MK 630. Similarly, a response of only 100 kg ha^{-1} from use of the technology will give gains of only (100 × 0.63) = MK 63.

The line in Figure 1 representing losses from use of

Table 6. Predicted net benefits (Malawi Kwacha ha^{-1}) and rates of return for commercial smallholders' use of chlorothalonil (Daconil®) on groundnuts for 17 seasons, at 1987/88 cropping season prices, Malawi.

Total gain	Extra cost: Chlorothalonil	Extra cost: Sprayer	Extra cost: Labor	Total loss	Net benefit	Rate/return[1]
480	343	52	82	477	3	1
380	343	52	66	461	81	-18
445	343	52	76	471	26	-6
266	343	52	48	443	-177	-40
214	343	52	40	435	221	-51
554	343	52	94	489	65	13
293	343	52	52	447	-154	-34
680	343	52	114	509	171	34
381	343	52	66	461	-80	-17
310	343	52	55	450	-140	-31
277	343	52	50	445	-168	-38
173	343	52	33	428	-255	-60
450	343	52	77	472	-22	-5
35	343	52	11	406	-371	-91
485	343	52	83	478	7	1
211	343	52	39	434	-223	-51
172	343	52	33	428	-256	-60
342[2]	343[2]	52[2]	60[2]	455[2]	-113[2]	-27[2]

For physical yield estimates see Table 4.

1. Rate return = Rate of return to additional investment.
2. Average values for the column.

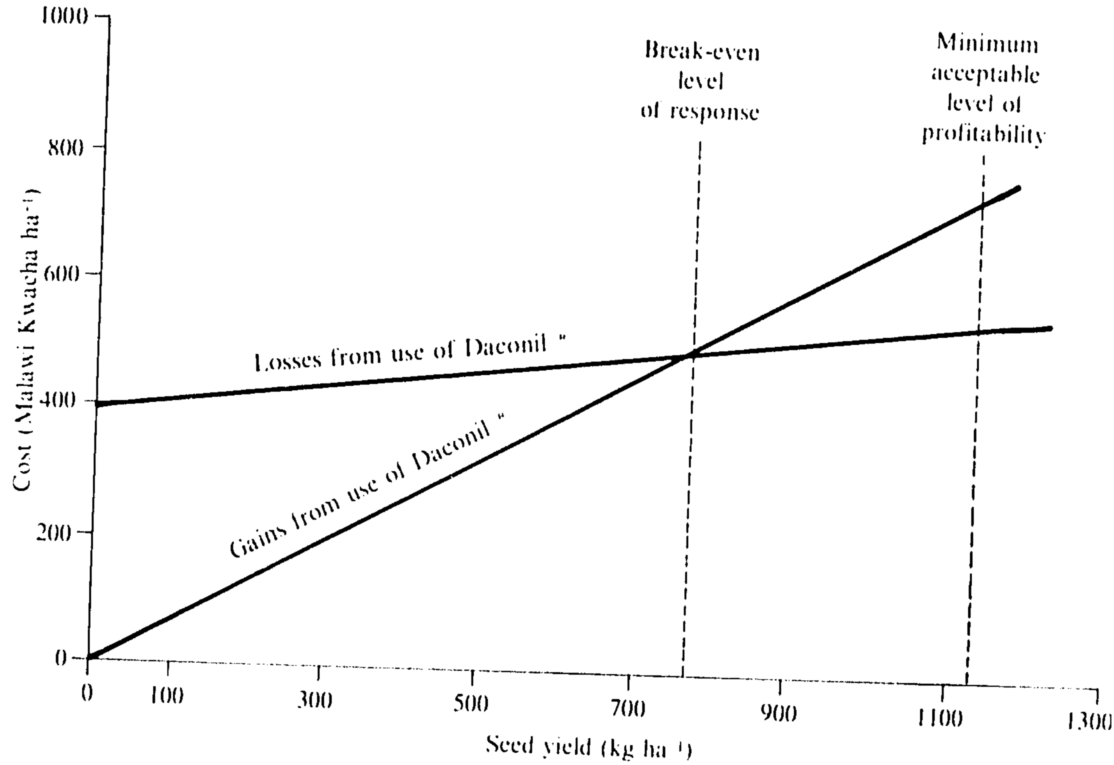

Figure 1. Financial implications of spraying chlorothalonil (Daconil ®) on groundnut (cvs Chitembana and Chalimbana), at 1987/88 cropping season prices for commercial producers, for smallholder farmers of Lilongwe Agricultural Development Division, Malawi.

chlorothalonil (Daconil®) is calculated by adding together all of the costs identified with using the technology. Some of these costs are relatively independent of the response achieved; the costs of the sprayer and of the chemical have already been paid for by the farmer, no matter what response is obtained. Therefore, the value of losses at a response of zero is the cost of the chemical (MK 343) plus the cost of the sprayer (MK 52), giving total losses, at no response, of MK 395.

What costs are indicated in Figure 1 for a response of 1000 kg ha^{-1}? The costs of the sprayer and of the chemical will remain the same, but there will be the labor costs of stripping, shelling, and grading the additional output: these costs were estimated at a total of MK 0.1 kg^{-1} seeds. The labor cost of processing the additional output of, for example, 1000 kg will be (1000 × 0.1) = MK 100; the addition of the MK 395, cost of the sprayer and chemical, results in a total loss of MK 495 for a response of 1 t ha^{-1}.

Referring to Figure 1, it can be seen that the break-even point for this technology is at approximately 750 kg seeds ha^{-1}. In general, if commercial farmers are unable to achieve this level of response, then they will suffer losses from use of the technology. The minimum level of acceptable profitability is a 40% rate of return on additional investment; this is achieved at a response level of approximately 1125 kg seeds ha^{-1}.

Comparing the estimated on-farm response to use of the technology over the past 17 seasons (Table 4) with Figure 1, it can be seen that only in 4 of the 17 seasons would commercial farmers have broken-even; in no year would farmers have made an acceptable profit, as the highest average on-farm response was 1080 kg ha^{-1}, compared to the minimum 1150 kg ha^{-1}.

Conclusions

This study has shown that — even with relatively high levels of management — smallholders' use of chlorothalonil (Daconil®) will not be profitable at current prices. Even though excellent control of foliar fungal diseases is achieved and a substantial yield response to the technology is obtained in almost all seasons, this will generally be insufficient to even cover the costs of the technology.

These results suggest that:

1. Chlorothalonil (Daconil®) should be deleted by the extension service as a recommended husbandry practice for smallholder production of Chitembana and Chalimbana groundnuts in LADD;
2. The LADD smallholder credit program should sponsor other, more potentially productive, technologies;
3. The use of chlorothalonil (Daconil®) should not be made compulsory for Chitembana seed producers;
4. Research should be oriented towards other potential ways of improving smallholder productivity on groundnuts, such as developing new cultivars with higher potential yields than Chitembabna Chalimbana or identifying responses to calcium, magnesium, and phosphorus fertilizer; and
5. Substantial price adjustments would need to be made to ensure the profitability of smallholders' use of chlorothalonil (Daconil®). (For example, a sensitivity analysis which was undertaken for this study showed that a reduction in the price of chlorothalonil (Daconil®) by 50%, coupled with a 33% increase in prices for seeds would be needed to enable acceptable rates of return to be achieved by most commercially oriented farmers).

Note

1. This paper is condensed from the report "An Economic Evaluation of Smallholders' Use of Fungicides on Groundnuts in LADD: A Report of the 1986/87 Daconil Study", which was produced by the Ministry of Agriculture in November 1987.

Discussion

Wightman: Did this study consider the amount of produce the farmer kept for seed and for his family's consumption? This factor may have reduced the gross income.

Mwenda: The farmers were "large" and commercially oriented with high credit rating. It was assumed that all the produce was sold.

Chiteka: How did you cost out the price of the sprayer?

Mwenda: The cost of hiring the sprayer, or the cost of loan repayment on purchase of the sprayer.

Chiteka: How was the labor costing arrived at, since some of the work is done by the farmer himself and the rest by hired labor?

Mwenda: Specific periods were taken and costing done on the basis of the actual time and man-hours needed for different tasks performed on the groundnut crop.

Waliyar: What is the economic importance of groundnut haulm in Malawi (with chlorothalonil spray, you improve the haulm quality)?

Mwenda: It is not utilized.

Manda: Having gone around where groundnuts are grown in Malawi, the demand for chlorothalonil (Daconil®) is increasing. If farmers are losing money using chlorothalonil (Daconil®), why is there a demand for it? Why is it that farmers in areas where chlorothalonil (Daconil® 2787-W-75) is used seem to be eager to use the chemical if it is not paying?

Mtambo: The crop sprayed with chlorothalonil (Daconil®) looks greener and more vigorous than the nonsprayed crop. This tends to attract the attention of farmers without thinking in terms of real yield and economic benefits.

Cusack: Chlorothalonil (Daconil®) is also widely used to spray the tomato crop.

3
Breeding

75

Suitability of Malawi Groundnut Cultivars for the Confectionery Market

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Abstract

This paper reviews progress of the National Groundnut Improvement Programme for Malawi in the development of confectionery groundnut cultivars. Data on the performance and oil quality of selected genotypes are presented. Problems encountered with the confectionery market and requirements for future research development are also given.

Sumário

Adaptabilidade dos Cultivares do Amendoim de Maláwi para o Mercado de Confeitaria. *Este artigo faz a revisão do progresso do Programa Nacional de Melhoramento do Amendoim de Maláwi no desenvolvimento de cultivares do amendoim para confeitaria. Dados sobre o comportamento e qualidade do óleo, de genótipos selecionados, são apresentados. Os problemas com o mercado de confeitaria e as necessidades para a investigação futura são também discutidos.*

Introduction

Groundnuts (*Arachis hypogaea* L.) are grown in all the three regions of Malawi in varying proportions, primarily for oil extraction and confectionery purposes. Mawanga and Mani Pintar are popular cultivars for the domestic oil industry, while cvs Chalimbana and Chitembana have characteristics more suited for the export confectionery market. The bulk of the confectionery grades are exported to UK and the remaining groundnuts are crushed for oil or processed internally into peanut butter, or roasted and packed as Tambala Kings by Sales Services Malawi Limited.

We review here the progress of the National Groundnut Improvement Programme (NGIP) for Malawi in the development of confectionery groundnut cultivars, their performance, their acceptability for the confectionery trade, and problems encountered so far.

Consumer Preference

Quality of the processed nuts is crucial for both the processor and the consumer. The final quality of edible groundnuts is assessed principally by the quality of the processed seed and by the chemical composition of the oil, protein, and carbohydrate fractions of the seed.

Goundnut seeds contain 12 fatty acids, 3 of which are present in amounts exceeding 5% of the fatty acid composition: palmitic, oleic, and linoleic (Young et al. 1972). These acids comprise about 80% of fatty acid composition. The oleic/linoleic acid (O/L) ratio is an indicator of oil stability, although correlation coefficients obtained vary from year to

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year. Worthington et al. (1972) were able to account for 10 73% of the variation and Brown et al. (1975) were able to account for 39% of the variation in oil stability by O/L ratios. However, these workers did not indicate a minimum value of O/L ratio for confectionery use.

Development of the Confectionery Groundnut Varieties

Many confectionery groundnut varieties have been developed at the Chitedze Research Station. Two of them have been accepted for confectionery purposes overseas, while others are being evaluated. These cultivars are discussed separately.

The large-seeded cultivars

Two large-seeded cultivars have been released for production in Malawi for the confectionery market. Chalimbana was the first cultivar to be released and became very popular for overseas confectionery purposes for three reasons:

1. Large seed size and quality of the seed,
2. Good flavor upon roasting, and
3. Long shelf life of the processed products.

Chitembana was later developed following complaints from overseas buyers that the seed size of Chalimbana was declining and blanching was a problem because of its seed shape. This declining seed size was probably because of the adulteration of Chalimbana seed with small-seeded types as a result of continuous recycling of the stock by the farming community.

Table 1 presents yield data for cvs Chalimbana and Chitembana together with their respective seed characteristics and percentages of oleic and linoleic fatty acid composition.

The dilemma facing groundnut breeders is that cultivars must satisfy both the requirements of the manufacturers, which are uniformity in seed size and round shape to enable easy blanching, and that of the consumer, which is stability of the processed product. As is evident from Table 1, both cvs Chalimbana and Chitembana are good for stability of the processed product since the O/L ratio is greater than 1.6:1, which is the minimum acceptable ratio for confectionery groundnuts (P. Brown, KP Foods, Chesterton Road, Eastwood Trading Estate, Rotherham, South Yorkshire, UK, personal communication, 1987). However, for the manufacturer, the seed shape and size of both cultivars are not uniform, making blanching difficult. Both cultivars are also very susceptible to common groundnut diseases. Parallel breeding programs were initiated to correct these defects, and these programs resulted in the development of rosette-resistant groundnut cultivars and other high-yielding genotypes of good quality.

Table 1. Yield, seed characteristics, and oleic and linoleic fatty acid composition (%) for two groundnut cultivars, Chalimbana and Chitembana, Malawi.

Seed characteristic	Chalimbana	Chitembana
Average seed yield (t ha^{-1})	1.5	1.5
Seed size (100-seed mass)	90	110
Seed shape	Irregular with oval flat surface	
Oleic acid (%)	48.46	49.54
Linoleic acid (%)	30.02	30.35
Oleic/linoleic acid (O/L) ratio[1]	1.61	1.64

1. Samples taken from the 1986/87 crop only.

The rosette-resistant cultivars

There are presently five rosette-resistant groundnut cultivars with good agronomic attributes but these fall short in other quality aspects required by the trade (Chiyembekeza 1987). The first cultivar to be released was RG 1. Ten years later, other rosette-resistant genotypes were developed of which four selections from the Rosette Resistant Intercross program — RRI/1, RRI/6, RRI/24, and RRI/32 — showed sufficient promise to warrant release for production by the farming community.

Of particular interest is the cultivar RRI/6. Vigorous screening both in greenhouses and fields showed RRI/6 to be totally resistant to rosette. Although the seed size of this cultivar was larger [70 g (100 seeds)$^{-1}$] than RG 1 [65 g (100 seeds)$^{-1}$], the cultivar showed some promise as a substitute to Chalimbana (because of the smaller seed size). However, the oil quality of RRI/6 fell short of the minimum requirements

Table 2. Yield data[1] and fatty acid composition (%) of selected groundnut genotypes, Malawi, 1984–87.

Genotype	Seed yield (t ha^{-1})	Fatty acid composition (%)[2] Palmitic (C 16:0)	Oleic (C 18:1)	Linoleic (C 18:2)	O/L ratio
RG 1	1.500	9.75	46.64	32.32	1.45
RRI 6	1.700	9.87	47.30	31.75	1.49
GNB CHT 11	1.161	9.33	52.62	26.00	2.03
GNB CHT 14	1.672	9.35	50.79	27.95	1.82
GNB CHT 24	1.217	9.55	51.91	27.01	1.93
GNB CHT 30	0.944	10.29	50.81	28.26	1.80
GNB CHT 41	1.753	10.28	49.96	26.90	1.86
Chitembana	1.543	10.59	49.54	30.35	1.64
ICGM 741	-	9.15	51.14	29.31	1.74
ICGMS 42	2.420	9.49	52.22	26.52	1.97
ICGMS 5	1.480	9.45	52.88	25.68	2.06
ICGMS 52	-	9.93	52.44	27.03	1.94
ICGMS 63	-	10.86	48.57	27.30	1.78
M 13	-	9.50	49.10	30.63	1.61
Flamingo	-	10.69	48.39	29.37	1.65

1. Mean of three seasons 1984/85, 1985/86, and 1986/87.
2. Samples taken from the 1986/87 crop only.

ments (Table 2), for the confectionery trade. This cultivar will continue to be utilized as a source of resistance to groundnut rosette.

Other confectionery genotypes

Few other confectionery genotypes originating from the various parallel breeding programs show promise for the confectionery market at least as far as the oil quality is concerned. Sixty samples were sent to ICRISAT Center, India, for fatty acid determination: 43 samples were from the NGIP and 17 from the SADCC/ICRISAT Regional Groundnut Improvement Program. Of these, only 19 had oleic/linoleic acid ratios of >1.55:1 and only two had oleic/linoleic acid ratios of >2:1.

Table 2 presents yield data and percentage of fatty acid composition of RRI 6 and RG 1, and selected genotypes from the NGIP and the SADCC/ICRISAT Regional Groundnut Improvement Program, which exhibited O/L acid ratios of 1.60:1 and above.

Reports of studies since 1970 on the genetic variability in fatty acid composition of groundnut genotypes have shown that the range of composition of different acids is greater than previously recognized (Norden et al. 1987). For example, groundnut genotypes are now known to have as low as 21% oleic acid content and as high as 43% linoleic acid (Treadwell et al. 1983).

Requirements for KP Foods Company Limited, UK

Minimum requirements sought by KP Foods Limited, who are the major buyers of Malawi confectionery groundnuts, are as follows (P. Brown, personal communication, 1987):

- Stability—Oil quality.
- Free fatty acids—Maximum 0.75 mg KOH g^{-1}.
- Peroxide value—Maximum 1.0 milliequivalent kg^{-1}.
- Oleic to linoleic acid ratio—Minimum 1.6:1.
- Blanchability—Seeds should be easy to process with loose smooth skin free from withering and wrinkles. Skin should be easily removed with minimum splitting and wastage.
- Size—Uniform. The basic market in Europe is for 40/50 grade.
- Shape—Almost round to enable easy blanching.

Appearance Clean, evenly graded, and free from foreign material and defects.

Color Generally not much of a critical factor, provided it has an acceptable color (red-skinned groundnuts are the only exception these are sold as raw groundnuts but the market in Europe is small).

The two key issues under scrutiny in Europe are aflatoxin and pesticide residues. However, Malawi groundnuts are free from both aflatoxin and pesticides residue problems.

Problems Encountered

For several years Malawi has been exporting confectionery groundnuts to Europe, particularly to UK. Buyers, only recently, have indicated dissatisfaction with Malawi groundnuts, following modifications to their processing machinery.

The main problem with Malawi groundnuts is lack of uniformity of shape, although oil stability is good (Table 1). The market is looking for uniform seed types, which are nearly round and of smaller size [with average counts of 40 50 per ounce (1 ounce = 28.35 g)], but between 60 g (100 seeds)⁻¹ and 70 g (100 seeds)⁻¹.

Although genotypes RRI 6 and F 685 (RG 1 × Shulamith × RMP 93) were preferred by buyers as possible substitutes for the Chalimbana type because of their size and shape, these genotypes were later rejected because of poor oil stability (both have O L ratios of 1.4:1, which is far below the 1.6:1 minimum).

The problem surfaced because of the lack of information feedback on trade requirements. Nevertheless, the NGIP, with the assistance of the SADCC ICRISAT Regional Groundnut Improvement Progam, has identified some genotypes (Table 2) that will be useful for future development of suitable confectionery genotypes.

Requirements for the Future

Combining yield and quality is a very tricky exercise and normally takes several years before a desired genotype can be released. Under Malawi conditions, this would take more than 15 years. Consumer preference, on the other hand, keeps changing.

For a breeder to keep up with the requirements of the processor and the consumer, there is need for the following:

1. Steady and timely feedback of information on minimum processing requirements. This would enable the breeder to change direction or emphasis on the breeding objectives.
2. Cataloging of all germplasm held by the SADCC/ICRISAT Regional Groundnut Improvement Program with regard to data on yield, seed size, seed shape, seed color, and O L ratios. This would provide useful information for breeders within the region especially in those countries producing groundnuts for confectionery purposes.
3. Breeders should aim to use parents with acceptable O L ratios as a start, or constantly select for this characteristic in segregating lines.
4. Be able to have fatty acid ratios determined in the region.

Acknowledgment

We would like to express our sincere gratitude to Dr R. Jambunathan of ICRISAT Center, India, for analyzing the 60 groundnut samples we sent to him for fatty acid composition. Without his help, data on fatty acid composition would not have been presented. We are also grateful to the SADCC ICRISAT Regional Groundnut Improvement Program for shipping the samples to ICRISAT Center on our behalf.

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Discussion

Rweyemamu: In Table 1, seed yield (kg ha^{-1}) is exactly the same (i.e., 1500 kg ha^{-1}) in both varieties. However, cvs Chalimbana and Chitembana have different seed sizes (i.e., 90 g [100 seeds]$^{-1}$ for Chalimbana and 110 g [100 seeds]$^{-1}$ for Chitembana). Are there any seed-yield components that could have led to such results?

Chiyembekeza: The other seed yield components were not significantly different for both varieties. The only significant differences were seed-size variables.

Wightman: Mani Pintar has an ideal size and shape. Why is it grown for oil extraction and not for confectionery purposes?

Chiyembekeza: The oil content is very high.

Kamangira: What evidence is there to confirm that aflatoxin and pesticide residue is not a problem in Malawi confectionery nuts?

Chiyembekeza: Absence of aflatoxin has been noted from reports of our groundnut buyers, mainly in UK, from their analyses before buying our nuts.

Progress of Groundnut Improvement Research in Zambia

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Abstract

The paper discusses the results of groundnut breeding trials conducted in Zambia during the 1985/86 and 1986/87 groundnut-growing seasons. The superior performance of the two long-duration entries—ICGMS 42 and MGS 3—over the local control variety, Makulu Red, has been established: these also possess large seeds and tolerance of leaf spots. Entry ICGMS 42 (MGS 4) has therefore been approved for prerelease on-farm testing in 1987. Two large-seeded confectionery selections from ICRISAT Center—HYQ(CG)S 19 and HYQ(CG)S 10—outyielded the local control, MGS 2. In addition to their superior seed size and quality, they appear to be more tolerant of leaf spots. Three short-duration entries from SADCC/ICRISAT Regional Groundnut Improvement Program, Malawi—ICGMS 11, ICGM 473, and ICGMS 21—gave high yields and quality seeds. The best of these, ICGMS 11, also showed good tolerance of leaf spots. Three promising valencia entries—ICGMS 281, ICGM 289, and ICGM 197—outyielded control varieties, Comet and Jacana. Though having a red skin, these showed a high degree of tolerance of leaf spots.

Sumário

Progresso da Investigação para o Melhoramento do Amendoim em Zâmbia. *O artigo discute os resultados dos ensaios de melhoramento do amendoim, feitos em Zâmbia, durante as estações de crescimento do amendoim de 1985/86 e 1986/87. O comportamento superior de duas aquisições de longa duração—ICGMS 42 e MGS 3—em relação ao controle local, a variedade Makulu Red, foi estabelecido. Estas veriedades também possuem sementes grandes e tolerancia ás manchas foliares. Assim, a aqusição ICGMS 42 (MGS 4), foi aprovada para os testes de campo de pré-libertação de 1987. Duas selecções de confeitaria, de sementes grandes, provenientes do ICRISAT-Centro—HYQ(CG)S 19 e HYQ(CG)S 10—produziram mais que o controle local, MGS 2. Em adição ao superior tamanho e qualidade da semente, elas parecem ser mais tolerantes às manchas foliares. Três aquisições de curta duração provenientes do Programa Regional de Melhoramento do Amendoim em ICRISAT/SADCC, Maláwi—ICGMS 11, ICGM 473 e ICGMS 21—produziram maiores rendimentos e qualidade da semente. A melhor destas aquisições, ICGMS 11, mostrou também boa tolerância às manchas foliares. Três aquisições promissoras do tipo Valência—ICGMS 281, ICGM 289 e ICGM 197—produziram rendimentos maiores que as variedades de controlo, Comet e Jacana. Ainda que possuindo tegumento vermelho, estas variedades mostraram ter um alto grau de tolerância às manchas foliares.*

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Introduction

Groundnut-producing areas of Zambia, varieties grown, earlier research work undertaken, major constraints to production, and breeding objectives and techniques used, have all been dealt with in detail in our earlier presentations (Sandhu 1985, Sandhu et al. 1985, and Sandhu et al. 1987).

The primary objective of the groundnut improvement program is to increase crop productivity, leading towards self-sufficiency in food and nutritional needs of the people in Zambia. Research on varietal improvement and stablizing yields will result in marketable surpluses for resource-poor farmers.

Germplasm Evaluation

The success of a breeding program largely depends on the extent of the genetic diversity present in the germplasm collection (Nigam 1987).

The genetic resource material collected has been evaluated at Msekera and successfully exploited as direct introductions, with the approval for prerelease on-farm evaluation of varieties MGS 2 (M 13) and MGS 4 (ICGMS 42). In addition, a few accessions have been identified as useful source for leaf spots tolerance (ICG 7888, PI 331304, ICG 4790, and ICG 6330), and are being used in our resistance-breeding program.

Field Trials Evaluation

Long-duration varieties

Breeding and selection has continued to develop improved varieties for areas where rainfall is assured. Production from these areas is important as the quality nuts produced are in great demand for local consumption and for high-value confectionery exports. Many entries in advanced stages of testing have been found potentially promising.

An advanced groundnut variety trial of 10 promising entries, including local control variety, Makulu Red, was conducted at five trial sites representing different environments during the 1985/86 and 1986/87 seasons. The purpose of the trial was to identify entries that give potentially higher yield, superior seed-size and quality, and better tolerance of leaf spots than the control variety. The experimental design was a randomized-block design with six replications. The plots consisted of six rows, 6-m long, 0.75-m apart, and with a 10-cm spacing between seeds (Table 1).

Three entries ICGMS 42, MGS 3, and MGS 6 recorded mean yield increases of 10%, 4%, and

Table 1. Performance of eight groundnut varieties in the Advanced Groundnut Variety Trial (Long Duration), at five trial sites, Zambia, 1985–87.

	Seed yield ($t\ ha^{-1}$)								
	Variety × Location					Variety × Season			Percentage
Variety	Msekera	Masumba	Chisamba	Mufulira	Kabwe	1985/86	1986/87	Variety mean	over control
Flamingo	2.064	1.810	0.619	0.888	0.609	1.593	0.803	1.193	100
ICGMS 36	1.790	1.826	0.797	0.821	0.645	1.493	0.859	1.176	99
ICGMS 42	2.280	1.910	0.868	0.788	0.714	1.656	0.967	1.312	110
MGS 3	2.224	1.728	0.708	1.015	0.536	1.696	1.242	1.242	104
MGS 5	2.045	1.738	0.668	0.774	0.467	1.543	0.733	1.138	95
MGS 6	2.145	1.835	0.679	0.905	0.470	1.641	0.772	1.207	101
SAC 58	2.257	1.520	0.592	0.923	0.448	1.522	0.773	1.148	96
Control									
Makulu Red	2.121	1.684	0.625	0.937	0.596	1.618	0.767	1.193	100
SE	-[1]	-	±0.069	-	-	±0.044	-	±0.031	-
Mean	2.116	1.756	0.695	0.881	0.561	1.595	0.808	1.202	-
CV (%)	-	-	-	-	-	-	-	20	-

1. Not available

1%, respectively, over the yield of the control cultivar, Makulu Red (1.193 t ha^{-1}), respectively. The best of the three, ICGMS 42 maintained its lead at all trial sites except Mufulira (acid soil) with average yield increases of 8% (Msekera) to 39% (Chisamba). During 1986/87, this variety gave the highest average yield increase of 26% over the local control, although during 1985/86 a reduced yield of 2% was recorded. ICGMS 42, because of its earlier maturity, secured a higher yield during 1986/87, when a shorter rainy season occurred. The second-ranked MGS 3 exceeded the yield of cultivar Makulu Red by 3–13% at all test locations, except Kabwe. It gave the highest average yield during the 1985/86 season. The two highest-yielding selections—ICGMS 42 and MGS 3—appeared to possess significantly higher leaf spots tolerance (below 7.0 rating) and better seed size than the local control [44 g (100 seeds)$^{-1}$, 7.7 rating]. In view of the better performance of ICGMS 42, it was approved for prerelease, on-farm testing in 1987.

A Southern African Development Coordination Conference (SADCC) Regional Groundnut Trial (Virginia) was carried out at two trial sites—Msekera and Chisamba—for 3 years (1983/84 to 1985/86). The trial included 14 promising SADCC/ICRISAT Groundnut Improvement Program (Malawi) selections and 2 local control varieties, Chalimbana and Makulu Red. The experimental design was 4 × 4 lattice with four replications. The plots consisted of three rows, 6-m long, 0.75-m apart, and with a 10-cm spacing between stations on ridges (Table 2).

One ICRISAT selection, ICGMS 42, exceeded the yield of the higher-yielding local control, Makulu Red (1.521 t ha^{-1}) by a significant mean margin of 10%. At Chisamba, it gave an average yield increase of 29%, although at Msekera, its yield was no better than the control variety. During the 1983/84 season, ICGMS 42 exceeded cultivar Makulu Red by an average yield margin of 20% and during 1985/86 season by 30%. Another promising

Table 2. Performance of 16 selections in the SADCC Regional Groundnut Trial (Virginia), Msekera and Chisamba, Zambia, over three seasons 1983–86.

	Seed yield (t ha^{-1})						
	Genotype × Location		Genotype × Season				Percentage
Entry	Msekera	Chisamba	1983/84	1984/85	1985/86	Variety mean	over control
ICGMS 35	1.478	1.063	1.179	1.299	1.334	1.270	83
ICGMS 36	1.841	1.210	1.248	1.847	1.482	1.526	100
ICGMS 37	0.844	0.890	0.817	1.046	0.738	0.867	57
ICGMS 38	1.350	1.156	0.964	1.443	1.352	1.253	82
ICGMS 39	1.368	1.062	1.103	1.298	1.245	1.215	80
ICGMS 40	0.723	0.823	0.674	0.990	0.656	0.773	51
ICGMS 41	0.974	0.768	0.715	1.066	0.832	0.871	57
ICGMS 42	1.949	1.408	1.307	1.740	1.989	1.679	110
ICGMS 43	1.195	1.133	1.126	1.373	0.993	1.164	77
ICGMS 44	0.861	0.798	0.823	0.996	0.669	0.829	55
ICGMS 45	1.539	0.921	0.957	1.456	1.277	1.230	81
ICGMS 46	0.821	0.866	0.778	1.018	0.735	0.844	55
ICGMS 47	1.510	1.072	1.187	1.398	1.288	1.291	85
ICGMS 48	1.338	1.089	1.071	1.376	1.193	1.213	80
Controls							
Makulu Red	1.954	1.089	1.090	1.945	1.529	1.521	100
Chalimbana	1.350	0.791	0.939	1.097	1.176	1.071	70
SE	±0.055			±0.067		±0.039	
Mean	1.318	1.009	0.999	1.337	1.156	1.164	-
CV (%)						16	

Table 3. Performance of 25 entries in the SADCC Regional Groundnut Trial (Virginia), Msekera and Chisamba, Zambia, 1986/87.

Entry	Seed yield (t ha^{-1}) Msekera	Chisamba	Mean	Percentage over control	Shelling percentage	100-seed mass (g)	Defoliation (%)
ICGMS 35	1.049	0.347	0.698	86	60	38	68
ICGMS 36	1.393	0.485	0.939	115	64	45	63
ICGMS 38	1.247	0.457	0.852	105	66	46	62
ICGMS 39	1.034	0.482	0.758	93	64	43	72
ICGMS 42	1.765	0.794	1.280	157	66	55	59
ICGMS 43	1.053	0.365	0.709	87	63	41	66
ICGMS 45	1.049	0.252	0.651	80	60	43	65
ICGMS 46	1.199	0.513	0.856	105	56	39	61
ICGMS 48	1.098	0.392	0.745	91	59	42	64
ICGMS 49	0.940	0.170	0.555	68	46	30	66
ICGMS 50	0.930	0.182	0.556	68	47	37	65
ICGMS 51	0.914	0.459	0.687	84	44	34	64
ICGMS 52	1.358	0.449	0.904	111	67	52	58
ICGMS 53	0.963	0.181	0.572	70	56	36	64
ICGMS 54	0.766	0.230	0.498	61	53	35	66
ICGM 336	1.338	0.351	0.845	104	66	43	63
ICGM 484	1.341	0.265	0.803	98	58	39	60
ICGM 608	0.905	0.456	0.681	84	62	46	69
ICGM 614	1.164	0.249	0.707	87	62	50	64
ICGM 623	1.206	0.243	0.725	89	65	48	59
ICGM 631	1.237	0.199	0.718	88	60	44	62
ICGM 633	0.991	0.286	0.639	78	58	46	64
ICGM 749	1.048	0.306	0.677	83	58	41	61
Controls							
MGS 2	1.233	0.370	0.802	98	57	51	63
Makulu Red	1.390	0.239	0.815	100	59	40	65
SE	±0.072	±0.046	-	-	±2	±1	±4
Mean	1.144	0.349	0.747	-	59	43	64
CV (%)	13	26	-	-	7	1	12

selection, ICGMS 36, recorded a mean yield equal to that of the control variety, but at Chisamba it excelled by a yield margin of 11%. The two most promising high-yielding selections ICGMS 42 and ICGMS 36 also have large attractive seeds and thin-shelled pods.

During the 1986/87 season, a reconstituted SADCC Regional Groundnut Trial (Virginia), which included 9 previously tested selections, 14 new entries, and 2 local controls MGS 2 and Makulu Red was conducted at two trial sites, Msekera and Chisamba. The experimental design was a 5 × 5 lattice with four replications. The plots consisted of three rows, 6-m long, 0.75-m apart, and with a 10-cm spacing between stations on ridges. The results are given in Table 3.

The three most promising selections ICGMS 42, ICGMS 36, and ICGMS 52, gave mean yield increases of 57%, 15%, and 11%, respectively, on the higher-yielding local control, Makulu Red (0.815 t ha^{-1}). At Msekera, ICGMS 42 gave a significant yield increase of 27% over the yield of Makulu Red (1.390 t ha^{-1}). At Chisamba, although yields were unsatisfactory, both ICGMS 42 and ICGMS 46 gave significantly higher yields than the better-yielding local control, MGS 2 (0.370 t ha^{-1}). Selections ICGMS 42 and ICGMS 52 have thin-shelled pods with large attractive seeds and appeared to possess tolerance of leaf spots (58–59% defoliation).

An ICRISAT International Confectionery Groundnut Variety Trial, which included 24 large-seeded selections and local control variety Chalimbana, was carried out at Msekera for two seasons, 1985/86 and 1986/87. The trial objective was to identify promising selections for high-yield potential and superior seed quality. The design was a 5 × 5 lattice with four replications. The plots consisted of three rows, 6-m long, 0.60-m apart, and with a 10-cm spacing between stations on ridges. The results indicated that despite 18 selections excelling the control variety, Chalimbana, by significant yield margins of 23–71%, the best seed mass of 54 g given by the third ranked HYQ(CG)S 30 compared poorly with 66 g recorded by the control variety. Furthermore, most of the selections tested showed high leaf spots severity (8.0–9.0 rating).

A second ICRISAT International Confectionery Groundnut Variety Trial, which included 20 large-seeded selections and the local control variety, MGS 2, was conducted at Msekera during 1986/87. The experiment used a randomized-block design with three replications; plots consisted of three rows, 6-m long, 0.60-m apart, and with a 10-cm spacing between stations on ridges. The results are given in Table 4.

Two promising selections, HYQ(CG)S 19 and HYQ(CG)S 10, gave significant yield increases of 32% and 25%, respectively, over local control, MGS

Table 4. Performance of 21 entries in the ICRISAT International Confectionery Groundnut Trial, Msekera, Zambia, 1986/87.

Entry	Seed yield (t ha⁻¹)	Percentage over control	Shelling percentage	100-seed mass (g)	Leaf spots score (1–9 scale)[1]
HYQ (CG)S 10	2.147	125	59	53	7.3
HYQ (CG)S 11	1.844	107	61	50	9.0
HYQ (CG)S 12	1.441	84	56	54	7.3
HYQ (CG)S 13	1.961	114	59	52	8.3
HYQ (CG)S 14	1.727	101	58	53	8.0
HYQ (CG)S 15	1.709	100	54	46	9.0
HYQ (CG)S 16	1.218	71	46	45	7.7
HYQ (CG)S 19	2.256	132	61	64	7.0
HYQ (CG)S 20	1.719	100	67	60	7.0
HYQ (CG)S 21	1.341	78	54	48	8.3
HYQ (CG)S 45	1.489	87	50	43	7.7
HYQ (CG)S 47	1.737	101	58	53	8.3
HYQ (CG)S 49	1.787	104	56	70	7.0
HYQ (CG)S 50	1.289	75	50	46	8.0
HYQ (CG)S 54	1.952	116	47	43	7.0
HYQ (CG)S 55	1.558	91	47	48	8.0
HYQ (CG)S 56	1.706	100	50	53	8.0
HYQ (CG)S 57	1.806	105	54	51	8.0
HYQ (CG)S 58	1.836	107	50	50	8.0
Controls					
Robut 33-1	1.265	74	40	42	8.0
MGS 2	1.714	100	62	56	7.3
SE	±0.110	-	±2.3	±1.7	±0.3
Mean	1.691	-	54	52	7.8
CV (%)	11	-	7	6	5.6

1. Scored on a 1-9 scale, where 1 = No disease, and 9 = 50-100% foliage damaged.

2 (1.714 t ha⁻¹). The best 100-seed mass of 70 g was given by the eighth ranking HYQ(CG)S 49 followed by 64 g in the top-ranked HYQ(CG)S 19; both significantly excelled the 56 g recorded by MGS 2. The best selection, together with two others, showed lower leaf spots severity than the control.

Short-season varieties

These are better suited to light-textured soils receiving low precipitation in the southern and western parts of Zambia. Natal Common and Comet are the predominant varieties grown in these areas. These are small-seeded spanish types and are highly susceptible to leaf spots. Under conditions of limited rainfall, it is difficult to secure significant increase in yield. However, better tolerance of leaf spots and superior size and quality of seeds could produce more stable and higher yields. Many entries in advanced stages of testing have been found to be potentially promising.

A SADCC Regional Groundnut Yield Trial (Spanish) was conducted at two trial sites—Masumba and Magoye—over three seasons from 1983/84 to 1985/86. The trial objective was to evaluate the performance of 34 promising SADCC/ICRISAT Regional Groundnut Improvement Program (Malawi) selections against two local control varieties, Comet and Natal Common. The design was a 6 × 6 lattice with four replications. The plots consisted of three rows, 6-m long, 0.6-m apart, and with a 10-cm spacing between stations of ridges. The results are presented in Table 5.

Three promising selections, ICGMS 11, ICGMS 2, and ICGMS 21, gave mean yield increases of 6%, 2%, and 1%, respectively, over the higher-yielding local controls Natal Common (1.406 t ha⁻¹). At Masumba, ICGMS 11 gave an average yield increase of 14% over the local controls, but this superior performance was not sustained at Magoye, where ICGMS 21 and ICGMS 2 gave as good a yield performance as that of the control, Natal Common. Two entries, ICGMS 2 and ICGMS 5 recorded better average yield performance in two of the trial seasons, 1983/84 and 1984/85. The three promising selections, ICGMS 5, ICGMS 11, and ICGMS 21, have large attractive seeds, while ICGMS 11 showed better tolerance of leaf spots.

During the 1986/87 cropping season, the above trial was reconstituted to include 11 previously tested selections and 23 new entries for comparison with the two local controls, Comet and Natal Common. The trial was conducted at two locations, Masumba and Magoye. The experimental design, plot size, and spacings remained unchanged. The results are given in Table 6.

Because of dry conditions experienced at Magoye, the yields obtained were unsatisfactory. The three most promising entries—ICGM 473, ICGMS 11, and ICGMS 1—gave mean yield increases of 17%, 11%, and 10%, respectively, over the higher-yielding control, Natal Common (0.954 t ha⁻¹), respectively. At Masumba, the best entry ICGM 473 gave 22% yield increase over the control variety (1.554 t ha⁻¹), followed by selections ICGMS 1 (10% increase) and ICGMS 11 (8% increase). At Magoye, the best entry ICGMS 11 and second-ranked ICGMS 56 gave yield increases of 20% and 18%, respectively, over the local control. Selection ICGMS 11, with large attractive seeds, also showed better tolerance of leaf spots. The large-seeded selections ICGMS 55 [59 g (100 seeds)⁻¹] had the lowest leaf spots severity rating (4.3) but gave a poor yield.

Many valencia accessions tried at Msekera in the past showed high tolerance of leaf spots but most of them had red skin, which has a low market acceptability. To identify promising genotypes, a SADCC Regional Groundnut Trial tested 14 valencia entries against 2 local controls—Comet and Jacana—at Msekera during the 1986/87 season. The design was a 4 × 4 lattice with four replications. The plots consisted of three rows, 6-m long, 0.60-m apart, and with a 10-cm spacing between stations on ridges. The results are summarized in Table 7.

Three promising entries, ICGM 281, ICGM 289, and ICGM 197 gave significant yield increases of 16%, 15%, and 14%, respectively, over the higher-yielding control variety, Jacana (1.215 t ha⁻¹). All the test entries showed significantly better leaf spots tolerance (3.8–8.0 rating) than the local control (9.0 rating). Entries with least leaf spots severity—ICGM 550, ICGM 561, ICGM 554, and ICGM 559—recorded poor yields and possessed seeds with unsatisfactory wine-colored skins. However, the best three entries recorded better seed-size than the local control Comet, but had red skin.

Future Collaborative Research with ICRISAT

Our collaborative groundnut improvement program with ICRISAT Center and the SADCC/ICRISAT Regional Groundnut Improvement Program

Table 5. Performance of 36 entries in the SADCC Regional Groundnut Trial (Spanish), Msekera and Chisamba, Zambia, over three seasons 1983-86.

	Seed yield (t ha^{-1})						
	Genotype × Location		Genotype × Season				
Entry	Msekera	Chisamba	1983/84	1984/85	1985/86	Variety mean	Percentage over control
ICGMS 1	1.435	1.063	1.371	0.976	1.401	1.249	89
ICGMS 2	1.632	1.224	1.724	1.143	1.417	1.428	102
ICGMS 3	1.421	1.136	1.551	0.945	1.339	1.278	91
ICGMS 4	1.449	0.784	1.145	0.841	1.365	1.117	79
ICGMS 5	1.796	1.027	1.598	1.134	1.502	1.411	100
ICGMS 6	1.282	0.875	1.238	0.837	1.161	1.079	77
ICGMS 7	1.444	0.901	1.300	0.972	1.242	1.172	83
ICGMS 8	1.301	0.713	1.026	0.934	1.062	1.007	72
ICGMS 9	1.619	1.057	1.582	1.008	1.426	1.339	95
ICGMS 10	1.530	0.931	1.446	1.002	1.244	1.231	88
ICGMS 11	1.839	1.143	1.643	1.224	1.606	1.491	106
ICGMS 12	1.620	0.931	1.369	0.973	1.486	1.276	91
ICGMS 13	1.459	1.039	1.431	0.932	1.385	1.249	89
ICGMS 14	1.335	1.105	1.450	0.894	1.315	1.220	87
ICGMS 15	1.585	1.131	1.523	1.086	1.464	1.358	97
ICGMS 16	1.422	1.050	1.253	1.013	1.444	1.237	88
ICGMS 17	1.627	1.075	1.532	1.063	1.459	1.351	96
ICGMS 18	1.748	0.854	1.183	1.172	1.549	1.301	93
ICGMS 19	1.422	1.085	1.360	1.083	1.318	1.254	89
ICGMS 20	1.554	1.096	1.450	1.089	1.437	1.325	94
ICGMS 21	1.586	1.242	1.720	1.006	1.515	1.414	101
ICGMS 22	1.602	1.159	1.600	1.101	1.441	1.381	98
ICGMS 23	1.512	0.936	1.281	0.994	1.399	1.225	87
ICGMS 24	1.416	1.039	1.226	1.012	1.445	1.228	87
ICGMS 25	1.374	0.947	1.147	0.916	1.421	1.161	83
ICGMS 26	1.473	1.128	1.566	0.972	1.363	1.300	92
ICGMS 27	1.546	1.104	1.666	0.943	1.367	1.325	94
ICGMS 28	1.519	0.902	1.386	0.930	1.318	1.211	86
ICGMS 29	1.356	1.078	1.542	0.754	1.355	1.217	87
ICGMS 30	1.570	0.887	1.331	1.058	1.297	1.229	87
ICGMS 31	1.528	1.074	1.083	1.186	1.634	1.301	93
ICGMS 32	1.566	1.050	1.431	1.086	1.407	1.308	93
ICGMS 33	1.570	1.152	1.603	1.022	1.459	1.361	97
ICGMS 34	1.579	1.066	1.383	1.050	1.535	1.323	94
Controls							
Comet	1.618	0.993	1.383	1.087	1.448	1.306	93
Natal Common	1.549	1.262	1.574	1.109	1.535	1.406	100
Mean	1.525	1.035	1.419	1.018	1.404	1.281	-

Table 6. Performance of 36 entries in the SADCC Regional Groundnut Trial (Spanish), Masumba and Magoye, Zambia, 1986/87.

Entry	Seed yield (t ha^{-1})			Percentage over control	Shelling percentage	100-seed mass (g)	Leaf spot score (1-9)[1]
	Masumba	Magoye	Mean				
ICGMS 1	1.711	0.385	1.048	110	76	35	8.8
ICGMS 2	1.487	0.350	0.919	96	67	35	9.0
ICGMS 5	1.596	0.305	0.951	100	69	46	7.0
ICGMS 9	1.578	0.253	0.916	96	73	38	8.5
ICGMS 11	1.683	0.424	1.054	111	70	47	6.3
ICGMS 12	1.459	0.369	0.914	96	68	51	6.3
ICGMS 13	1.443	0.296	0.870	91	70	48	7.0
ICGMS 21	1.459	0.299	0.879	92	68	38	8.5
ICGMS 29	1.308	0.289	0.799	84	63	33	6.5
ICGMS 30	0.711	0.168	0.440	47	50	39	4.8
ICGMS 31	1.350	0.196	0.773	81	73	41	7.0
ICGM 437	1.302	0.216	0.759	80	71	44	6.8
ICGM 473	1.895	0.342	1.119	117	76	35	8.5
ICGM 522	1.200	0.225	0.713	75	69	36	8.3
ICGM 721	1.363	0.312	0.838	86	72	34	8.0
ICGM 734	1.420	0.312	0.866	91	73	36	8.0
ICGMS 55	0.888	0.099	0.495	52	53	59	4.3
ICGMS 56	1.443	0.418	0.931	98	65	36	7.5
ICGMS 57	1.184	0.093	0.639	67	61	39	5.0
ICGMS 58	0.946	0.245	0.596	62	51	43	6.5
ICGMS 59	1.371	0.242	0.807	85	70	41	8.0
ICGMS 60	1.336	0.369	0.853	89	68	53	7.5
ICGMS 61	1.286	0.176	0.731	77	63	52	6.8
ICGMS 62	0.805	0.071	0.438	46	62	37	5.3
ICGMS 63	1.341	0.258	0.800	84	67	58	5.3
ICGMS 64	1.376	0.340	0.858	90	63	54	5.3
ICGMS 65	0.935	0.310	0.623	65	58	42	7.0
ICGMS 66	1.459	0.379	0.919	96	70	42	7.8
ICGMS 67	1.230	0.397	0.814	85	63	42	8.3
ICGMS 68	1.417	0.382	0.900	94	70	41	7.3
ICGMS 69	1.297	0.317	0.807	85	68	44	8.0
ICGMS 70	1.159	0.224	0.692	73	64	45	8.3
ICGMS 71	1.517	0.285	0.901	94	66	44	7.3
ICGMS 72	0.771	0.112	0.442	46	56	34	5.5
Controls							
Natal Common	1.554	0.353	0.954	100	73	34	8.8
Comet	1.485	0.273	0.899	92	71	32	8.0
SE	±0.086	±0.043	-[2]	-	±2	±2	±0.3
Mean	1.327	0.280	0.804	-	66	41	7.1
CV (%)	13	31	-	-	6	1	8.0

1. Scored on a 1-9 scale, where 1 = No disease, and 9 = 50-100% foliage damaged.
2. Not available.

Table 7. Performance of 16 entries in the SADCC Regional Groundnut Trial (Valencia), Zambia, 1986/87.

Entry	Seed yield (t ha^{-1})	Percentage over control	Shelling percentage	100-seed mass (g)	Leaf spots score (1-9 scale)[1]
ICGM 177	1.289	106	60	26	8.0
ICGM 197	1.387	114	66	27	7.0
ICGM 281	1.411	116	64	28	7.5
ICGM 284	1.160	95	63	25	7.8
ICGM 285	1.015	84	56	25	8.0
ICGM 286	1.320	109	60	28	8.0
ICGM 289	1.398	115	68	26	7.5
ICGM 525	0.812	67	59	39	4.5
ICGM 550	0.579	48	54	35	3.8
ICGM 554	0.464	38	56	26	4.3
ICGM 559	0.360	30	53	29	4.3
ICGM 561	0.408	34	52	25	4.0
ICGMS 30	0.878	72	62	34	5.3
ICGMS 31	1.093	90	65	31	8.0
Controls					
Jacana	1.215	100	61	32	9.0
Comet	1.029	85	64	25	9.0
SE	±0.046	-	±2	±0.6	±0.2
Mean	0.989	-	60	28	6.6
CV (%)	9	-	5	0.4	5.2

1. Scored on a 1-9 scale, where 1 = No disease, and 9 = 50-100% foliage damaged.

(Malawi) has been valuable and should be continued and further expanded to address the following problems:

- Lack of varieties adapted to the various agroecological areas, which limits the potential groundnut production in Zambia.
- Need for a greater priority to develop and select high-yielding varieties possessing large-seeded confectionery export quality nuts
- Need to identify and develop suitable genotypes showing high tolerance of leaf spots, important pests, soil-moisture stress, and acid-soil condition ("pops").
- Need for an emphasis to select pink- or buff-skinned valencia genotypes with high tolerance of leaf spots and high-yield potential.
- Need to augment the variability in the germplasm pool by assembling the desired genotypes.

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Discussion

Wanchinga: How are the production figures for groundnuts derived? From sales figures or yield estimates of planted area?

Sandhu: Figures presented for Zambia were compiled from the Central Statistical Office in Zambia, based on their formulae for yield assessment and from actual reported production.

Groundnut Breeding in Tanzania: Present Approach and Future Projections

F.F. Mwenda[1]

Abstract

The present objectives of the Tanzanian groundnut improvement program are to improve yield through breeding; to use better management practices; and to minimize the effects of production constraints such as diseases, pests, and drought. To achieve these objectives, the genetic base has been expanded. As a stop-gap measure to improve production, two potentially high-yielding varieties—Spancross and Robut 33-1—were released. Future improvement efforts would be to search for genotypes suitable for intercropping in various agroecological zones differing both in rainfall pattern and altitude.

Sumário

O Melhoramento do Amendoim na Tanzania: Aproximação Actual e Projecções Futuras. *Os actuais objectivos do programa tanzaniano de melhoramento do amendoim são o aumento do rendimento atravéz do melhoramento, o uso de melhores práticas culturais e a minimização dos efeitos de limitantes da produção como doenças, pragas e sequia. Para conseguir estes objectivos, a base genética tem que ser expandida. Como uma das medidas para o aumento da produção, duas variedades de alto rendimento potencial Spancross e Robut 33-1 foram libertadas. Futuros esforços para o melhoramento devem incluir a procura de genótipos adaptados à consociação, para as várias regiões agroecológicas, as quais diferem no padrão da precipitação e na altitude.*

Introduction

Groundnut is an important food and cash crop in Tanzania. As a food crop it is rich in proteins and is a source of high-quality cooking oil, which is in short supply in the country. As a cash crop, it provides cash to the small farmer. Practically all of the crop is produced by the resource-poor farmer who traditionally intercrops it with other crops, particularly cereals. There are no large-scale estates and groundnut is very rarely grown as a sole crop. The crop is grown in most parts of the country at altitudes < 1700 m above sea level (Rao and Mwenda 1987) but major areas of production are southeastern, central, and western areas. The cultivars currently grown are Red Mwitunde and its variants in the southeast, local landraces, and a fair number of exotics (Rao and Mwenda 1987) in the other areas. Average yields are very low (about 500 kg ha^{-1}). This is attributable to the use of inherently low-yielding cultivars, poor management practices, and inefficient or nonexistent disease and pest controls. There is an urgent need for appropriate strategies to solve

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ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1989. Proceedings of the Third Regional Groundnut Workshop, 13-18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P 502 324, India: ICRISAT.

these problems because of its importance, coupled with the low average yields and the high demand for the crop. This paper gives an account of the present and future approaches to improve groundnut production through breeding.

Background

Groundnut improvement in Tanzania was initiated by the Overseas Food Corporation in the late 1940s. Emphasis then, as now, was to produce groundnut cultivars with higher-yielding ability than those currently in use locally, and to remove or reduce the constraints limiting production. But unlike now, priority was on cultivars suitable for large-scale mechanized production. This initial phase of the scheme resulted in the release of Red Mwitunde, which is still widely grown by local farmers in the southeast Tanzania.

The current phase of groundnut improvement started in the late 1970s under two separate projects at two separate centers: the Oilseeds Research Project at Naliendele Research Institute initiated in 1977, and the Pulses and Groundnut Improvement Program of the Sokoine University of Agriculture initiated in 1979 (Doto and Keswani 1983). The major objective of both programs is to improve groundnut yield through breeding, better management practices, and eliminate common limitations to production, such as diseases, pests, and drought. Both programs have close and useful links with ICRISAT Center and the SADCC ICRISAT Regional Groundnut Improvement Program in Malawi.

Present Approach at Naliendele

In any crop improvement program, and especially where rapid progress is desired, an essential first step is to create a variable population from which selections can be made. In a self-pollinating crop, such as groundnut, this involves assembling many lines and varieties of different genetic makeup. In the current phase, much effort was placed to collect germplasm from within and outside Tanzania to widen the genetic base, which stood at little more than 50 genotypes initially in 1977. The variability was further limited as most genotypes belonged to short-duration type of the spanish and valencia groups. The germplasm collecti[illegible] present consists of over 1000 lines and varieties imported from various countries as well as locally collected cultivars (Table 1) representing all the three major botanical groups. The variability of our present gene pool was further enlarged with the introduction of segregating populations arising from crosses made at ICRISAT Center.

Table 1. Sources of groundnut germplasm assembled at Naliendele Research Institute, Tanzania, from 1980.

Source	Number of samples
ICRISAT Center	670
SADCC ICRISAT Regional Groundnut Improvement Program	76
Zimbabwe	32
Zambia	38
USA	31
Argentina	7
Mozambique	11
Senegal	8
Kenya	8
Local collection	174
In stock before 1980	164
Total	1219

With a greatly expanded gene pool, and the urgent need to produce a high-yielding cultivar to replace the low-yielding local cultivars, an intensive and extensive selection and testing program was embarked upon in the early stages of this phase. The major priority in this initial phase has been yield. Many lines in advanced yield trials before 1979 were replaced with newly introduced material, while the number of sites have been extended to cover most of the groundnut-growing areas of Tanzania (Tables 2 and 3). This initial thrust resulted in the release of two potentially high-yielding cultivars Spancross in 1983, and Robut 33-1 in 1985 both of which are foreign introductions. The two releases are of a general nature and were intended as a stop-gap measure to improve groundnut production in the country. Spancross (Nyota) yields highest under most conditions but suffers from a lack of dormancy, while Robut 33-1 (Johari) is more suitable under local farming practices. Both of them have average yields of over 1 t ha^{-1} compared with 0.5 t ha^{-1} for most local cultivars and Red Mwitunde.

Since these releases, there has been a slight but essential shift of emphasis in the present approach. The priority now is to search for varieties suitable for

Table 2. Performance of 11 entries, in advanced trials, at eight sites, Tanzania, 1978/79.

	Seed yield (t ha^{-1})							
Entry	NAL[1]	MSI[1]	NAC[1]	SUL[1]	NDO[1]	UYO[1]	MWA[1]	BWA[1]
Tifspan	1.294	1.551	1.379	1.550	1.261	1.425	1.500	2.205
69.29.2	1.035	1.541	1.382	1.450	2.011	1.875	0.904	1.909
70.1.1.1 (valencia)	1.173	1.707	1.280	1.650	2.142	1.600	0.896	2.023
69.63.2.5	1.035	1.589	1.214	1.675	1.952	1.500	0.865	2.409
Natal Common	1.034	1.448	1.398	1.475	1.841	1.875	0.918	1.909
69.62.2.1	1.174	1.754	1.230	1.650	1.701	1.700	0.914	2.114
69.62.2.5	1.055	1.302	1.398	1.500	1.970	1.775	1.140	2.227
69.17.6	1.065	1.294	1.440	1.550	1.880	1.600	1.040	1.886
69.35.1	0.892	1.518	1.406	1.550	1.975	1.573	0.823	1.750
69.99.1.2.4 (valencia)	1.086	1.746	1.337	1.700	1.790	1.625	1.149	1.909
69.1.5	0.994	1.404	1.542	1.600	1.963	1.850	0.107	1.978
SE	±0.067	±0.140	±0.078	±0.121	±0.148	±0.168	±0.117	±0.150
CV (%)	13.3	18.2	11.4	16.8	15.3	20.4	23.8	14.4

1. Sites: NAL = Nalıendele, MSI = Msijute; NAC = Nachingwea, SUL = Suluti; NDO = Ndolela; UYO = Uyole; MWA = Mwanhala; BWA = Bwanga.

Table 3. Performance of 10 entries, in advanced yield trials at nine sites, Tanzania, 1986/87.

	Seed yield (t ha^{-1})								
Entry	NAL[1]	NAC[1]	SUL[1]	UKI[1]	TUM[1]	ILO[1]	GAI[1]	HOM[1]	IFA[1]
2-5 × Robut 33-1	1.024	0.975	0.816	0.781	0.549	1616	0.512	0.272	1.148
1 529	0.638	0.907	0.682	0.886	0.611	1.924	0.584	0.358	1.564
69.62.2.5	0.998	0.903	0.979	0.837	0.749	1.534	0.472	0.263	1.680
Robut 33-1	1.197	0.835	1.267	0.619	0.576	2.072	0.446	0.263	1.404
668 73	0.537	0.777	0.8[illegible]2	0.713	0.735	1.742	0.616	0.154	1.256
Spancross	1.280	0.763	0.828	0.889	0.644	1.751	0.640	0.342	1.656
69.21.2.3	0.796	0.720	1.336	0.610	0.490	1.950	0.600	0.251	1.632
Bebiano Encarnado	0.759	0.628	0.614	0.602	0.568	1.306	0.520	0.128	1.408
Tifspan	0.969	0.617	1.129	0.766	0.520	1.773	0.620	0.192	1.524
Local	0.589	0.621	1.234	0.787	0.762	1.428	0.632	0.106	1.744
SE	±0.051	±0.040	±0.076	±0.036	±0.058	±0.074	±0.046	±0.025	±0.045
Mean	0.879	0.775	0.969	0.749	0.620	1.710	0.564	0.233	1.502
CV (%)	16.8	10.3	23.6	14.3	29.9	13.0	38.8	29.9	5.7

1. Sites: NAL = Naliendele; NAC = Nachingwea; SUL = Suluti; UKI = Ukiriguru; TUM = Tumbi; ILO = Ilonga; GAI = Gairo; HOM = Hombolo; IFA = Ifakara.

specific agroecological zones. Early-maturing spanish and valencia types have been tested in zones with short (3 4 months) rainfall seasons. These areas have a bimodal rainfall pattern with the possibility of two crops each year. Late-maturing virginia types have been tested in zones with a longer unimodal rainfall pattern (4 5 months). However, past results (Tables 4 and 5) indicate that the late-maturing types tend to perform better than early-maturing types at zones with long periods of rain and vice versa.

Hybridization was attempted in 1985 but met with little success because of lack of facilities and skilled manpower. It will, however, be our first priority and will form the basis of the breeding work in our future projections.

Looking Ahead

The previous two phases have concentrated on high yields and high oil content, to alleviate the oilseed deficit in the country. With two improved varieties now in the market there is a need for change in our future breeding activities. A shift in emphasis from recommending varieties of a general-purpose nature to the search for more specific uses, such as in intercropping, and those that are suited to different agroecological zones is now required. Agroecological zones will be categorized according to both altitude and rainfall pattern.

Until now, screening and selecting for disease and pest resistant or tolerant genotypes have received minimal attention. This aspect will receive greater attention in future. Already many genotypes with reasonable resistance to the major diseases exist. Efforts to transfer these genes to promising varieties through hybridization will continue to be a priority. Drought tolerance will be investigated and the transfer of seed dormancy to the spanish and valencia types will receive particular attention.

Table 4. Performance of entries in Groundnut Variety Trials, at four long-season sites, Tanzania, 1986.

Entry	Maturity group[1]	Pod yield (t ha⁻¹)			
		Suluti	Ukiriguru	Tumbi	Uhambule
Mani Pintar	LS	3.818	1.007	2.164	1.107
Apollo	LS	3.808	0.981	2.031	1.086
Behiano Encarnado	SS	2.917	0.503	1.870	1.086
Spancross	SS	2.712	0.842	2.351	0.776
Makulu Red	LS	2.710	0.574	1.877	1.157
Valencia R 2	SS	2.662	0.519	2.752	0.835
6 77	SS	2.662	0.638	2.211	0.982
Njombe 3	LS	2.642	0.384	1.576	0.898
69.62.2.5	SS	2.635	0.915	2.024	0.857
Dixie Runner	LS	2.572	0.561	1.376	1.086
S.E. Runner	LS	2.518	0.334	1.322	1.358
Red Mwitunde	LS	2.295	0.601	1.884	1.169
69.99.1.2.6	SS	2.276	0.434	2.538	0.815
Chihangu	LS	2.224	0.354	1.062	0.793
Robut 33-1	MS	1.944	0.322	2.378	0.648
Local	-	2.796	0.735	2.171	1.461
SE		±0.072	±0.036	±0.011	0.919
Mean		2.699	0.609	1.182	±0.113
CV (%)		13.2	29.2	47.4	0.996
					45.3

1. LS = Long season; SS = Short season; MS = Medium season.

Table 5. Performance of entries in Preliminary Groundnut Variety Trials, at three short season sites, Tanzania, 1986.

Entry	Maturity group[1]	Pod yield (t ha^{-1})		
		Ismani	Hembolo	Gairo
Spancross	SS	2.153	1.833	1.710
Bebiano Encarnado	SS	1.967	1.416	1.607
6/77	SS	1.787	1.596	1.851
Madi	SS	1.765	1.545	1.504
69.62.2.5	SS	1.541	1.589	1.498
Jacana	SS	1.510	1.561	1.719
169.29.2	SS	1.338	1.567	1.493
NWS 11	SS	1.323	1.124	1.572
69.99.1.2.6	SS	1.204	1.004	1.451
Robut 33-1	MS	1.132	1.828	1.408
Mani Pintar	LS	1.072	1.871	1.276
Valencia R 2	SS	0.982	1.205	1.655
S.E. Runner	LS	0.676	1.216	1.491
Njombe 3	LS	0.675	1.413	1.610
Red Mwitunde	LS	0.367	1.058	1.678
Local	-	0.813	1.001	1.565
SE		±0.053	±0.067	±0.027
Mean		1.270	1.439	1.568
CV (%)		20.8	23.9	14.5

1. LS = Long season; SS = Short season; MS = Medium season.

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A Progress Report on the Performance of Advanced Groundnut Breeding Lines in Various Agroecological Zones of Tanzania[1]

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Abstract

*Twenty entries of advanced breeding lines and varieties of groundnut (*Arachis hypogaea *L.) were evaluated during the 1985/86 groundnut-growing season and 34 entries during the 1986/87 season for their performance in four different agroecological zones of Tanzania. The highest yields were from Ilonga and Morogoro where seed yield ranged from 0.938 t ha^{-1} to 1.888 t ha^{-1} in 1985/86 and from 1.033 t ha^{-1} to 1.948 t ha^{-1} in 1986/87. Plant density and number of pods plant^{-1} were consistently positive, and related to yield and due attention ought to be paid to these factors if we are to optimize the groundnut yield. Four entries in multilocational trials performed consistently as well as or better than the control variety, Natal Common, during the 2 years of study.*

Sumário

Um Relatório Intermédio Sobre o Comportamento das Linhas Melhoradas Avançadas do Amendoim nas Várias Zonas Agroecológicas da Tanzania. *Foram avaliadas 20 linhas melhoradas avançadas de amendoim (*Arachis hypogaea L.*), durante a estação de crescimento do amendoim de 1985/86, e 34 outras, durante a estação de 1986/87, quanto ao seu comportamento em quatro diferentes zonas agroecológicas da Tanzania. Os mais altos rendimentos foram obtidos em Ilonga e Morogoro, onde o rendimento de semente variou de 938 kg ha^{-1} a 1888 kg ha^{-1}, em 1985/86, e de 1033 kg ha^{-1} a 1948 kg ha^{-1}, em 1986/87. A densidade das plantas e o número de vagens por planta foram consistentemente positivos e relacionadas com o rendimento. Adequada atenção deve ser dada a estes factores se se quiser optimizar o rendimento do amendoim. Quatro aquisições comportaram-se consistentemente tão bem ou melhor que a variedade da testemunha, Natal Common, durante os dois anos de estudos multilocais.*

Introduction

Groundnut yields in Tanzania are generally low, averaging about 600 kg ha^{-1} (Nigam 1984), as the yield has remained at that level over a period of time. Increased production in recent years has been attributed to increased area grown and not to increased yields (FAO 1983). Many limiting factors have been

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identified in groundnut production in southern Africa (Nigam 1984), including the lack of agroecologically adapted cultivars. Farmers have to plant material of mixed origin and often at suboptimal populations because of the high cost or nonavailability of seed. At present, only a few groundnut cultivars are available to Tanzanian farmers. Since most of the area grown to groundnut is managed by small farmers (Tanzania: Ministry of Agriculture 1972) the crop is often grown for home consumption and considered a valuable cash crop.

In realizing the importance of the problems mentioned above, the Pulses and Groundnut Project funded by the International Development Research Centre (IDRC) was initiated in 1980 at the then Faculty of Agriculture, Forestry and Veterinary Science, Morogoro, with the following objectives for groundnuts:

1. to develop high-yielding varieties with high oil and protein content and resistance to drought;
2. to develop early- and late-maturing varieties suitable for relevant agroecological zones of Tanzania; and
3. to develop matching agronomic packages for groundnuts.

The project is run with a multidisciplinary approach. The work reported in this paper is an assessment of the performance of some breeding lines of groundnut (bunch type) evaluated in multilocational variety trials during the 1985/86 and 1986/87 growing seasons.

Materials and Methods

Following the collection of germplasm, both locally introduced and from other countries, selection and hybridization were made for bunch lines with promise for high yield and disease resistance under Morogoro conditions. These germplasm lines were tested initially in replicated trials at Morogoro, and then at four other sites. The sites used were Tumbi and

Table 1. Seed yield (t ha⁻¹) of 20 groundnut entries in a multilocational trial, Tanzania, 1985/86.

Entry	Ilonga	Ukiriguru	Tumbi (Tabora)	Morogoro	Mean
New Mexico Valencia A	1.178	0.737	0.352	0.180	0.612
Tamnut 74	1.888	0.653	0.368	0.274	0.796
1/94	1.230	0.682	0.413	0.187	0.628
Mamboleo	1.635	0.567	0.408	0.239	0.712
1/80	1.497	0.808	0.471	0.272	0.762
1/84	1.454	0.682	0.440	0.262	0.710
Starr	1.585	0.643	0.284	0.214	0.682
1/65	1.449	0.580	0.312	0.180	0.630
1/106	1.222	0.607	0.393	0.271	0.623
1/69	1.438	0.722	0.378	0.221	0.690
2/108	0.986	0.717	0.263	0.183	0.537
PI 315608	1.485	0.716	0.415	0.183	0.700
2/101	0.938	0.640	0.303	0.174	0.514
Comet	1.740	0.781	0.333	0.138	0.748
1/89	1.362	0.609	0.371	0.124	0.617
Spanhoma	1.695	0.678	0.433	0.144	0.738
Natal Common	1.873	0.651	0.390	0.186	0.775
1/117	1.707	0.667	0.366	0.181	0.730
PI 33709	1.405	0.825	0.373	0.148	0.688
Za-Kienyeji	1.683	0.645	0.333	0.167	0.706
SE	±0.244	±0.075	±0.002	±0.059	
Mean	1.456	0.682	0.370	0.196	
CV (%)	34	22	18	60	

Mwanhala (Tabora region), Ukiriguru (Mwanza region), and Ilonga (Morogoro region).

Twenty entries were in the 1985/86 trial and 34 entries in the 1986/87 trial. The design used in all trials was randomized complete blocks, with four replications. The plot size used was 3 m × 2 m. Seed was sown singly in 50-cm rows in hills spaced 10-cm apart. A phosphate fertilizer (50 kg ha^{-1} of P) was applied to the trials at Tumbi and Mwanhala.

Fourteen variables was recorded at each location but only seed yields and its components will be discussed in this paper.

Collaborators were also requested to record and score any diseases observed. Insect attack was rarely observed and only one station (Mwanhala) recorded the use of endosulfan (Thiodan 35®). All plots were weeded twice using hand-hoes.

Results and Discussion

Yields

T 80, T 69, PI 315608 (an Israeli line) and Spanhoma performed consistently as well as or better than the local control, Natal Common, at most locations but particularly in the Morogoro region during the 2 years of study (Tables 1 and 2). The highest yields were obtained at Ilonga where seed yields ranged from 0.938 t ha^{-1} to 1.888 t ha^{-1} in the 1985/86 season and from 1.033 t ha^{-1} to 1.948 t ha^{-1} in the 1986/87 season. Rainfall in 1986/87 varied considerably among sites with 1251.3 mm at Mwanhala, 1037.9 mm at Tumbi, and only 434.9 mm at Ukiriguru and 420.8 mm at Ilonga. Rainfall distribution pattern was not recorded at Ukiriguru and Ilonga.

None of the most promising lines in 1985/86 were retained for further testing with 25 new lines in multilocational trials in 1986/87. Of the new entries, six performed consistently as well as or better than the local control, Natal Common, at all locations. These are T 37, T 3, Baka, Ex-Ismani, AH 139, and Jonca. Further testing is required to confirm the consistency of performance over locations and seasons.

Correlation and regression analyses

Results in 1985/86 indicated a close relationship between numbers of pods plant^{-1} and yield at all locations (r = 0.403 at Ilonga, 0.519 at Ukiriguru, 0.781 at Tumbi, and 0.699 at Morogoro) while plant density was related to yield at three of the four locations (r = 0.357 at Ilonga, 0.118 at Ukiriguru, 0.060 at Tumbi, and 0.027 at Morogoro).

Results in 1986/87 also showed that plant density and yield were consistently related (r = 0.013 at Ilonga, 0.482 at Ukiriguru, 0.240 at Tumbi, and 0.233 at Mwanhala) and number of pods plant^{-1} was related to yield at three of the four locations. However, consistent relationships over the two seasons were observed at some locations.

In both seasons at Ukiriguru, plant density (r = 0.508 and 0.482) and number of pods plant^{-1} (r = 0.431 and 0.164) were closely associated with seed yield.

At Tumbi, plant density was consistently related to yield (r = 0.354 in 1985/86, 0.240 in 1986/87) and number of pods plant^{-1} was related to individual plant yield (r = 0.781 in 1985/86, and 0.079 in 1986/87) as well as to yield (unit area)$^{-1}$ (r = 0.395 in 1985/86, 0.079 in 1986/87). The 100-seed mass was weakly related to individual plant yield (r = 0.217 in 1985/86, and 0.470 in 1986/87).

It was noticed that time to maturity was negatively correlated with yield at Tumbi, Mwanhala, and Ukiriguru in 1986/87 (r = -0.197, -0.180, and -0.123). This suggests that short-duration cultivars may be better adapted to drier areas but confirms the need for more evidence.

Conclusions

These results emphasize the importance of plant density in obtaining maximum yields and identify number of pods plant^{-1} as being the major determinent of yield.

Many entries in the trials have shown promise for yield, particularly T 69, T 80, PI 315608, and Spanhoma. The entries T 3, Baka, Ex-Ismani, AH 139, and Jonca are also worthy of further testing in multilocational trials and it is suggested that the newly released Johari be used as the local control entry.

Acknowledgments

The authors wish to thank the IDRC for the Financial Support to the Pulses and Groundnut Project at the Sokoine University of Agriculture and to ICRISAT for organizing this workshop and sponsoring our participation.

Table 2. Seed yield (t ha⁻¹) of 34 bunch-type groundnut entries in a multilocational trial, Tanzania, 1985/86.

Entry	Ilonga	Ukiriguru	Tumbi	Mwanhala	Mean
New Mexico Valencia A	1.513	0.350	0.817	0.325	0.751
Tanmut 74	1.855	0.423	0.700	0.400	0.845
1/37	1.850	0.294	0.817	0.583	0.886
Unknown	1.398	0.231	0.708	0.446	0.696
1/94	-[1]	0.363	0.842	0.454	0.553
1/4	-	0.411	0.908	0.633	0.651
1/90	-	0.344	0.565	0.400	0.436
1/80	1.948	0.386	0.850	0.525	0.927
T 3	1.768	0.278	0.775	0.717	0.885
Starr	1.551	0.337	0.800	0.521	0.802
1/68	1.480	0.358	0.908	0.692	0.860
1/69	1.578	0.321	0.817	0.525	0.810
2/108	1.226	0.262	0.675	0.333	0.624
PI 315608	1.715	0.409	0.833	0.504	0.865
Tifrun	1.525	0.494	0.908	0.529	0.864
Bako	1.768	0.324	0.858	0.738	0.922
1/86	1.495	0.358	0.867	0.408	0.782
2/114	1.305	0.235	0.767	0.538	0.711
Manyema	1.426	0.266	0.746	0.442	0.720
Comet	1.473	0.398	0.664	0.638	0.793
2/91	1.606	0.316	0.808	0.525	0.814
Unknown	1.622	0.368	0.892	0.475	0.839
Mafinga	1.033	0.252	0.717	0.454	0.614
Unknown	1.524	0.323	0.750	0.450	0.761
1/24	1.513	0.353	0.808	0.367	0.760
Ex-Njombe	1.207	0.344	0.700	0.675	0.732
Spanhoma	1.744	0.381	0.767	0.750	0.911
Natal Common	1.688	0.293	0.775	0.592	0.837
Zabalaya	1.503	0.364	0.775	0.628	0.818
2/91	1.528	0.428	0.825	0.675	0.864
Ex-Ismani	1.678	0.383	0.808	0.625	0.874
AH 139	1.595	0.387	0.750	0.483	0.804
Jonea	1.624	0.400	0.742	0.558	0.831
Bebiano Vermelha	1.638	0.343	0.683	0.342	0.752
SE	±0.153	±0.045	±0.054	±0.099	
Mean	1.561	0.346	0.783	0.528	
CV (%)	20	26	14	38	

1. Not available.

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Discussion

Nigam: What are the CVs of your yield trials? Is it phenotypic or genotypic correlation? If your CVs in some of your trials are so high and noting the fact that you have worked out phenotypic relationship, what purpose do these results serve? Yield per se is the best selection criterion in groundnut.

Reuben: In some of the trials, very high CVs were reported. Correlations worked out were phenotypic. Authors emphasized the consistency of their results even though the environmental components were not separated out.

Chiyembekeza: I would like to have some clarification on the 20 lines you evaluated, beginning from the 1985/86 season. When you say that crosses for these were made in 1980, how many growing seasons do you have to enable stabilization of the lines and have them in a trial after 5 years only?

Reuben: The crosses referred to were in fact made several years prior to 1980.

Hildebrand: You suggest from your results that pods plant^{-1}, because of its close association with yield, could be a good selection index. I submit that its suitability is low and would be no better than selecting for yield alone.

Groundnut Improvement Program at the ICRISAT Sahelian Center: Research Problems, Priorities, and Strategies

B.J. Ndunguru[1], D.C. Greenberg[2], and P. Subrahmanyam[3]

Abstract

Groundnut production in West Africa has been declining. The major constraints to groundnut production in West Africa are: lack of cultivars with resistance to drought; diseases and insect pests; poor agronomic and cultural practices that are not adequate to take advantage of yield potential of cultivars; aflatoxin contamination, which lowers the market value; low yields from lack of complete physiological adaptation of groundnuts and associated microorganisms to the environment; fluctuations in the commercial market limiting production and utilization; crop growth variability; windstorms and sandblasting. The Groundnut Improvement Program established at the ICRISAT Sahelian Center, Niamey, Niger, seeks to develop high-yielding breeding lines adapted to various agroecological requirements of West Africa, by incorporating resistances to major biotic and physical stress factors and to develop agronomic practices suitable for resource-poor farmers in the region, in collaboration with national and international research programs. The strategies employed to achieve these goals are presented. The authors report on the performance in 1987 in Niger of groundnut lines from SADCC/ICRISAT Regional Groundnut Program (Malawi) and discuss potential areas for collaboration between the two regions.

Sumário

Programa de Melhoramento do Amendoim do Centro ICRISAT em Sahel: Problemas, Prioridades e Estratégias da Investigação. *A produção de amendoim na Africa Ocidental está em declinio. As maiores limitantes para a produção de amendoim na Africa Ocidental são: falta de cultivares resistentes à seca; doenças e pragas de insectos; praticas culturais pobres, que não são adequadas para tirar vantagem do rendimento potencial dos cultivares; contaminação com aflatoxina, que baixa o valor de mercado; baixos rendimentos, como resultado da falta de uma completa adaptação fisiológica, do amendoim e microorganismos associados, ao ambiente; flutuações no mercado comercial, limitando a produção e a utilização; variabilidade no crescimento da cultura; ventos fortes e tempestades de areia. O Programa de Melhoramento do Amendoim estabelecido no Centro ICRISAT em Sahel, Niamey, Niger, procura desenvolver linhas melhoradas de alto rendimento, adaptadas às várias necessidades agroecológicas da Africa Ocidental, atravéz da incorporação de resistência aos mais importantes factores bióticos e fisicos*

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de "stress", e desenvolver práticas agronómicas adaptadas aos agricultores, pobres em recursos, da região, em colaboração com os programas de investigações nacionais e internacionais. As estratégias empregues para a obtenção destes objectivos são apresentadas. Os autores reportam sobre o comportamento, em 1987, em Niger, das linhas de amendoim oriundas do Programa Regional de Amendoim SADCC/ICRISAT (Maláwi) e discutem as potenciais áreas de colaboração entre as duas regiões.

Introduction

Groundnut (*Arachis hypogaea* L.) was introduced to West Africa from South America, where it originated, by Portuguese traders and explorers in the 16th and 17th centuries. The completion of the railway line from Bamako to Dakar in 1923, and of the railway from Lagos to Kano, resulted in considerable expansion of groundnut cultivation in Senegal, Mali, Nigeria, and Niger, with Britain and France providing an assured market for the produce (Cummins 1986; Morris 1987).

Groundnut is important for its oil (44-56%) and protein (25-34%), and is a valuable commodity for both human beings and for consumption by livestock, and therefore is an important cash and food crop.

Groundnut-producing Areas in West Africa

The West African Region produces about 60% of the total groundnut production in Africa, and is one of the largest groundnut-producing regions in the world (Table 1). The Sahelian countries were major exporters of groundnut products in the past. Senegal is the largest producer followed, in order, by Nigeria, Cameroon, Ghana, Gambia, Mali, Chad, and Côte d'Ivoire. Groundnut is one of the most important crops in gross value and in value of exports in many countries of the region (Anonymous 1982).

Production has been declining in recent years (Fig. 1). This decline in production has been attributed to, among other factors to drought, pest and disease epidemics, and to the instability of the market and low producer prices (Abdoulaye 1982; Misari et al. 1982).

The crop is cultivated mainly in the area bounded by the 450-mm and 1500-mm isohyets and within this range early (e.g., cv 55-437) and late cultivars (e.g., cv 28-206) are grown depending on the rainfall pattern and distribution and the length of the growing season.

Constraints to Groundnut Production in West Africa

The major constraints to groundnut production in West Africa are:

- lack of cultivars possessing resistance to drought, diseases, and insect pests;
- poor agronomic and cultural practices that do not allow cultivars to reach their full yield potential;
- aflatoxin contamination, which lowers market value;

Table 1. Area, yield, and production of groundnut in 13 countries in West Africa[1].

Country	Area (× '000 ha)	Average yield (t ha^{-1})	Production (× '000 t)
Benin	88	0.80	70
Burkina Faso	119	0.67	79
Cameroon	320	0.44	140
Chad	170	0.53	90
Côte d'Ivoire	90	0.96	86
Gambia	101	1.23	124
Ghana	118	1.10	129
Guinea	130	0.58	75
Mali	200	0.60	120
Niger	120	0.35	42
Nigeria	590	1.04	616
Senegal	600	1.20	720
Sierra Leone	14	1.00	14

1. Samples taken from the 1986/87 crop only.

Source: Anonymous (1987). Groundnut. FAO Monthly Bulletin of Statistics 10:15.

Figure 1. Groundnut production (1961-85) in Senegal and Nigeria. Source: FAO (1987).

- low yields because of lack of complete physiological adaptation of groundnuts and associated microorganisms to the environment; and
- fluctuations in the commercial market, limiting production and utilization.

In addition, crop-growth variability in the poor sandy soils of the Sahel, and windstorms and sandblasting during early crop growth, can be very damaging to groundnut crops.

Research Program Objectives

The Groundnut Improvement Program was established at the ICRISAT Sahelian Center (ISC), Niger, in September 1986, and became fully staffed by January 1987. The Program seeks to develop high-yielding breeding lines adapted to the various agroecological requirements of West Africa, by incorporating resistances to major biotic and physical stress factors and to develop agronomic practices suitable for small farmers in the region. This work will be carried out in close collaboration with the national and international research programs in the region such as the Peanut Collaborative Research Support Program (Peanut CRSP), Institut français de recherche scientifique pour le développement en coopération (ORSTOM), Institut de recherches pour les huiles et oléagineux (IRHO), as well as Centre regional de formation et d'application en agrométéorologie et hydrologie opérationnelle (AGRHYMET).

Drought

Drought is clearly one of the major factors limiting groundnut production in West Africa, especially in the Sahel. Variability in the rainfall distribution may be as important as amount of rainfall.

As drought in the Sahel appears to be characterized by its unpredictability, with potential damaging drought spells occurring at any time during the cropping season, we are devising a system to screen cultivars and germplasm for drought tolerance under such conditions of variable distribution. We are also assembling and evaluating groundnut germplasm that has shown drought tolerance elsewhere, e.g., at ICRISAT Center. Attempts will also be made to select genotypes with a combination of earliness and reasonable dormancy that could be valuable under the erratic rainfall patterns found in the region. The effects of drought stress on pod rots and aflatoxin contamination of groundnut will be investigated.

Diseases

Diseases are one of the major constraints to groundnut production in West Africa. Many fungal and virus diseases have been reported from the region and of these, groundnut rosette virus, leaf spots, pod rots, peanut clump, and seedling diseases are widespread and destructive. A groundnut rosette epidemic in 1975 resulted in the destruction of about 55% of an estimated 1.3 million ha of groundnut in Nigeria (Yayock et al. 1976). In the same year in Niger, groundnut production was reduced from 217000 t (mean of 1961 74) to 42000 t (an 80% decrease in groundnut production) with an average yield of only 131 kg ha^{-1} due to a severe epidemic of groundnut rosette. Leaf spots in conjunction with rust cause extensive damage to groundnut crops in medium- and high-rainfall areas of West Africa. Although these diseases can be managed by the application of certain pesticides, it is very clear that at present it is not economically feasible for the small-scale farmers in the region to use them. Hence, developing high-yielding varieties with disease resistance is one of the major objectives of the Groundnut Improvement Program at ISC. Germplasm lines and breeding populations with resistance to late leaf spots and rust developed at ICRISAT Center were assembled at ISC and are being evaluated in different locations in the region. Rosette-resistant lines developed in West Africa, and in the SADCC/ICRISAT Regional Groundnut Improvement Program in Malawi are being assembled at ISC for evaluation in the region. Combining resistances to groundnut rosette and foliar diseases in short-cycle varieties will receive high priority. The occurrence and distribution of groundnut diseases will be determined through systematic disease surveys in the region. The losses in pod and haulm yields from diseases will be determined, where such information is scant. The effects of environmental factors on disease development will be investigated in different agroclimatic zones. The occurrence and distribution of pathotypes of leaf spots and rust pathogens will be determined in collaboration with scientists at the Centre de coopération internationale en recherche agronomique pour le développement (CIRAD), France.

Aflatoxins

Aflatoxin contamination in groundnut is a serious problem in many groundnut-producing countries of West Africa. In the groundnut-growing areas of West Africa, the crop is vulnerable to invasion by *Aspergillus flavus* Link ex. Fr. before harvest, because pods are commonly damaged by soil insects and pathogens (McDonald and Harkness 1967). Since the crop is grown mainly by resource-poor farmers using hand tools there exists a high possibility of damage to pods at lifting and shelling (Gibbons 1986). The unpredictable droughts in the Sahel coupled with late rains, which can result in the cracking and rewetting of pods, and improper storage conditions are all factors that may facilitate *A. flavus* invasion and aflatoxin accumulation. Various crop handling and storage methods have been designed to reduce aflatoxin contamination in groundnut. However, these methods have not been fully adopted by farmers in the region. It has, therefore, become necessary to utilize genetic resistance in the hope of developing genotypes with reasonable resistance to seed invasion by *A. flavus* and/or aflatoxin production. At ISC, we are estimating the levels of aflatoxins in groundnut samples collected from the farmers and the local markets in collaboration with Peanut CRSP of Texas A&M University. The sources of resistance to seed invasion by *A. flavus* and/or aflatoxin production identified at ICRISAT Center, in USA and Senegal, are being assembled to test their performance in multilocational trials in the region. Studies will also be conducted to integrate genetic resistance and agronomic practices in reducing the aflatoxin contamination.

Insect pests

Insect pests are important because of the direct damage they cause, and also indirectly as vectors of viruses, e.g., *Aphis craccivora*, which spreads groundnut rosette. In West Africa, where groundnut is grown by small-scale farmers, it may be prudent to develop insect-resistant varieties and/or to implement integrated pest-management strategies to increase stability in crop production (Lynch et al. 1986).

We have established pest-monitoring plots to identify groundnut pests and also to determine their population density and abundance. Early results in Niger indicate that millipedes and termites are the most important pests, and management strategies are being worked out.

Investigations on crop growth variability

Variation in crop growth is one of the major limiting factors of groundnut production in the Sahel. During surveys in Niger in 1986 and 1987, we observed considerable variability in crop growth in farmers' fields, especially in sandy soils, in all major groundnut-producing areas of the country. Affected plants appeared to occur at random, irrespective of the field contour. This variation in crop growth is particularly serious at ISC.

The factors contributing to the variation in crop growth are not fully elucidated. We considered that lack of organic matter, nutrient imbalance and soil biotic stress factors were possible causes and we have initiated investigations on the role of various abiotic and biotic factors on crop-growth variability at ISC. Our initial findings indicate that crop-growth variability can be reduced and yield increased by the application of soil pesticides.

Plant nutrition

Soils in the Sahel are sandy, poor in nutrients, low in organic matter, and have a very low buffering capacity. Phosphorus status is low in large areas. Several countries in West Africa have phosphate deposits and the potential does exist for these countries to exploit them (McClellan and Notholt 1986). Because of their low solubility, the reactivity of these indigenous rock phosphates is low when applied directly (Bationo et al. 1985). Solubility can be increased by partial acidulation and we have initiated studies to evaluate the response of groundnuts to various sources of rock phosphate. The utilization of gypsum, which also is locally available, to correct both sulfate and calcium deficiencies, is being evaluated.

Cropping systems

Groundnuts in West Africa are grown either sole or as an intercrop with sorghum, pearl millet, maize, and other crops on ridges or on the flat. Under traditional farming systems, the farmers cultivate the same piece of land year after year and this can lead to a decline in yield.

Research has been conducted on various aspects of the groundnut crop and recommendations exist for seedbed preparation, varieties, seed dressings, planting dates, plant populations, fertilizer rates, and effective measures to control weeds, insects, and diseases. We are evaluating the extent to which these practices have been utilized to stabilize and improve groundnut production as well as to reduce risks and crop losses. We are seeking to improve or modify recommendations to make them more appropriate for farmer conditions.

Adaptation of groundnut cultivars in West Africa

Lack of cultivars with resistance to drought, diseases, and insects has been cited as one of the major constraints to groundnut production (Cummins 1986). Although there are many national and international programs working on groundnuts, the genetic variability in the region may be very narrow and coordination of groundnut improvement efforts in the region, lacking. We are attempting to diversify the genetic base so that improved varieties adapted to different ecological zones in the region may be developed. We are introducing selected groundnut breeding and germplasm lines to the West African region and selecting genotypes with earliness and/or drought tolerance for drier areas and longer-duration material with foliar disease resistance for high-rainfall areas. Suitable parents for hybridization are being identified.

Performance in Niger in 1987 of SADCC Regional Groundnut Cultivar Trials

The three SADCC/ICRISAT Regional Groundnut Cultivar Trials were grown at two locations in Niger during the 1987 rainy season; ISC, Sadoré (13° 18′ N; altitude 210 m; 568-mm mean annual rainfall), and the Institut national de la recherches agronomique du Niger (INRAN) station at Bengou (17° 59′ N; altitude 200 m; 839-mm mean annual rainfall). However, the rainfall in Niger in 1987 was appreciably below the long-term average with 458-mm rainfall at Sadoré and 611-mm rainfall at Bengou. Temperatures are much higher than those of the Central Malawian plateau and the duration of the rainy season is much shorter at about 90–105 days.

Despite these climatic differences, some entries in these trials performed well. Data on selected entries in the SADCC Regional Groundnut Trial (Spanish) are given in Table 2. Haulm yields are also shown as these are a very important source of animal feed in all groundnut-growing areas of West Africa. The SADCC Regional Groundnut Trial (Spanish) was harvested 99 days after planting at Bengou and 103 days after planting at Sadoré, as the soil and plants had completely dried out at both locations. We found that ICGMS 5 and ICGMS 13 performed particularly well at Bengou, giving significantly higher pod yields than the best control, 55-437, and haulm yields equal to that of 55-437. These entries also had much larger seed size than the control

Table 2. Performance of 16 entries in the SADCC Regional Groundnut Cultivar Trial[1] (Spanish), INRAN Bengou and ISC Sadoré, Niger, rainy season 1987.

	Bengou				Sadoré			
Entry	Haulm yield (t ha^{-1})	Pod yield (t ha^{-1})	Shelling percentage	100-seed mass (g)	Haulm yield (t ha^{-1})	Pod yield (t ha^{-1})	Shelling percentage	100-seed mass (g)
ICGMS 1	2.79	2.03	68	35	0.87	0.70	58	25
ICGMS 2	3.05	2.20	69	36	0.58	0.58	63	24
ICGMS 5	3.49	2.52	63	59	1.14	0.50	44	37
ICGMS 11	4.37	2.10	67	48	1.19	0.48	41	35
ICGMS 12	3.10	2.00	62	51	1.33	0.61	40	34
ICGMS 13	3.18	2.44	66	50	0.89	0.36	45	29
ICGMS 21	3.40	2.34	69	37	0.87	0.66	61	27
ICGMS 31	3.89	1.57	61	47	1.06	0.72	48	37
ICGM 473	4.01	1.88	67	35	1.20	0.80	62	26
ICGM 721	3.00	1.76	73	35	0.98	0.73	66	25
ICGMS 59	4.57	1.99	63	44	1.04	0.65	50	32
ICGMS 64	3.66	0.94	63	59	1.44	0.90	52	47
ICGMS 66	3.23	1.99	62	50	0.83	0.47	50	26
ICGMS 68	4.00	2.17	66	50	1.02	0.61	51	28
Controls								
55-437 (spanish bunch)	3.17	2.00	67	34	0.52	0.50	59	25
28-206 (virginia bunch)	3.49	1.47	61	36	0.96	0.31	44	26
SE	±0.44	±0.15	±3	±2	±0.13	±0.10	±3	±3
Trial mean (36 entries)	3.84	1.69	63	45	1.06	0.53	45	29
CV (%)	20	15	10	7	22	31	11	16

1. 6 × 6 triple lattice, plot size 6 m^2.

cultivars and may be valuable for local confectionery purposes. Three further cultivars, ICGMS 2, ICGMS 21, and ICGMS 68, also performed well at Bengou, with high pod yields and high shelling percentages. The performance at Sadore was much poorer than at Bengou; this was not surprising as groundnuts are not widely grown in the region because of the short growing season, low and erratic rainfall and extremely sandy, nematode-infested soils. Despite these constraints, the performances of ICGMS 1, ICGMS 21, ICGM 473, and ICGM 721 (all with reasonable pod yields and acceptable shelling percentages) were quite remarkable. ICGMS 64 gave high haulm and pod yields, but its shelling percentage was rather low. Yields at Sadoré were variable because of the localized growth crop variability, which is common in sandy soils in West Africa and makes experimentation very difficult.

Most of the entries in the SADCC Regional Groundnut Trial (Alternate Branching) were harvested 106 days after planting at Bengou and 107 days after planting at Sadoré as the soil was dry and plants were drying out at Bengou and soil and plants were completely dry at Sadoré. At Bengou (Table 3), we identified three entries, ICGMS 38, ICGMS 39, and ICGMS 42, that gave pod yields equal to or better than the best control, 55-437. Haulm yields of ICGMS 38 and ICGMS 42 were also much higher than the controls. As expected with alternate-branching lines, the seed size of these three entries was considerably larger than that of the controls. As groundnuts in Malawi normally take 150-160 days to mature, the performance of these lines in a 105-day season at Bengou is quite remarkable. The low shelling percentage of ICGMS 42 would suggest that this line would have a much higher potential yield in longer-season conditions, which would be found slightly further south in the Sudanian-Northern Guinea zones. ICGMS 42 has given consistently high yields in southern Africa and appears to have

Table 3. Performance of 12 entries in the SADCC Regional Groundnut Cultivar Trial[1] (Alternate Branching), INRAN Bengou and ISC Sadoré, Niger, rainy season 1987.

	Bengou				Sadoré			
Entry	Haulm yield (t ha^{-1})	Pod yield (t ha^{-1})	Shelling percentage	100-seed mass (g)	Haulm yield (t ha^{-1})	Pod yield (t ha^{-1})	Shelling percentage	100-seed mass (g)
ICGMS 35	6.05	1.57	56	47	1.20	0.73	55	42
ICGMS 36	6.84	2.08	57	52	1.07	0.46	46	42
ICGMS 38	5.24	2.71	69	57	0.56	0.45	44	39
ICGMS 39	3.49	2.50	61	50	0.90	0.51	57	42
ICGMS 42	5.61	2.60	54	61	1.35	0.46	47	43
ICGMS 43	4.26	2.27	59	49	1.04	0.60	59	37
ICGMS 45	7.70	2.05	56	40	1.18	0.31	40	28
ICGMS 48	4.84	1.85	59	51	1.44	0.67	42	38
ICGMS 52	4.74	2.33	51	61	1.56	0.39	47	43
ICGM 336	7.84	2.09	60	54	1.14	0.44	45	30
Controls								
55-437 (spanish bunch)	3.34	2.50	67	41	0.47	0.43	63	25
28-206 (virginia bunch)	4.56	1.85	60	36	0.62	0.26	56	31
SE	±0.50	±0.21	±4	±3	±0.15	±0.08	±2	±3
Trial mean (25 entries)	6.18	1.82	57	48	1.14	0.39	45	34
CV (%)	14	20	11	11	23	36	9	14

1. 5 × 5 triple lattice, plot size 6 m^2.

very wide adaptability. It was not surprising that the alternate branching lines did not perform very well at Sadoré where the season was even shorter and rainfall less than Bengou. However, ICGMS 36, ICGMS 39, and ICGMS 43 gave relatively good pod yields and acceptable shelling percentages, when compared with the controls.

The SADCC Regional Valencia Groundnut Cultivar Trial was also grown at both Sadoré and Bengou, but in this trial there were no significant differences in pod or haulm yield. This trial looked very promising during the early vegetative growth stages, but this promise was not translated into final pod production. Selected entries from the SADCC Groundnut Cultivar Trials (Spanish, and Alternate Branching) will go into ICRISAT Cultivar Trials in Niger and possibly Nigeria in 1988. The SADCC Regional Trials will also be repeated at two locations in Niger during the 1988 rainy season.

Considering the extreme differences in climate between Central Malawi, where the entries in the SADCC Regional Trials were selected, and Niger, it is remarkable that any of these lines performed well in comparison with the local control cultivars. We have also found that some groundnut germplasm lines collected from eastern and southern Africa performed very well in Niger in 1987. This would suggest that collaboration between programs in West Africa and southern Africa could well be a very fruitful approach to germplasm improvement, particularly when considering the drier parts of both regions.

Conclusion

We have attempted to define the major constraints of groundnut production in West Africa and the strategies to be employed to improve groundnut production. We are hosting our first West African Regional Groundnut Workshop in September 1988, where national research programs and other agencies involved in groundnut research have indicated their interest in participation. Our proposed program will naturally be modified as a result of the discussions and recommendations arising from the meetings.

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Discussion

Wightman: With reference to the experiment where you added 10 kg a.i. carbofuran ha^{-1}, to what do you attribute the response? Carbofuran is an insecticide and nematicide and you have used an extraordinarily high rate.

Ndunguru: The response appears to be in fact because of nematode control.

An Update on Groundnut Breeding Activities at ICRISAT Center with Particular Reference to Breeding and Selection for Improved Quality

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Abstract

Groundnut breeding activities at ICRISAT Center are organized into six project areas. Having already made reasonable progress with incorporating resistance/tolerance to single-stress factors, a high priority is now attached to develop genotypes with resistance/tolerance to multiple-stress factors. A brief update on progress in this direction is presented. The groundnut varieties resulting from different project activities are currently organized into five international trials for distribution internationally. Groundnut varieties derived from ICRISAT Center activities have been released or are in various stages of release to farmers for general cultivation in different national programs. Progress in breeding at ICRISAT Center for improved quality traits is described.

Sumário

Uma Actualização das Actividades do Melhoramento do Amendoim no Centro ICRISAT com Particular Referência ao Melhoramento e Selecção para o Aumento da Qualidade. *As actividades de melhoramento do amendoim no Centro ICRISAT estão organizadas em seis áreas de projecto. Depois de se ter conseguido um razoável progresso na incorporação da resistência/tolerância a factores de "stress" simples, alta prioridade foi dada ao desenvolvimento de genótipos com resistência tolerância a factores de "stress" multiplos. Uma breve atualização sobre o progresso nesta direção é apresentado. As variedades de amendoim resultantes das diferentes actividades dos projectos, estão actualmente organizadas em cinco ensaios internacionais para serem distribuidos internacionalmente. As variedades de amendoim derivadas de actividades do Centro ICRISAT, foram libertadas, ou estão em vários estádios de libertação para os agricultores, para o cultivo em diferentes programas nacionais. Progresso no melhoramento para o aumento dos factores de qualidade, feito no Centro ICRISAT, é apresentado em detalhe.*

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Introduction

The groundnut section of the Legumes Program at ICRISAT Center is organized into the following 15 broad-based projects:

1. Biology and management of foliar diseases of groundnut.
2. Biology and management of aflatoxin contamination of groundnut.
3. Biology and management of groundnut diseases caused by soil fungi, bacteria, and nematodes.
4. Biology and management of groundnut diseases caused by viruses, prokaryotes, and viroids.
5. Adaptation to specific environments and requirements.
6. Drought stress effects on groundnut.
7. Investigations on nutrient stresses and exploitation of *Rhizobium* and mycorrhizae to increase groundnut production.
8. Exploitation of *Arachis* species to improve the cultivated groundnut.
9. Identification and utilization of host plant resistance to insect pests and associated organisms.
10. Biology and management of pests of stored groundnuts.
11. Integrated pest management with emphasis on *Spodoptera litura* and groundnut leaf miner.
12. Termite control in groundnuts.
13. Evaluation of nutritional and food quality of groundnut.
14. Photoperiod effects in groundnut.
15. International cooperation.

These projects were formulated in 1985 by merging several interrelated, independent projects and were reviewed at the Institute level in 1987. These are multidisciplinary and demand active collaboration and cooperation of all groundnut scientists working at the Center. Genetic exploitation and improvement, although a very significant component of the management, is considered as one of many approaches that need to be integrated into one management package so that returns to the farmer are maximized from each unit of money spent.

The Breeding Unit at the Center is actively involved in project numbers 1, 2, 4, 5, 8, 9, 13, and 15. In each project, we have a prioritized list of stress factors, where amelioration through genetic means is being attempted.

In 1987, the direction of thrust of the groundnut breeding activities changed. Having made reasonable progress in incorporating resistance/tolerance to single-stress factors, we now attach a high priority to developing genotypes with resistance/tolerance to multiple-stress factors. We have recently begun the zonalization of groundnut-growing environments, based on both biotic and abiotic stress factors. This will help us to determine the most appropriate combination of different stress factors operating in a region.

The following breeding activities are currently being pursued under different projects:

Project	Priority stress factor	Breeding activity
1	Late leaf spot Rust Early leaf spot	Breeding for resistance to foliar diseases.
2	Aflatoxin contamination	Breeding for resistance to *Aspergillus flavus*.
4	Tomato spotted wilt virus Peanut mottle virus (PMV) Peanut stripe virus (PStV)	Breeding for resistance to bud necrosis disease. Screening advanced breeding lines for PMV tolerance. Screening germplasm lines for tolerance/resistance to PStV.
5	No stress Single biotic or abiotic stresses Multiple stresses	Breeding for adaptation to specific environments and requirements.
9	Thrips, Jassids, Aphids *Spodoptera* Groundnut leaf miner	Breeding for resistance to insect pests.
15		Regional and international varietal trials. Supply of seed material.

The progress made with these areas and the future direction of research in each is briefly reviewed.

Breeding for Resistance to Foliar Diseases

There are now several identified or confirmed resistant sources to groundnut rust disease at ICRISAT Center. Most of the rust and late leaf spot material have been evaluated at several other places, and they have, in general, maintained their resistance. Most of the rust and late leaf spot resistant material belong to subspecies *fastigiata* and have commercially unacceptable pod shape. Through hybridization and selection, we have been able to transfer rust and late leaf spot resistance to commercially acceptable and agronomically superior genetic backgrounds. Some of the most promising foliar disease resistant selections, which may be released for general cultivation in India in the near future, include ICG(FDRS) 4, ICG(FDRS) 10, and ICGS(FDRS) 43. However, we have not been able to identify sources of resistance to early leaf spot.

Breeding for resistance to *Aspergillus flavus*

Aflatoxin contamination is a complex problem and it can occur at preharvest, harvest, or postharvest stages in the field and also during storage at the processor consumer level. Genetic improvement in the resistance level is considered as one of several approaches to resolve this problem. Genetic resistance, together with better crop management practices and optimal storage conditions, can significantly reduce contamination.

Seven lines, which are sources of dry seed resistance to *A. flavus*, have been identified and used in the breeding program. The resulting derivatives have been tested for level and stability of resistance to *A. flavus* and for yield potential in multilocational trials. Our success has been limited: we have neither been able to improve upon level of resistance nor yield potential already available in some of the resistant sources, which are commercial varieties. We have, however, been able to transfer stable resistance into different genetic backgrounds and some of these lines outyielded local control varieties at certain locations.

Breeding for Resistance to Virus Diseases

At present, our breeding program involves developing resistant/tolerant varieties to bud necrosis disease (BND) and peanut mottle virus (PMV). Some preliminary screening is also being conducted to identify resistance/tolerance to peanut clump virus (PCV).

Bud necrosis disease, caused by tomato spotted wilt virus and transmitted by thrips, occurs in serious proportions in India and is becoming increasingly important in many other countries. By breeding for vector resistance, we have been able to reduce considerably BND incidence. Recent studies on virus tolerance have shown that virus multiplication is less in some of these lines (ICRISAT 1988, p. 234). Currently we are using both vector-resistant and virus-tolerant lines to improve the level of BND resistance. Most of the vector-resistant sources that we have used are unattractive plant types, are poor yielding, late maturing, and possess runner-growth habit. The only exception appears to be ICG 2271. We have now developed agronomically desirable bud necrosis tolerant lines, such as ICGV 86029, ICGV 86030, ICGV 86031, and ICGV 86032, which possess higher yield potential.

Some rust and late leaf spot resistant source lines, used in our foliar diseases resistant breeding [EC 76446(292) and NC Ac 17133(RF)], do not transmit PMV through seed. Other resistant sources (e.g., NC Ac 2240, an insect-pest resistant source) show tolerance of PMV and with yield losses lower than susceptible varieties. Breeding lines, involving these sources as parents, have been screened for nonseed transmission and tolerance of PMV. Eight of these showed no yield loss due to PMV.

Recently, in collaboration with Australian and Indonesian scientists, we have started screening germplasm lines for resistance to peanut stripe virus (PStV) in Indonesia.

Breeding for Adaptation to Specific Environments and Requirements

This is our major breeding project in which we hope to develop material for varying requirements, from no-stress to multiple-stress situations. In our zonalization exercise, we are attempting to identify complexes of important factors that operate in different environments to target our breeding efforts towards these. Most progress so far has been for no-stress situations or where stresses could be overcome by management means. Using this and other improved breeding lines with resistance tolerance to single-stress factors, we are now aiming to develop lines with multiple resistances. Progress made for no-stress situation in different maturity groups is described below.

Early-maturity group. Early-maturing varieties are advantageous in areas where the growing season is short, or the crop is grown in a residual-moisture situation and can also be useful in multiple-cropping situations. However, maturity period for the same variety varies from location to location depending upon the temperature regime, solar radiation, moisture availability, and other factors. This problem can be partially overcome by using cumulative heat units (degree days) to determine harvesting dates. This system uses accumulated daily average temperature units above the base temperature for groundnut taken as 10°C over the cropping duration $[(T_{max} + T_{min})/2 - T_{base}]$. At ICRISAT Center, a crop duration of 75 days in the rainy season corresponds to 105 ± 6 days in the postrainy season, while a crop duration of 90 days in the rainy season corresponds to 120 ± 6 days in the postrainy season. Based on 14-year daily temperature records, 1240 degree days are accumulated in 75 days in the rainy season, and 1475 degree days in 90 days in the postrainy season. Accordingly, we harvest our crop whenever these many heat units are accumulated, irrespective of seasons. A comparison of the shelling percentage of these early-maturing breeding lines and the normal-maturity types indicate that the former varieties mature earlier than normal varieties. We also estimated oil content of some of these early-maturing varieties in staggered harvests, and found that sound mature seeds in early harvests had normal oil content.

Medium- and late-maturing group. Our success in the medium- and late-maturing group has been satisfying: ICGS 11 (ICGV 87123) in central and peninsular India, and ICGS 44 (ICGV 87128) in western India have been released for postrainy season cultivation. Other varieties awaiting release for the rainy season cultivation are ICGS 1 (ICGV 87119), ICGS 5 (ICGV 87121), and ICGS 11 (ICGV 87123) in northern India, and ICG(FDRS) 4 (ICGV 87157), and ICG(FDRS) 10 (ICGV 87160) in peninsular India. Two other varieties are in prerelease testing stages [ICGS 44-1 (ICGV 87784) and ICGS 37 (ICGV 87187)]. In addition, there are 45 lines for rainy season and 13 for postrainy-season evaluation in the All India Coordinated Oilseed Research Programme.

Tolerance of Drought

Reddy et al. (1985) summarized the work at ICRISAT Center on drought resistance in groundnut. Earlier, we have relied solely on screening advanced breeding lines emanating from other breeding activities. We identified nine lines among foliar-diseases resistant selections, which showed tolerance to drought. All the nine included NC Ac 17090 in their parentage. This parent line is drought tolerant and is more efficient than others in extracting water from surface layers of soil. As we have now devised screening techniques and have enough information on sources of drought resistance, we have initiated breeding for drought resistance, using five resistant lines in our first cycle of crossing.

Tolerance of Multiple Stresses

We monitor all advanced breeding lines for tolerance resistance to multiple-stress factors. This helps us identify additional merits or weaknesses, if any, of advanced lines. Table 1 lists some of the multiple-stresses tolerant lines from the foliar diseases resistance group. The current crossing programs generally involve parents with multiple resistances.

Breeding for Resistance to Insect Pests

We have made satisfactory progress in identifying sources of resistance to thrips and jassids. Work is being done to incorporate this resistance into high-yielding background material. We now attach greater emphasis to *Spodoptera* and leaf miner, which are of increasing importance. Our entomologists are screening germplasm/breeding lines to locate useful levels of resistance to these pests.

Table 1. Performance of some multiple disease- and pest-resistant groundnut lines at ICRISAT Center, rainy seasons 1986 and 1987 and postrainy season 1986/87.

	Pod yield (t ha^{-1})			Reaction to			
Variety	1986 rainy season	1986/87 postrainy season	1987 rainy season	Rust[1]	Late leaf spot[1]	Jassids (%)[2]	Leaf miner[3]
ICGV 87333	2.7	6.3	1.6	3.0	7.5	3.3	7.5
ICGV 87334	2.4	6.0	1.4	3.0	7.5	2.7	5.6
ICGV 87335	2.4	5.6	1.0	2.6	5.8	5.0	6.5
ICGV 87167	2.3	4.4	0.8	2.8	7.6	4.3	7.0
ICGV 86606	2.7	6.2	1.6	3.0	8.0	4.3	5.6
ICGV 87183	2.8	5.3	1.4	3.3	7.6	3.3	6.5
Controls							
Robut 33-1	1.5	-	-	9.0	9.0	22.7	8.0
JL 24	1.4	5.0	1.8	9.0	9.0	-	8.3
SE	±0.17	±0.34	±0.09				
CV (%)	13.2	10.9	12.3				

1. Scored on 1-9 scale, where 1 = No disease, and 9 = 50-100% foliage destroyed during rainy season.
2. Scored as percentage of yellowed foliage during 1984.
3. Scored on a 1-9 scale, where 1 = No insect, and 9 = 90-100% foliage damaged during rainy season 1987.

International Cooperation

We reorganized the various international trials and observation nurseries into five trials:

Trial	Number of entries
International Early Groundnut Varietal Trial (IEGVT)	24+1[1]
International Medium and Late Groundnut Varietal Trial (IMLGVT)	34+2
International Confectionery Groundnut Varietal Trial (ICGVT)	23+2
International Foliar Diseases Resistant Groundnut Varietal Trial (IFDEGVT)	35+1
International Insect Pest Resistant Groundnut Varietal Trial (IIPRGVT)	14+2
International Drought Nursery (IDN)	16+2

1. Local control(s).

We intend to continue distributing these trials for at least two seasons at each location before revising them. The Center program caters for the requirements of Asia, East and Central Africa, and other areas not covered by the regional programs. In the geographic areas of the regional programs, it operates through the newly developed material at the Center being fed into regional programs as preliminary trials.

So far we have sent IEGVT to 20 locations, IMLGVT to 16 locations, ICGVT to 13 locations, IFDRGVT to 10 locations, IPRGVT to 5 locations, and IDN to 2 locations. These include 14 countries in Africa, 6 in Asia, and 2 each in Mesoamerica and Australia. Results of some of these are presented in Table 2.

Breeding for Confectionery Groundnut

Groundnut quality includes economic and sensory quality characteristics. Economic quality character-

Table 2. Performance of high-yielding ICRISAT groundnut breeding lines in four International Trials, with reference to local cultivars in selected countries.

Trial	Country	ICGV no.	Pod yield (t ha^{-1})	Improvement over local cultivar (%)
Confectionery	Burundi	86027	3.6	80
	Cyprus	86733	8.3	23
	Korea	86979	3.6	89
	Nepal	86959	2.8	47
	Pakistan	86564	3.1	63
	Zambia	86979	3.5	52
Early Maturity	Bangladesh	86015	3.2	60
	Burkina Faso	86065	3.0	23
	Haiti	86061	4.1	37
	Mali	86047	3.1	25
	Philippines	86015	3.0	50
	Thailand	86015	2.7	42
Medium and Late Maturity	Egypt	86234	6.8	183
	Pakistan	87778	3.8	80
	Philippines	87131	1.9	280
Foliar Diseases Resistance	Bangladesh	87183	3.6	125
	Swaziland	87157	4.7	42
	Thailand	87358	3.9	77

istics refer to "grade factors" that are well defined and influence the monetary value: in pre-1980 literature, groundnut quality was synonymous with grade factors. Sensory quality is the summation of all physical and chemical characteristics of edible groundnut seed or their product that influence human senses. Sensory quality traits tend to be subordinated by the grade factors particularly at moisture levels less than 10%, perhaps because of lack of in-depth research on sensory factors. Quality maintenance is a continuous process. Any breakdown in the system from planting to consumption may reduce quality, which cannot be restored once lost.

Sufficient information is available on curing, handling, and storage. Of equal importance is the effect of maturity on quality. After maturity and curing, economic and sensory qualities are established. During handling and storage, maintenance of quality and prevention of deterioration of quality should be ensured.

Current challenges for edible groundnut

Aflatoxin. Aflatoxin contamination is the major factor reducing the quality of groundnut. The tolerance level in USA is 20 ppb; in Canada, 15 ppb; in most EEC countries, 5 ppb or lower.

Chemical residues. The presence of chemical residues in groundnut seed reduces its edible value, and this is becoming an important issue. We must find alternatives to the use of chemicals, or develop safer chemicals.

Fat content. Groundnut has a relatively high fat content and with the increasing emphasis on use of low-caloric food, it is important that edible groundnuts should have a low but balanced fat content to satisfy the demand of a health-conscious population.

Quality issues for the manufacturer

The manufacturers' and importers' concerns are excessive foreign material, uniformity in seed size, and the need to provide a reliable and consistent product. A plant breeder can develop varieties, which have uniformity in seed size.

Quality issues for the marketeer

The marketing groups seek improved and specific flavor characteristics; maintenance of a good flavor and aroma throughout processing and on the shelf; maintenance of a reasonable shelf life; improved appearance; and product distinctiveness. Shelf life and flavor lend themselves to genetic manipulations but require great effort.

Quality factors of edible-groundnut seed

Various physical, sensory, chemical and nutritional factors determine the quality of edible-groundnut seed.

Physical factors

- **Intact testa.** Many varieties possess the genetic defect of a split testa. Such varieties are prone to *A. flavus* attack and should not be selected for edible use.
- **Seed size.** Groundnut seeds are graded into different categories before their economic value is determined. The groundnut grades followed by the US National Peanut Council are given in Table 3.

Table 3. The groundnut grades followed by U.S. Peanut Council[1].

Grade	Counts Ounce[2]	Seed shape
Pod		
Virginia Jumbo inshell	9–11	-
Virginia Fancy inshell	11–13	-
Seed		
Virginia Extra-large	28–32	Elongated
Virginia Medium	38–42	Elongated
Virginia no. 1	45–55	Elongated
Virginia no. 2	Splits	-
Runner Jumbo	38–42	Round
Runner Medium	40–50	Round elongated
Runner no. 1	60–70	Round
Runner splits	-	-
Spanish Jumbo	60–70	Elongated
Spanish no. 1	70–80	Round/elongated
Spanish splits	-	-

1. Source: National Peanut Council of America (1986).
2. 1g = 0.03527 ounces.

- **Seed shape.** Seeds of regular and uniform shape with tapering ends are highly valued. Tapering ends also facilitate blanching. Two-seeded pods with a moderate constriction generally ensure tapering seed ends.
- **Ease of blanching.** Manufacturers and processors find it costly to process varieties that are difficult to blanch.
- **Resistance to seed splitting and damage.** Varieties prone to seed splitting and damage during and after processing are less acceptable. The tendency to split is commonly associated with low-moisture content of seed.
- **Moisture content.** A moisture content in the range of 5.5–7% is normally acceptable. A moisture content above 7% encourages mold growth and leads to an unacceptable loss in weight on processing.

Sensory factors

- **Seed color.** Pink or light brown testa colors are preferred: seeds having variegated or dark-red skins are not liked. Variegated seeds result in nonuniform color development during roasting, whereas seeds with dark-red skin appear difficult to blanch. Color of the raw groundnut seed is attributed to both the testa and the oil. Tannins and catechols are responsible for testa color. The color of the oil is mainly because of the presence of carotenoids. The characteristic color of roasted groundnut is primarily because of sugar and amino-acid reactions, with subsequent production of melanins.
- **Texture.** A firm and crisp texture is preferred for roasted nuts. Soft or mushy roasted groundnuts will be rejected by the consumer even though they exhibit an attractive color and good flavor.
- **Flavor.** Consumption of groundnut as nuts and in the manufacture of peanut butter is based on the use of roasted groundnut seed. Amino acids and carbohydrates are precursors of the roasted flavor. Aspartic acid, glutamic acid, glutamine, aspargine, histidine, and phenylalanine give the nut its typical roasted flavor. Degree of roasting and roasting time exert a significant influence on the strength of odor and flavor of roasted nuts. Pattee et al. (1982) reported improvement in flavor score with increase in seed size (seed diameter) provided the crop was harvested at full maturity and the recommended curing and storage practices were followed (Table 4).
- **Wholesomeness.** Raw and roasted groundnuts

Table 4. Effect of seed size on flavor scores of peanut butter[1].

	Seed size (mm)			
	5.95	6.35	6.74	7.14
Flavor score[2,3,4]	4.8	5.1	5.3	5.3
Flavor score[5]	1	1	2	3

1. Source: Pattee et al. (1982).
2. Scores are an average of three location replications. A 10-point scale was used: 10 = Excellent; 1 = Very poor.
3. Indicates significantly different at $P < 0.01$.
4. Consumer taste panel (40 members).
5. Professional taste panel (6 members).

should be free from foreign material, unadulterated with toxic or noxious substances (pesticides, mycotoxins, etc.), not infested with insects or rodents, free of spoilage and pathogenic microorganisms.

- **Chemical and nutritional factors.** Groundnut seeds contain relatively large quantities of proteins (25–34%) and oil (44–56%) and have an average high energy value of 564 cal (100 g seed)$^{-1}$.
- **Protein.** Currently little attention is paid to protein quality in groundnut. With increasing demand for more protein supplies and balanced dietary sources of protein, it may become an important consideration. The limited amino acids of blanched but unroasted groundnut and roasted groundnut protein are lysine, threonine, and methionine. Other amino acids that could be limiting are isoleucine and valine.
- **Oil.** As many as 12 fatty acids have been reported in groundnut oil, only three are present in amounts exceeding 5% palmitic, oleic, and linoleic (Ahmed and Young 1982). Groundnut oil contains about 80% unsaturated acids with more oleic acid (47%) than linoleic acid (33.7%) as reported by Carpenter et al. (1974). There is a conflict between the keeping quality and nutritional quality requirements. There is a negative correlation between linoleic-acid content and oil stability (Holley and Hammons 1968). The wider ratio of oleic acid to linoleic acid in groundnut oil was considered as an indicator of more stable oil (Brown et al. 1975). For improved nutrition, high linoleic-acid content is desirable because the acid, in addition to being an essential fatty acid, has a hipochole-sterolennic effect. Variation in fatty acid composition is present in groundnut germplasm. It is possible to improve the fatty acid composition through breeding efforts.
- **Carbohydrates.** The cotyledons of groundnut seed contain about 18% carbohydrates. Sucrose is the most abundant saccharide in groundnut seed and is involved in the browning reaction responsible for principal changes occurring in color and flavor during roasting.
- **Minerals and vitamins.** Some of the inorganic minerals and vitamins may be deficient in groundnut seed from the dietary standpoint.

Most of the factors associated with physical, sensory, and chemical and nutritional quality are highly influenced by genotype, location, growing-season conditions, crop management, harvesting, curing, and storage. Failure to meet optimum requirements of any one of these aspects will result in decrease in quality.

Quality factors of in-shell groundnut. In addition to the factors already discussed for edible groundnut seed, the following factors are important when in-shell groundnut is marketed for edible purpose: pod color and type, pod size and shape, pod texture, pod cleanliness and freedom from damage, absence of blind nuts (pops).

Bright cream-colored pods, which are free of dirt and damage, are most attractive to the eye. Large, elongated, and constricted two-seeded virginia pods are generally preferred for roasting and eating in shell. Thick-shelled pods are desirable for roasting, as they can be roasted without disintegration. Strongly striated pods carry much soil with them after harvest, which is an undesirable feature in roasted groundnuts. Presence of blind nuts in the stock lowers the quality of the produce. The 3-4 seeded, small valencia types are preferred for consumption as freshly boiled groundnuts.

Breeding for confectionery types at ICRISAT Center

Development of groundnut cultivars with large seed mass (virginia market type) is an important activity in groundnut breeding at ICRISAT Center. Promising lines, derived from crosses between large-seeded germplasm lines and high-yielding adapted varieties, are selected by pod yield, shape, size, and texture and higher seed mass [>80 g (100 seeds)$^{-1}$] with desirable seed characteristics, such as seed shape and color. Performance of some of the selected lines at

Table 5. Performance of some high-yielding confectionery groundnut varieties under high-input conditions, ICRISAT Center, postrainy season 1986/87.

Variety	Branching habit[1]	Pod yield (t ha^{-1})	Shelling percentage	Percentage of extra-large seeds	100-seed mass (g)	Oil content (%)	Protein content (%)
ICGV 86563	A	5.97	66	40	70	46.6	26.4
ICGV 86576	S	5.78	63	75	78	49.6	25.2
ICGV 86565	S	5.66	62	71	70	49.6	26.2
ICGV 86580	S	5.49	71	90	116	43.1	29.3
ICGV 86583	S	5.17	62	72	70	49.5	26.3
ICGV 86571	S	5.05	55	84	60	47.3	24.9
ICGV 86026	S	5.03	66	72	90	49.2	29.7
ICGV 86581	S	4.79	67	88	106	45.0	28.7
ICGV 86577	S	4.76	76	87	119	46.6	28.8
ICGV 86579	S	4.04	75	93	108	46.4	29.8
ICGV 86564	A	3.69	64	53	90	51.0	26.5
Controls							
M 13	A	2.83	55	10	67	45.6	24.0
Chandra	A	2.30	52	26	76	47.3	23.6
SE		±0.301					
CV (%)		10					

1. A = Alternate branching, ssp *hypogaea*; S = Sequential branching, ssp *fastigiata*.

ICRISAT Center is given in Table 5. After replicated evaluation at ICRISAT Center and cooperative research stations, the selected lines are channeled to the national programs through international trials. Results obtained from the 1986 International Confectionery Groundnut Varietal Trial are summarized in Table 2. Most of these varieties have been bred for their high-yielding ability under no-stress conditions and we are now trying to incorporate stress resistances in these and other new confectionery varieties.

Issues involved in a breeding program for quality

Different market types are used in different end products. It is important to choose the right market type to work on, depending on the local agroecological conditions and the market demand. It will be difficult for the national programs of many developing countries to have the necessary facilities to monitor most of the sensory, chemical, and nutritional factors. In such cases, "grade factors" are easy to monitor under field conditions. Proper monitoring of grade factors can ensure, to some extent, adherence to reasonable sensory quality factors, such as wholesomeness and flavor.

Stability of seed mass

The experience of groundnut breeders who have participated in the International Confectionery Groundnut Varietal Trial indicates that the seed mass is generally not maintained across locations. Similarly, when bold-seeded lines from USA and Malawi were grown at ICRISAT Center they did not maintain their seed mass. Data on 100-seed mass obtained from the International Confectionery Groundnut Varietal Trial conducted at 10 locations were analyzed for stability following Finlay and Wilkinson (1963). This study indicated significant genotype × environment interactions. To overcome this problem, it is imperative that the breeder should have access to diverse testing locations to select stable germplasm lines for crossing and to develop breeding lines with stable seed mass.

Shelf life versus nutritional requirement

There appears to be no easy answer to this dilemma. Genetic variation in fatty-acid composition is present in germplasm for exploitation in either direction.

Crop duration and seed mass

Most of our present day, bold-seeded cultivars are of longer duration and may not be appropriate in regions where the growing season is short. In such cases, where possible, either the growing season should be lengthened or the crop duration be reduced through management. Early-maturing cultivars generally have low seed mass. What then should be the minimum crop duration that will not adversely affect the grade quality?

Aflatoxin contamination

The problem can at best be overcome or reduced through better crop management, proper curing and drying, and storage. Failure in any one of these steps could result in the aflatoxin contamination of the produce and products. Genetic manipulation alone cannot help to eliminate this problem.

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Discussion

Reuben: How can you develop a variety with all the objectives you have mentioned to meet quality issues for the manufacturers, such as sensory factors, quality factors of groundnut in shell, etc., and still meet the yield requirements? Can you develop a perfect variety?

Nigam: It is not entirely impossible to develop a perfect variety. Not only at ICRISAT but at many other breeding programs, particularly in USA, breeders have been successful to combine desirable characteristics in a single variety. However, it is difficult, time consuming, and requires many sophisticated analyses, which many national programs in the developing world may not be able to afford. Since confectionary groundnuts are meant for export to developed countries where processors, buyers, and consumers are quality conscious, it is important that we give due considerations to these requirements if we want to stay in the market.

Some studies have indicated positive association between flavor score and seed size. It is likely that by improving seed size we might also improve flavor of groundnut.

Kannaiyan: How stable are your newly developed large seed size varieties across locations in your international nursery?

Nigam: In general, we find reduction in seed mass in large seeded confectionery lines when they are grown away from home environment. This holds true for most of the confectionery material, whether it originates from USA, Malawi, or ICRISAT Center. From our international trials, we have been able to identify lines that are more stable for seed mass as well as pod yield, when compared to others.

General Discussion on Breeding

Wanchinga: (to Dr Bock) Do we have any evidence of differences in consumer preference in SADCC countries? If so, how is our Regional Program addressing this?

Bock: A survey has not yet been done to determine this because of shortage of staff. The issue will be addressed at some future date.

Wanchinga: Does the Regional Program envisage recruiting an economist?

Bock: Not at the present time. Priorities for recruitment of scientific disciplines will be determined by this meeting.

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Entomology

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Contribution of Insects to Low Groundnut Yields in Southern Africa

J.A. Wightman[1]

Abstract

An assessment of the importance of insects as constraints to groundnut production in five countries of the SADCC region of southern Africa was made during the 1986/87 groundnut-growing season. Previous experience had pointed to the need to pay most attention to the root zone. The survey showed that white grubs were a particular problem in Zimbabwe as pod and root eaters, where the sandy soils rendered the short-duration crop particularly vulnerable. The density and diversity of this taxon were surprisingly high. Termites are a major problem in Botswana where they are primarily associated with the drought conditions that so often prevail in that country. However, they also caused severe crop loss (up to 100%) in dry areas of other countries. Many pod-boring species were revealed to cause crop loss, the most important being millipedes, followed by wireworms, false wireworms, and doryline ants (the doryline ants being a new record). White grubs and termites also damaged pods. The results of experimental research indicated that insecticides increased the damage caused by some species of termites, perhaps because predatory ants were more susceptible to the insecticides than the target species. The application of a soil insecticide increased the seed yield by 23.8%, 53.1%, and 60.1% at three sites in Malawi and had no effect at two others. There is evidence that soil insects as a whole cause as much yield loss in the region as pathogens, the main differences being the greater number of species involved and the variability between farms, districts, and seasons. The options that are available to initiate rational control programs are few. They relate mostly to management practices within the farming system as a whole.

Sumário

Contribuição dos Insectos para o Baixo Rendimento do Amendoim na Africa Austral. *Uma avaliação da importância dos insectos como limitantes para a produção do amendoim, foi realizada durante a estação de crescimento do amendoim de 1986/87, em cinco países da Africa Austral, na região de SADCC. Experiências anteriores apontaram para a necessidade de dar mais atenção à zona radicular. O inquérito mostrou que as lagartas brancas são um problema particular em Zimbabwe, como comedores das vagens e raízes, onde os solos arenosos tornaram as culturas de curta duração particularmente vulneráveis. A densidade e diversidade deste taxon foi surpreendentemente alto. Termites são um dos principais problemas em Botswana, onde estão associados, primáriamente, às condições de sequia, que frequentemente ocorrem naquele país. Contudo, elas também causaram severas perdas de rendimentos (até 100%) em zonas secas de outros países. Muitas espécies brocadoras das vagens foram apontadas como causadoras de perdas de rendimento, sendo as mais importantes as centopeias, seguidas pelas lagartas alfinete,*

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falsas lagartas alfinete e formigas doryline (sendo estas ultimas uma observação nova). Lagartas brancas e termites também danificaram as vagens. Os resultados da investigação indicaram que os insecticidas aumentaram os danos causados por algumas espécies de termites, possivelmente porque as formigas predadoras foram mais suscéptiveis aos insecticidas, que as espécies alvo. A aplicação de um insecticida do solo, aumentou o rendimento de sementes em 23,8%, 53,1% e 60,1% em três locais em Maláwi e não produziu efeito noutros dois. Existe evidência que os insectos do solo, como um todo, causam tanta perda de rendimento como os patógenos, com as maiores diferenças a aparecer no maior número de espécies envolvidas e na variabilidade entre campos, distritos e estações. O número de opções disponíveis para o início de um programa de controle racional são poucas. Elas estão normalmente relacionadas com as práticas de maneio dentro do próprio sistema da produção como um todo.

Introduction

From November 1986 to May 1987, I had the task of assessing the importance of insects as pests of groundnuts in southern Africa. A brief visit during the previous growing season had indicated that, apart from *Aphis craccivora* Koch (about which we know quite a lot), the main insect-related problems were underground. I have, as yet, no reason to change my mind about the importance of this cohort of insects. I went to Chitedze, near Lilongwe, Malawi, with many interrelated objectives in mind.

Of major importance, was a survey of farmers' fields to assess the density of soil insects (including millipedes) and to get an indication of how much damage they were causing.

The survey was backed up by experimental work, some of which was carried out by members of various national programs. Before the tour began, Dr K.R. Bock contacted various people to see if they were in a position to carry out a 'doomsday experiment' in which a field was divided up into two groups of plots, one half of which were treated with a strong dose of insecticide and the others left as controls. Another set of two experiments was carried out at Chitedze. In one, I simulated the effect of plant mortality on yield, and in the other I made a detailed assessment of the influence of many biotic factors on crop and plant yield. The latter included an evaluation of the new slow release formulation of three insecticides that was discussed at the previous workshop (ICRISAT 1987a) and was a sequel to experiments carried out in India in an Overseas Development Natural Resources Institute (ODNRI)/ICRISAT joint venture.

It is unwise to draw firm conclusions from one survey of about 100 fields stretched across such a huge area of land, but the data present clear implications that should not be ignored. In this paper, I report our findings and indicate the meaning of the survey and experimental data in the context of what we know about the effects of other biotic constraints to groundnut production in southern Africa.

One of the biggest problems in dealing with soil insects is the continual need to reinforce in the minds of nonfarmers and nonentomologists the fact that these 'worms' can cause drastic yield losses even though they cannot be seen without digging up the plant.

The Constraints

This account is limited to insects even though the farmers were equally concerned about crop losses caused by vertebrates, including a variety of small mammals, pigs, hippopotami, monkeys, and birds, such as guinea fowl and crows.

Insects

Those insects living on the foliage and flowers that are mainly of potential importance, unless insecticide application becomes widespread, are *Empoasca (signata)* jassids, *Helicoverpa armigera* (Hübner), *Spodoptera littoralis* (Boisduval), *Agrotes* spp greasy cutworms, Meloidae (blister beetles), thrips, and many species of grass hoppers, locusts, and crickets. The subterranean insects, with which I am most concerned, are discussed in some detail. They are less well known than the foliage-dwelling insects, so that, in many cases, specific and sometimes generic names cannot be or have not been designated by the Commonwealth Institute of Entomology.

White grubs. White grubs are the larvae of scarabaeid beetles, the so-called cockchafers, hanetons, May or June bugs, and maikaefer of Europe and North America. My observations in southern Africa indicated that the adults waited in the soil until after the rains came before emerging to mate and perhaps to feed. I found eggs 10 cm or more below the soil surface. There are usually three larval instars. In other parts of the semi-arid tropics, the fully grown third instar larva digs down to the cooler, moister strata of the soil to form an earthen cell and pupate. It is in this condition that they await the next rainy season. The larvae feed on the roots of many crops, including maize and groundnut. In the case of the latter, they eat the fine lateral roots and the tap roots, as well as damaging (not just boring) the developing pods. Smith and Barfield (1982) have seven entries for the whole of Africa under this heading. The survey may have turned up as many as 42 species, some of which may be new to science. It is emphasized that this is a generalized account of white-grub biology in these environments. I found white-grub eggs and newly hatched larvae at least 2 months after the main rains had arrived, indicating that the life cycles of some species may not be as I have described. The possibility that one generation can live for two seasons should not be ignored.

Millipedes. It seems that wherever records of insect damage to groundnuts in Africa have been made, millipedes are always mentioned. They make holes in the developing pods, the size of the holes being determined by the diameter of the millipede. They do not always damage the developing seed. My collection specimens have not yet been identified.

Wireworms (Elateridae) and false wireworms (Tenebrionidae). Although these insects belong to quite different families of beetles, they look alike and cause similar damage to groundnut pods. They are primarily borers. The collection includes a possible 14 species of wireworm larvae, including *Prosephus* spp, *Pseudolophoeus protensus* Gerstaecker, *Cardiophorus* sp, and *Dyakus* sp. None of the 16 possible species of false wireworm has been identified beyond the subfamily level. We know little about the life cycles of these taxa but they probably live for more than one season in the larval stage.

Termites. About half my collection consisted of termites, and I still await their identification. I could recognize several groups. There were the little grey species, living about 15 cm below the soil surface. These exist by digesting soil organic matter. *Microtermes* sp caused considerable damage to drought-stressed plants, particularly in Botswana, but I saw fields with 5-100% damage caused by members of this genus just before harvest in southern Malawi. *Macrotermes* spp appear around the bases of plants and eat the stem bases. The 'felled' stems are then removed by other species of termite, including *Odontotermes* spp. This means that their total contribution to crop losses may be obscured because the evidence is continually being removed.

***Hilda patruelis* Stal (Homoptera: Tettigometridae).** Hilda lives on the roots of groundnut plants. It apparently injects a toxin into the phloem that results in the relative rapid death, within a few days, of its host and the subsequent spread of the pest. It is attended by small black ants. The insect and its biology are described by Weaving (1980) and Taylor (1981). Hilda has been found in all parts of southern and East Africa, but I do not know how far it has spread northward along the western seaboard. I found a related species (*Hypochthonella caeca* China and Fennah) on groundnut roots in southern Zambia. A previous record of this species from Zimbabwe was that it caused 70% crop loss (Rose 1962), although I found no evidence for this, or any other level of damage.

***Dorylus* spp (Formicidae).** Doryline ants are blind, vegetarian species that first came to my attention at ICRISAT Center when they destroyed the pods of some valuable material in our Botanic Garden. They make neat 3 mm diameter holes in the pods and remove the seeds. These biotic constraints act at three levels:

They induce plant mortality. Plant death at the seedling stage is most likely to be caused by fungal diseases (Mayeux 1985) although white grubs and wireworms can also either cause plant death or be associated with it. Groundnut rosette virus (GRV) can stunt young plants to the extent that they may as well be dead, because they contribute nothing to the crop, and are, anyway, overgrown if their neighbors are more robust. Death later in the season is more likely to be caused by insects, especially by termites.

The transfer of photosynthates to the pods is impeded. This can be caused by fungi destroying leaf tissue or blocking the vascular system. Defoliating insects remove leaves or parts of leaves. Some termites take away whole stems. White grubs damage roots, thereby impeding water and nutrient uptake and opening the way for other pests or diseases to enter the plant.

The product can be damaged or destroyed. Pod damage before harvest can be caused by all the soil insects listed above, as well as by vertebrate pests, and fungal pod rots. Immediate postharvest damage, which occurs after harvest but before the crop is removed from the field, is mainly caused by termites and vertebrates.

The survey

Some general details of the survey are included in Table 1. The field was measured (paced out) and an assessment was made of the plant density. As this involved walking around and across the field, I was able to detect signs of virus disease and insect attack, and could also assess the intensity of foliar diseases and *Alectra*.

The insect-sampling procedure involved examining 20 plants taken at random from the field. Early in the season, I counted the aphids on each plant. Most attention was devoted to underground parts of the plant and to the soil around the roots. The roots were examined carefully to see if white grubs had been eating them. The pods were counted, a separate note being made of the number of damaged pods and the nature of the damage. A cylinder of soil, centered on the plant, 20-cm deep and of 10-cm radius, was searched for insects.

This was a lower rate of sampling than was originally intended, but the data (Tables 2–5) show that the insects were sufficiently dense for it to give an indication of their abundance. I rationalized that if the insects in which we were interested were associated with < 5% of the plants in the field (a rate of < 1 of the 20 sampled), they probably would not be too important. Very often there were so many of a given kind of insect that it was not possible to count them all before they disappeared, as for instance, when we opened a termite nest. In this case, we recorded an estimated number or wrote '>100'. However, for the groups where it was impossible to record how many insects were uncovered, (Hilda, termites, and *Dorylus* spp), I have tabulated the number of plants (/20) affected.

In the tables the insects are divided into three categories according to their feeding site. White grubs eat pods as well as roots but root damage is more important. 'Stem feeding' may not seem to be an appropriate designation for soil insects, but *Macrotermes* spp eat through the base of stems and

Table 1. Some details of the insect survey of groundnut crops in five SADCC countries, 1987.

Country (Region)	Period of survey (1987)	Weeks after sowing	Number of fields	Plant density (× '000 plants ha⁻¹)	Comments
Botswana (SW)[1]	1–4 Feb	6–8	3	-	Research farms only
Malawi (C)[2]	20–23 Jan	5	18	35–40	Wide ridges, long duration, hand hoe
(S)	13–16 Apr	28–30	10	30–40	Harvesting
Tanzania (S)	21–29 Mar	8–20	12	Variable	Close to harvest
(C)	29 Mar to 3 Apr	12–14	5	Variable	Variable cultivation
Zambia (SC)	10–12 Feb	8–10	11	10–200	Variable cultivation methods, long duration, popular
(E)	17–19 Mar	16–20	13	10–200	Variable cultivation methods, long duration, popular
Zimbabwe (C)	27–29 Jan 5–7 Mar	16–20	29	50–200	Sandy soils

1. SW = South west, C = Central, S = Southern, SC = South central, E = East.
2. Twelve fields revisited during 29 Apr to 1 May 1987.

Table 2. Number of soil insects (per 100 groundnut plants) associated with groundnut in Central Malawi, late-January 1987.

Insect	Mitundu (6 fields)	Likundu (4 fields)	Chileka (6 fields)	Nsalu (3 fields)
Root feeders				
White grubs	18.4	50.7	39.7	76.1
Hilda patruelis (plants)[1]	9.0	8.5	0	0
Pod borers				
Millipedes	36.4	11.8	19.7	26.7
Wireworms[2]	1.1	14.4	13.3	0
Microtermes (plants)[1]	21.3	24.0	21.0	30
Dorylus sp (plants)[1]	2.1	3.8	3.7	0
Stem feeders				
Microtermes (plants)[1]	6.5	4.7	6.6	16.7
'Other' termites (plants)[1]	7.7	0	1.0	1.6

1. Number of plants affected per 100 plants.
2. Wireworms (Elateridae) + false wireworms (Tenebrionidae).

can destroy whole plants in this way. *Odontotermes* sp can cover whole plants with a sheet of soil. They then remove the plant from within their aerial gallery and decamp, leaving nothing but the encrustations.

In Central Malawi (Lilongwe Plain), white grubs were particularly abundant at Nsalu (Table 2). Even though it was early in the season, damage caused by white grubs could be detected as stunted top growth. In one field, 11% of the plants were thus affected. I was able to follow up a heavy Hilda infestation at Mitundu. One farmer planted early (before the rains) to take advantage of the high preseason prices. Unfortunately, Hilda found his field; because of heavy damage he did not harvest it.

Millipedes and *Microtermes* were present throughout but wireworms had a spotty distribution. The other termites and *Dorylus* were at low densities.

In southern and central Zambia (Table 3), the most noteworthy features were the populations of *Microtermes* around Mumbwa and Kabwe, and the concentrations of *Dorylus*, also near Kabwe. In eastern Zambia, the picture was different (Table 4). In the silty soils of the Luangwa Valley, millipedes were the predominant 'insect'. Around Chipata, the pattern was similar to Central Malawi. However, it should be added that the insect fauna in the light-red soils, such as those found in and around the Msekera Research Station, were almost devoid of insects that were likely to cause damage to groundnut plants. It appeared that the soil was so hot and dry, at least in the collecting zone, that free-moving insects would have been driven to deeper soil strata and the other insects would have been killed whereas, in Kabwe, west of Chipata, the sandy soils had fauna more akin to that which I had found in South Zambia. The level of pod damage was relatively high in the Luangwa Valley. This was almost entirely because of millipede activity.

Table 3. Number of soil insects (per 100 groundnut plants) associated with groundnut in southern and central Zambia, February 1987.

Insect Type of damage	Choma (3 fields)	Mumbwa (5 fields)	Kabwe (3 fields)
Root feeders			
White grubs	2.4	14.6	19.2
Hilda patruelis (plants)[1]	3.7	2.1	2.6
Pod borers			
Millipedes	0	1.7	9.9
Wireworms	0	10.4	2.4
Microtermes (plants)[1]	3.0	30.3	25.2
Dorylus sp (plants)[1]	0	6.6	9.5
Stem feeders			
Microtermes (plants)[1]	3.1	5.2	2.4
'Other' termites (plants)[1]	3.0	14.2	2.4
Root damage (%)	52.7	36.5	24.7
Pod damage (%)	0	0	0

1. Number of plants affected per 100 plants.

Table 4. Number of soil insects (per 100 groundnut plants) associated with groundnut in eastern Zambia, February 1987.

Insect Type of damage	Chipata (S) (5 fields)	Luangwa valley (5 fields)	Kabwe (3 fields)
Root feeders			
White grubs	13.3	3.0	19.2
Hilda patruelis (plants)[1]	1.0	2.1	2.6
Pod borers			
Millipedes	3.0	40.2	9.9
Wireworms	5.0	1.3	2.4
Microtermes (plants)[1]	3.4	8.2	25.2
Dorylus sp (plants)[1]	0	8.5	9.5
Stem feeders			
Microtermes (plants)[1]	4.3	0	2.4
'Other' termites (plants)[1]	4.0	3.3	2.4
Root damage (%)	27.4	14.5	24.7
Pod damage (%)	5.6	9.0	-

1. Number of plants affected per 100 plants.

There was also a contrast between the first three localities, surveyed in Zimbabwe, and the second three (Table 5). The former were almost due south of Harare in the medium to low-rainfall zone, while the latter were at about the same latitude as Harare in the highest-rainfall zone. White grubs were not common in the Masvingo and Chilimanzi areas. These were in the lowest-rainfall areas. This is in contrast to the other areas, where the high density of nearly 1 plant^{-1} in the Chinhoyi area brought the average of these four localities to 1 white grub (2 plants)$^{-1}$. As a white-grub larva can achieve the dimensions of a woman's little finger, they were almost certainly reducing crop yields in these areas and almost certainly contributing to the uneven crop growth. Hilda was present at low levels, but my visit was early in the season and there was still the potential of a flare-up, as in Malawi. The pod borers, as a whole, were not well represented and were not commented on by the farmers. However, they did complain about termites attacking the pods while they were drying in the field. Their description of soil coating the drying plants points to *Odontotermes* spp being responsible for the phenomenon.

No data are presented for Botswana and Tanzania. The foremost constraint to production in Botswana is drought. Termites probably come next. The observations I made with A. Mayeux, together with his comments and those of other people in a position to know the situation, point to the possibility that termites, probably *Microtermes* spp, kill 20-40% of the plant population and damage a third of the pods.

My visit to southern Tanzania was in many ways the most rewarding because I was presented with the greatest diversity of production methods, from bush clearings to well maintained and apparently high-

Table 5. Number of soil insects (per 100 groundnut plants) associated with groundnut in Zimbabwe, February 1987.

Insect Type of damage	Masvingo (5 fields)	Chilimanzi (4 fields)	Manyene (4 fields)	Chinhoyi (4 fields)	Mawere (6 fields)	Wedza (6 fields)
Root feeders						
White grubs	11.1	7.5	37.3	91.8	33.3	45.4
Hilda patruelis (plants)[1]	4.0	0	0	2.5	3.3	1.7
Pod borers						
Millipedes	0	0	1.4	5.1	2.6	0
Wireworms	0.4	1.0	3.0	3.7	12.1	2.5
Microtermes (plants)[1]	0	1.6	0	8.1	0	0
Dorylus sp (plants)[1]	0	3.6	0	0	0	0
Stem feeders						
Microtermes (plants)[1]	0	0	0	0	0	0
'Other' termites (plants)[1]	2.6	0	2.9	11.2	0.8	2.5
Root damage (%)	3.6	-	1.4	40.2	38.9	56.7
Pod damage (%)	3.0	-	-	2.2	8.3	5.2

1. Number of plants affected per 100 plants.

yielding fields forming part of a sound rotation. I neither found nor had a report of white grubs damaging plants or pods, but found low-density populations of wireworms, termites, and millipedes. I did not make systematic searches of the fields that formed part of shifting agricultural systems. However, my foraging in the soil of these multicropped fields revealed considerably fewer insects per unit effort than I would have found in a field elsewhere in the region where crop rotation of near monocultures is practiced. This leads to two hypotheses: firstly, that this is an example of how, in a diverse system, no one group of the fauna is allowed to buildup into what we think of as a pest population. Secondly, I think that it is also likely that, as the physical parameters of a newly opened (burned) piece of bush are totally different to that which were there before, it will take several years for the insects that are adapted to such environments to exploit them. This category of insect includes white grubs. They do not fly far, have low fecundity, and usually have only one generation per annum. I think that such farm sites may be abandoned because of the buildup of pests rather than the depletion of nutrients.

Hilda was not common, although we were told that groundnut growing had been discontinued in one area because of 'the black ants'. I wondered if the farmers were referring to the small black ants that always attend Hilda when it is living on groundnut plants.

In central Tanzania, I was the victim of drought. The second rains had not come, so no crop had been sown, and the crop that was sown with the first rains had just been harvested.

If future circumstances permit, I should like to survey fully the central, western, and northern parts of Tanzania. I skirted all around the border of Mozambique, but never to my knowledge actually crossed it. In view of the intensity of groundnut production in parts of this country, and the reports of serious termite damage (Vera and Hugo 1987), the need for a systematic survey is clear. Botswana needs a more extensive search, and a visit to Swaziland could also be made at the same time.

The Implications

Data derived from experiments

The doomsday experiments carried out by Kisyombe and Wightman (1987) at five sites in Malawi showed that the application of a soil insecticide (dieldrin at 2.0 kg a.i. ha^{-1} along the ridge top) resulted in an increase in yield of 23.8% at Makola, 53.1% at Chitala, 60.1% at Ngabu, and 'no significant difference' at Mbawa and Chitedze. The latter two sites came out of grass fallow that season, and had low population levels of the insects we were interested in. Killing 8 white grubs (100 plants)$^{-1}$ apparently contributed to the 53% increase in yield at Chitala, and killing 15 white grubs (100 plants)$^{-1}$ was associated with the 24% increase in yield at Makola. Other insects were also killed by the insecticide so that it is not possible to give a more precise picture. The only conclusion that I feel it is safe to draw from this set of experiments is that white grubs appear to be able to inflict a measurable level of damage at relatively low densities (at say 10 white grubs [100 plants]$^{-1}$). Furthermore, the site results reflect the degree of variability between fields in soil-insect population density that I found on the survey and would expect to find throughout the region.

The main insecticide trial at Chitedze suffered from a lack of insects. However, by examining individual plants (40 from each of the 30 plots) we found that 210 plants had root damage and that there were 20% fewer pods on these plants than on those with no damage (Table 6)(Wightman and Wightman 1987). Other causes of yield reduction included *Macrotermes* that reduced the number of pods on the plants it attacked by an average of 11.6%. Neither of these two potential pests was particularly damaging at this site, the worst damage being inflicted by termites while the crop was drying in the field after harvest. They accounted for an 18.6% loss in haulm weight in plots where no insecticide had been applied.

Another experiment carried out at Chitedze indicated that, with the sowing pattern of the local farmers, there would only be compensation after plant death if more than 30% mortality occurred 17 days after sowing, and if there was more than 50% mortality 26 days after sowing (Wightman 1987). This means that when considering the effects of plant mortality on yield (in Central Malawi conditions) it is safe to assume that there is a linear relationship within the specified limits.

The survey results show that there was 10% of pod damage but this was early in the season. By harvest time, the total number of pods scarified by termites or bored by members of the other taxa was higher than this. The late-season survey in southern Malawi

Table 6. Constraints, in terms of the incidence of the number of plants and plots affected, percentage loss to total pods and harvestable pods, all treatments combined, found in an insecticide trial, Chitedze, Malawi, 1986/87. (Sample size = 40 plants plot^{-1}, 30 plots, and 1200 plants).

Type of constraint	Number of plants affected	Number of plots	Percentage loss per plant	
			Total pods	Harvestable pods
Major constraints				
Root damage (White grub)	210(17.5)[1]	30	19.8	6.6
Macrotermes	108(9.0)	14	11.6	6.3
Minor constraints				
Fusarium	7(0.6)	5	15.7	27.8
Verticillium	15(1.2)	8	27.7	35.0
Microtermes	4(0.3)	1	12.3	21.6
Alectra	12(1.0)	3	35.8	25.5
GRV[2]	5(0.4)	4	37.8	58.3
GSND[2]	1(0.1)	1	66.6	72.7

1. Percentage of plants in parentheses.
2. GRV = Groundnut rosette virus.
GSND = Groundnut streak necrosis disease.

indicated that it would be in the range of 20-40%, although the meaning of this in terms of lost revenue is not clear. Where it was normal to sell unshelled groundnuts, as in parts of Tanzania and Zimbabwe, it could be imagined that damaged pods would sell at a lower price, but this did not seem to be the case. In Malawi, a 'spot survey' showed that pods with borer damage and termite scarification formed about 10% of those offered for sale in the supermarket in Lilongwe. This is despite the fact that the association between insect damage and the incidence of aflatoxin has been known for many years (McDonald and Harkness 1965). It appears that the loss in quality can be ignored, so that the actual loss, in terms of unsaleable seeds, was probably no more than 15%.

Estimation of damage caused by white grubs

An indication of the influence of an herbivorous insect on the biomass and production of its host can be obtained studying the feeding efficiency of the insect (Wightman 1979). The insect larvae of a given species would have to eat approximately the same amount of food to reach the preadult stage, provided they have been living in more or less the same conditions. The amount of food consumed is related to the mass achieved as the efficiency of the conversion of food to body tissue is fairly constant for insects living on similar food. For example, arthropod herbivores eat about 11 times their own mass (Wightman and Rogers 1978). So a white grub with a maximum dry mass of 100 mg (equivalent to 500 mg live mass) would have eaten about 1.1 g of roots during its growth period. Many of the white grubs we encountered were heavier than this, so this is a conservative estimate.

The dried root of a short-duration groundnut plant weighs about 4 g (T. G. Shanower, ICRISAT, personal communication, 1988). Thus, the root biomass of 1 ha of groundnut with a 100 000 plants ha^{-1} is 400 kg. If there are 50 white grub larvae (100 plants)$^{-1}$, there are 50 000 in the whole field and they would consume 55 kg of root tissue. Although white grubs sometimes feed on the tap root, they usually eat the lateral roots. This means that they are likely to sever the roots without eating them, so that much more than 55 kg of root tissue ha^{-1} is destroyed. The stunting of plants that is characteristic of white grub damage occurs because the supply of water and nutrients via the peripheral roots is impaired. This simple calculation indicates that, in the conditions of northern Zimbabwe, perhaps half of the functional root tissue of the 'average' crop was removed by white grubs in the season of the survey. This has clear implications on the ability of a crop to withstand drought.

Comparison of Damage Caused by Insects with That Caused by Other Biotic Constraints

When trying to put the damage caused by soil insects to groundnut crops into perspective, I looked through the literature to find data relating the incidence or the intensity of the other biotic constraints on yield. There does seem to be much data of the kind I need relating to southern Africa; so I included other parts of the world in my search. Davies (1975a, 1975b, 1976), working in Uganda in the 1960s on the control of GRV by killing the vector with insecticides, achieved 15.3–68.3% increases in yield. At about the same time a 13.5% increase in yield was achieved at Chitedze by applying dimethoate to a late-sown crop (Agricultural Research Council of Central Africa, Rhodesia, Zambia, Malawi 1965). This was again thought to be due to GRV control. Misari et al. (1980) state that GRV caused a 70% loss in production in Nigeria's main groundnut-growing area. However, they also state that the annual national loss caused by this disease is normally 3%. This certainly fits my impression that GRV outbreaks are sporadic, but when they appear they can be very bad.

Groundnut streak necrosis disease (GSND) is too much of a new entity in the region to make many conclusions. Indications so far are that it reduces the yield of individual plants by 70%. In 1986, some fields in the Upper Shire Valley had as many as 60% of the plants infected; this disease would clearly have reduced the yields in these fields by 40–50%.

We seem to know more about the yield losses caused by foliar diseases. In demonstrating the benefits of ultra-low volume (ULV) sprayers for disease control, McDonald and Fowler (1981) more than doubled the yield of experimental crops at Samaru, Nigeria. Yayock (1981), also working in Nigeria, obtained 5.6–11.7% increases at Gwarzo and 12.7–48.6% at Kano by controlling foliar diseases. The level of response varied from one genotype to another. The recognition of the importance of genotypic responses is extremely important in experiments of this kind. In comparing the response of 20 genotypes to disease control, Subrahmanyam et al. (1984) achieved yield increases ranging from virtually zero in resistant lines to fourfold in the most susceptible lines. Hildebrand (1987) obtained 27.5% and 34.9% increases in pod yield at two sites near Harare by spraying fungicide on cv Egret eight times during the 1984/85 season. At Chitedze, the yield response to foliar disease control has varied from 7.9% for ICGM 36 to 98.6% for Malimba (ICRISAT 1987b, p. 247). Perhaps the best record of all is also from Chitedze: Ngwira (1985) reports 13 years' records of the effect of controlling early leaf spot on the yield of Chalimbana. The increase ranged from 37% to 133%, with an average of 66.3%. Thus, losses caused by fungal diseases can be severe in experimental conditions, where there is a buildup of inoculum, in the soil. In trying to estimate what happens in farmers' fields, an estimate of 40% is probably close to reality.

Mayeux (1985) demonstrated that it was possible to almost double the stand density by protecting seed with fungicide. The effect of his treatments on the viability of damaged seed was particularly marked.

Estimates of yield losses caused by insects are largely restricted to termite activity in West and East Africa and in India. This information has been reviewed by Hebblethwaite and Logan (1985) and points to losses in the region of 40–50% ascribed to *Microtermes* spp and 5–10% to *Odontotermes* spp. In trying to put this information together, I prepared a small budget that is open to discussion and modification according to local circumstances. In this case, I had a Zimbabwean Communal Lands field in mind where the yield potential of the genotype was 5 t ha^{-1}. The sequence of events (Table 7) was 10% seedling mortality, white grubs damaged the root causing a 50% reduction in pod numbers. Fungal and virus diseases caused a further 50% loss. Pod borers destroyed 20% of the pods and termites removed a further 20% of the pods during drying. This left about 0.7 t, which is the yield expectation level of communal land farms.

Table 7. A 'damage budget' for a groundnut crop with a yield potential of 5 t ha^{-1}, but struck by a series of pests and diseases.

Yield potential	Constraints	Sequential loss	'Potential' remaining (t)
5.00 t	Seedling mortality	10%	4.50
	White grub damage	50%	2.25
	Foliar diseases and virus diseases	50%	1.12
	Pod borer damage	20%	0.90
	Termite damage	20%	0.70

Options for Future Action

In my opinion the needs are:

- to resurvey several times over a larger area, including that already examined, to check whether the situation is static;
- 'hot spots', thus detected, should be used for 'doomsday' experiments, to establish the relationships between soil-insect density and yield loss; and
- specialist help should be organized to help with the identification of the major taxa.

Controlling soil insects in groundnut fields in southern Africa

It is stressed that the insects we are dealing with do not only influence the yield of groundnuts. They are pests of the whole farming system. The roots of other crops in the rotation are almost certainly attacked. The lodging of maize as a result of termite attack is a common sight in the region.

Insecticides are the first option to be considered. The paper by Mwenda and Cusack in this Workshop is sufficient to indicate that chemical inputs are not easy to fit into the economic structure of the crop. The farm survey showed that one or two farmers in Zimbabwe had applied insecticides. Some wanted to, especially for white grub and termite control, but they did not know what to use.

If soil insecticides have a place in the region, it would seem that it is feasible with commercial farmers in Zimbabwe, who produce 10% of the country's groundnut crop and apply fertilizer to the crop. If the insecticide was mixed with the appropriate fertilizer it could be safe and relatively cheap. Applying such a mixture to maize would avoid the risk of product contamination with insecticides. However, even soil insecticides have their problems. The field at Chitedze showed a significant increase in *Macrotermes* spp activity in some treatments. I suspect that this was because ants, the predators of termites, were killed by the insecticides.

Natural control processes were clearly at work among the soil insects. Any white grub exposed on the soil surface for more than a few minutes was attacked by ants. Diseased white grubs were also found. Insecticides may not be at all beneficial in the long term.

Host-plant resistance may have a role to play in the long term. Scientists at ICRISAT Center are currently determining the chemical basis for host-plant resistance in groundnut. This research may help us 'design' suitable genotypes for areas with soil-insect problems.

Aspects of farm management can help. For instance, removing cereal stubbles from fields at the end of the season will prevent the buildup of termite populations during the dry season. The adoption of farm machinery that is drawn by draft animals will ensure the deeper and more thorough cultivation of the soil. This breaks up termite nests that are near the surface and exposes white grubs, wireworms, etc., to bird predators. The effects of intercropping and other such farming practices in the southern Africa context are not known, although the paucity of the soil-insect populations in Tanzania's mixed-cropping systems has already been alluded to.

Conclusions

The survey and the supplementary experimental work have indicated that the soil-insect cadre in the groundnut fields of southern Africa is more complex and more important than previously suspected. The 'complexity' refers to the number of species involved, the difficulties in studying them and the problems in controlling them. The 5-month tour has provided a basis for future research. There is no doubt that soil insects are reducing the yields of some groundnut fields across the region.

Acknowledgment

Well over 100 scientists, technicians, field officers, and extention workers helped me in many ways to complete this survey. I cannot mention them all by name even though I should like to. However, I can, by virtue of the unique role they played, make a special mention of Dr K.R. Bock, who arranged itineraries and made sure that the correct facilities were at hand, and my daughter, Abi, who was patient, long-suffering, and hardworking and still managed to be good company.

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Discussion

Chiteka: There is a rather high percentage of root damage caused by insects, e.g., 40.2% at a community-area site.

Wightman: There was very high rate of visible damage to roots caused by insects. The figures are estimated values.

Ramanaiah: Insect pests on groundnuts appear sporadically and seasonally. So the surveys should be more intensive and should be linked with national scientists to get feedback on information. Surveys conducted by Dr Wightman should be linked with storage-pest surveys also.

Sibale: Would Dr Wightman explain or justify his 'damage budget' because it appears to me that diseases cause a lot more yield loss than pests.

Wightman: This is the usual impression one gets from walking through groundnut fields in Malawi, but if the plants are examined during the growing season it becomes clear that the insects living underground are inflicting considerable damage to the plants. The 'budget' is for a farm in a communal area in Zimbabwe where the soils are sandy and the groundnut-growing season is short. The damage in such conditions is not difficult to assess, once the symptoms are learnt.

Ndunguru: Could it have been cost effective if the surveys were conducted by teams covering various disciplines rather than each discipline carrying out its own survey?

Bock: There are no full-time groundnut entomologists in the region.

Kannaiyan: The white-grub damage (about 50%) is based on a 1-year survey, that too in Zimbabwe. It should be reconfirmed in future surveys in the SADCC region to establish the importance of white-grub damage on groundnut.

Maliro: One season's data are likely to lead us into taking the wrong decisions for SADCC research since pest occurrence might be very variable between seasons. It would be better to have a survey of several seasons' duration because only that would give us a true picture.

Recent and Ongoing Research on Insect Pests of Groundnut in Zambia

S. Sithanantham[1], N.S. Irving[1], and P. Sohati[1]

Abstract

Many insect pests have been found on groundnut in Zambia. However, the distribution of the pests within the country as well as the extent of loss they cause are not yet clarified. Brief visits by ICRISAT entomologists indicated the likely importance of termites, white grubs, jassids, thrips, and aphids (as vectors of groundnut rosette virus) in Zambia. A preliminary on-station field test during 1986/87 at Msekera showed that soil insects caused about 13% loss in yield of sound seeds. Another on-station trial with two insecticides—endosulfan and pirimiphos ethyl—applied to soil, showed that the former, applied once at planting and again 8 weeks later, caused significant reduction in plant mortality and in quantity of pods damaged by soil insects, but the seed-yield differences were not significant. On-farm replicated trials around Msekera showed that the varieties Chalimbana, M 13, and 4a/8/2 suffered significantly less plant mortality because of the soil insects than Makulu Red. During the 1987/88 groundnut growing season, on-station and on-farm trials have been initiated to estimate the avoidable loss because of soil insects. Preliminary screening of breeders' promising entries and pest-resistant selections from ICRISAT for tolerance of or resistance to major pests has been initiated. Farmers' storage practices and perceptions of storage losses were also studied in the Eastern Province. Future plans and priorities are briefly indicated.

Sumário

Investigação Recente e Currente Sobre Pragas de Insectos do Amendoim em Zâmbia. *Grande número de pragas de insectos foram encontradas sobre o amendoim em Zâmbia. Contudo, a distribuição das pragas no país, assim como a extensão das perdas por elas causadas, ainda não estão esclarecidas. Visitas breves de entomólogos do ICRISAT indicaram a possível importância das termites, lagartas brancas, jassides, tripes e afídeos (como vectores do virus da roseta do amendoim), em Zâmbia. Um ensaio de campo preliminar, feito em 1986/87, em Msekera, mostrou que os insectos do solo causaram cerca de 13% de perdas no rendimento de sementes cheias. Outro ensaio de campo, com dois insecticidas — endossulfão e etil pirimifos — aplicados no solo, mostrou que o primeiro, uma vez aplicado durante a sementeira e novamente 8 semanas mais tarde, causaram reduções significativas na mortalidade das plantas e na quantidade de vagens danificadas por insectos do solo. Mas, não ocorreram diferenças no rendimento de sementes. Ensaios de campo replicados em torno de Msekera, mostraram que as variedades Chalimbana, M 13 e 4a/8/2 tiveram uma significantemente menor mortalidade de plantas, devido ao uso de insecticidas de solo, que a variedade Makulu Red. Durante a estação de*

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crescimento do amendoim de 1987 88, iniciaram-se os ensaios em estação e nos campos dos camponeses, com o objectivo de estimar as perdas evitáveis, devido aos insectos do solo. Foi iniciada a avaliação preliminar, para a tolerância ou resistência às mais importantes pragas, de aquisições promissoras dos melhoradores e de selecções resistentes a pragas provenientes do ICRISAT. Foram também estudadas, na Provincia Oriental, as práticas de armazenamento dos agricultores e a determinação das perdas de armazenamento. Planos futuros e prioridades são resumidamente indicados.

Introduction

Insect pests and diseases are considered to be among the major causes for low groundnut yield in Zambia (Sandhu et al. 1985). During 1982 84 many insect pests were identified on groundnut (Irving 1984). Visits by ICRISAT entomologists during 1984 86 have suggested the likely importance of termites, white grubs, jassids, thrips, aphids (as vectors of groundnut rosette virus), and storage insects (Amin 1984; Wightman 1986) but there is little quantified data on their distribution and economic importance. The present paper reviews recent research in Zambia and briefly summarizes ongoing activities and future research plans relating to insect pests of groundnut.

Table 1. Insect pests occurring on groundnut in Zambia.

Common name	Scientific name	Family	Type of damage	Reference[1]
Aphid	*Aphis craccivora*	Aphididae	Sap sucking; disease vector	a,b
Jassid	*Empoasca dolichi*	Cicadellidae	Sap sucking	a,b,c
Thrips	*Frankliniella schultzei*	Thripidae	Sap sucking	a,b,c
Hilda	*Hilda patruelis*	Tettigometridae	Sap sucking	a,b,c
Whitefly	*Bemisia tabaci*	Aleyrodidae	Sap sucking	a
Giant bug	*Anoplocnemis curvipes*	Coreidae	Sap sucking	a
Stink bug	*Aspavia albidomaculata*	Pentatomidae	Sap sucking	a
Flea beetle	*Monolepta signata*	Chrysomelidae	Defoliation	a
Semilooper	*Chrysodeixis acute*	Noctuidae	Defoliation	a
Bollworm	*Helicoverpa armigera*	Noctuidae	Defoliation	a
Flower beetle	*Mylabris* spp	Meloidae	Flower damage	c
Termites	*Microtermes* sp	Termitidae	Root pod damage	a,b,c
White grubs	*Sericini* sp	Scarabaeidae	Root pod damage	d
	Anomala sp	Scarabaeidae	Root pod damage	d
	Adoretus sp	Scarabaeidae	Root pod damage	d
Ants	*Dorylus* sp	Formicidae	Pod damage	d
Wireworm	-	Elateridae	Pod damage	d
False wireworm	-	Tenebrionidae	Pod damage	c,d
Weevil	*Tetragonothorax anguicollis*	Curculionidae	-	d

1. (a) Irving (1984); (b) Amin (1984); (c) Wightman (1986); (d) J.A.Wightman, ICRISAT Center (unpublished data).

Insects and Other Pests

Among sucking insects, the damage by jassids and thrips appears to be common and substantial (Table 1). An estimate of 10–30% loss in yield due to jassids in Malawi and Zambia was made by Amin (1984). However, this particular season is regarded to be exceptional. Aphids (*Aphis craccivora*) are important as vectors of groundnut rosette virus.

The root sucking bugs (*Hilda patruelis*) occur only occasionally as pests. Among chewing insects, termites (mainly *Microtermes*) and white grubs appear to be important (Wightman 1986). Millipedes are also important in pod damage in some areas. Rodents seem to be a major source of storage loss in the Eastern Province (Sithanantham et al. 1987). The relative abundance of soil insects and millipedes, as studied in limited surveys during 1986, are detailed by Wightman elsewhere in this workshop in his paper on surveys in this region. We need to clarify the species composition of jassids and thrips occurring on groundnuts in Zambia. Irving (1984) refers to jassids occurring in Zambia as *Empoasca dolichi*, which has also been recorded from Zaire (Metcalf 1968) and Malawi (Ghouri 1979). Recent collections of jassids in Zimbabwe have, however, been identified as *E. signata* (J.A. Wightman, ICRISAT Center, personal communication 1988). Although the thrips species reported has been determined as *Frankliniella schultzei*, this should be re-examined, in view of more recent collections of *Megaluro thrips sjostedti* (Trybom) from nearby Malawi.

Further efforts are required towards clarifying the distribution and severity of damage by the major insects—termites, white grubs, jassids, thrips, and aphids, besides storages pests in different groundnut-growing areas of Zambia.

Avoidable Loss Due to Soil Insects

One on-station assessment was conducted near Msekera, during 1986/87, based on suggestions from the ICRISAT entomologist (Wightman 1987). Two plots (10 rows × 10 m each) of cv Chalimbana were grown side by side and one of these was protected from soil insects by applying dieldrin at 2 kg a.i. ha^{-1} at planting. All other practices were common for these plots. The yield of seeds—both undamaged and total—was recorded for both the plots at harvest. Based on the difference in yield between the protected and unprotected plots, the avoidable loss was calculated as 2.3% (27 kg ha^{-1}) for total seed yield and as 12.8% (147 kg ha^{-1}) for undamaged seed yield. This suggests that damage to seeds by soil insects may be important in quantifying the extent of loss caused to the crop yield. In these plots, the major soil insect was the false wireworm occurring at about 5 (10 m zones)$^{-1}$. More of such tests are necessary to obtain a broadbased estimate of the extent of lost caused by soil insects.

Varietal Differences in Soil-insect Damage

Plant mortality caused by soil insects was studied on four groundnut varieties—Chalimbana, Makulu Red, M 13, and 4a/8/2—in six replications each in farmers' fields at five villages around Chipata, in collaboration with agronomists. The extent of overall mortality differed considerably between locations (Table 2). However, the variety Makulu Red alone was found to suffer greater plant mortality than the other three varieties. This recent result has provided an indication that adequate varietal differences in susceptibility to soil-insect pests are available in groundnut.

Insecticides Against Soil Insects

A randomized-block design trial, with six replica-

Table 2. Plant mortality in four groundnut cultivars due to soil insects in five on-farm locations around Msekera Research Station, Zambia, 1986/87.

	Plant mortality (mean per 30 m^2 plot)			
Location	Chalimbana	M 13	4a/8/2	Makulu Red
Kalunga	0.2	0.1	0	0.4
Lutembwe	0	0.2	0	0.2
Kalichero	1.0	2.3	2.0	2.8
Chiparamba	0	0.7	0.8	4.3
Msekera	1.5	0.7	2.8	13.8
Overall	0.5a	0.8a	1.1a	4.3b[1]

1. Differences between cultivars significant at 1% level.

tions and the following treatments, was conducted at Msekera during 1986/87.

Endosulfan	1.0 kg ha^{-1}	once at planting
Endosulfan	1.0 kg ha^{-1}	at planting + 8 weeks later
Pirimiphos ethyl	2.5 kg ha^{-1}	once at planting
Pirimiphos ethyl	2.5 kg ha^{-1}	at planting + 8 weeks later
Nontreated control		

The plots were of 6 rows of 4 m, with 75-cm spacing between rows and 10 cm between stations. The results (Table 3) indicated that endosulfan (once and twice) gave relatively better control of soil insects than pirimiphos ethyl by reducing the number of plants killed and the weight of damaged pods but the differences between treatments were not significant for pod or seed yields. Improvements have been made in the planning of such trials for further evaluation of other insecticides.

Ongoing research

Two on-station trials, one each at Msekera and Masumba, each with two cultivars, are directed towards assessing losses caused by soil insects. In collaboration with agronomists, 15 on-farm trials are in progress in five districts of the Eastern Province, following the same treatment methods as adopted in Malawi recently by Kisyombe and Wightman (1987). Each of these trials include four varieties: Chalimbana, Makulu Red, ICGMS 42, and MGS 2. Preliminary evaluation of available pest-resistant selections from ICRISAT, in addition to high-yielding selections, has been initiated. Preliminary trials on off-season incidence of pests and on planting-date effects have also been initiated. A survey to assess the pest situation in farmers' fields has been planned. A pilot survey on storage practices of farmers and their perception of storage losses among food legumes has just been completed and results are available in a report (Sithanantham et al. 1987).

For the Future

The regional importance of the major sucking insects and soil pests should be critically assessed both by surveys and by appropriate on-farm trials to estimate the avoidable losses because of the major pests in each region. As a short-term measure, cheap and effective insecticides should be identified to minimize crop losses. Nevertheless, the long-term approach should be to minimize or avoid insecticide use and to develop environmentally compatible methods, such as pest-resistant varieties and cultural practices. Varietal resistance to insect pest should be vigorously pursued and even tolerant genotypes with good agronomic traits should be considered for use in integrated pest management. The role of cultural practices in influencing the pest-damage levels should be critically examined in collaboration with

Table 3. Effects of two insecticides in controlling plant mortality due to soil insects and on groundnut crop yield, Msekera Research Station, Zambia, 1986/87.

Treatment	Plant mortality per 6 m^2 plot	Crop yield (g) per 6 m^2 plot: Total pods	Damaged pods	Total seeds
Endosulfan (once)	1.29a[1]	846	51c	575
Endosulfan (twice)	0.80b	864	48c	552
Pirimiphos ethyl (once)	1.48a	767	136ab	486
Pirimiphos ethyl (twice)	1.36a	810	123b	501
Control	1.41a	842	181a	534
SE (m)	±0.16	NS[2]	±16.0	NS

1. Values followed by the same letter are not significantly different.
2. NS = Not significant.

agronomists. The overall approach for the Zambian situation would be to ensure that losses because of soil pests and sucking insects are minimized through low-cost technology. The status of soil insects in relation to the aflatoxin problem also needs elucidation. The role of aphids as vectors of the virus diseases should be closely monitored to develop appropriate integrated virus-vector management strategy.

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5

Country Reports

Groundnut Research under Low-rainfall Conditions in Botswana

A. Mayeux[1] and G.S. Maphanyane[2]

Abstract

The low groundnut production in Botswana is because of erratic rainfall, lack of suitable cultivars, poor crop management, and absence of industrial processing that could stimulate production towards reaching self-sufficiency in vegetable oil. A few imported cultivars from India and West Africa seem promising under low-rainfall conditions but the establishment of a national breeding program may be the most effective way of providing better-adapted varieties. Sowing at 75 cm × 20 cm spacing and the addition of gypsum is recommended to improve seed quality. Response to fertilizer (P) is negligible under low-rainfall conditions. Hilling of groundnut plants was found to have a negative effect on pod yield and harvest quality. Use of a fungicide (captan) as a seed dressing has markedly improved plant establishment by controlling Aspergillus niger. *Termite damage is the most important problem but chemical control is often uneconomical because of low yield potential.*

Sumario

Investigação Sobre Amendoim em Condições de Baixa Precipitação em Botswana. *A baixa produção do amendoim em Botswana é devida à precipitação errática, à falta de cultivares adaptados, ao pobre maneio cultural e à ausência de processamento industrial, que possa estimular a produção em direcção à auto-suficiência em óleo vegetal. Alguns cultivares importados, da India e da Africa Ocidental, parecem ser promissores nas condições de baixa precipitação. Mas, o estabelecimento de um programa de melhoramento nacional, deve ser a maneira mais eficiente de providenciar variedades melhores e adaptadas. Para melhorar a qualidade da semente recomenda-se a utilização de um compasso de 75 cm × 20 cm e a adição de gesso. A resposta à adubação (P) é negligível em condições de baixa precipitação. Semear plantas de amendoim em grupos, mostrou ter efeitos negativos no rendimento de vagens e na qualidade da colheita. O uso de um fungicida (captan), como revestimento da semente, melhorou marcadamente o estabelecimento das plantas, atravéz do controlo do* Aspergillus niger. *Danos causados por termites são o problema mais importante, mas o controle químico é frequentemente anti-económico, devido ao baixo rendimento potencial.*

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ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1989. Proceedings of the Third Regional Groundnut Workshop, 13-18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P 502 324, India: ICRISAT.

Introduction

Groundnut production in Botswana is still at a subsistance level being grown mostly by traditional farmers for home consumption (roasting, boiling, etc.). Although there are a few commercial farmers, the national production remains low and has decreased over the years because of various production constraints, such as lack of seed, drought stress, poor market conditions, labor problems, and poor agronomic practices. Production is characterized by low and variable yields (Fig. 1). Botswana imports around 2000 t of vegetable oil per annum, a demand sufficient to warrant more effort directed at improving production to reach self-sufficiency in vegetable oils.

The Seed Multiplication Unit is doing all it can, to improve seed quantity, seed quality, and seed value and this effort must be extended to farmers through good cultural practices. This involves soil preparation, optimum planting time, optimum plant density, row planting to make easier weeding control, and other soil-management practices. This effort can only be successful if it is accompanied by

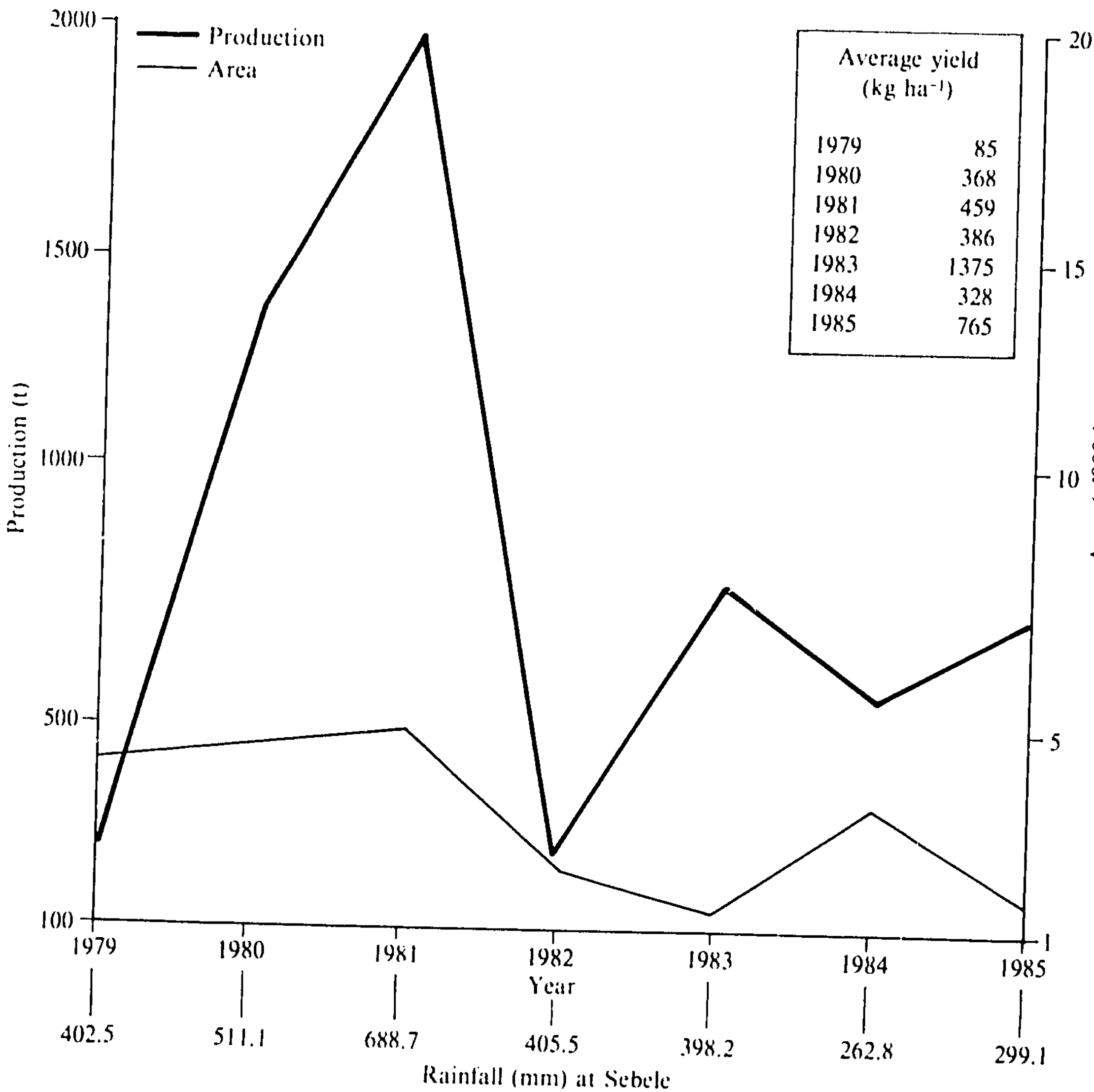

Figure 1. Groundnut production and area planted to groundnut, Botswana, 1979–85.

development of oil- and confectionary-processing industry to encourage commercial production of groundnut.

The Department of Agricultural Research has established an oilseed program with the broad objective of addressing all aspects of groundnut production to assist farmers.

Cultivar Improvement

Cultivar introduction and local collection were the earliest approaches to improve groundnut production by seeking to identify one or more cultivars well adapted to Botswana's rainfall conditions.

In 1984, 170 cultivars were imported. After three seasons of erratic rainfall (Fig. 2), with a deficit of 36.1% in comparison with the 10-year average, none of these cultivars was significantly superior to the locally grown Spanish cultivar, Sellie.

However, a few genotypes and cultivars introduced from ICRISAT Center (India) seem promising (Table 1) and warrant further testing, notably the genotype ICGS 60, which is slightly earlier than Sellie (8 days). An introduction from Senegal, 55 437 (spanish), has been entered into the seed-production scheme. This cultivar is grown in the drier parts of Senegal. In Botswana, it performs as well as Sellie but has superior characteristics, notably shelling percentage and seed quality (Table 1). It

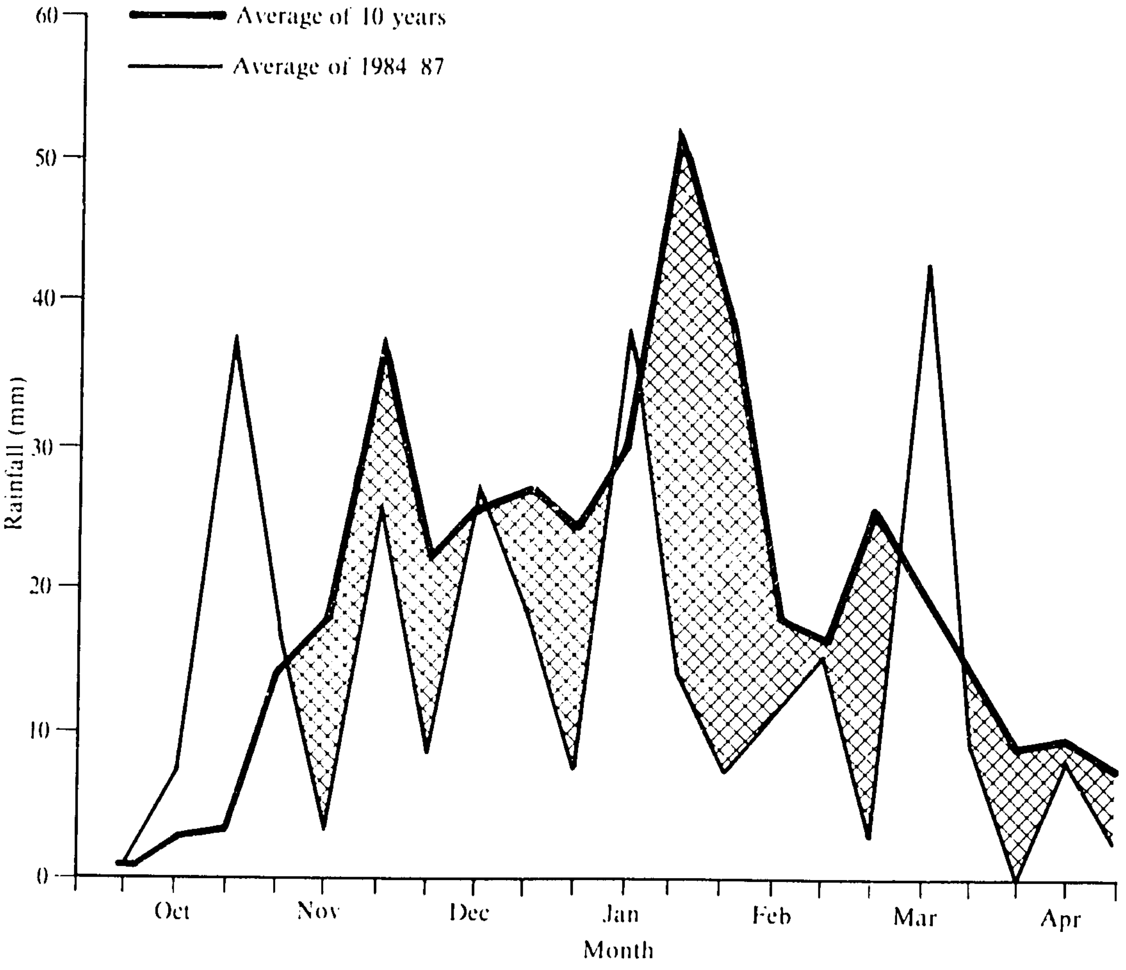

Figure 2. Rainfall distribution and deficit (*shaded*) at Sebele Research Station, Botswana, 1984-87.

Table 1. Performance of selected ICRISAT groundnut genotypes, Sebele, Botswana, 1984-87.

Genotype	Pedigree	Pod yield (kg ha^{-1})	Shelling (%) (mixed seeds)	Shelling (%) (good seeds)
ICGS 60	MGS 7 × G 201	988.9	58.9	46.8
ICGS 22	Ah 65 × Chico	904.3	58.8	40.9
ICGS 50	Goldin I × Faizpur 1-5	897.0	62.9	48.1
ICGS 36	TMV 7 × Chico	882.8	62.3	49.6
ICGS 85	2-5 × Robut 33-1	869.4	61.1	46.3
ICGS 74	2-5 × Robut 33-1	853.9	62.3	43.4
ICGS 23	GAUG 1 × 72 R	833.3	62.1	36.4
ICGS 55	ICGS 22 × TG 2E	821.1	62.7	48.3
ICGS 4	Ah 6279 × TG 16	802.7	49.5	36.7
ICGS 49	Gangapuri × L.No 95A	794.1	62.2	49.3
ICGS 26	Tifspan × 28-206	672.9	57.8	40.1
ICGS 28	72 R × Chico	667.2	62.2	43.2
Controls				
Sellie		715.6	59.2	39.7
55-437		841.6	65.5	44.9

also has a better flowering coefficient, needing fewer flowers (11.5) for the production of one harvestable pod than Sellie (18.3).

A new set of 24 cultivars was imported from ICRISAT Center in 1987, specifically for earliness. Cultivars commonly grown in Botswana take 140 150 days to maturity and this prevents flexibility in planting dates, since the growing season is of similar length.

A national groundnut breeding program will commence in 1988 to develop cultivars better adapted to drought stress conditions (recurrent selection) and of shorter growth cycle (back crossing with the cv Chico as the recurrent parent).

Phosphorus and Calcium Fertilizer Studies

Groundnut requires fertilizer for good growth and development with phosphorus (P) and calcium (Ca) being the most important elements. Phosphorus increases root and plant development and consequently increases the uptake of other nutrients. Calcium improves pod filling and seed size.

A field experiment was conducted in a sandy soil for three cropping seasons, to compare four rates of phosphate [single superphosphate (10.5% P), at 0, 5.2, 10.5, and 15.7 kg ha^{-1}], and gypsum at 0 or 1000 kg ha^{-1}. The cultivar Sellie was used. Results for three seasons are presented in Table 2.

Under low-rainfall conditions (269.9 mm in 1984/85; 281.0 mm in 1985/86; and 283.5 mm in 1986/87), groundnut response to mineral fertilizer was low and not significant. Although it was noted that phosphate increased pod numbers, these pods could not all reach complete maturity because of drought stress. This resulted in a decrease in shelling percentage of good seeds with increasing single phosphate application and this minimized treatment yield differences.

Apparently, gypsum used alone has a beneficial effect on productivity and quality. This suggests an application of calcium is essential, whenever groundnuts are grown, and probably the benefit is also through improvement of soil pH, which is generally low in Botswana (4.0-5.0 of $CaCl_2$).

Under drought conditions, groundnut response to mineral fertilization is often limited by the level of mineral content in the leaves. It becomes constant once a certain level is reached in the leaves.

Knowledge of this level can help farmers determine fertilizer requirements. Table 3 summarizes these reference contents in sandy soil according to Institut de recherches pour les huiles et oléagineux (IRHO) experience.

Plant Density Studies

Plant density under low-rainfall conditions must be

Table 2. Effect of phosphate fertilization in the presence or absence of calcium on groundnut (cv Sellie) yield under drought conditions, Botswana, 1984-87.

Yield component	Phosphate	1984/85		1985/86		1986/87		Mean	
		0[1]	1000[1]	0[1]	1000[1]	0[1]	1000[1]	0[1]	1000[1]
Pod yield (t ha^{-1})	0[2]	0.936	1.311	0.969	0.981	0.603	0.660	0.836	0.984
	50[2]	1.112	1.110	1.000	0.953	0.678	0.690	0.930	0.918
	100[2]	0.928	1.240	1.057	1.076	0.520	0.566	0.835	0.961
	150[2]	1.023	1.089	1.000	0.924	0.867	0.530	0.963	0.848
Pod yield (g plant^{-1})	0[2]	11.4	13.1	8.7	9.1	6.9	7.3	9.0	9.8
	50[2]	15.3	10.4	8.6	8.7	7.8	8.0	10.6	9.0
	100[2]	13.0	13.9	9.4	9.7	6.4	6.6	9.6	10.1
	150[2]	10.5	11.6	8.9	8.5	9.6	6.4	9.7	8.8
Shelling percentage of good seeds									
	0[2]	52.4	56.0	-	-	53.9	52.4	53.2	54.2
	50[2]	54.7	54.2	-	-	52.9	46.1	53.8	50.2
	100[2]	46.8	44.5	-	-	43.2	48.1	45.0	46.3
	150[2]	46.4	47.2	-	-	50.8	48.9	48.6	48.1

1. kg ha^{-1} of gypsum.
2. kg ha^{-1} of single superphosphate.

Table 3. Mineral element content in groundnut leaves, Botswana.

Element	Content above which response to fertilizer is weak	Leaf content from field experiment[1]
N	3.5 %	3.78 %
P	0.225 %	0.16 %
K	0.8-1.0 %	2.50 %
Ca	1.2 %	2.05 %
Mg	0.5 %	0.60 %
S	0.25 %	0.28 %

1. Leaf samples from control plots without fertilizer.

well understood to ensure optimum yield and seed quality.

A field experiment to study different spacings was conducted at Sebele Research Station in 1985/86 and 1986/87. Spacing between rows (60 cm, 75 cm, and 90 cm) was combined with different spacings within rows (10 cm, 20 cm, and 30 cm). Yield and its components for varying plant densities is shown in Table 4.

Under low-rainfall conditions, groundnut is unable to achieve its full production potential. Despite significant increases in individual plant yields with decreasing plant density, the highest yield per unit area was achieved at the highest plant density. However, the low and medium densities resulted in better seed quality as indicated by 100-seed mass and 100-pod mass, and may provide the best economic return. Using Botswana Agricultural Marketing Board's (BAMB) shelled-groundnut prices[1] (1987/88) of 67.2 Thebe kg^{-1} for grade 1, 61.1 Thebe kg^{-1} for grade 2, and 44.5 Thebe kg^{-1} for grade 3, it is evident that farmers can obtain better returns from medium plant densities, which can generally be classified as grade 1 or 2 than from higher densities, which often only produce grade 3. Using yield and grade data from Table 4, monetary returns would be as follows:

(1) medium plant density 342 kg ha^{-1} (shelled) × 67.2 = 229.82 Pula (yield data in Table 4) or 342 kg ha^{-1} (shelled) × 61.1 = 208.96 Pula (2) high plant density 392 kg ha^{-1} (shelled) × 44.5 = 174.44 Pula.

Cultural Practices

Farmers have a tendency to mound groundnuts during the first weeding operations. A trial conducted at Sebele Research Station showed that this practice has a deleterious effect on pod yield and harvest

1. 100 Thebe = 1 Pula; 1 Pula is approximately US $ 0.5.

Table 4. Results of plant density studies, Sebele Research Station, Botswana, 1985-87[1].

Spacing (between and within rows)	Theoretical population ha^{-1}	1985/86	1986/87	Mean
		Pod yield (kg ha^{-1})		
90 cm × 30 cm	37000	594.3	421.6	508
75 cm × 20 cm	66600	718.5	421.5	570
60 cm × 10 cm	166000	776.8	560.4	668
		Pod yield (g $plant^{-1}$)		
90 cm × 30 cm	37000	15.1	14.2	14.6
75 cm × 20 cm	66600	11.9	7.9	9.9
60 cm × 10 cm	166000	5.9	5.5	5.7
		Shelling percentage		
90 cm × 30 cm	37000	60.2	57.5	58.9
75 cm × 20 cm	66600	58.5	61.4	60.0
60 cm × 10 cm	166000	59.5	58.1	58.8
		100-pod mass (g)		
90 cm × 30 cm	37000	52.4	46.0	49.2
75 cm × 20 cm	66600	50.6	45.3	48.0
60 cm × 10 cm	166000	44.1	35.9	40.0
		100-seed mass (mixed seeds) (g)		
90 cm × 30 cm	37000	19.5	20.3	19.9
75 cm × 20 cm	66600	19.6	19.2	19.4
60 cm × 10 cm	166000	15.9	16.2	16.3

1. Rainfall during growth: 248.4 mm in 1985/86, and 290.3 mm in 1986/87.

quality. Even if mounding does allow better development of pegs on the upper nodes, it causes a staggering of maturity in spanish cv Sellie. As spanish cultivars do not possess seed dormancy, this leads to a situation where the earliest pods are liable to sprout whilst the later ones have not matured. This situation is common in seasons with late rainfall. This results in a reduction in the shelling percentage (Table 5) and increase in the number of single-seeded pods, which cause difficulties in mechanical shelling.

Under low-rainfall conditions, flat sowing and regular interrow cultivation are recommended to minimize evaporation and improve water infiltration on sandy soils.

Pests and Diseases

Termite (*Microtermes* sp) damage is the main problem under low-rainfall conditions, but it is doubtful if chemical control is economical under conditions

Table 5. Effect of mounding on groundnut (cv Sellie) yield and its components, Sebele Research Station, Botswana, 1986/87.

Treatment	Pod yield (kg ha^{-1})	Pod yield (g $plant^{-1}$)	Shelling (%)	100-pod mass (g)	100-seed mass	Single-seeded pods (%)
No mounding	361.0	3.1	63.8	65.1	25.0	7.2
Mounding	244.0	2.3	59.4	59.4	23.4	12.2

of low yield potential. Different chemicals, such as carbofuran and Gamma BHC, are being assessed and the economies of different formulations are being investigated.

Spectacular improvements have resulted from the use of fungicide seed dressing (captan) to control *Aspergillus niger*. Increases in emergence of 20-40% have been recorded where captan has been used at the rate of 0.2% (20 g of fungicide per 10 kg of seed). Farmers have readily adopted the use of seed dressing.

Other pests and diseases have remained relatively unimportant on groundnut because of the prevalence of drought conditions.

Discussion

Nigam: At ICRISAT Center, we have identified some germplasm lines with a maturity period comparable to Chico but with better pod quality. I suggest that Botswana's national program should obtain those germplasm lines, and after evaluation, use them in their crossing program.

Mayeux: We thank ICRISAT Center for its offer. We are sure that ICRISAT can help Botswana in its national breeding program.

Research on Groundnuts in Mozambique

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Abstract

A survey was conducted to identify pests (insect and noninsect) that affect the groundnut crop in Mozambique. Yield losses caused by rust and leaf spots were studied. There were no losses because of the very late incidence of the diseases. Studies on animal traction are presented with special reference to winter plowing and its advantages. A method to study and select cultivars for farmers with different levels of inputs is presented.

Sumário

A Investigação do Amendoim em Moçambique. *Foi conduzido um inquérito para a identificação das pragas (insectos e não insectos), que afetam o amendoim em Moçambique. Foram estudadas as perdas de rendimento causadas pela ferrugem e manchas foliares. Estudos sobre tracção animal são apresentados, com especial referência para a lavoura do inverno e as suas vantagens. É apresentado um método para estudar e seleccionar cultivares para os agricultores com diferentes níveis de "inputs".*

Introduction

Groundnuts are grown mainly by small-scale peasant farmers in Mozambique. It was estimated in 1980 that groundnuts are grown on about 200 000 ha by about 5.7 million people, or 45% of Mozambique's population. For small-scale farmers, groundnuts are important both as a subsistence food crop as well as a cash crop. The marketable surplus commands a high price as food in urban areas and is a valuable source of edible oil. Groundnut production in Mozambique has declined in recent years (from 4952 t in 1981 to 2019 t in 1985 of government-marketed groundnut) because of the following reasons:

1. The area grown to groundnut is decreasing because of insecure conditions.
2. Irregular rainfall pattern, including drought, floods, and unseasonal rains.
3. Poor cultural practices.
4. Pests, diseases, and weeds.
5. Lack of good-quality seed.
6. Lack of marketing opportunities.
7. Lack of suitable implements and farm power.
8. Growing of unimproved groundnut landraces.
9. Low soil fertility.
10. Lack of technical and extension personnel.

Research on Groundnut

Surveys

In addition to farmer surveys conducted at the beginning of this project to evaluate groundnut pro-

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duction problems, additional surveys were conducted to evaluate pest incidence. Many pests were identified as important but occurrence and intensity of infestation is dependent on many factors, such as climate and planting time. In no two crop seasons were the same pests of importance in any particular area.

The following pests were noted as major constraints to groundnut production in Mozambique.

Termites. Locally called "Munchem", these usually appear during dry periods. It is a serious pest as it usually attacks gynophores resulting in pod loss. Later, termites also attack and damage the pods.

A secondary problem, arising from termite damage, is the incidence of aflatoxin especially when rain occurs during harvesting. Liver cancer, which is frequent in the province of Inhambane, is possibly because of the consumption of aflatoxin-contaminated groundnuts.

To escape the termite problem in the field, the farmers in Mozambique harvest groundnuts as early as possible.

Aphids. Aphids appear on groundnut whenever there is a dry spell of 15–20 days and is a common pest of groundnut throughout Mozambique. During the off-season, the aphids survive mainly on volunteer groundnut plants.

In experiments conducted on plant densities, it was observed that aphid attack was more serious in plots with 222 000 plants ha^{-1} than in plots with 333 000 plants ha^{-1}.

Foliage-feeding pests. Among the leaf-eating insect pests, the important ones are *Helicoverpa* and *Spodoptera*.

Helicoverpa occurs in some years especially when the crop is in the pod-formation stage. Local varieties of groundnut can recover from damage caused by this insect by rapidly producing new foliage.

Spodoptera causes considerable yield losses in some years in a few isolated localities, but overall, damage is of minor significance.

Mites. Three species of mites belonging to the Tetranychydae family are common in Mozambique. They are *Tetranychus neocaledonicus*, *T. amicus*, and *Eotetranychus falcatus*. They are not considered important pests.

Thrips (*Scirtothrips*). They are common in the southern provinces of Mozambique. They usually appear during drought periods.

White grubs. White grubs are serious pests in isolated areas.

False wireworms. The larvae frequently attack developing pods and in some years the loss is as high as 20–30%. The species is yet to be identified. They usually enter immature pods through round holes and feed on the seeds. Later, termites may also attack these damaged pods.

Hilda patruelis. This insect was observed in both the southern and northern Mozambique but in a few isolated localities. It was also observed to be associated with cashewnut trees.

Nematodes. *Meloidogyne* damage is commonly seen during low-rainfall years. The species of *Meloidogyne* are yet to be identified in Mozambique. The foliage turns yellow and then withers. The yellow slowly disappears once there is rain. Gall formation on roots is a common symptom.

Noninsect pests. The most important among noninsect pests are rats, moles, crows, monkeys, etc. Rats cause serious damage in stored groundnuts. In the field, rats damage seeds at planting and mature pods just before harvesting. Nearly 20 species of rats have been identified in the country. Moles move below soil surface (2–4 cm) and feed on groundnut pods and cassava tubers, if intercropped with groundnut. The major losses occur at pod maturity. Crows and other birds cause serious damage to the mature crop. It is difficult to control birds in small groundnut fields.

Monkeys cause severe damage in areas near forests.

Weeds. They are a major constraint to production as they cause very high yield losses. Future work on weeds and weed control management will be intensified.

Study of yield losses due to rust and leaf spot diseases on groundnut

This study was conducted with variety Bebiano Branco at the Faculty Farm at Maputo for 2 years during January–April with the objective of determining the yield losses because of rust and leaf spot diseases. The trial included four treatments: chlorothalonil (Daconil®) to control rust and leaf spots; tridemorph (Calixin®) for rust control; carbendazim (Bavistin®) for leaf spots control; and water spray (control).

Incidence of leaf spot diseases was generally low and rust only appeared at the end of the crop period. Thus, there were no significant yield increases resulting from fungicide protection.

Use of Animal Traction in Groundnut Production

Many farmers in the groundnut-growing coastal areas of southern Mozambique own cattle, whereas in the north there are fewer cattle because of the infestation of the tsetse fly. Many investigations were made in conjunction with farmers and these included assessing the effect of winter plowing on many farms in the Maputo and Inhambane provinces.

One winter plowing was done during June–July depending upon soil-moisture conditions. In general, winter plowing was done immediately after winter showers. In the control plots, winter plowing was not done.

Weed growth was tremendously reduced in the winter-plowed plots. This facilitated the postwinter land preparation. There was an increase of about 40% in the area covered per pair of draft animals for winter plowing. Other advantages observed in winter-plowed plots were:

- higher yields due to early planting;
- early planting allowed the crop to escape rosette-disease infestation; and
- uniform and deep plowing because of less weed growth.

Varietal Trials on Groundnut

By doing systematic varietal trials, we have accumulated data that needs to be studied in a way that will allow the recommendation of improved cultivars both to the small-scale and large-scale farmer, the main difference between the two farmer categories being mainly the level of technology and available inputs as well as the total cropped area.

Recommendations for the farmers must be based on the relationship between cultivar performance and the environment. There are two possibilities for relating the crop performance to environment:

1. *By comparing the cultivar yield with one or more climatic factors.* In this case, we can either compute a single value, which includes the important climatic factors or identify the most important climatic constraint (e.g., rainfall in southern Mozambique) and correlate it with crop yield over years and locations.
2. *By comparing yield of a new cultivar with that of a local cultivar across a wide range of environments.*

In the present study, we used the second possibility because of nonavailability of rainfall data. In Figure 1, the yield of local cultivar, Bebiano Branco, over years (1980–83) and locations is presented. The regression curves between the cv Bebiano Branco (selected as representing the environment) and the cvs Starr and Tamnut, among others, were compared using data from the 1980–83 period and are presented in Figures 2 and 3.

We computed a weighted linear regression equation by giving more importance to the yield values from trials with low CV (%) than to trials with high CV (%).

To weight the regression equation, we repeated the same value as many times as the number given by the formula 100/CV (%) adjusted to the nearest whole number.

The fitness of the curves were of:

- 92.8 for Bebiano Branco vs Starr.
- 99.5 for Bebiano Branco vs Tamnut.

Results

Figure 3 shows that Tamnut gives lower yields than Bebiano Branco at all yield levels (environmental conditions) showing that Bebiano Branco is a higher-yielding cultivar for all situations.

The relationship for Bebiano Branco vs Starr showed a different picture. Starr has slightly lower yields than Bebiano Branco at the lower levels but is more productive at higher-yield levels. This indicates that:

1. Bebiano Branco is a more suitable cultivar for small-scale farmers who grow only rainfed

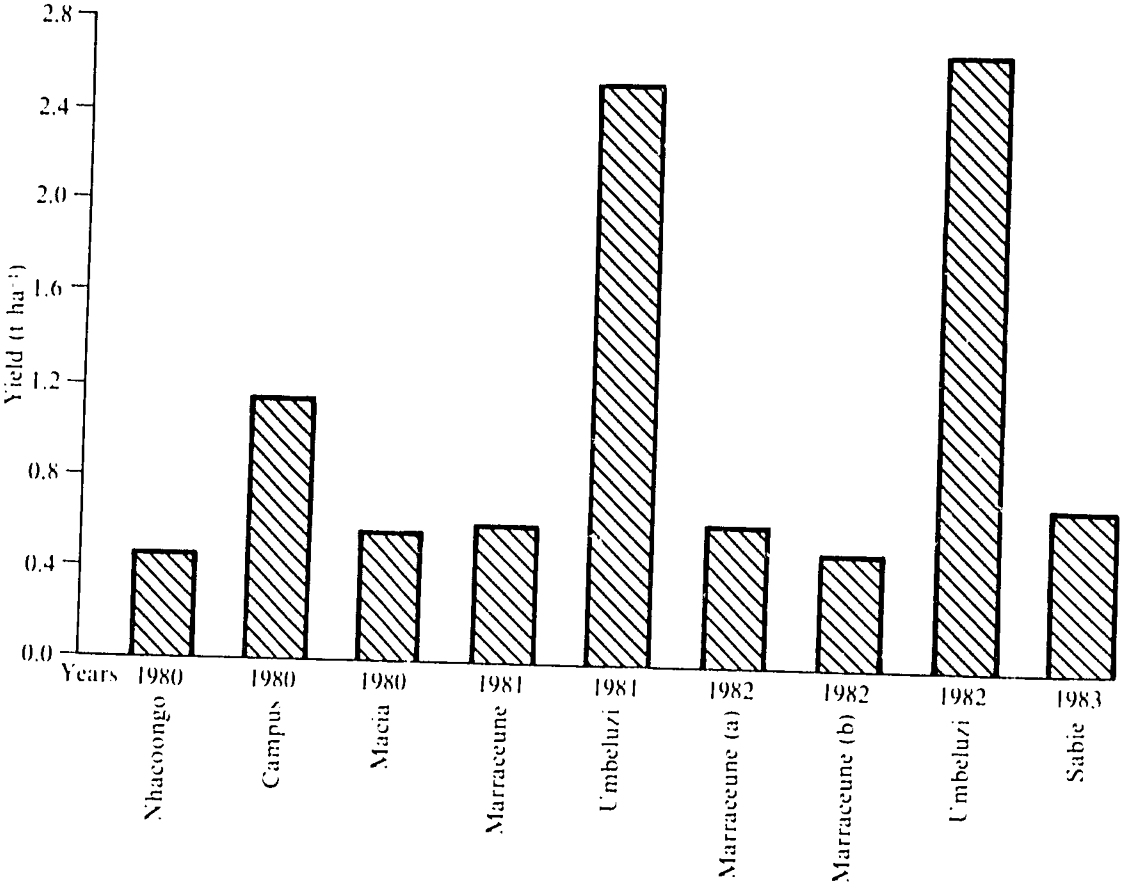

Figure 1. Yield of local cultivar, Bebiano Branco, at different locations in southern Mozambique, 1980–83.

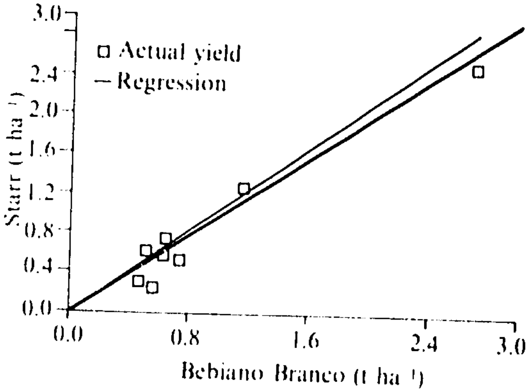

Figure 2. Comparison of yields of two groundnut cultivars, Bebiano Branco and Starr, over a range of environments in southern Mozambique, 1980–83.

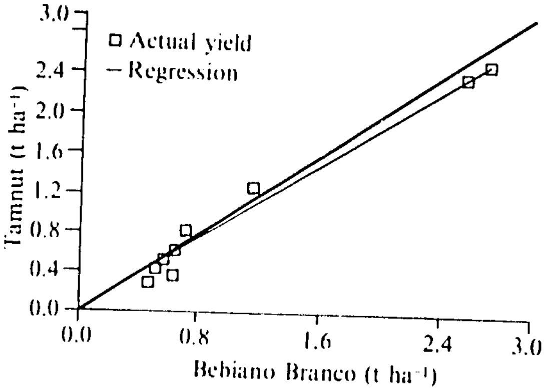

Figure 3. Comparison of yields of two groundnut cultivars, Bebiano Branco and Tamnut, over a range of environments in southern Mozambique, 1980–83.

groundnut. It has better yield stability and has the ability to withstand years of low rainfall and poor environment with less risk of very low yields.
2. In the case of the large-scale farmer, the opposite is true. Starr is more suitable than Bebiano Branco, being a cultivar more responsive to better environments.

Discussion

Raya: What is the disease situation in Mozambique. There is no mention of it in the paper.

Freire: We presented our work on yield losses because of diseases. Diseases are yet to be studied in detail.

Wightman: Will it be possible to repeat the survey on pests?

Ramaniah: Now that we have an entomologist, it should be possible to carry out further surveys in those zones where there is no war.

Wightman: Will it be possible to carry out simple insecticide no insecticide trials of the kind carried out by Kisyombe and myself last year in Malawi?

Ramanaiah: Yes, it should be possible to do this if ICRISAT can provide the materials.

Chiteka: How does producer price affect production? To what extent does marketing, both internal and external, affect production?

Freire: Shortage of seed, resulting from insecurity, causes problems in production. Poor rainfall and droughts result in poor production. Farmers are growing only a small amount because of insecure conditions.

Ramanaiah: Seed production in Mozambique is still in the initial stage.

Cole: Are groundnuts in experimental plots grown with or without inputs? I suggest that experiments should have inputs to get an idea of the diseases and fungicidal effects.

Ramanaiah: Groundnuts are grown under no-input, rainfed conditions in the experiments. Observations under high input and irrigated conditions exhibited more leaf spot disease attack.

Recent Groundnut Research in Swaziland

Y.P. Rao[1] and G.T. Masina[2]

Abstract

*Results of groundnut germplasm evaluation, foliar disease control by spraying chlorothalonil (Bravo®), and disease epidemiological observations for the 1985/86 and 1986/87 growing seasons are reported. The low rainfall in the 1986/87 season adversely affected both crop production and disease development. Significant yield differences between cultivars were observed in both seasons. The mean pod yield for 1985/86 was 3.32 t ha⁻¹, seed yield 2.12 t ha⁻¹, and shelling percentage 63.4%. These figures were higher than those of 1986/87 by 35.3%, 46.9%, and 15.4%, respectively. Pod yields approaching 4 t ha⁻¹ were obtained with 5 out of 15 genotypes tested in 1985/86, while only 3 out of 20 cultivars gave yields above 2.7 t ha⁻¹ in 1986/87. Genotypes ICGMS 9 and ICGMS 33 performed well in both seasons. Chlorothalonil significantly increased pod yields by 35.9% and seed yields by 39.3% in 1985/86, but no significant increases were obtained in 1986/87. Late leaf spot (*Phaeoisariopsis personata*) in 1985/86 and rust (*Puccinia arachidis*) in 1986/87 were the most predominant diseases; chlorothalonil spray controlled late leaf spot more effectively than rust.*

Sumário

Recente Investigação Sobre o Amendoim na Suázilandia. *Os resultados da avaliação do germoplasma do amendoim, do controle de doenças foliares atravéz da pulverização com clorotalonil (Bravo®) e observações epidémiologicas da doença, durante as estações de crescimento de 1985/86 e 1986/87, são apresentados. A baixa precipitação da estação de 1986/87 afetou adversamente tanto a produção, como o desenvolvimento de doenças. Em ambas as estações foram observadas diferenças significativas entre o rendimento de vários cultivares. O rendimento médio de vagens, em 1985/86, foi de 3320 kg ha⁻¹, o rendimento de sementes de 2119 kg ha⁻¹ e a percentagem de descasque de 63,4%. Estes valores foram maiores que os de 1986/87, em 35,3%, 46,9% e 15,4% respectivamente. Rendimentos de vagens a cerca de 4000 kg ha⁻¹, foram obtidos em 5 dos 15 cultivares testados em 1985/86, enquanto que, em 1986/87, apenas 3 dos 15 cultivares produziram rendimentos maiores que 2700 kg ha⁻¹. Os cultivares ICGMS 9 e ICGMS 33 tiveram um bom comportamento em ambas as estações. A utilização de clorotalonil produziu aumento significativo de rendimento de vagens, de 35,9%, e de sementes, de 39,3%, em 1985/86, mas não se obtiveram aumentos significativos em 1986/87. A mancha tardia (*Phaeoisariopsis personata*), em 1985/86, e a ferrugem (*Puccinia arachidis*), em 1986/87, foram as doenças predominantes. O clorotalonil controlou as manchas tardias mais eficientemente do que o ferrugem.*

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ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1989. Proceedings of the Third Regional Groundnut Workshop, 13-18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P 502 324, India: ICRISAT.

Introduction

In Swaziland, groundnuts are grown in most parts of the country, but production is more concentrated in the middleveld. The area under groundnut production has declined rapidly in recent years most likely as a result of competition with more remunerative crops, such as dry beans, maize, cotton, and tobacco, and because of a poor price structure. Groundnut yields have also been very low (< 0.5 t ha^{-1}) and may be attributed to inferior cultivars, poor management, losses because of pests and diseases, erratic and inadequate rainfall, and other factors. Researchers have also paid little attention to groundnuts in the past, but the situation is now improving.

During the 1985/86 and 1986/87 groundnut-growing seasons, our research efforts on groundnuts were directed towards germplasm evaluation, disease control, and disease epidemiology, and the results are reported in this paper.

Materials and Methods

Fifteen selected cultivars in 1985/86 and 20 in 1986/87 were tested under nonsprayed and sprayed conditions in a split-plot design, replicated thrice. (Protection treatments were the 'main plots' and cultivars the 'subplots'.) Chlorothalonil (Bravo®) at 3.0 ml. (1 L of water)$^{-1}$ was sprayed four times at fortnightly intervals, commencing halfway through the groundnut-growing season. In 1985/86, fungicide application commenced on 9 Jan and ended on 20 Feb 1986, while in 1986/87 it commenced on 13 Jan and ended on 24 Feb 1987. Foliar diseases were scored using the ICRISAT 1-9 scale, while bacterial wilt was expressed as a percentage of wilted plants.

The seeds were sown on 31 Oct in 1985 and 1986, 10 cm apart in 0.6-m rows. A compound fertilizer 2:3:2 (N:P:K) at 350 kg ha^{-1} was applied. A net plot of 1.2 m^2 was harvested from each treatment for yield estimation. The harvested pods were sun-dried for several days before weighing.

Results and Discussion

Prevailing weather conditions

It will be noted that rainfall in the 1985/86 season was adequate and well distributed, especially between December and February, which are usually drought-prone months and critical for crop production in Swaziland (Table 1). On the other hand, 1986/87, with 41% less rainfall than the previous season and 30% less than the long-term average, was clearly unfavorable both for crop production and disease development. Total rainfall in February was only 12 mm. Thus, results of widely differing seasons are presented here for comparison.

Disease epidem[illegible]y

Bacterial wilt and early leaf spot (*Cercospora arachidicola*) were the earliest diseases to appear in the crop. Bacterial wilt ceased when the plants were 8-10 weeks old, while early leaf spot was generally confined to the lower and middle parts of the plants.

Table 1. Rainfall at Luyengo, Swaziland, 1985/86 and 1986/87.

Month	1985/86 Rainfall (mm)	1985/86 Number of rainy days	1986/87 Rainfall (mm)	1986/87 Number of rainy days	Long-term average Rainfall (mm)	Long-term average Number of rainy days
October	68	5	57	9	97	13
November	154	12	64	16	147	16
December	113	20	144	15	170	16
January	231	18	121	15	175	14
February	165	16	12	2	109	12
March	110	10	160	14	78	10
April	163	9	36	8	71	8
Total	1005	90	594	79	847	89

These two diseases were followed by phoma leaf blotch, late leaf spot (*Phaeosariopsis personata*), and rust (*Puccina arachidis*), which attain menacing proportions within 3-4 weeks, if weather conditions are favorable. At Luyengo, late leaf spot has been the most important disease followed by rust and phoma leaf blotch. It is apparent that late leaf spot and phoma leaf blotch are favored by humid conditions, while rust enjoys relatively dry conditions. Groundnut rosette virus occurred sporadically. Despite the favorable weather in 1985/86, phoma leaf blotch severity remained unexpectedly low.

Germplasm evaluation and disease control

In both seasons, there were significant differences among genotypes in yields and shelling percentage (Tables 2-8). In the 1985/86 season, the mean pod yield was 3.32 t ha⁻¹, the seed yield 2.12 t ha⁻¹, and shelling percentage 63.4%. In the 1986/87 season, the corresponding figures were 2.15 t ha⁻¹, 1.13 t ha⁻¹, and 54.2%.

Comparing the two seasons, it is evident that

Table 2. Yield and shelling percentage (means of sprayed and nonsprayed treatments) of 15 selected groundnut genotypes, Luyengo, Swaziland, 1985/86.

Genotype	Pod yield (t ha⁻¹)	Seed yield (t ha⁻¹)	Shelling (%)[1]
ICGMS 2	3.401 a	2.513 a	73.9 a
ICGMS 9	3.818 a	2.624 a	68.7 a
ICGMS 22	3.749 a	2.527 a	67.4 a
ICGMS 33	3.679 a	2.235 a	60.8 a
ICGMS 36	2.152 c	1.361 c	63.2 a
ICGMS 42	3.610 a	2.291 a	63.2 a
ICGM 336	3.470 a	2.242 a	64.6 a
Egret	3.124 ab	1.722 bc	55.1 b
P 84/5/256	2.631 bc	1.527 bc	58.0 b
C 346/5/8	2.846 bc	1.777 bc	62.4 a
C 347/5/6	3.297 a	2.167 a	65.7 a
P 105/3/7	3.374 a	2.041 ab	60.5 ab
P 84/6/124	3.297 a	1.666 bc	50.5 b
MGS 9	3.700 a	2.652 a	71.7 a
Control			
Natal Common	3.658 a	2.434 a	66.5 a
SE	±0.285	±0.209	±6.9
Mean	3.320	2.119	63.4
CV (%)	21.0	24.2	26.2

1. Column means followed by the same letter do not differ significantly at the 5% level of probability ($P < 0.05$).

Table 3. Effect of spraying on yield and shelling percentage of 15 selected groundnut genotypes, Luyengo, Swaziland, 1985/86.

Treatment	Unshelled yield (t ha⁻¹)	Shelled yield (t ha⁻¹)	Shelling (%)[1]
Chlorothalonil (Bravo®) spray	4.047 a	2.636 a	66.0 a
Control	2.594 b	1.600 b	62.0 a
SE	±0.064	±0.019	±0.84
Mean	3.321	2.118	64.0
CV (%)	12.9	6.7	8.8

1. Column means followed by the same letter do not differ significantly at the 5% level of probability ($P < 0.05$).

Table 4. Disease reaction of 15 groundnut genotypes, Luyengo, Swaziland, 1985/86.

Genotype	Disease score[1]: Late leaf spot	Rust	Phoma leaf blotch	Bacterial wilt (% plants killed)
ICGMS 2	9	2	4	4.4
ICGMS 9	9	3	3	5.3
ICGMS 22	9	2	4	4.4
ICGMS 33	9	2	4	2.8
ICGMS 36	5	3	2	3.9
ICGMS 42	5	3	2	2.5
ICGM 336	5	3	3	3.6
Egret	6	4	2	1.7
P 84/5/256	5	2	1	0.0
C 346/5/8	7	2	2	2.5
C 347/5/6	7	3	2	1.5
P 105/3/7	8	2	3	12.0
P 84/6/124	5	4	3	3.1
MGS 9	9	1	3	4.8
Control				
Natal Common	9	1	3	3.9

1. Scored on a 1-9 scale, where 1 = No disease, and 9 = 50-100% of foliage destroyed.

Table 5. Number of late spot lesions per leaflet in 15 groundnut genotypes grown with and without fungicide protection, Luyengo, Swaziland, 1985/86.

Genotype	Mean number of lesions leaflet^{-1}	
	Chlorothalonil (Bravo®) spray	Control
ICGMS 2	2.6	57.0
ICGMS 9	5.0	56.2
ICGMS 22	2.5	73.3
ICGMS 33	0.4	45.0
ICGMS 36	0.7	35.0
ICGMS 42	0.6	37.0
ICGM 336	0.7	26.4
Egret	0.3	29.3
P 84/5/256	1.5	20.5
C 346/5/8	1.3	26.4
C 347/5/6	3.7	23.8
P 105/3/7	3.2	33.4
P 84/6/124	0.6	19.6
MGS 9	8.7	47.7
Control		
Natal Common	2.1	61.3
Mean	2.3	39.5

groundnut yields in 1985/86, a normal season, were much higher than those in 1986/87, which was characterized by erratic and inadequate rainfall. Crops in 1985/86 outyielded those of 1986/87 by 35.3% in pod yield by 46.9% in seed yield, and by 14.5% in shelling percentage. Thus drought is an additional factor to reckon with in germplasm evaluation and selection of suitable cultivars in Swaziland.

Experience over the past 8 years has shown that drought spells are commonly encountered between December and February, a very crucial period in the production of maize, groundnuts, and other crops. Farmers are always nervous during this period. In 1985/86, pod yields approaching 4 t ha^{-1} were obtained with several genotypes, while in the 1986/87 season only three genotypes managed to exceed 2.7 t ha^{-1}. ICGMS 9 and ICGMS 33 have performed well in both seasons, suggesting that they possess drought tolerance. The only drawback with these genotypes appears to be their susceptibility to late leaf spot and rust. ICGMS 22, which gave the highest yield, in the 1985/86 season, was unfortunately not included in the 1986/87 trial.

Chlorothalonil significantly increased pod yield by 35.6% and seed yield by 39.3% in 1985/86 but did not result in significant yield increases in 1986/87. Also genotype-spray interactions were not significant in either season.

Table 6. Yield and shelling percentage (mean of sprayed and nonsprayed treatments) of 20 selected groundnut genotypes, Luyengo, Swaziland, 1986/87[1].

Genotype	Pod yield (t ha^{-1})	Seed yield (t ha^{-1})	Shelling (%)
ICGMS 2	2.434 a	1.023 a	42.0 d
ICGMS 9	2.704 a	1.623 a	60.0 a
ICGMS 33	2.758 a	1.717 a	62.3 a
ICGMS 36	1.802 ab	0.896 bc	49.7 bcd
ICGMS 42	2.158 a	1.074 a	49.8 bcd
NC Ac 2.821	1.405 b	0.659 bc	47.0 bcd
ICGM 336	2.156 a	1.142 a	53.0 a
Egret	1.508 b	0.656 bc	43.5 cd
P 84/6/67	1.894 a	0.966 ab	51.0 bc
P 84/6/63	0.977 b	0.459 c	47.0 bcd
P 84/5/256	1.897 a	1.004a	52.9 ab
C 346/5/8	2.857 a	1.382 a	52.2 b
C 347/5/6	2.536 a	1.382 a	54.5 a
P 105/3/7	2.326 a	1.247 a	53.6 a
P 84/6/124	1.938 a	0.964 bc	49.7 bcd
ICG (FDRS) 1	2.46 a	1.411 a	57.2 a
ICG (FDRS) 3	1.732 b	0.810 bc	46.6 bcd
ICG (FDRS) 12	2.466 a	1.149 a	46.8 bdc
NC Ac 17090	2.648 a	1.440 a	54.4 a
Control			
Natal Common	2.266 a	1.381 a	60.9 a
SE	±0.043	±0.201	±2.8
Mean	2.147	1.125	54.2
CV (%)	39.2	42.9	12.8

1. Column means followed by the same letter do not differ significantly at the 5% level of probability ($P < 0.05$).

Table 7. Effect of spraying on yield and shelling percentage of 20 selected groundnut genotypes, Luyengo, Swaziland, 1986/87.

Treatment	Pod yield (t ha^{-1})	Seed yield (t ha^{-1})	Shelling (%)
Bravo® spray	2.377	1.272	52.7
Control	1.961	1.023	52.8
SE	±0.119	±0.069	±0.33
Mean	2.147	1.147	52.8
CV (%)	42.9	46.9	4.91

Table 8. Disease reaction of 20 groundnut genotypes grown with and without fungicide protection, Luyengo, Swaziland, 1986/87.

	Disease score[1]			
	Nonsprayed control		Chlorothalonil (Bravo®) spray	
Genotype	Late leaf spot	Rust	Late leaf spot	Rust
ICGMS 2	4	8	Trace	5
ICGMS 9	7	6	Trace	4
ICGMS 33	2	9	Trace	4
ICGMS 36	4	6	Trace	5
ICGMS 42	3	8	Trace	5
NC Ac 2821	5	8	Trace	6
ICGM 336	2	7	Trace	5
Egret	2	7	Trace	4
P 84/6/67	3	7	Trace	3
P 84/6/63	2	7	Trace	4
P 84/5/256	2	8	Trace	5
C 346/5/8	5	6	Trace	3
C 347/5/6	5	8	Trace	5
P 105/3/7	2	8	Trace	5
P 84/6/124	4	7	Trace	4
ICG (FDRS) 1	5	2	Trace	Trace
ICG (FDRS) 3	2	2	Trace	Trace
ICG (FDRS) 12	6	2	Trace	Trace
NC Ac 17090	6	2	Trace	Trace
Control				
Natal Common	2	8	Trace	6

1. Scored on a 1-9 scale, where 1 = No disease, and 9 = 50-100% of foliage destroyed.

Late leaf spot in 1985/86 and rust in 1986/87 were the dominant diseases. Chlorothalonil reduced the late leaf spot infection, but was only moderately effective against rust.

Conclusions

Late leaf spot is the most devastating disease in Swaziland when humid conditions prevail, but it can be effectively controlled with fungicides such as chlorothalonil, which resulted in significantly higher yields, in the 1985/86 season. Therefore, late leaf spot control in susceptible cultivars in the latter half of the growing season appears most crucial. Three to four fungicide sprays at fortnightly intervals may greatly benefit the crop when conditions are favorable for disease development. Rust, which appears to enjoy relatively dry conditions, is not as effectively controlled by fungicide application as late leaf spot. Use of high levels of resistance, as found in the ICG (FDRS) material from ICRISAT Center, could be the best strategy to minimize yield losses due to rust. Phoma leaf blotch, which can be as destructive as late leaf spot in very humid conditions, is somewhat erratic and unpredictable. Fungicide sprays can effectively reduce losses due to phoma leaf blotch. In addition, resistance to phoma leaf blotch is available in some cultivars, such as C 346/5/8, C 347/5/6, and P 84/5/256, which were developed in Zimbabwe.

Discussion

Kannaiyan: How widespread is the bacterial wilt of groundnut in farmers' fields in Swaziland? Is it occurring commonly every season there?

Rao: It appears every season at Luyengo and in farmers' fields in the area.

Nigam: There are several sources of resistance available against bacterial wilt in Indonesia, such as Swartz 21 and others. These sources could be obtained from ICRISAT Center and screened again under Swazi conditions.

Rao: Such sources of resistance are most welcome.

Raya: Have you done any work to determine disease severity of bacterial wilt?

Rao: Yes, observations have been made on the distribution pattern of wilt, which usually occurs in scattered plants.

Groundnut Improvement Program in Tanzania: Problems and Research Objectives

J.Y. Chambi[1]

Abstract

*The factors that limit groundnut production in Tanzania, contributing to a shortage of locally produced edible oils, are listed. The current objectives of the Tanzanian groundnut improvement program are discussed. Future emphasis in groundnut improvement in the country would involve an intensified search for genotypes resistant to early leaf spot (*Cercospora arachidicola*), and rust (*Puccinia arachidis*) as well as those adapted to three agroecological zones; investigations on how cultural practices influence pest and disease development; and initiation and strengthening of on-farm trials to assess farmers' resources and problems.*

Sumario

Programa de Melhoramento do Amendoim na Tanzania: Problemas e Objectivos da Investigação. *São listados os factores que limitam a produção de amendoim na Tanzania e contribuem para a escassez de óleos alimentares, produzidos localmente. São discutidos os actuais objectivos do programa de melhoramento do amendoim da Tanzania. O futuro enfase do melhoramento do amendoim no pais, devera envolver uma procura intensificada de genótipos resistentes à mancha temporã (Cercospora arachidicola) e ferrugem (Puccinia arachidis) e de genótipos adaptados às três regiões agroecológicas, investigações sobre a influência das práticas culturais no desenvolvimento de pragas e doenças e o inicio e reforço dos ensaios nos campos dos camponeses, para avaliar os seus recursos e problemas.*

Introduction

In Tanzania, there is a shortage of locally produced edible oils primarily because of declining production of oilseeds by farmers. The total annual processing capacity of installed oil mills is estimated at 237 000 t of seed. Cottonseed accounts for about 90 000 t, the remainder consisting of other oilseeds including sunflower, sesame, soybean, groundnut, and copra (coconut). However, total purchases of the five oilseeds in 1985–86 season amounted to 16 500 t leaving a deficit of about 131 000 t (Tanzania: MDB, Ministry of Agriculture and Livestock Development 1986).

During the late 1950s, groundnuts were the second most important source of edible oil after cottonseed oil. However, by the mid-70s groundnut made only a small contribution, being the fourth largest after cottonseed, sunflower, and sesame (excluding copra). Currently, groundnut contributes little to the national oil-mill industry partly

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ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1989. Proceedings of the Third Regional Groundnut Workshop, 13–18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P. 502 324, India: ICRISAT.

because the largest proportion of total production does not enter the official marketing channels.

While it does not contribute much to the oil-mill industry, groundnut is still an important and valuable crop to the farmer both as a food supplement and a cash crop. This crop is grown in most areas of Tanzania up to 1500 m above-sea-level in areas of marginal fertility and erratic rainfall where other major cash crops are not well suited. As a legume, it fits in well within the farming system where intercropping is predominant and neither mineral fertilizers nor manure are rarely used. The component crops, which are normally cereals, benefit from the nitrogen fixed by the symbiotic relationship between the legume and *Rhizobium* bacteria.

Yields are low, averaging about 400 kg ha^{-1} with a range of 250–600 kg ha^{-1} depending on cropping system, management, and weather. Factors that are considered limiting to improved production of this crop are:

1. Lack of seed of well-adapted and high-yielding varieties.
2. Prevalence of diseases and insect pests and lack of practical and cheap control measures.
3. Poor agronomic practices, including suboptimal plant population, late sowing, poor weed control, etc.
4. Erratic and poorly distributed rainfall resulting in frequent dry spells.
5. Lack of a centralized seed production and distribution system, which is forcing farmers to use poor-quality seeds.
6. Poor marketing infrastructure and low producer prices.

Therefore, the main objectives of the groundnut improvement program in Tanzania may be summarized as follows:

1. To identify and develop high-yielding varieties that are adapted to the main agroecological production zones in Tanzania. These varieties should have high oil content for oil production.
2. To identify sources of resistance to the major diseases prevalent in Tanzania and to incorporate these into adapted cultivars through breeding.
3. To develop and recommend practical methods of insect pests and disease control, which can be of use to small farmers.
4. To develop and recommend improved agronomic packages for groundnuts.
5. To investigate the role of groundnuts in the existing and improved farming systems.

Rainfall in the Main Production Areas

The major groundnut-producing areas in Tanzania may be divided into three agroecological zones by duration of rainfall during the growing season. Thus Zone I is characterized by a long growing season with a rainfall duration of about 150 days (5 months). Zone II has a rainfall duration of about 110–120 days and may be termed a medium-growing season, while zone III has a rainfall duration of 90 days or less and is the short-season zone. Selection of varieties to fit into the various zones must take due consideration of the duration of the available moisture and coincide crop maturity with favorable weather for harvesting and proper drying. Research has clearly demonstrated that early sowing is a major factor contributing to improved groundnut yield.

Disease

Of the many diseases affecting groundnuts in Tanzania, early leaf spot (*Cercospora arachidicola*), late leaf spot (*Phaeoisariopsis personata*), rust (*Puccinia arachidis*), seedling disorders (*Aspergillus* sp), and rosette virus are among the most important.

Leaf spots and rust

Leaf spots and rust are prevalent in all groundnut-growing areas. Research at Naliendele has indicated that leaf spots and rust together account for yield losses of up to 36%. Results have also shown that Natal Common, a spanish-type cultivar is more susceptible than the virginia type Red Mwitunde at a long-season site. Results for Red Mwitunde in 1954 are similar for a comparison of healthy and diseased plants (Table 1). Despite varying severity among seasons, leaf spots and rust are considered to be the most economically important diseases.

Aspergillus spp

Aflatoxin contamination, as a result of invasion by *Aspergillus* spp, is a serious problem. However, it reduced germination and caused seedling disorders in infected seeds resulting in uneven stands and poor

Table 1. Groundnut yield loss assessment due to foliar disease, Naliendele, Tanzania, 1953/54, 1981/82, and 1982/83.

Variety	Season	Yield (t ha^{-1})	
		Sprayed[1]	Nonsprayed
Natal Common	1981/82	2.166	1.440
	1982/83	1.127	0.637
Red Mwitunde	1981/82	1.843	1.138
	1982/83	0.785	0.665
	1953/54[2]	1.747	1.342

1. Fungicide used was chlorothalonil (Daconil®)
2. Based on a comparison of healthy (no disease) and diseased plants

establishment. The severity is influenced by poor postharvest handling, such as late drying of the crop after harvest. This emphasizes the importance of growing cultivars suited to the duration of the growing season to avoid harvesting under wet-weather conditions.

Groundnut rosette virus (GRV) disease

During the 1950s, GRV disease threatened groundnut production of the Overseas Food Corporation farmers in Tanzania. It was reported that Natal Common was very susceptible while Red Mwitunde was found to have a good level of tolerance in the field. Early sowing, close spacing, and control of the aphid vector were recommended. During the past 15 years, GRV has not been reported as being serious and, in most cases, the incidence of infected plants has been <1%. GRV is still a potentially serious disease, but low incidences during the past few years have not provided the breeders and pathologists with an opportunity to select and evaluate cultivars for resistance.

Insect Pests

Termite attack is considered the major insect pest problem in groundnuts and that can account for 15-20% loss of stand in severe cases. No worthwhile control measures have been developed. The groundnut hopper, *Hilda patruelis* is an important pest but occurs sporadically and yield losses have not been assessed. Aphids, apart from their importance as a vector of GRV, cause no noticeable damage to the crop.

Future Plans

Given the information now available from past research of the groundnut program, more emphasis should now be placed on:

1. An intensified search for cultivars resistant to both leaf spots and rust, and adapted to the three agroecological zones. A proposal to establish a subcenter of the program in Zone III will go a long way toward catering for such climatic conditions.
2. Investigation on how cultural practices, such as intercropping may influence pest and disease development.
3. Initiation and strengthening of on-farm trials to improve our knowledge of farmers' resources and problems.

Reference

Tanzania: MDB, Ministry of Agriculture and Livestock Development. 1986. Annual Review of Oil Seeds 1986. Tanzania: MDB, Ministry of Agriculture and Livestock Development.

Discussion

Mulila: What steps are being taken to get around the problem of seed production in Tanzania?

Chambi: Currently, arrangements/permissions are being sought from the Ministry of Agriculture to permit private producers, including small farmers, to produce the seed under our supervision as "Common Seed Grade", but so far this arrangement has not been approved/initiated.

Hildebrand: Recently in Zimbabwe, it has proved difficult to encourage large-scale producers because of the inability of the Seed Cooperative to offer sufficiently attractive incentives as government price controls did not allow sufficient flexibility, in prices to be set to cover cost of handling, packing, distribution, etc.

Reuben: Why did you drop Natal Common from your multilocational trials? Natal Common was better than Red Mwitunde in your time of planting trial and it performed well in your yield-loss assessment because of pest disease attack.

Mwenda: Natal Common was dropped from advanced yield trials because a selection from this variety, 69.62.2.5, proved to be a better yielder than Natal Common. Hence, 69.62.2.5 was used in the place of Natal Common in advanced yield trials.

Chambi: Natal Common and Red Mwitunde were used as the more-adapted varieties. However, Natal Common was dropped from the variety trials test after being replaced by Spancross (Nyota), which is a higher-yielding spanish variety.

Wightman: Your interest in intercropping is important. We have found at ICRISAT Center that this practice reduces insect intensity. I commend the move for on-farm research. The conditions that exist on Tanzanian research stations are quite different from those on farmers' fields.

Sandhu: On-farm testing can be taken up once a high-yielding variety has been identified. Did you take up SADCC groundnut trials in Tanzania and results thereon?

Chambi: We have already identified two varieties and recommended the same for production by farmers, i.e., Nyota (Spancross) and Johari (Robut 33-1). Included are packages, such as time of planting in various agroecological zones, spacings, land preparation, and weed control (time and frequency of weeding).

Maliro: The time-of-planting experiments in Tanzania show results very similar to Malawi's data. Now we want to trace which factors are important (e.g., plant population, diseases, rosette, soil fertility, etc.). Is there any data noted in Tanzania on the possible causes of dramatic yield decreases with late planting?

Hildebrand: Experience in Zimbabwe indicates that yield is closely associated with lack of radiation and temperature in the early part of the crop cycle (preflowering phase). In the 1972/74 period, a reduction in mean hours of sunshine per day during the period 20-70 days after sowing, resulted in a yield of about 50%. Delays in planting, later into the rainy season, are likely to coincide with increasing cloudiness, and thus decreasing radiation.

Groundnut in Mauritius

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Abstract

The paper presents an overview of the groundnut production industry in Mauritius and highlights research needs in relation to the major constraints to production, which are land scarcity and climatic, edaphic, biological, and socioeconomic problems. The scope and direction for future development are also described.

Sumário

O Amendoim nas Mauricias. *O presente artigo apresenta uma visão geral da industria de produção de amendoim nas Mauricias, realçando as necessidades de investigação em relação às principais limitantes da produção, que são a escassez de terras e problemas climáticos, edáficos, biológicos e sócio-económicos. O espectro e direcção para o desenvolvimento futuro é também descrito.*

Introduction

Mauritius which covers 1 840 km² forms part of the Mascarene Archipelago in the South-West Indian Ocean. It is situated at latitude 20° S and longitude 57° E about 880 km east of the Malagasy Republic and 2 000 km off the coast of East Africa. Mauritius is volcanic in origin with a coastal plain that rises to a central plateau where the altitude varies from 275 m to 730 m. The climate is maritime, tropical in summer, and subtropical in winter (Padya 1984).

The island has an area of 186 500 ha of which 90 000 ha (48% of total area) is under cultivation (Mauritius: Public Relations Office of the Sugar Industry 1987). Sugarcane is grown on 84000 ha representing 93% of the total cultivated area. Hence, the agriculture is dominated by sugarcane, and the national policy is to diversify agricultural production without reducing sugar production.

Groundnut is an established crop in Mauritius; it has been cultivated for several decades exclusively for local consumption. Sugarcane and tea are the main export crops, and groundnut ranks sixth in importance after tomato, tobacco, and potato (Table 1). Among the food crops, groundnut has an advantage over others as it can be successfully cultivated during the cyclonic season, when few other crops can be grown. Therefore, groundnut has a special place in Mauritian agriculture as it does not compete with other food crops for the limited available land. The current emphasis on agricultural diversification has stimulated more interest in the development of groundnut not only for the local market but also for export.

This paper highlights the various aspects of

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Table 1. Relative importance of groundnut in comparison with other crops grown in Mauritius, 1985[1].

Crop	Area harvested (ha)	Production (t)	Value (Rs × 10⁶)
Sugarcane	78000	645800	3400
Tea	3900	8100	206
Tomato	690	9000	62
Potato	860	23300	47
Tobacco	540	840	29
Groundnut	700	2170	26
Maize	1030	4900	20

1 Source: Mauritius Ministry of Agriculture and Natural Resources and the Environment (1985).

groundnut production and its uses in Mauritius. The major constraints to production are discussed together with the research options. The scope and direction for future developments are also indicated.

Production

The groundnut industry has always been oriented towards supplying the local market. This limited market has not given the motivation for extensive development of production. In the context of the national policy of agricultural diversification, some importance was given to the crop in the 1970s. This led to a doubling of production from some 700 t to 1 500 t (Table 2). Thereafter, production stagnated until the early 1980s when it started to increase again. Today, an equilibrium has been established where production is sufficient to meet domestic demand.

The early increase in production was to a great extent associated with the adoption of new agronomic practices. These were established at the Mauritius Sugar Industry Research Institute (MSIRI) and resulted in higher yields (Table 2). Later, increases in production were brought about by increases in the area under cultivation. In the future, area expansion alone, if at all possible, will not be sufficient to increase production. This will have to be achieved through agronomic and technological improvement.

Table 2. Groundnut production in Mauritius, 1968–86[1].

Year(s)	Production of in-shell nuts (t)	Production of in-shell nuts (kg capita⁻¹)	Average yield (t ha⁻¹)
1968–70	706	0.9	2.9
1971–73	1505	1.8	3.7
1974–76	1322	1.5	3.5
1977–79	1080	1.2	3.6
1980–82[2]	1622	1.7	3.3
1983–85[2]	2165	2.2	3.1
1986[2]	2250	2.3	3.1

1 Source: Mauritius Ministry of Agriculture and Natural Resources and the Environment (1972–84).

2. Data provided by Ministry of Agriculture and Natural Resources and the Environment, Mauritius.

Production Systems

All of the groundnut is produced on sugarcane lands. Production is undertaken by two producer groups, i.e., sugar estates and planters. The former accounts for 86% of production (Table 3). Two systems of production have been developed to produce groundnut while not reducing sugarcane production; these are pure-stand cultivation on sugarcane rotational lands and intercropping with sugarcane.

In the first system, the land available between the harvest of the last sugarcane ratoon and the replantation is used. Thus, the groundnut crop optimizes the utilization of land that would otherwise have remained unoccupied for about 4 months. This system accounts for 45% of the groundnut produced (Table 3). In the second system, sugarcane is intercropped with groundnut, and this accounts for 55% of production (Table 3). The principle of this system is to use the first 4–5 months after cane plantation when the canopy is not fully developed. A short-duration groundnut cultivar is grown in the inter-

Table 3. Groundnut production systems in Mauritius, 1986.

Producer group	Interrow (t)	Interrow (%)	Pure stand (t)	Pure stand (%)
Sugar estates	1103	49	822	37
Other planters	140	6	185	8
Total	1243	55	1007	45

(Table 3 columns grouped under "Production of in-shell nuts".)

rows and harvested before the canopy closes. Likewise, in ratoon sugarcane, groundnut is planted just after the cane is harvested. In plant sugarcane, one or two rows of groundnut are planted in every cane interrow while in ratoon cane, only one row of groundnut is planted in alternate cane interrows. Intercropping of both plant and ratoon sugarcane with groundnut does not reduce sugarcane yield.

Uses

The forms in which groundnut is consumed in Mauritius are few. Groundnut is sold mainly as in-shell boiled or roasted nuts, and 92% of these products are processed by peddlers. The industrial processing of groundnut is relatively recent. Only 8% is transformed into shelled roasted nuts and peanut butter. There is no oil production from local groundnut as this has been found uneconomical. All of the country's oil requirement is met from imported crude, edible oil which is refined locally.

Research Needs on Production Constraints

As already mentioned, the groundnut industry has been stagnant in recent years. If production is to be increased, the various constraints must be removed. These are discussed in relation to the research program.

Land scarcity

At present, all the suitable agricultural land in Mauritius is already under cultivation. Under the present agricultural policy, it is not acceptable to replace sugarcane with other crops. Hence, any increase in groundnut production can only be achieved by increasing productivity on sugarcane lands. Already, all the groundnut is produced either on sugarcane rotational lands or by intercropping with sugarcane. The aim of the research program is to develop optimal cropping systems. For Mauritius, this implies maximum exploitation of rotational and intercropping systems.

Fifty-five percent of the groundnut crop is intercropped with sugarcane. The production might be increased by the development of triple intercropping mixtures comprising sugarcane, maize, and groundnut. This is possible because it is recommended to plant only one row of maize in alternate interrows of sugarcane, thereby leaving half the interrows unoccupied. Groundnut could be planted in these 'free' interrows. Another method of optimizing the system is to increase the plant density to increase yield. The pairing of cane rows has been proposed to enable sowing at much higher densities and the cropping of older ratoons. This practice has not been very successful with the presently grown groundnut cultivar. Furthermore, the pairing of cane rows has also not been generally accepted by farmers. The cropping of rotational lands represents 45% of production. The possibility of increasing rotational lands available by reducing the cane cycle might offer some prospects. This merits investigation.

Climatic constraints

The climate of Mauritius is characterized as being tropical in summer and subtropical in winter (Padya 1984). This feature of the climate leads to three main constraints to groundnut production; these are seasonally low temperature, high rainfall, and drought.

Groundnut requires a relatively warm season to produce maximum yields. In Mauritius, the mean maximum temperature in the warmest region varies from 31.2°C in February to 25.9°C. Studies on the date of sowing have established that groundnut should ideally be sown in summer and extend from mid-September to early March.

The annual rainfall is variable and ranges from less than 1000 mm on the coastal region to more than 5000 mm on the central plateau. Most of the rains fall from December to April. Thus on the coast the crop suffers from drought when planted in September to November, and on the central plateau it suffers from excessive rainfall when planted from December to February. The combination of high temperature and excessive rainfall is ideal for the development of diseases and also cause rotting of nuts. The development of tolerant cultivars offers the best possibility to overcome this problem.

Drought, although usually of very short duration in Mauritius, can severely limit groundnut yield. Two strategies can be adopted to overcome this. Firstly, the crop can be irrigated where possible. In most cases this is not possible mainly for economic reasons. Alternately, the drought-prone months can be avoided, but this restricts the areas that can be sown.

Edaphic constraints

The two main soil problems that affect groundnut production are rockiness and acidity. The former results from the volcanic origin of the island, and the latter is found on the central plateau where the soil is heavily leached.

The first problem can be resolved by derocking. On sugar estates, coarse derocking has already been carried out and further improvement can be achieved through finer derocking of the top soil. On most planters' lands, derocking must be initiated. The operational cost is so high that it prohibits its development on an extensive scale. Therefore, there is a need to investigate methods to reduce the operational cost for better acceptability.

One of the main obstacles preventing the development of groundnut production on the central plateau is soil acidity. High-yielding, disease-resistant virginia-type and valencia-type cultivars have been recommended but because of soil acidity pod filling is poor. It has been shown that this can be remedied by the application of gypsum (Mauritius Sugar Industry Research Institute 1972, 1986). However, the practice has not been adopted probably because of the high cost of gypsum. The selection of cultivars tolerant to acidity appears to be the most plausible approach.

Biological constraints

The main biological constraints are:

1. low yield,
2. length of crop cycle,
3. plant morphology,
4. susceptibility to disease, and
5. rotting of nuts.

The groundnut yield directly influences the profitability. To increase the profitability and hence stimulate further interest in the crop, strategies could be adopted to optimize yield. The selection of higher-yielding cultivars is one of the main methods of achieving this aim. Secondly, the density could be increased especially in sugarcane interrows and this might entail a change in the planting pattern.

The exploitation of both rotational lands and the interrows of sugarcane depends greatly on the length of the crop cycle. This is more critical when intercropping, and the selection of short-duration cultivars is important to produce groundnut before the cane canopy closes.

When intercropping sugarcane, the intercrop should not affect the yield of cane. One of the characteristics that must be considered is plant morphology. Tall-statured plants shade sugarcane and, hence, affect yield.

Leaf diseases are important factors limiting yield. In Mauritius, the two main diseases affecting groundnut are rust (*Puccinia arachidis*), early leaf spot (*Mycosphaerella arachidicola* W.A. Jenkins), and late leaf spot (*Mycosphaerella berkelyi* W.A. Jenkins) to which the presently grown cultivar is highly susceptible. The first approach to this problem is to select cultivars for resistance. Selection for resistance has been successful but unfortunately the cultivars were otherwise not acceptable. The second approach is to use fungicides but this leads to an increase in production costs.

As the groundnut season coincides with the rainy season, the nuts often rot at harvest. Artificial drying can be used but this increases the production costs. Hence, low-cost drying systems must be established. Solar drying should be investigated.

Socioeconomic constraints

There are three major socioeconomic constraints:

1. specific consumer preference,
2. high cost of production, and
3. labor shortages.

Consumer preference cannot be easily changed. In Mauritius, the spanish-type groundnut cultivar, Cabri, has always been consumed. Both the peddlers and the consumers have developed a preference for Cabri for different reasons. The introduction of new cultivars is likely to face strong consumer resistance unless these conform to the consumers' preference. In the past, a high-yielding valencia-type cultivar was identified but it was not exploited mainly because of market resistance. Close attention should therefore be paid to consumer acceptability during selection.

Groundnut production is relatively costly. This results from the highly labor-intensive nature of some of the cultural operations and from the use of biocides. Mechanization must be introduced to reduce production costs and render the crop more profitable.

The development of industry and tourism has significantly influenced the labor market in Mauritius. This has already resulted in seasonal labor shortages in the agricultural sector. The future is not promising unless remedial action is taken. The only approach is mechanization. It is important to establish the most efficient and practical means of developing such a mechanization program. At present, mechanical planting is possible but lifting and threshing remain to be mechanized. So far the conventional threshers tested have not given satisfaction.

The use of pesticide should be reduced by the introduction of disease-resistant cultivars and by the application of an efficient integrated pest management program.

Future Development

Although the groundnut crop is well established in Mauritius, its future depends on the development of new strategies and the exploitation of new markets.

The three main priorities are:

1. To identify the place of the crop in the agricultural system within the framework of the diversification program.
2. Further development of production for the local market.
3. The development of production for export.

The place of groundnut in local agriculture

The first phase of this project has already been initiated. The project involves the indexing of all sugarcane lands for their characteristics and suitability for crop production. The indexing of cane fields on sugar estates has been completed and the data are continually updated. Currently, small planters' cane fields are being indexed. Once this database is completed it should be possible to determine more precisely the place of each crop in the agricultural system. The information can be utilized for the more efficient exploitation of sugarcane lands for the production of various crops.

Development of production for the local market

The development of the groundnut industry for oil production is not envisaged as it has been demonstrated that this is not economical. If production is to be developed for the local market then the demand for particular products must be established. Only then can a strong campaign be mounted to promote consumption and hence stimulate production further. At present the greatest demand is for roasted nuts and peanut butter.

Development of production for export

The most important development is the exploitation of the export market for confectionery and roasted nuts. This a very specialized and demanding market but it is also highly lucrative. It will require the selection of new cultivars with the appropriate quality.

Conclusions

The groundnut industry has a future in Mauritius but if it is to progress further, the priorities and the place of the crop in the agricultural diversification program must be clearly established. Future developments must concentrate mainly on production for the domestic and export markets. This will require new cultivars with the appropriate quality and agronomic characteristics and the development of intensified cropping systems to optimize land use. A reduction in production costs, through the mechanization of certain operations, would also render the crop more attractive and stimulate production. It is only by adequate research efforts that production and marketing problems can be resolved and the goals achieved.

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Discussion

Sithanantham: Do you have no pest problems in groundnut?

Ismael: Although some pests are present (*Lamprosema indicata*, leaf tier, etc.) they do not constitute a major problem. If there is an outbreak of these pests, they can be controlled by insecticides.

Sithanantham: Do white grubs root grubs attack your sugarcane as these pests are potential pests of groundnut elsewhere?

Ismael: They are not a problem in Mauritius.

Mayeux: We know you have land-space problem but did you compare the performance of groundnut between intercropping system and sole crop?

Ismael: Yes, generally, yield was proportional to the density planted.

Sandhu: For acid soils, has lime application been tried? Which 'pops'-tolerant varieties are available? Have you tried Makulu Brown, South Eastern Runner, and Copperbelt Runner?

Ismael: Experiments carried out here have shown that soil amendment (gypsum, lime, sand) can remedy the problem of pod filling in acid soils but the use of gypsum is not possible because of the high cost of application. Only the local variety, Cabri, is grown. As for the second part of your question the answer is no. The cultivars must be short cycled and bush type so as not to affect the sugarcane.

Muacanhia: Did you assess rosette virus?

Ismael: There is no rosette virus in Mauritius. Only leaf spot diseases and rust are important.

Waliyar: I think in Mauritius rust and late leaf spot are very important. Bacterial wilt appears to be important in certain parts in this country.

Cole: Is the wet season the cooler months?

Ismael: No, they are the summer months; the high temperature from December to March coincide with the rainfall season and lead to the disease problem.

Maliro: Since you irrigate sugarcane, it is possible that the high yields in intercropped groundnuts could have a contribution from the irrigation (as you say you don't irrigate sole-cropped groundnuts).

Groundnut Research in Zaire and Prospects for the Future

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Abstract

The paper discusses the importance of groundnuts in Zaire and the constraints that limit groundnut production in the country. It reviews both past and current research work on breeding and agronomy. The future trends in groundnut research are projected.

Sumário

Investigação do Amendoim em Zaire e Previsões para o Futuro. *O artigo discute a importância do amendoim em Zaire e as limitantes para a produção do amendoim no país. Revê a investigação passada e presente nos campos do melhoramento e agronomia. As tendências para a investigação do amendoim são projectadas.*

Introduction

Groundnut, *Arachis hypogaea* L., is one of the most important grain legume crops in Zaire. It is a major component of traditional mixed cropping system in many areas in the country. The crop is grown in all the provinces and occupies about 10% of the area cultivated with food crops.

In Zaire, groundnuts are domestically consumed as an oil source in soup. They are also roasted, boiled, or eaten raw and provide cash income to smallholder farmers. The crop also provides sulfur-containing amino acids that can reduce cyanide problems through human metabolism in the diet of people in Zaire who rely on cassava as a basic staple food (IITA 1987, pp. 93–95).

Most groundnuts are grown by small-scale farmers on 0.2–0.6 ha plots and often in association with other food crops, such as cassava and maize. The average grain yield obtained by small farmers is only between 350 kg ha^{-1} and 850 kg ha^{-1}, because of biotic and abiotic constraints.

Constraints to Groundnut Production

The major diseases limiting yield are early and late leaf spot and rosette virus spread by a major pest, the groundnut aphid (*Aphis craccivora*), which also reduces the groundnut growth by feeding on the plant. In recent years, pod borers, termites, and millipedes have also been damaging the crop.

The inherent low fertility and low soil pH (between 3.5 and 5.0) tend to limit groundnut yields. It has been observed that levels of calcium, phosphorus, and magnesium are deficient in most groundnut-growing areas in Zaire, while levels of aluminium tend to be excessive. These conditions are conducive to the 'pops' problem.

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Many farmers grow local varieties, some of which have degenerated and now produce poor-quality seed. Most farmers do not have enough seeds for subsequent sowing. In addition, local and some improved varieties appear to have only a low yield potential. Poor cultural and crop management practices also limit yield.

Research Background

Studies on groundnut in Zaire started in 1936 (de Preter 1953). By 1960, 200 cultivars had been introduced by the Institut national d'études agronomiques au Congo (INEAC) from USA, Brazil, Uruguay, Argentina, Niger, Mozambique, Senegal, and South Africa. Belgian researchers had previously conducted intensive mass selection and retained a few promising varieties, A 28, G 17, A 1052, A 1055, P 43, and A 65, which gave seed yields between 0.9 t ha^{-1} and 1.9 t ha^{-1}. Among these varieties, A 65, a valencia type, gave highest yields and was the best adapted variety in different ecological conditions of Zaire. It is still used as a national control.

From 1960 to 1984, research on groundnut was discontinued. In 1983, the Department of Agriculture launched the Projet de recherche agronomique appliquée et vulgarisation (RAV), jointly financed by the Government of Zaire and the United States Agency for International Development. This RAV project is working on major food crops of Zaire, i.e., cassava, maize, and grain legumes.

The mission given to the Grain Legume Program is to conduct research on groundnut, common beans, cowpeas, and soybean, using a multidisciplinary approach.

Specific objectives for groundnut research are to develop high-yielding, disease- and insect-resistant varieties that are adapted to the different ecological zones and which are acceptable to consumer taste and preference, and to develop cultural packages for groundnut production.

Varietal Selection and Breeding Trials

The National Legume Program started working on groundnut in September 1985. Its first task was to reassemble and reconstitute the local collection of all the ancient varieties of INEAC. Thereafter, new groundnut materials were introduced from ICRISAT Center, Senegal, and Brazil.

Varieties from the local collections and those recently introduced were evaluated for seed yield.

Breeding trials were established in September 1986 and included several replicated yield trials of ICRISAT material (Zaire: PNL, Department of Agriculture 1986a, 1986b). These included preliminary and advanced variety trials of long- and short-duration groundnut, and preliminary and advanced groundnut variety trials of material resistant to early leaf spot (*Cercospora arachidicola*).

Other trials were initiated in the 1987/88 planting season at Gandajika, Mvuazi, and Kiyaka stations (Zaire: PNL, Department of Agriculture 1987). These included a preliminary yield trial of varieties with large seeds (19 entries from HYQ(CG)S were evaluated); preliminary yield trial of leaf spot resistant varieties [18 entries from ICRISAT Foliar Disease Resistant Selection or ICG (FDRS) series]; and advanced yield trials of ICGS(F) series, and of short-duration groundnut selections. Recently, a selection nursery was planted at Gandajika station. It included seven crosses from ICRISAT (Zaire: PNL, Department of Agriculture 1987): Robut 33-1 × NC Ac 17090; Robut 33-1 × 54/944/911; Robut 33-1 × 102/CS 49/91; PI 259747 × NC Ac 17133 (RF); EC 76446 (292) × DHT 200; EC 76446 (292) × NC Ac 17133 (RF); and CS 30 × CS 11.

From the results of last year's observations it appears that

1. There is no rosette- or leaf-spot-resistant material among the varieties in the local collection;
2. The natural leaf spot severity was high and enabled assessment of resistance to be made with confidence. No genotype from ICRISAT showed a resistant reaction to leaf spot; however, many promising leaf-spot-tolerant varieties were identified. These were: ICG (FDRS) 4, ICG(FDRS) 42, ICG(FDRS) 26, ICG(FDRS) 23, ICG(FDRS) 3, and ICG(FDRS) 33; and
3. ICRISAT material from ICRISAT Center, India, does not seem to adapt well to the ecological conditions of Zaire.

Agronomy Trials

Previous studies by INEAC showed that time of sowing is very important. Delay in sowing leads to significant yield reduction and to severe groundnut rosette virus attacks. It has also been demonstrated that planting groundnut at high-population densities (30 cm × 15 cm) resulted in the reduction of rosette (de Preter 1953). The National Legume Program has not as yet embarked on an extensive study of cultural practices.

From a study on intercropping cassava with groundnut conducted by the National Cassava Program, it has been shown that groundnut is suitable for intercropping with cassava and its yield is little or not affected by the intercropped cassava. A preliminary study conducted on low pH soil with calcium deficiency has shown that the application of lime (oxides of lime) resulted in marked increase in groundnut yield. The study also indicated a positive interaction between lime and fertilizer application (P_2O_5 and K_2O) resulting in reduction in the percentage of empty pods (Zaire: PNL, Department of Agriculture 1986b).

To determine what changes might be introduced into the existing farming methods, the National Legume Program is conducting surveys to find out what the farmer is doing, what is happening on farm, and why the farmer acts as he does. With better understanding of what the farmer is doing already, it might be possible to suggest new ways in which production could be increased.

Future Research Perspectives

Considering the production constraints and the limited available research results, efforts are now necessary on the following aspects:

1. Screening for leaf spot resistance, rosette resistance, and against soil-insect damage;
2. Screening for adaptation to acid soil and to low soil fertility;
3. Screening for adapted long- and short-duration varieties and for varieties suitable for intercropping with maize;
4. Development of cultural practices and integrated pest management strategies for groundnut production; and
5. Production of good quality foundation seeds and subsequent multiplication for distribution to farmers.

To achieve these objectives, the National Legume Program will collaborate with ICRISAT Center and other groundnut research centers in Africa, and the SADCC/ICRISAT Regional Groundnut Improvement Program to exchange material and information as well as to obtain duplicate breeding populations and desired crosses.

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Special Topics and Agronomy

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Evaluation of New Rapid Methods for Aflatoxin Detection in Groundnuts in Zimbabwe

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Abstract

Two new rapid methods that use monoclonal antibodies to detect aflatoxins in groundnuts were tested. The Quantitox is an enzyme immunoassay using microtitre wells and the Aflatest is based on monoclonal antibodies adsorbed onto an affinity column. It was confirmed that aflatoxin contamination occurs preharvest and that storage under low-moisture conditions prevents any further toxin development. There were differences in susceptibility of the locally bred cultivars to aflatoxin development. The Aflatest procedure was useful to rapidly screen groundnut samples for aflatoxin contamination, but there were problems with the Quantitox method. Aflatoxin contamination occurred in the field prior to harvest and was not aggravated by storage conditions at Cleveland Depot during 1987. There was a 19.23% incidence of aflatoxin contamination in the samples taken in early 1987, but it was not related to the farm management system (communal, small-scale commercial, and large-scale commercial) or any particular pest or disease.

Sumário

Avaliação de Novos Métodos Rápidos para a Detecção de Aflatoxinas no Amendoim em Zimbabwe. *Foram testados dois novos métodos rápidos, que usam anticorpos monoclonais para a deteção de aflatoxinas. O Quantitox é uma imuno-análise de enzimas, usando poços de microtitulação, e o Aflatest é baseado na absorção de anticorpos monoclonais numa coluna de afinidade. Foi confirmado que a contaminação com aflatoxinas ocorre antes da colheita e que o armazenamento em condições de baixa humidade, previne o futuro desenvolvimento da toxina. Os cultivares melhorados localmente apresentaram diferenças de suscéptibilidade para o desenvolvimento da toxina. O procedimento do Aflatest foi util para a avaliação rápida da amostras de amendoim quanto à contaminação com aflatoxinas. Mas, houveram problemas com o método Quantitox. A contaminação com aflatoxinas ocorreu no campo, antes da colheita, mas não foi agravada pelas condições de armazenamento no Depósito de Cleveland, em 1987. Observou-se uma incidência de aflatoxinas de 19,23% em amostras colhidas no início de 1987, mas isto não estava ligado ao sistema de maneio dos campos (comunal, comercial de pequena escala e comercial de grande escala) ou com qualquer doença ou praga particular.*

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Introduction

Aflatoxins are highly toxic and carcinogenic substances that are produced by certain strains of fungi of the *Aspergillus flavus* group and also in some countries by the *A. parasiticus* group when grown under favorable conditions on suitable substrates (Mehan and McDonald 1986). Not all strains are aflatoxigenic as toxin production is a function of the genetic constitution and the environment (Bushnell 1965).

Research has shown the profound effects of these toxins on human and animal health, particularly noticeable in dairy cattle, pigs, and poultry, where feeding practices involve a high intake of concentrated feeds. Even at low levels, aflatoxins can cause hepatitis, reduced growth rate, and suppression of the immunological response (Wyllie and Morehouse 1978). It is therefore vital to monitor all groundnut crops for its presence.

Aflatoxin contamination can occur prior to or postharvest depending on agronomic, climatic, and edaphic factors because spores of the fungus are almost universally present. During preharvest and immediately postharvest, the fungus in the soil can enter through damaged pods and infect the seed, and also in storage. If the stored seeds germinate and grow they may produce aflatoxin by metabolic activities.

In Zimbabwe, contamination normally occurs preharvest. Several contributing factors, such as low end-of-season rainfall, damaged pods that often contain discolored seeds and broken testae, and cultivation in lighter soils that tend to have a higher incidence of aflatoxin contamination than the heavier soils, have been identified (du Toit 1977).

Originally, biological methods were used to detect the presence of aflatoxin. These were soon replaced by chemical methods that have become more and more refined. The standard chemical method used in Zimbabwe is based on the thin-layer chromatography (TLC) method developed by the Association of Official Analytical Chemists in 1970. Last year, we tested the new immunoassays that use monoclonal antibodies to detect very low levels of aflatoxin.

May and Baker have produced two: the Quantitox, an enzyme immunoassay, using a 96-well microtitre plate, which can handle 31 samples replicated three times for accurate determination of aflatoxin B_1; and the Aflatest, based on monoclonal antibodies adsorbed onto an affinity column. The latter provides a test for total aflatoxins in minutes using simple equipment and with a minimum of expertise. Semiquantitative results can be obtained by examining the fluorosil tip under ultraviolet light or against standards provided, or quantitatively by using a fluorimeter. These methods have the distinct advantage that hazardous aflatoxin standards are not handled. They are at least five times faster than standard TLC methods without loss of specificity or sensitivity (detects as little as 20 $\mu g\ kg^{-1}$).

Materials and Methods

Field samples

Samples were drawn from the three farming sectors: 10 from communal farmers (<0.25 ha per field); 10 from small-scale commercial farms (1–5 ha of groundnuts); and 6 from large-scale commercial farms (20–100 ha of groundnuts).

The first two sector samples were from the Mangwende area and the third group of samples from the Enterprise and Beatrice areas near Harare.

Samples were taken in a diagonal line across a field, excluding the end 10 m on each end of the diagonal. Sufficient groundnuts were harvested to make a 1 kg sample. Samples were stored at 4°C until the exercise was completed. Pods were removed from the plants and left to dry naturally until their moisture content was reduced to 7%, after which mature pods were selected for further testing and stored in paper bags at room temperature (20–23°C).

Samples from stored groundnuts

Experimental stacks of commercial groundnuts were built. There were sufficient bags (90 kg of each) of Egret and Flamingo to build 1 200 bag stacks but smaller stacks of Valencia (124 bags) and Plover (228 bags) had to suffice.

Every 50th bag that went onto the stack was marked with red paint for identification of future samples. Stacks were turned every month and 1 kg samples drawn from the marked bags; 24 samples each of Flamingo and Egret, 4 of Plover, and 2 of Valencia. Moisture content was determined each time on a moisture-meter.

Sample preparation. One-kg samples of ground-

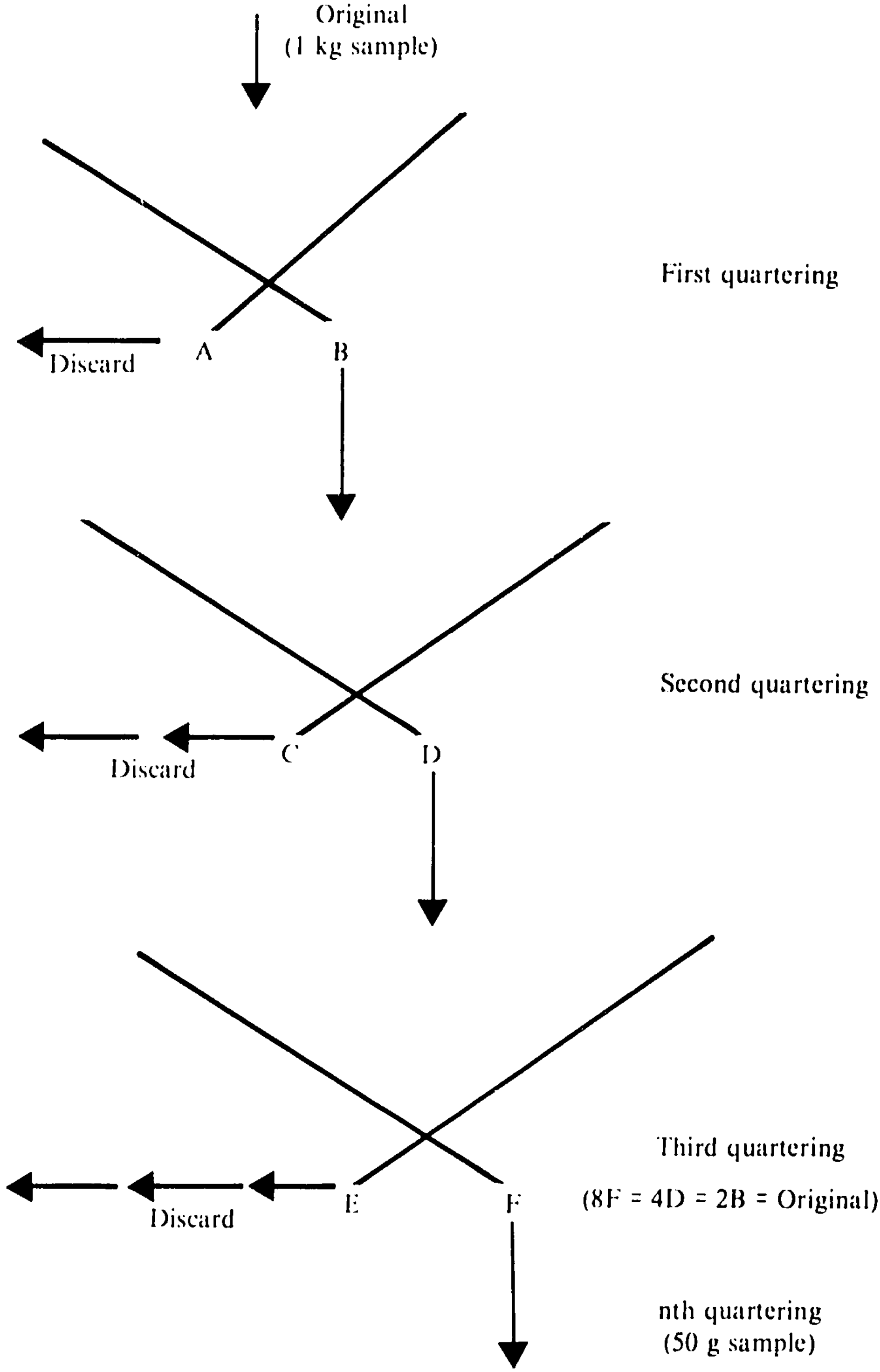

Figure 1. Quartering technique used to obtain a small, but representative, sample of groundnuts.

nuts from field samples or from experimental stacks were thoroughly mixed and a sample for analysis drawn by a quartering method (Fig. 1). Regular samples from the stacks were submitted for TLC analysis for aflatoxin. Both field samples and experimental stack samples were analyzed for aflatoxin by the Quantitox and Aflatest methods.

A description of the methods is pertinent at this point.

The Aflatest is based on an aflatoxin-specific monoclonal antibody affinity column through which the sample is slowly pushed — any aflatoxin in the sample adheres to the affinity column, the filtrate passes through. The conjugated aflatoxin-antibody complex is eluted from the column with methanol and collected in a fluorosil tip. The fluorescence of the sample is compared under ultraviolet light with a set of standards.

The Quantitox method is also based on aflatoxin-specific monoclonal antibodies. Aflatoxin is coated onto the base of wells in microtitre plates. The test sample is added to the wells and if aflatoxin is present, the free aflatoxin will compete with fixed aflatoxin for the antibody enzyme-conjugate, which is now added. On washing, most of the free aflatoxin-enzyme conjugate is washed out. The enzyme substrate, which is subsequently added, combines with any remaining antibody conjugate and turns blue. The color intensity is, therefore, inversely proportional to the amount of aflatoxin present in the original sample. The reaction is terminated by adding a stopping solution and the optical densities (ODs) of the samples are compared with those of the uncontaminated standards and the values are read off from a standard curve supplied with the kit.

Susceptibility of local cultivars

Four local cultivars Flamingo, Egret, Plover, and Valencia, were tested for their susceptibility to infection by *A. flavus*. Twenty undamaged seeds of each cultivar were selected and five put into each of four bottles of sterile, distilled water and allowed to soak for 2 min. The water was replaced with a 0.5% aqueous solution of sodium hypochlorite and the seeds allowed to soak for 3 min. This solution was drained from the bottles and the seeds of each cultivar were placed on each of four plates of Czapeks Dox Rose Bengal streptomycin-amended medium and incubated at 25°C for 8 days.

Results

Farmers' samples

Five out of the 26 samples collected from the three farming sectors (6 samples from the commercial, 10 from the small-scale commercial, and 10 from the communal farms) were contaminated with aflatoxin.

Two were from communal farmers, two from small-scale commercial farms, and one from large-scale commercial farms. Seven cultivars, Flamingo, Egret, Makulu Red, Swallow, Valencia R 2, Natal Common, and Bob White, were represented but contamination was encountered only on three of those: Flamingo (one sample), Makulu Red (one sample), and Valencia R 2 (three samples).

Stored samples

No evidence of aflatoxin contamination was detected by the Aflatest in the monthly samples taken at Cleveland Depot throughout the sampling period from March to August 1987, and this was confirmed by the standard TLC test results.

The Quantitox results were confusing. All Flamingo samples were apparently contaminated throughout the experimental period as no color developed. All the ODs for Plover samples were higher than the reference standard, which represents the maximum OD for no aflatoxin. Moisture contents for the four cultivars under test dropped from just over 6% to 5.2% during the sampling period.

Susceptibility of local cultivars

Flamingo (20% natural infection of seeds with *A. flavus*) was the most susceptible of the four cultivars tested, followed by Valencia R 2 (15%) and Egret (10%). Plover was least susceptible (5%).

Conclusions

The samples collected from farms were very small, so conclusions are very tentative and much larger areas should be sampled to obtain an accurate picture of aflatoxin distribution. Aflatoxin contamination was detected in 19.23% of samples. These compare well with the results of Bushnell (1965), who found 18% of the seeds in the crop contaminated, and du Toit who measured contamination of crops over a 10-year period and found the lowest level was around 16% and the highest around 50%. The 1986/87 season fits into the lower end of his range, indicating that in spite of the drought, pods remained intact and no fungus entered the pods.

Aflatest and TLC results indicated that no aflatoxin contamination had occurred in storage: not surprisingly, because the moisture content of the seeds in 1987 was well below the critical 9% for *A. flavus* growth to commence.

The anomalous Quantitox results require further investigation. One explanation may be that Flamingo contains an analogue that mimics aflatoxin in the test but this was not evident in the Aflatest, which is based on a similar antibody-antigen reaction. Alternatively, some substance in Flamingo may inhibit color development of the enzyme substrate and, therefore, give the appearance of being grossly contaminated. The maize standard used for the Quantitox is obviously not ideal when testing groundnuts because one of the cultivars, Plover, had ODs higher than the uncontaminated standard; it seems that a groundnut standard for the groundnut tests should be considered.

It is recommended that the Aflatest procedure be used for rapid screening of groundnuts as they are delivered to depots. The method takes 30 min to complete and contaminated groundnuts can be kept aside at source. This will ensure that the whole consignment does not become infected, thereby condemning it all to crusher grade and losing valuable export confectionery nuts.

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Discussion

Nigam: Did I hear you say that aflatoxin does not go to groundnut oil? As per my information, it does go into oil. Would you like to comment?

Cole: I had taken the information from literature and I stand corrected.

Waliyar: In the Aflatoxin Workshop held at ICRISAT Center, last October, both Aflatest and Enzyme-Linked Immunosorbent Assay (ELISA) techniques for aflatoxin detection were demonstrated. These techniques are more useful for qualitative detection than quantitative detection.

Cole: These methods would be used for initial separation of contaminated groundnuts from uncontaminated groundnuts. If levels were high they would be sent to the Government Chemistry Laboratory for TLC determination of exact quantities of aflatoxin present.

Production of Certified Chitembana and Mawanga Groundnut Seed by the Smallholder Farmer: The Malawi Experience

P.K. Sibale[1] and P.J. Mtambo[2]

Abstract

A new strategy was developed and implemented to alleviate the shortage of certified seed and give the smallholder farmer an access to newly released groundnut cultivars and a role in the production of the seeds of those cultivars. The paper outlines the experiences gained in implementing the strategy and makes recommendations to improve the system.

Sumário

Produção de Semente Certificada de Amendoim das Variedades Chitembana e Mawanga pelos Pequenos Agricultores - A Experiencia do Malawi. *Uma nova estratégia foi desenvolvida e implementada, com vista a aleviar a carência de semente certificada e dar ao pequeno agricultor acesso aos cultivares recentemente libertados e um papel importante na produção de semente dos mesmos cultivares. Este artigo descreve as experiências ganhas na implementação desta estratégia e faz recomendações para o melhoramento do sistema.*

Introduction

Groundnuts play a vital role in smallholder agriculture and contribute significantly to the dietary requirements of Malawians in most parts of the country. They provide more than 25% of all smallholder agricultural cash income and supply approximately half of Malawi's demand for edible oil. As an export crop, groundnut ranks fourth after tobacco, tea, and sugar. The role played by groundnuts in improving soil fertility in smallholder agriculture is also of paramount importance. Recent estimates of smallholder groundnut production indicate the importance of this crop in smallholder agriculture (Table 1).

Prior to the 1984/85 season, the National Seed Company of Malawi (NSCM) was the sole producer of certified seed in the country, after initial field inspection, laboratory testing, and certification by the Seed Technology Unit of the Ministry of Agriculture. The certified groundnut seed produced by NSCM was insufficient to meet the smallholder farmers' demand. Moreover, certified groundnut seed often broke during processing by NSCM and subsequent distribution by the Agricultural Development and Marketing Corporation (ADMARC).

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Table 1. Estimated groundnut production by the smallholder farmers, Malawi, 1982–87[1].

Season	Area (ha)	Estimated production (t)
1982 83	93611	57481
1983 84	145362	55052
1984 85	129286	58432
1985 86	176293	88297
1986 87	209938	88073

1 Source: Malawi Ministry of Agriculture (1987a)

This made farmers lose confidence in certified groundnut seed.

Three cultivars were being grown by the smallholder farmer. Chalimbana, a large-seeded confectionery type was grown on the central plateau areas. Mani Pintar, a high-yielding oil-type groundnut, was recommended for growing in the Lake Shore areas, especially in Salima Agricultural Development Division. Malimba, an early-maturing spanish variety was recommended for the Lower Shire Valley.

In 1980, two more cultivars were released by the Department of Agricultural Research. Chitembana, a large-seeded confectionery groundnut, was released to supplement Chalimbana on the central plateau areas. Apart from having the same yield potential as Chalimbana, this new cultivar had better seed shape, shelled easier by hand, and exhibited superior yield response under disease-controlled situations. Mawanga, a variegated red and pink nut with superior yielding ability and with oil content 50%, was to supplement Mani Pintar on the Lake Shore areas.

Unfortunately, the smallholder farmer could not get access to the newly released cultivar because of the seed-supply problem.

To alleviate these problems, a new strategy that involved the smallholder farmer in the production of certified seed was developed and implemented to make available to him certified seed of such crops as groundnuts.

Methodology

The concept of using smallholder farmers to produce certified seed demanded new arrangements that would ensure certified seed production in adequate quantities without compromising on the quality of the seed. The essential elements of the new scheme were:

1. **Decentralization of seed production.** Each Agricultural Development Division (ADD) would produce certified seed to meet the seed requirements of its smallholder farmers.
2. **Participation of smallholder farmers in seed production.** The selection of the farmers to be involved and their supervision would be the responsibility of the ADD extension staff.
3. **Restructuring of certified seed prices.** To allow for an incentive to smallholder certified seed producers, the prices for certified seed offered by the farmer at the selling point would be higher than the price for commercial seed.
4. **Decentralization of seed quality control.** It was envisaged that each ADD would be served by a local seed quality control unit (i.e., seed inspectorate service and laboratory testing facility).
5. **Close liaison between various institutions within the seed industry,** i.e.,
   - ADD's involvement in smallholder certified-seed production;
   - plant bre[illegible]s from the Ministry of Agriculture and the University, who would be required to conduct a regular cultivar maintenance program for the released cultivars,
   - the NSCM that would provide small quantities of basic seed for use by the smallholder farmer in the production of certified seed it was envisaged that NSCM would be requested to supply basic seed on a 2-year cycle;
   - ADMARC whose role would be to market, distribute, and store certified seed produced by the smallholder farmer;
   - the Department of Agricultural Extension;
   - the Planning Unit Department; and
   - the Seed Technology Unit.

   This liaison would be fostered at the national level by the Seed Technology Working Party.
6. **Training.** An important element for the success of this exercise was the development and implementation of a training scheme in Seed Technology for the Extension Staff, the smallholder farmer, and ADMARC seed-marketing staff. The trainers would be the crop breeders and seed technologists. This was necessary to instill a common purpose among all those who would be

involved in the actual implementation of the scheme.

7. **Budgeting.** By the nature of this new strategy and because it was appreciated from the beginning that this would be an expensive exercise, it was implicit that the Ministry of Agriculture would fund the exercise.

Production

Implementation of this exercise began on a small scale in Unit 28 of the Lilongwe Agricultural Development Division (LADD) in the 1984/85 season and in Kasungu Agricultural Development Division (KADD). Selected extension personnel from the ADD Headquarters and from the field participated in a seminar at Chitedze Research Station for 1 week, where general principles of seed technology, description of cv Chitembana, groundnut agronomy, and control of groundnut diseases were taught. Follow-up was conducted for extension officers who were to supervise the target smallholder seed producers.

The ADD selected the participating farmers and these were registered with Seed Technology Unit (STU). Sufficient Chitembana seed (to plant 0.4 ha) was issued on credit to each farmer from NSCM. Throughout the growing season, field inspections were conducted by STU personnel to check on compliance with certification standards.

Prior to the harvesting period, STU organized a 1-day premarketing seminar to which ADMARC staff and extension personnel were invited. Subjects covered included:

a. What to do with seed from those farmers who failed field inspection tests.
b. The need to buy only well-graded Chitembana seed from those farmers who passed the inspections.
c. Issuing of new sacks to pack seed.
d. Arranging for special days to buy certified Chitembana seed to minimize risk of cultivar mixtures.
e. Need for extension staff to be present during sales to identify the farmers who passed the field inspection.
f. Proper labeling of certified seed, e.g., 28/6/85, where 28 stood for extension area where seed was produced, 6 for registration number of the farmer, and 85 for the year the seed was produced. The sack would be stenciled with the number, one tag label placed inside the bag, and another attached outside the bag.
g. Storage procedure to be followed by ADMARC personnel to minimize storage losses.

Table 2. Groundnut seed yield, farmers' performance during inspection, and area passed in Unit 28 of Lilongwe Agricultural Development Division (LADD) and Kasungu Agricultural Development Division (KADD), Malawi, 1984/85.

Location	No. of farmers passed	No. of farmers failed	Area (ha) passed	Seed yield (t)
Unit 28 (Lilongwe)	231	11	94.7	65
Kasungu	110	11	44.0	30

Table 2 presents the number of farmers who passed/failed field inspections, the hectarage passed, and the seed yield during the 1984/85 season in Unit 28 of LADD and in KADD.

From the success of the 1984/85 preliminary exercise in smallholder production of certified seed, the scheme was expanded to cover the production of Chitembana certified seed in LADD, KADD, and Mzuzu ADD (MZADD), and of Mawanga certified seed in Salima ADD (SLADD) during the 1985/86 production season.

Preproduction and premarketing training activities were intensified and expanded to cover the entire production areas. The experience gained during the 1984/85 season was useful in the coordination of the expanded program for the 1985/86 season. Table 3

Table 3. Groundnut seed yield, farmers' performance during inspection, and area passed in four Agricultural Development Divisions (ADDs), Malawi, 1985/86[1].

Location	No. of farmers passed	No. of farmers failed	Area (ha) passed	Seed yield (t)
Kasungu	1299	138	520.0	213.3
Lilongwe	1237	79	494.8	302.0
Mzuzu	134	26	53.6	17.0
Salima	1044	80	418.0	551.0[2]

1. Source: Malawi: Ministry of Agriculture (1986).
2. Pod yield as Mawanga seed in Salima ADD is sold in shell.

Table 4. Groundnut seed yield, farmers' performance during inspection, and area passed in four Agricultural Development Divisions, Malawi, 1986/87[1].

Location	No. of farmers passed	No. of farmers failed	Area (ha) passed	Seed yield (t)
Kasungu	630	106	252.0	138.6
Lilongwe	678	49	271.2	149.3
Mzuzu	254	23	103.2	36.0
Salima	340	10	197.8	269.6[2]

1. Source: Malawi: Ministry of Agriculture (1987b).
2. Pod yield as Mawanga seed in Salima ADD is sold in shell.

presents a summary of the picture at the end of the 1985/86 season.

During the 1986/87 season, the exercise was repeated on a reduced scale in SLADD, KADD, and LADD. Table 4 presents the figures for 1986/87 season.

Seed production figures in Tables 3 and 4 indicate that the new system is workable. In the 1984/85 season, 95 t of certified seed was produced; in the 1985/86 season, 1083 t; and in the 1986/87 season, 594 t. The figures also show that the smallholder farmer is capable of producing certified seed whose quality is of an acceptable standard. The fact that the seed produced has readily been bought or issued on credit to the smallholder farmers, with no surplus seedstocks, indicates that the system has been filling a real demand for seed.

Discussion on the Experiences

It is pertinent here to elucidate some of the experiences gained in implementing this strategy. Three major problems that were experienced are detailed below:

a. **Too many farmers on scattered fields.** The use of the smallholder farmers (each farmer with a 0.4-ha field) in certified-seed production necessitates that too many smallholder farmers will be involved in producing the required seed tonnage. In the implementation of the scheme, the situation was worsened by the scattering of numerous small fields over a wide area. The time and costs involved in carrying out the various activities were tremendously increased. This was a big strain on the limited budget, technical personnel, and facilities under government disposal. Similar experiences were noted in Taiwan (Sung 1965) when they used small-scale seed growers in certified-seed production.

Having observed the effects of numerous small-scale seed producers on the efficiency of the overall seed multiplication program, the following solutions are proposed:

i. Each ADD involved in the scheme should map out a strategy of seed multiplication on a zoning system. The selection of a zone would be by suitability of the area, accessibility, and possibility to produce the required amount of seed.
ii. Seed farms should be concentrated in the zoned area as opposed to having them scattered over too wide an area. Experience in Dowa West has shown that it is possible to concentrate seed farms in extension blocks.
iii. Supplying on credit inputs that raise the crop yield per hectare. This would reduce the total planted area as well as the number of seed growers.

b. **Funding of the scheme.** During the three seasons the scheme has been operating, the Ministry of Agriculture has funded all the operating costs. Experience has shown that the funding has been on an ad hoc basis with no formalized budget allocation for this exercise. Delays in disbursement of the funds and the insufficiency of funds have hampered the effective management of this scheme. The following proposals are made to enhance the management of this exercise:

i. Sufficient budgetary allocation with funds disbursed in a timely manner, is required to meet the operating costs of both the STU and the ADD staff. Additional seed inspectors need to be recruited and trained.
ii. A system needs to be worked out where part of the proceeds from the sale of certified seeds are injected back into the smallholder seed-multiplication fund, to ease the budgetary constraints.

c. **Marketing of seed.** The scheme faced many problems associated with marketing of the certified seed

i. At the planning stage of the scheme, a 10 tambala kg^{-1} price difference between certified and commercial seed was agreed upon as an incentive to smallholder farmers engaged in seed production. This was meant to reflect the additional work involved in meeting the minimum certification standards. However, the price differential was not always maintained. To alleviate the resulting problems, it is recommended that the price differential, as an incentive, should be strictly adhered to.

ii. To avoid admixtures of the certified seed with seed of other varieties grown in an area, an arrangement needs to be made between ADD extension staff, ADMARC staff, and the farmers regarding the weekdays when seed would be presented for sale at ADMARC markets. Experience during the seasons has shown that selling certified seed on weekends should be avoided because of religious obligations by farmers and or ADMARC ADD extension personnel.

iii. In some instances, poor labeling of certified seed and use of old sacks were observed. This practice does not give a good image of certified seed. It is suggested that the ADD headquarters should be responsible for proper labels and prestenciled new sacks for use by the farmers.

Seed promotional effects

During the past three seasons, the importance of using high-quality seed of improved cultivars has been given some publicity through the media and through the field days held on farmers' fields. Undoubtedly the publicity has had some positive impact. However, the Ministry of Agriculture needs to coordinate and intensify these efforts. Promotion of seed should be comprehensive enough to reach all farmers in the target area, intensive enough to have a positive impact on their choice of seed, and consistent enough to use improved seed in each planting season (Gregg 1983). Besides seed multiplication, the program has also educated farmers in good crop husbandry. Farmers have benefited from the numerous supervision trips, to their fields, undertaken by ADD and STU personnel.

Conclusions

Production of certified Chitembana and Mawanga seed by the smallholder farmer in Malawi has been successful. Considerable quantities of improved seed have been injected into the smallholder farming community through this scheme. The publicity given to the scheme through the media and field days has offered an opportunity to stir the conscience of the smallholder farmer with regard to the importance of using high-quality seed of improved varieties.

Experiences here and elsewhere have shown that certified seed production by the smallholder farmer is a costly exercise. It is, therefore, recommended that the scheme should limit its function to the multiplication of only those newly released improved cultivars of self-pollinating species and of vegetatively propagated crops where commercial seed production may not as yet be available. From the experience so far gained, we see an important continuing role of the scheme in future.

Acknowledgment

We would like to express our sincere gratitude to Mr J.H. Luhanga, Seed Technologist, Chitedze Research Station, for his untiring efforts in the planning and implementation of the seed production scheme reported here. We are also grateful to the Malawi Government for permission to present this paper at this workshop.

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Discussion

Sandhu: At what stage of crop growth and thereafter is roguing done?

Mtambo: We conduct three field inspections. The first roguing inspection is done during the vegetative stage; the second during the flowering stage; and the third is done for farmers who were given warning to rogue their fields and those who were advised to weed to facilitate the field inspections.

Sandhu: What kind of seed is being produced: prebasic, basic, or certified seed?

Mtambo: Certified seed only is multiplied by smallholder farmers. Prebasic or basic seed multiplication is handled by the National Seed Company of Malawi.

Recent Developments in Agronomic Research in Zambia, 1985-87[1]

M.S. Reddy[2], K. Kanenga[2], J.C. Musanya[2], and G. Kelly[2]

Abstract

The national objectives are to increase the production of groundnuts and grain legumes towards achieving self-sufficiency in food and vegetable oils and to generate marketable surpluses for export. The Groundnut Agronomy Research Program has identified many agroecological zones for appropriate research. Results of various recent groundnut trials are discussed.

Sumário

***Recentes Avanços na Investigação agronómica na Zâmbia, 1985-87.** Os objectivos nacionais são a expansão da produção do amendoim e leguminosas, em direcção à auto-suficiência em alimentos e óleos vegetais, e gerar excedentes mercantis para exportação. O programa de investigação agronómica do amendoim identificou várias zonas agro-ecológicas para a realização de investigação apropriada. São discutidos os resultados de vários ensaios do amendoim realizado recentemente.*

Introduction

Groundnut seed contains about 60% oil and over 30% protein. It is used in the preparation of vegetable oils, eaten raw, or used in confections. High-quality groundnuts are an important export commodity and can earn valuable foreign exchange. The by-product of oil expression (cake) is a useful animal feed.

Zambia grows groundnut over 330 000 ha, the Eastern Province accounting for about 47% of this area. Average yields are around 900 kg ha^{-1}. Under improved management they can be three times higher, 1 ha producing 1 500 kg of vegetable oil and 750 kg of protein.

The interim plan in the new economic recovery program endeavors to increase production by 10% in 1988.

Rainfall Distribution Patterns

Monthly distribution of rainfall at Msekera Regional Research Station (Plateau) and Masumba Subresearch Station (Luangwa Valley) are presented in Table 1.

At Msekera, sowing rains fell early in 1985/86 and 1986/87. Rainfall quantity and distribution was favorable for all crops at nearly all locations in Eastern Province. The 2-week drought commonly experienced in January-February did not take place and termite damage, often associated with drought, was not severe. December was the wettest month.

1. The paper was presented by K. Kanenga.

2. Legume Agronomist, Msekera Regional Research Station, P.O. Box 510089, Chipata, Zambia.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1989. Proceedings of the Third Regional Groundnut Workshop, 13-18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P 502 324, India: ICRISAT.

Table 1. Monthly rainfall (mm) distribution for two locations in eastern Zambia, 1972-87.

Month	Msekera Mean 1972-85	Msekera 1986-87	Masumba Mean 1983-85	Masumba 1986-87
October	18.6	44.3	22.7	50.1
November	64.5	105.1	84.0	62.0
December	247.2	307.4	164.4	184.2
January	257.9	186.3	187.0	97.0
February	244.5	186.2	185.5	115.5
March	158.2	94.3	148.9	62.5
April	64.0	11.1	82.2	50.0
May	2.8	Trace	Trace	Trace
Total	1057.7	934.7	853.7	621.40

However, total rainfall for Msekera and Masumba was lower than the long-term mean.

Constraints to Groundnut Production

The factors limiting production are:

- the lack of suitable high-yielding and disease-tolerant cultivars,
- the use of poor quality, nontreated and inadequate quantities of seed for sowing, resulting in poor germination and low plant density,
- delays in sowing, weeding, and harvesting because of competition for labor by the maize crop, which being the staple crop is given first priority for inputs.

Objectives

National objectives are to expand the production of groundnuts and grain legumes towards achieving self-sufficiency in food and vegetable oils and to generate marketable surpluses for export. To this end, the groundnut agronomy research program was initiated to:

- develop agronomic recommendations for newly released cultivars by conducting on-station and on-farm agronomic trials,
- examine yield responses to fertilizer use, early sowing, increased plant density, and improved weeding practices,
- determine land- and labor-saving benefits by evaluating intercropping, relay cropping, and crop rotations involving cereals and legumes,
- evaluate the potential of new agronomic packages on farmers' fields in cooperation with the Adaptive Research Planning Team, and
- develop simple labor-saving devices to ease labor bottlenecks. Since the groundnut agronomy program has a national mandate, many agroecological zones have been identified for conducting groundnut agronomy research: the traditional major groundnut-producing areas of Eastern, Central, and Northern Provinces; low-rainfall areas of Southern Province having light-textured soils; areas of acid soil and high rainfall in Northern and North-Western Provinces; and valley areas having high summer temperatures but comparatively short seasons.

Research Progress

On-station research in 1985/86 was reduced slightly to allow more on-farm research. The trials conducted at Msekera included spacing trials with MGS 2 (M 13) and Egret and the 2nd year of a maize-groundnut residual nutrient trial to measure responses of groundnut to residual fertilizer when following maize fertilized at different levels. There was also a maize/groundnut intercrop trial comparing variable row arrangements and plant densities.

In 1986/87, the program at Msekera was increased slightly and included spacing trials with different varieties: weed control, nitrogen fixation and intercrop trials including maize and other crops such as sorghum, cotton, sunflower, and pigeonpea.

Variety and plant density trials

Trials at Msekera included Egret, 4a/8/2, MGS 2 (M 13), and MGS 5 (Sigaro Pink 35). MGS 5 was also included in trials conducted under valley conditions.

Seed yields were good in 1985/86 and shelling percentage and foliar-disease severity were not greatly influenced by changing population density.

Table 2. Yield response of groundnut variety MGS 2 (M 13) to plant density and time of sowing, Msekera Regional Research Station, Zambia, 1986/87.

Spacing (cm)	Target plant density (× '000 ha^{-1})	Actual plant density (× '000 ha^{-1}) Sowing date 24 Nov 1986	Actual plant density (× '000 ha^{-1}) Sowing date 22 Dec 1986	Seed yield (t ha^{-1}) Sowing date 24 Nov 1986	Seed yield (t ha^{-1}) Sowing date 22 Dec 1986
90 × 25	44	44.9	40.3	1.715	1.193
75 × 15	89	88.6	89.9	2.403	1.661
60 × 15	111	109.6	108.0	2.170	1.650
90 × 10	111	106.2	98.8	2.609	1.856
75 × 10	133	125.8	127.7	2.409	1.902
60 × 10	167	151.3	129.3	2.597	1.821
75 × 7.5	178	139.6	123.5	2.629	1.902
60 × 7.5	222	164.8	161.4	2.887	2.117
Mean		116.3	109.9	2.428	1.763

Table 3. Yield and nodulation response of four groundnut varieties to inoculation with three *Rhizobium* strains, Msekera Regional Research Station, Zambia, 1986/87.

Variety	*Rhizobium* strain NC 92	*Rhizobium* strain RP 182.3	*Rhizobium* strain NC 43.3	Control	Mean
	Nodule numbers at 78 DAS[1] (nodules $plant^{-1}$)				
Chalimbana	242	345	303	331	305
Makulu Red	161	136	190	178	166
MGS 2 (M 13)	172	153	177	203	176
4a 8 2	178	175	285	260	224
SE		±23.2			±23.2
Mean	188	202	239	243	
	Nodule dry mass at 78 DAS[1] (g)				
Chalimbana	0.66	0.55	0.61	0.49	0.58
Makulu Red	0.28	0.23	0.36	0.17	0.26
MGS 2 (M 13)	0.15	0.15	0.15	0.19	0.16
4a/8/2	0.44	0.31	0.41	0.37	0.38
SE		±0.04			±0.04
Mean	0.38	0.31	0.38	0.31	
	Seed yield (t ha^{-1})				
Chalimbana	1.567	1.294	1.386	1.418	1.416
Makulu Red	2.107	2.217	2.242	2.079	2.161
MGS 2 (M 13)	1.908	1.222	1.922	1.894	1.736
4a/8/2	1.878	2.035	2.077	1.952	1.985
SE		±0.082			±0.082
Mean	1.865	1.692	1.907	1.836	

1. DAS = Days after sowing.

Table 4. Response of five groundnut varieties to lime and leaf spot control in on-farm trials in Eastern Province, Zambia, 1985/86 (mean of 11 trials).

Variety	Treatment				Treatment			
	Control (No treatment)	+ Lime[1]	+ Fungicide[2]	Mean	Control (No treatment)	+ Lime[1]	+ Fungicide[2]	Mean
	Seed yield (t ha^{-1})				Pops content(%)			
Chalimbana	1.315	1.440	1.766	1.507	6.6	3.0	5.0	4.9
Makulu Red	1.849	1.962	2.216	2.009	8.5	4.2	6.0	6.2
Egret	1.690	1.809	1.939	1.813	6.3	4.2	6.0	5.5
Copperbelt Runner	1.247	1.273	1.593	1.371	3.5	4.0	4.0	3.8
MGS 2	1.630	1.599	2.022	1.750	4.3	5.0	6.0	5.1
SE		±0.039		±0.051		±0.6		±0.8
Mean	1.546	1.617	1.907		5.8	4.8	5.4	

1. 1.5 t ha^{-1} of lime.
2. One application of thiophanate methyl + maneb (Labilite®) at 75 80 days after sowing.

In 1986/87, yield differences were larger and most varieties produced significantly better yields at densities of 88 000 plants ha^{-1} and 111 000 plant ha^{-1} than at 44 000 plants ha^{-1}, which is typical of farmers' fields. A little further advantage was achieved by sowing MGS 2 at densities higher than 111 000 plants ha^{-1} (Table 2). Delayed sowing also caused a reduction in the yield of MGS 2 (Table 2).

Nutrition

A maize-groundnut residual fertility trial in 1985/86 showed that there were no significant differences in the response of groundnut to residual fertility when the crop followed the maize crop, which had been fertilized at different levels.

A trial conducted in 1986/87 to measure the response of selected groundnut cultivars to inoculation with different strains of rhizobia showed no differences among strains and none between inoculated and noninoculated treatments (Table 3). There were, however, differences among varieties.

Research on the pH-induced "pops" problem continued and five cultivars were grown with and without lime, and leaf spot control, on farmers' fields in 1985/86. Lime application had little effect on yield but resulted in a reduction in "pops" content. There were significant yield increases achieved from a single application of thiophanate methyl + maneb (Labilite®) at 75-80 days after sowing (Table 4). In 1986/87, the lime treatment was excluded but two plant densities were used. There were marked increases in yield with increasing plant density and once again a single application of thiophanate methyl + maneb (Labilite®) resulted in a significant yield increase (Table 5). In view of the consistent

Table 5. Yield response (t ha^{-1}) of four groundnut varieties to low and optimal plant densities and leaf spot control in on-farm trials in Eastern Province, Zambia, 1986/87, (mean of four trials).

Variety	Treatment (plant density[1]/ leaf spot control[2])			
	44444/ Nil	88888/ Nil	88888/ Labilite®	Mean
Chalimbana	0.766	1.003	1.336	1.035
Makulu Red	0.671	1.122	1.302	1.032
MGS 2	1.091	1.167	1.550	1.269
4a/8/2	0.896	1.248	1.421	1.188
SE		±0.043		±0.050
Mean	0.856	1.135	1.402	

1. Plants ha^{-1}.
2. Nil or one application of thiophanate methyl + maneb (Labilite®) at 75 80 days after sowing.

Table 6. Response of groundnut to the adoption of improved cultural practices, Msekera Regional Research Station, Zambia, 1986/87.

Treatment[1] a b c d e	Plant density at harvest (× '000 ha⁻¹)	Seed yield (t ha⁻¹)	Shelling (%)	Early leaf spot score (1-9 scale)[2]
LSD+LPP+1W+US+LPT	40	0.460	53	4.0
LSD+LPP+1W+US+EPT	43	0.935	65	5.0
LSD+LPP+1W+SP+LPT	42	0.676	62	5.0
LSD+LPP+2W+US+LPT	43	0.674	66	6.0
LSD+RPP+1W+US+LPT	80	0.694	66	5.0
LSD+LPP+1W+SP+EPT	42	1.180	64	4.5
LSD+LPP+2W+US+EPT	43	1.028	67	5.5
LSD+LPP+2W+SP+LPT	43	0.950	62	5.5
LSD+RPP+2W+US+LPT	80	0.801	65	6.0
LSD+RPP+2W+US+EPT	83	1.443	67	5.5
LSD+RPP+1W+SP+EPT	87	1.579	64	4.5
LSD+RPP+1W+US+EPT	82	1.094	64	5.5
LSD+LPP+2W+SP+EPT	43	1.246	67	5.0
LSD+RPP+2W+SP+LPT	77	0.866	60	5.0
LSD+RPP+1W+US+EPT	87	1.427	66	5.0
LSD+LPP+2W+SP+EPT	40	1.381	68	5.5
ISD+LPP+1W+US+LPT	40	0.666	56	5.0
ISD+RPP+1W+US+EPT	84	1.210	68	5.0
ISD+LPP+1W+SP+LPT	39	0.682	60	4.5
ISD+LPP+2W+US+LPT	39	0.862	65	5.0
ISD+RPP+1W+US+LPT	75	1.032	68	5.5
ISD+LPP+2W+US+EPT	42	1.330	65	4.5
ISD+LPP+2W+US+EPT	43	0.875	68	5.0
ISD+RPP+2W+US+LPT	64	0.836	63	5.5
ISD+RPP+2W+US+LPT	68	0.990	68	6.0
ISD+RPP+2W+US+EPT	86	1.214	68	6.0
ISD+RPP+1W+SP+EPT	90	1.946	67	6.0
ISD+RPP+1W+SP+LPT	89	0.810	64	5.5
ISD+RPP+2W+SP+LPT	87	1.416	67	4.5
ISD+RPP+2W+SP+LPT	80	1.062	64	6.0
ISD+RPP+1W+US+EPT	89	1.415	66	6.0
ISD+RPP+2W+SP+EPT	85	1.392	66	5.0
SE	±6	±0.147	±3.20	±0.37
Mean	60	1.068	64.67	5.2
CV (%)	14	19	7	10

1. Treatments : (a) LSD = Local seed (nontreated), ISD = Improved seed (treated);
(b) LPP = Low plant density, RPP = Recommended plant density;
(c) 1W = One weeding, 2W = Two weedings;
(d) US = Nonsprayed, SP = One Labilite® application;
(e) LPT = Late planted, EPT = Early planted.

2. Scored on a 1-9 scale, where 1 = No disease, and 9 = 50-100% foliage destroyed.

yield increase (24%) during the past 2 years, the recommendation of a single application of fungicide, thiophanate methyl + maneb (Labilite®), applied to farmers' fields seems reasonable from the pathologists' and agronomists' point of view.

Assessment of production technology

A "steps-in-technology" trial was conducted at Msekera in 1986/87 to assess the benefit that can be derived from the adoption of improved cultural practices. The treatment using improved seed, recommended plant density, early sowing, weeding, and one application of thiophanate methyl + maneb (Labilite®) gave the highest yield of 1.945 t ha^{-1}. The treatment representing the nonadoption of recommended practices gave the lowest yield of 0.46 t ha^{-1} (Table 6).

Groundnut intercropping

In 1985/86, maize-groundnut intercropping trials were initiated to assess the intercropping benefits of sowing the two crops in different row arrangements (1:1 and 1:2) and also by varying the plant densities of, and fertilizer input to, the two component crops.

Table 7 Results of maize/groundnut intercropping trial, Msekera Regional Research Station, Zambia, 1985/86 cropping season (groundnut results only).

Treatment	Groundnut plant density at harvest (× '000 ha^{-1})	Pod yield (t ha^{-1})	Seed yield (t ha^{-1})	Seed yield LER[1]	Shelling (%)	Number of seeds in 100 g	Early leaf spot score on 2 Feb 1986 (1-9 scale)[2]	Early leaf spot score on 1 Apr 1986 (1-9 scale)[2]	Defoliation on 5 Feb 1986 (%)	Defoliation on 3 Apr 1986 (%)
Sole groundnut	86.8	1.684	1.154	1.00	68	112	4	8	43	81
1 maize: 1 groundnut 50% M[3] + 50% G[3]-F_1	45.6	0.758	0.537	0.47	71	111	5	8	45	81
1 maize: 1 groundnut 75% M + 50% G-F_1	44.2	0.595	0.425	0.37	72	109	4	8	45	84
1 maize: 1 groundnut 75% M + 50% G-F_2	44.2	0.461	0.332	0.29	72	121	4	8	45	82
1 maize: 1 groundnut 100% M + 100% G-F_1	72.0	0.362	0.256	0.22	70	125	5	9	44	83
1 maize: 1 groundnut 100% M + 100% G-F_2	68.7	0.433	0.290	0.26	67	134	5	8	47	83
2 maize: 1 groundnut 67% M + 33% G-F_1	30.6	0.361	0.253	0.22	70	106	4	8	45	80
2 maize + 1 groundnut 67% M + 67% G-F_1	45.3	0.451	0.320	0.28	71	120	4	8	47	82
2 maize: 1 groundnut 67% M + 67% G-F_2	48.9	0.403	0.285	0.24	71	117	4	8	45	84
2 maize: 1 groundnut 100% M + 67% G-F_2	47.5	0.375	0.265	0.23	71	114	4	8	48	84
2 maize: 1 groundnut 100% M + 67% G-F_2	42.3	0.345	0.236	0.20	68	126	5	8	48	86
SE	±1.7	±0.043	±0.031	±0.03	±1.6	±4.1	±0.3	±0.3	±1	±1.5
Mean	52.4	0.566	0.396	0.34	70	118	4.4	8.1	46	83
CV (%)	5	13	14	16	4	6	11	7	5	3

1. LER = Land-equivalent ratio.
2. Scored on a 1-9 scale, where 1 = No disease, and 9 = 50-100% foliage destroyed.
3. M = Maize and G = Groundnut.

Maize grain yield in different intercropping combinations increased significantly with increase in maize population and additional fertilizer application. A 1 maize (M): 1 groundnut (G) intercrop treatment (with 100% M, 100% G plant density, and additional fertilizer to maize) gave the maximum intercropping advantage of 21% which was significantly higher than either of the sole crops. A 2 m: 1 g intercrop treatment (with 100% M, 67% G plant density, and additional fertilizer to maize) gave 15% intercropping benefit. All other intercropping treatments gave slightly lower or higher yield advantage compared to the sole crops (Table 7).

In 1986/87, a further groundnut intercropping trial was carried out to examine the performance of groundnut when intercropped with other component crops to identify the most profitable combination. Under Msekera conditions, groundnut with sunflower produced the maximum groundnut yield of about 86% of the sole groundnut, followed by groundnut/pigeonpea, producing 78% of the sole crop (Table 8). Performance of groundnuts with the

Table 8. Results of groundnut intercropping trial, Msekera Regional Research Station, Zambia, 1986/87 (groundnut results only).

Treatment	Groundnut plant density at harvest (× '000 ha^{-1})	Seed yield (t ha^{-1})	Seed yield land equivalent ratio (LER)	Shelling (%)	Early leaf spot score (1-9 scale)[1]	Total LER
2 maize: 1 groundnut	28.2	0.283	0.30	66.3	5	1.13
2 sorghum: 1 groundnut	27.8	0.318	0.35	66.2	5	1.21
1 cotton: 1 groundnut	40.0	0.439	0.46	66.9	5	1.34
1 sunflower: 1 groundnut	42.5	0.813	0.86	68.9	4	1.62
1 pigeonpea: 1 groundnut	61.2	0.650	0.78	68.5	5	1.48
Sole groundnut	84.4	1.060	1.00	69.8	5	All sole crops
SE	±1.8	±0.150	±0.21	±1.1	±0.4	
Mean	47.3	0.594	0.63	67.8	5	
CV (%)	7	44	57	3	14	

1. Scored on a 1-9 scale, where 1 = No disease, and 9 = 50-100% foliage destroyed.

Table 9. Results of groundnut weed control trial, Msekera Regional Research Station, Zambia, 1986/87.

Treatment	Actual plant density (× '000 ha^{-1})	Seed yield (t ha^{-1})	Total weed dry matter (t ha^{-1})
One weeding (45 DAS)[1]	84.4	1.403	0.867
Two weedings (20 and 45 DAS)	87.0	1.648	0.209
Weed free (20, 45, and 70 DAS)	83.1	1.547	0.165
Preemergence herbicide only	85.4	1.338	0.721
Herbicide + one weeding (45 DAS)	84.8	1.667	0.126
Control (no weeding)	74.8	0.698	1.582
SE	±1.4	±0.064	±0.120
Mean	83.3	1.384	0.611
CV (%)	3.4	9.8	39.1

1. DAS = Days after sowing.

two cereals was generally low, ranging from 30% to 35% of sole groundnut. There were no significant differences between sole or intercrop groundnut for incidence of leaf spot diseases.

Weed control

Most groundnut farmers weed their crops on one occasion -which is invariably too late—around 50-60 days after sowing (DAS). This is because of the competition for labor by maize weeding. Weed control studies with cv Chalimbana showed that one hand weeding 45 DAS resulted in doubling of yield compared with no weeding treatment. Two hand weedings at 20 and 45 DAS increased yield by 125% over no weeding (Table 9). The preemergence herbicide alachlor (Lasso 48®) combined with one hand weeding 40 to 50 DAS was equally effective. The use of preemergence herbicide will go a long way to reduce the labor competition bottleneck at weeding.

Discussion

Freire: Do you have an explanation as to why yield was higher (about 500 kg ha^{-1}) with one weeding than with two?

Kanenga: Most probably it was because of wrong time of weeding. The pods could have been formed and damaged during the weeding process.

Effect of Ridge Spacing and Plant Population on Groundnut Yield in Malawi

C.E. Maliro[1]

Abstract

Between 1962/63 and 1977/78, many spacing/population experiments were conducted in Malawi. These experiments examined groundnut yield responses to changes in plant population from varying plant spacings within the ridge. In most cases, significant yield increases were not obtained. The experiment reported here was conducted from 1979/80 to 1981/82 to examine responses to ridge spacing. The results showed that yield increases of 14-26% could be obtained through closer ridge spacing.

Sumario

Efeitos da Distancia Entre Camalhões e da População de Plantas no Rendimento do Amendoim no Maláwi. *Muitos ensaios de compassos populações foram conduzidos no Maláwi entre 1962 63 e 1977 78. Estes ensaios examinaram as respostas do rendimento do amendoim a mudanças na população de plantas, atravéz da mudança da distancia entre camalhões. Na maioria dos casos não se obtiveram aumentos de rendimento significativos. O ensaio reportado aqui, foi conduzido de 1979 80 a 1981 82, com o objectivo de examinar as respostas à distancia entre camalhões. Os resultados mostraram que, aumentos de rendimento da ordem dos 14-26% podem ser obtidos atravéz do uso de distancias entre camalhões mais pequenas.*

Introduction

The traditional plant spacing for groundnuts in Malawi "was ridges spaced at 90 cm; two rows of plants per ridge; planting stations spaced at 30 cm within the row; two seeds planted per planting station" (Malawi: Ministry of Natural Resources 1965). This traditional spacing gives a theoretical plant population of 14.81 plants m^{-2}. Groundnut yields, in response to the variations in this spacing, have been tested in Malawi from the 1962 63 cropping season. Spacing population experiments concentrated on varying between-planting-station spacing, within-ridge spacing, and number of rows per ridge (ARCM 1973, pp. 19 23, and 1974, pp. 21 23; Malawi: Department of Agriculture 1970, pp. 23 26, 1971, pp. 29 30, 1972, pp. 87 89, and 1973, pp. 96 97; Malawi: Ministry of Natural Resources 1965, pp. 28 30, and 1967, pp. 23 25). In these experiments, within-ridge spacings between 5 cm and 37 cm were tested; as well as those having 1 or 2 rows (plant populations of 4.86 29.16 plants m^{-2}).

Both runner and bunch cultivars were used in the spacing experiments; these included Mwitunde, Dixie Runner, Early Runner, Makulu Red, and Chalimbana. Other cultivars used were a local cultivar Amani, a runner (Malimba), and a spanish bunch (not specified). The trial sites spanned a wide range of ecological areas of Malawi: low altitude

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ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1989. Proceedings of the Third Regional Groundnut Workshop, 13 18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P 502 324, India: ICRISAT.

(hot and somewhat dry) to medium altitude (warm and adequate rains), and a range of light to heavy soils. These trials usually showed that yield differences (if present) were very small between in-row spacing. Only in a few trials were substantial yield differences recorded from either higher or lower populations. In one season, rosette incidence was substantially decreased with higher plant populations.

Thus, the recommended spacing became "ridges spaced at 90 cm; one row of plants ridge^{-1}; within-ridge spacing of 15 cm; one seed station^{-1}"; thus giving a theoretical plant population of 7.41 plants m^{-2}. The rationale for the new recommendation was not on yield considerations (a wide range of spacings gave similar yields) but a compromise between seed costs (7.41 plants m^{-2} to 14.81 plants m^{-2}) and rosette minimization.

In 6 of the 15 spacing experiments, 90 cm and 68.6 cm ridge spacings were compared. These showed that yield benefits could be obtained at the narrow row interval. Therefore, the objective of this experiment series was to examine yield responses to changes in interridge spacing.

Materials and Methods

The experiment was conducted at the Chitedze Research Station under rainfed conditions (Lilongwe plain) from 1979/80 to 1981/82 cropping seasons. The design was a split plot with five replications. For the first two seasons, the main plots were ridge spacings (R) at three levels (90 cm; 75 cm; and 60 cm); the subplots were three cultivars (C) (Chalimbana, a runner; E 879/6/4 (now called Chitem-

Table 1. Effect of ridge spacing on seed yield (t ha^{-1}) of three groundnut cultivars (Chalimbana, E 879/6/4, and E 885/1/4/B) at Chitedze Research Station, Malawi, 1979–82.

Ridge spacing (cm)	Chalimbana	E 879/6/4	E 885/1/4/B	Mean
		1979/80		
90	1.287	1.249	-	1.268
75	1.349	1.309	-	1.329
60	1.497	1.390	-	1.444
45	-	-	-	-
Mean	1.378	1.316		
CV (%) (main plots)	3			
CV (%) (subplots)	10			
		1980/81		
90	2.120	2.587	1.696	2.134
75	2.312	2.800	1.995	2.369
60	2.287	2.700	2.360	2.475
45	-	-	-	-
Mean	2.240	2.721	2.017	
CV (%) (main plots)	10			
CV (%) (subplots)	12			
		1981/82		
90	1.669	1.628	0.861	1.386
75	-	-	-	-
60	2.158	2.033	1.042	1.744
45	2.244	2.178	1.330	1.920
Mean	2.024	1.946	1.081	
CV (%) (main plots)	18			
CV (%) (subplots)	14			

bana), a runner; and E 885/1/4/B, a bunch). In the 1981/82 season main plots were cultivars and subplots were ridge spacings. For all treatments the intra-ridge spacing was 15 cm and there was only 1 row of plants ridge^{-1} and 1 seed hill^{-1}. Diseases were not controlled. Only in the 1979/80 season, aphids were controlled by use of dimethoate (Rogor®).

Results and Discussion

Seed yield

In the 1979/80 season, a dry spell occurred when the crop was podding and again during the second half of seed-filling period. The 1980/81 season had no serious dry spells, but the 1981/82 season had a dry spell during the mid-seed-filling period. Therefore, with respect to rainfall distribution, the three seasons could be classified as bad, good, and fair, respectively; the yields (Table 1) reflect the seasons' quality.

Swanevelder (personal communication, 1982) suggested that the relative yield advantage of close rows is likely to be higher under limiting growth conditions, such as moisture deficit and low fertility. At ICRISAT (ICRISAT 1981, pp. 168-170) it was observed that the top 10 cm soil layer, of close groundnut rows, had lower maximum soil temperature than those recorded in wider rows. This was due to more solar radiation being intercepted by leaves in narrow rows than in wide rows. Thus, in dry seasons, the fruiting zone could be kept cool and moist for a relatively longer time in narrow rows than in wide rows, thereby providing a favorable environment for pod development for a longer time. These experiments do not support Swanevelder's suggestion and the benefit expected in considering the ICRISAT experience in regard to temperature effects.

Crops with 60 cm between ridges significantly outyielded the wider ridges (Table 1). In the 1979/80 season the cultivar E 885/1/4/B was excluded from statistical analysis because of segregation for plant habit. For the bad 1979/80 and fair (1981/82) seasons the C × R interaction was not significant; as shown by the nearly parallel lines in Figure 1 (a and c). However, in the good season (1980/81) C × R interaction was almost significant ($P = 10\%$) because the runner cultivar, in 75-cm ridges gave the highest yield, while yield of the bunch cultivar was greatest for the closest ridge spacing (Fig. 1b).

The majority of the smallholder farmers in Malawi sow groundnuts 1-4 weeks after the onset of the rains. This is because groundnuts are given a lower priority relative to crops like maize and tobacco. Also fertilizer use by most farmers is minimal; hence, the fertility level of their fields is low. Thus, it should be expected that the relative yield advantages of narrow rows for Malawian farmers would always be high even for runner cultivars.

In 1980/81 and 1981/82 season, seed yield was graded into market grades used for market-price determination. There was a tendency for the premier

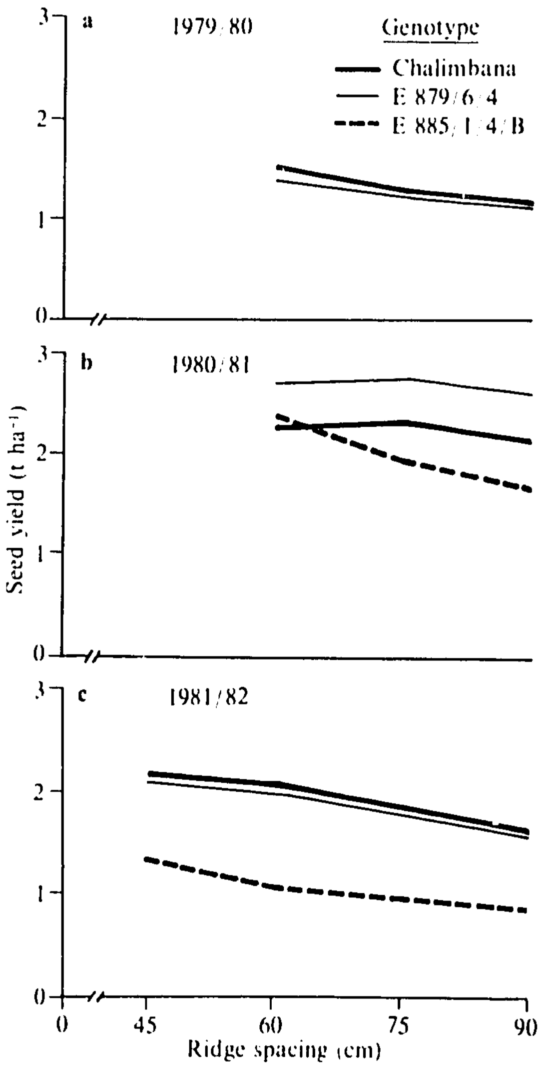

Figure 1. Effect of ridge spacing on seed yield at Chitedze Research Station, Malawi, 1979-82.

grade (GDA%) to increase with closer ridge spacing in the good (1980/81) season. However, this effect was absent in the 1981/82 (fair) season. This spacing effect associated with increase in quality groundnuts was also observed by Buchanan and Hauser (1980) with Florunner groundnuts in Georgia and Alabama, USA.

Plant population

In the good and fair seasons (1980/81 and 1981/82), the harvest (actual) plant populations were very close (at least 94%) to the planned (desired) plant populations (Table 2). However, in the bad season the actual plant populations were not very close to the planned populations (80–85%).

Other yield-related factors

Ridge spacing did not affect number of pods plant^{-1} in the bad season (1979/80). However, number of pods plant^{-1} decreased with decreased ridge spacing in both the good and fair season. In the fair season, decreased ridge spacing resulted in decreased number of pods plant^{-1}.

The 100-seed mass was not affected by ridge spac-

Table 2. Effect of ridge spacing on harvest (actual) plant population (plants m^{-2}) on three groundnut cultivars (Chalimbana, E 879/6/4, and E 885/1/4/B), Chitedze Research Station, Malawi, 1979–82.

Ridge spacing (cm)	Chalimbana	E 879/6/4	E 885/1/4/B	Mean
		1979/80		
90	6.33	6.20	-	6.265(7.41)[1](85)[2]
75	7.47	6.82	-	7.145(8.89)[1](80)[2]
60	8.89	9.17	-	9.030(11.11)[1](81)[2]
45	-	-	-	-
Mean	7.563	7.397	-	-
CV (%) (main plot)	8			
CV (%) (subplot)	6			
		1980/81		
90	7.04	7.07	6.93	7.013(95)[2]
75	8.53	8.53	8.48	8.513(96)[2]
60	10.54	10.57	10.23	10.447(94)[2]
45	-	-	-	-
Mean	8.703	8.723	8.547	
CV (%) (main plot)	3			
CV (%) (subplot)	4			
		1981/82		
90	7.25	7.14	7.25	7.215(97)[2]
75	-	-	-	-
60	11.13	10.71	10.67	10.837(98)[2]
45	14.50	14.28	14.17	14.317(14.81)[1](97)[2]
Mean	10.960	10.710	10.697	
CV (%) (main plots)	2			
CV (%) (subplots)	3			

1. Theoretical (expected) plant population.
2. Percentage of harvest (actual) population over expected population.

ing. Only in the good season and only for the bunch cultivar did shelling percentage increase with decrease in ridge spacing. Rosette-disease incidence was negligible in all three seasons of this experiment. However, from previous studies conducted in Malawi it was noted that closer spacing decreased rosette incidence.

Conclusions

These experiments have shown that closer ridge (row) spacing is a potential means of increasing groundnut yields in Malawi, and should be explored further. Although the yield advantages of close rows for runner cultivars may not be large in good seasons, these are highly unlikely since groundnuts are always planted late, hence the relative yield advantages of close rows should be appreciable on the farms.

However, there is need for economic studies on the effects of adopting 60-cm ridges for the benefit of farmers with similar management to these trials, i.e., early planting.

Before recommending 60-cm ridges to smallholder farmers, there is a need to verify these yield advantage under smallholder farmers' growing conditions in different groundnut-growing areas of Malawi.

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Effect of Plant Density on Performance of Four Groundnut Cultivars in Tanzania

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Abstract

*Groundnut (*Arachis hypogaea *L.) is mostly cultivated by small farmers as a rainfed crop. The average yields in Tanzania have been estimated at 600 kg ha⁻¹ of dried pods. The major constraints to production are low and unreliable rainfall, unadapted cultivars, low plant densities, and pests and diseases. This study was conducted at Sokoine University of Agriculture to assess cultivar and plant-density effects on groundnut yield. The results indicate that the low yields in 1987 were because of the drought experienced in the area and the unsuitable soil at the site. It is suggested that variety improvement to produce better adapted cultivars must be continued, emphasizing breeding for resistance to drought and breeding for higher yield. Thus, the physiology of drought resistance in groundnuts in relation to plant density requires further study.*

Sumário

Efeito da Densidade de Plantas no Comportamento de Quatro Cultivares do Amendoim na Tanzania. *O amendoim (Arachis hypogaea L.) é maioritariamente cultivado por pequenos agricultores como cultura de sequeiro. Os rendimentos médios, na Tanzania, foram estimados em 600 kg ha⁻¹ de vagens secas. As principais limitantes da produção são a precipitação baixa e incerta, cultivares não adaptados, baixas densidades das plantas, pragas e doenças. Este estudo foi conduzido na Universidade Agricola de Sokoine, com o objectivo de avaliar cultivares e os efeitos da densidade de plantas no rendimento do amendoim. Os resultados indicam que, os baixos rendimentos de 1987 foram resultado da seca, que se fez sentir na região, e aos solos não apropriados do local. Foi sugerido que o melhoramento varietal, para a produção de variedades melhores e adaptadas, deve ser continuado, enfatisando-se o melhoramento para a resistência à seca e para maiores rendimentos. Consequentemente, a fisiologia da resistência à seca no amendoim, em relação à densidade das plantas, requer estudos ulteriores.*

Introduction

Groundnut (*Arachis hypogaea* L.) is an important crop in Tanzania, and is widely grown in areas with an altitude below 1500 m. The most important groundnut-growing regions include Mtwara, Tobora, Shinyanga, Kigoma, and Mwanza where rainfall is between 500–1200 mm per year (Acland 1971). Total area sown to the crop in Tanzania increased from below 50 000 ha in the early 1960s to 100 000 ha in 1980 (Mwenda et al. 1985).

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Optimum plant density and good quality varieties are the key to increased groundnut productivity (Shear and Miller 1960; Enyi 1977; Yayock 1979; Tarimo 1986). This study was undertaken to investigate the effect of plant density on the performance of four groundnut varieties at Morogoro.

Materials and Methods

The trial was conducted at Sokoine University of Agriculture Farm in Morogoro region, Tanzania (6° 5′ S, 37° 37′ E) during the 1987 (March June) cropping season. The farm is 525 m above sea level with an Oxisol soil having a pH of 6.1. The site had been used for common bean (*Phaseolus vulgaris* L.) production in the previous cropping season. The four bush type cultivars included were MGC 81, MGC 91, MGC 242, and MGC 92.

The design used was a split plot with four main treatments, four subtreatments, and four replications. The main plots were cultivars and the subplots were plant densities of 20, 10, 7, and 5 plants m^{-2}. Seed was sown by hand on a flat seedbed and spaced 10 cm, 20 cm, 30 cm, and 40 cm apart depending on the plant density in rows spaced 50 cm apart. Plot size was 16 m^2. Triple superphosphate (TSP) was applied at 12 kg P ha^{-1} at sowing, and ammonium sulfate (SA) was applied at 20 kg ha^{-1}, 14 days after sowing (DAS). Foliage insects, such as webworm (*Lamprosema indica*), were controlled by using dimethoate (Rogor 40EC®) at 800 g a.i. ha^{-1}. Termites (*Microtermes* spp) were controlled by Toxadrin® 40WP at a rate of 4 kg ha^{-1}. The trial was kept weed-free throughout the growing season.

Results and Discussion

As the yields were low and the coefficient of variation generally high, the experiments need to be repeated. The results of the experiments were as follows:

a. The plant densities were below the expected average value of 11 plants m^{-2} and yield values were also below average. The low yields were mainly because of poor crop emergence and establishment because of the drought experienced during the growing season. Soil type may also have presented difficulties in penetration of the peg.

b. There were substantial variations among the varieties seed yield components. The number of pods plant^{-1} were less than 50% of the pegs formed per plant. Similar results have been observed by other researchers at Sokoine University Farm.

c. The number of pods plant^{-1} decreased with increasing plant density.

d. Number of seeds pod^{-1} did not differ significantly among cultivars or densities. Lack of significance could be attributed to the fact that this characteristic is not markedly affected by environmental factors.

e. The seed size was significantly different among cultivars, but not among the plant densities.

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Effect of Time of Weeding on Groundnut Yield[1]

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Abstract

A field experiment was carried out to determine the optimum weeding regime using three groundnut genotypes—MGC 81, MGC 96, and a locally available cultivar from the market (MM)—in competition with natural weed population. Weeding done within the first 6 weeks, either once at 4 or 6 weeks or twice at 2 and 4 weeks after groundnut emergence, had no detrimental effect on groundnut seed yield. Weed infestation beyond the first 6 weeks reduced yields by about 46% for MGC 81, 47% for MGC 96, and 55% for MM compared with weed-free plots. Regardless of the weeding regimes under consideration, MGC 81 gave consistently higher yields, compared with MGC 96 and MM, which was ascribed to its efficient pod filling and large seed. Increasing periods of weed infestation increased weed dry mass at the expense of groundnut yield.

Sumário

Efeito da Data de Capina no Rendimento do Amendoim. *Um ensaio de campo foi conduzido para determinar o regime óptimo de capina, usando três genótipos de amendoim MGC 81, MGC 96 e um cultivar local disponível no mercado (MM) em competição com populações naturais de infestantes. A capina feita durante as primeiras 6 semanas, tanto uma vez na quarta ou sexta semana, ou duas vezes nas segunda e quarta semanas depois da emergência do amendoim, não tiveram efeito negativo no rendimento de sementes de amendoim. Contaminação com infestantes, para além das primeiras 6 semanas, reduziram os rendimentos em cerca de 46% para o MGC 81, 47% para o MGC 96 e 55% para o MM, quando comparados com os talhões livres de infestantes. Independentemente dos regimes de capina considerados, MGC 81 produziu rendimentos consistentemente maiores, quando comparado com o MGC 96 ou o MM, o que foi atribuido ao seu eficiente enchimento de vagens e às sementes grandes. Aumentando os periodos de infestação, aumentou-se a massa seca de infestantes, à custa do rendimento de amendoim.*

Introduction

One of the main problems facing small-scale farmers engaged in groundnut production in many developing countries is increased losses because of weeds (Benson 1982; Deat 1982; and Koch et al. 1982). Studies on critical periods of weed competition have reported varied results, such as 45 days after sowing (Rajan et al. 1982) and 15–45 days after sowing (Naidu et al. 1985). Raghvani et al. (1984) reported the need to weed groundnuts at 15, 30, 45, and 60 days after sowing to maximize yields and net returns. In USA, Hill and Santelmann (1969)

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reported that groundnuts kept weed-free for 6 weeks after planting experienced no yield loss from weeds emerging later.

On the other hand, uncontrolled weed growth has been reported to cause yield losses of at least 50% under irrigation in Libya (Omran 1961) and up to 70% in the Sudan (Drennan and Jennings 1977) and were as high as 63–88% under rainfed cultivation in the Sudan (Deat 1982).

The results reported here were recorded from a study to evaluate the competitive ability of three groundnut varieties against a natural weed population; and to determine the optimum weeding regime for maximizing seed yield.

Materials and Methods

A field experiment was conducted at Sokoine University of Agriculture (Morogoro) during the 1986 and 1987 February-June rainy season. Groundnut genotypes MGC 81 (I/94) and MGC 96 (Starr), which are both bunch types, and ex-Morogoro market (MM), a spreading type, were used. The experiment contained split plots in a randomized complete-block design with four replications. Groundnut varieties were assigned to the main plots and eight weeding regimes (subplots) were tested on each of the varieties. Control plots consisted of weed-free and weed-infested plots up to the time of harvest. The treatments are summarized in Table 1.

Plot size for the subplot treatments was 3 m × 2.5 m. Sowing was done at the end of February 1986 and the beginning of April 1987. One seed hill^{-1} was sown by hand in 50-cm rows while maintaining a within-row spacing of 10 cm to give a plant population of 200 000 plants ha^{-1}. Triple superphosphate (46% P_2O_5) at 50 kg ha^{-1} was applied on the crop row before sowing. Weeding between rows was done using hand hoes and weeds on the crop row were pulled out by hand.

The following variables, amongst others, were recorded from within the 3.75 m^2 harvest area, which comprised the three middle rows, leaving 0.5 m at either end:

1. Weed composition,
2. Dry mass of weed top growth before (groundnut) harvesting,
3. Dry mass of groundnut shoots,
4. Groundnut seed yield,
5. Number of pods plant^{-1}, and 6. 100-seed mass.

Table 1. Summary of eight subplot treatments at the time of weeding experiment, Morogoro, Tanzania, rainy seasons 1986 and 1987.

Treatment (weeding regime)	Designation
Weed-free throughout	Weeded control[1]
Weed-infested throughout	Unweeded control
One weeding at 2 weeks	2 WAE[2]
One weeding at 4 weeks	4 WAE
Two weedings at 2 and 4 weeks	2, 4 WAE
One weeding at 6 weeks	6 WAE
Two weedings at 6 and 8 weeks	6, 8 WAE
Two weedings at 8 and 10 weeks	8, 10 WAE

1. Achieved by weeding at 2, 4, and 6 weeks after groundnut emergence.
2. WAE = Weeks after emergence of groundnuts.

Results and Discussion

Weed composition and dry mass

The weed population consisted predominantly of broadleaf types, estimated at about 83% of the population in 1986, and about 69% of the population in 1987. The weed species present in the experimental area are listed in Table 2. Actual weed counts are not presented here.

Table 2. Weed species in the experimental area, Morogoro, Tanzania, rainy seasons 1986 and 1987.

Broadleaf
- *Ageratum conyzoides* L.
- *Launaea cornuta* (Oliv and Hiern) C. Jeffrey
- *Commelina benghalensis* L.
- *Tridax procumbens* L.
- *Trichodesma zeylanicum* (Burm. f.) R. Br.
- *Achyranthes aspera* L.
- *Eurphobia hirta* L.
- *Amaranthus dubius* Mart.
- *Oxygonum sinuatum* (Hochst, and Stend, and Meisn) Dammer

Grass
- *Cyperus rotundus* L
- *Rottboellia cochinchinensis* (Lour.) Clayton
- *Echinochloa colora* L.
- *Panicum maximum* Jacq.
- *Eleusine indica* (L.) Gaertn.
- *Cynodon nlemfuensis* Vanderyst

For two genotypes and the market sample in both seasons, weed dry-matter yields were highest for unweeded plots. There was no significant difference in weed suppression between varieties but plots weeded once at 2 weeks after emergence (WAE), 4 WAE or twice at 2 WAE, 4 WAE had very little subsequent weed growth resulting in the lowest dry masses that were comparable to the weeded control plots (Table 3). Under conditions of limited moisture (1987) weeds thrived better than groundnuts, producing dry-matter yields that were higher than those recorded under adequate rainfall (1986) for most of weeding regimes. This is an indicator of the greater efficiency of weeds in utilizing growth resources compared to groundnuts.

Table 3. Weed dry masses (t ha^{-1}) harvested from treatments at the time of weeding experiment, Morogoro, Tanzania, rainy seasons 1986 and 1987.

Weeding regime	Variety			Marginal mean
	MGC 81	MGC 96	MM	
	1986			
Weeded control	0.0	0.0	0.0	0.0 a[1]
Unweeded control	59.4	67.4	70.8	65.8 d
2 WAE[2]	0.4	0.3	0.4	0.4 a
4 WAE	0.6	0.6	0.6	0.6 a
2, 4 WAE	0.7	0.3	0.2	0.4 a
6 WAE	15.9	16.2	16.1	16.1 b
6, 8 WAE	15.2	17.6	14.5	15.8 b
8, 10 WAE	18.5	22.7	29.4	23.5 c
Mean	13.8	15.6	16.5	
	1987			
Weeded control	0.0	0.0	0.0	0.0 d[1]
Unweeded control	49.5	72.6	44.6	55.6 a
2 WAE	0.4	0.7	0.7	0.6 d
4 WAE	1.8	3.7	4.4	3.3 d
2, 4 WAE	0.9	0.7	0.5	0.7 d
6 WAE	15.1	18.3	16.8	16.7 cd
6, 8 WAE	21.2	29.6	16.2	22.3 bc
8, 10 WAE	23.4	33.4	29.4	28.7 b
Mean	14.1 a[3]	19.9 a	14.1 a	

1, 3. Means followed by the same letter do not differ significantly ($P < 0.05$), according to Duncan's Multiple Range Test.
2. WAE = Weeks after emergence.

Seed yield and yield components

Seed yield could be assessed only during the 1986 rainy season. Because of insufficient rainfall during the 1987 season (Table 4) the experiment was terminated 12 WAE and performance was assessed by determing the dry mass of groundnut top growth.

During the 1986 rainy season, MGC 81 gave consistently high yields followed by MGC 96 and MM, in that order, for all the weeding regimes tested (Table 5). Weeded controls gave the highest seed yields while unweeded controls gave the lowest seed yields for all genotypes, clearly demonstrating the concept of economic yield replacement by weed dry matter production. Where the trend was clear, as was the case for MGC 81, weeding once at 4 WAE or 6 WAE or twice at 2 and 4 WAE gave yields similar to those obtained under weed-free conditions. Therefore, a weed-free period between the 2nd and 6th weeks after groundnut emergence was found necessary to maintain high yields. This trend was also evident in 1987 when groundnut dry-matter production was assessed instead of yield (Table 6). Similar results have been reported elsewhere (Hill and Santelmann 1969, 1969; Raghvani et al. 1984). In this study, where weeding was not done by the 6th week, tall-statured weeds such as *Rottboellia cochinchinensis*, *Euphorbia hirta*, and *Panicum maximum* completely shaded groundnuts, thereby inhibiting branching, pegging, and general development.

Though weed dry-matter production was not significantly different between varieties, the results suggest that MGC 81 has a higher-yielding potential

Table 4. Rainfall distribution at Morogoro[1], Tanzania, rainy seasons 1986 and 1987.

Month	Total rainfall (mm)	
	1986	1987
February	70.1	-
March	155.5	-
April	143.7	108.2
May	157.7	132.7
June	11.4	Trace
July	-	4.0

1. Meteorological Station Records, Sokoine University of Agriculture, Morogoro, Tanzania.

Table 5. Groundnut seed yield (t ha⁻¹) for different weeding regimes, Morogoro, Tanzania, rainy season 1986.

Weeding regime	Variety MGC 81	MGC 96	MM	Mean
Weeded control	1.128 b[1]	0.895 b	0.815 a	0.946
Unweeded control	0.213 a	0.170 a	0.245 a	0.209
2 WAE[2]	0.695 ab	0.688 ab	0.558 a	0.647
4 WAE	1.030 b	0.735 ab	0.658 a	0.808
2, 4 WAE	1.260 b	0.720 ab	0.528 a	0.836
6 WAE	1.170 b	0.830 ab	0.440 a	0.813
6, 8 WAE	0.738 ab	0.720 ab	0.698 a	0.718
8, 10 WAE	0.605 ab	0.475 ab	0.365 a	0.482
Mean	0.855	0.654	0.538	

1. Means in the main body of the table followed by the same letter do not differ significantly ($P < 0.05$), according to Duncan's Multiple Range Test.
2. WAE = Weeks after emergence.

(Table 5) and that both MGC 81 and MGC 96 were slightly more competitive against weeds than MM. The latter is indicated by the extent of yield loss recorded when the first weeding was delayed to the 8th WAE. This resulted in average yield reductions of about 46% for MGC 81, 47% for MGC 96, and 55% for MM, compared with weed-free plots. Yield losses of this magnitude (Omran 1961) and higher (Drennan and Jennings 1977) have been reported in other studies. Pod production plant⁻¹ was highest when plots were kept weed-free throughout the season (averaging 27 pods for MGC 96, 21 pods for MGC 81, and 14 pods for MM) and was significantly reduced if plots were not weeded at all. Generally, pod production did not show any consistent relationship with increasing periods of weed infestation prior to the first weeding. However, weeding done 6 WAE or later generally decreased pod production, seed yield plant⁻¹, and 100-seed mass. The higher yield recorded for MGC 81 could be ascribed to its higher yield potential and possibly its competitiveness resulting in a higher proportion of filled pods and larger seed size (Table 7) compared with MGC 96 and MM.

Table 6. Effect of weeding regimes on top growth dry matter yield (t ha⁻¹) of three groundnut varieties, Morogoro, Tanzania, rainy season 1987.

Weeding regime	Variety MGC 81	MGC 96	MM	Mean
Weeded control	2.4	2.6	2.4	2.5 a[1]
Unweeded control	1.2	1.1	1.5	1.3 b
2 WAE[2]	1.8	1.7	1.9	1.8 ab
4 WAE	1.3	1.7	1.8	1.6 b
2, 4 WAE	1.6	2.1	2.1	1.9 ab
6 WAE	2.1	1.0	1.9	2.0 ab
6, 8 WAE	1.4	1.1	1.6	1.4 b
8, 10 WAE	1.8	1.4	1.6	1.6 b
Mean	1.7[3]	1.7 a	1.9 a	

1, 3. Marginal means followed by the same letters do not differ ($P < 0.05$) significantly, according to Duncan's Multiple Range Test.
2. WAE = Weeks after emergence.

Table 7. Yield components for three groundnut varieties, time of weeding trials, Morogoro, Tanzania, rainy season 1986.

Yield component	Range of values		
	MGC 81	MGC 96	MM
Average number of pods plant^{-1}	8–21	6–27	7–15
Seed yield plant^{-1} (g)	5.7–25.2	5.3–22.0	5.4–[illegible]0.8
100-seed mass (g)	43.8–49.6	34.7–44.5	37.6–48.3

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Discussion

Maliro: You said that with higher plant population, weeding might be difficult for farmers. Some published work has shown less weed trouble with higher plant populations (crop quickly smothers the weeds).

Rweyemamu: I agree. But high plant population does not result in economic weed control of the crop. Whatever high plant population is used, weeding is still required especially in the early days of the crop growth.

Sithanantham: Do the findings on the timing of weeding relate favorably with farmers' present practices or do they have potential for adoption by farmers in your region?

Rweyemamu: I cannot comfortably comment on favorable time for farmers to weed groundnuts. This is because we have not done on-farm trials. However, under Farming Systems Research Project at Sokoine University of Agriculture, such studies have been initiated. On the effect of plant population, farmers complain that with high plant population (which is relative) weeding becomes a problem. This is because farmers have to spend more time in weeding than when the crop is grown under low plant populations.

The Oilcrops Network: the Past, The Present, and the Future

A. Omran[1]

Abstract

The objectives and achievements of the Oilcrops Network during Phase I (1981-84) and Phase II (1984-87) are outlined. Presently, the Network supports the Ethiopian Oilcrops Program; receives oilcrops germplasm; multiplies germplasm in Ethiopia and dispatches germplasm to member countries. The Network ensures flow of relevant information and helps coordinate training of technicians working on oilseeds. The paper projects the future activities of the Network including the proposal to develop an International Oilcrops Research Unit.

Sumário

A Rede de Culturas Oleaginosas: O Passado, O Presente e O Futuro. *Os objectivos e realizações da Rede de Culturas Oleaginosas, durante a Fase I (1981-84) e Fase II (1984-87), são delineados. Presentemente, a rede suporta o programa de oleaginosas etíope, recebe germoplasma de oleaginosas, multiplica germoplasma na Etiopia e envia germoplasma para os países membros. A rede assegura o fluxo de informação importante e apoia a coordenação do treino de técnicos trabalhando em oleaginosas. O artigo projecta as futuras actividades da rede, incluindo a proposta de desenvolvimento de uma Unidade Internacional de Investigação de Oleaginosas.*

The Past (What Was)

Edible oilseeds rank second in importance among food crops after cereals. However, they have been largely neglected by the international scientific community. Soybean and groundnut received notable attention. Sunflower, rapeseed, and cottonseed received moderate attention. The third group (sesame, safflower, niger seed, castor, and linseed) received little attention from developed as well as developing countries. This third group comprise key crops for millions of small-scale farming families in developing countries.

Recognizing this situation, International Development Research Centre (IDRC) devoted considerable efforts in support of national programs on annual edible oilcrops in the People's Republic of China, Sri Lanka, India, Pakistan, Egypt, Ethiopia, Sudan, Tanzania, Malawi, and Mozambique. It was realized that there could be considerable benefit from linking the efforts of the various projects into a research network. Thus, IDRC took the lead in establishing this international Oilcrops Network for scientists in eastern Africa and South Asia. After two phases of hard work, the Network is beginning to achieve many of the original objectives. Contacts among scientists in the IDRC-supported oilseed projects are established through the newsletter, the workshop, and a few visits between the scientists. However, many scientists in self-supported national projects are still working in remote stations facing

1. Network Coordinator, IDRC Oilcrops Network for East Africa and South Asia, P.O. Box 2003, Addis Ababa, Ethiopia.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1989. Proceedings of the Third Regional Groundnut Workshop, 13-18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P 502 324, India: ICRISAT.

scientific as well as psychological problems of isolation.

The concept of the Network began to reach these isolated scientists and the response was great. The Network Advisor/Coordinator visited many of these scientists in remote stations. Scientists there began to feel that they were part of the world again. They started contacting, through the Network, their colleagues in the same disciplines and working elsewhere on the same crops.

The Network participants started to realize that this is their Network. The Advisor is trying to encourage and guide the young scientists and they have now a strong voice in the workshops and the newsletter. Most of the Advisor's activities begin from the participants' recommendations.

Objectives of Phase I (1981-84)

The general objective of Phase I was to establish effective, practical liaison between the IDRC oilseeds projects in India, Pakistan, eastern Africa, Egypt, the Sudan, Ethiopia, and Sri Lanka; assisting meanwhile in the Ethiopian oilseeds projects.

Achievements of Phase I

The Network Advisor helped in the development and start-up of the Ethiopian Highland Oil Crops Project (Niger seed, linseed, rapeseed with related *Brassica* sp, and sunflower) until it was firmly under the direction and control of the Project Leader. The Advisor then continued as a plant breeder in aspects of the project as the Project Leader saw fit. The Advisor helped also in the formulation and start-up of the Ethiopian Lowland Oil Crops Project (groundnuts, sesame, safflower, and castor) and participated in the collection of Ethiopian germplasm.

An oilcrops library was developed, and computer references on oil crops are being regularly received.

The Advisor visited every project in the Network at least once a year, established correspondence with the Project Leaders, and provided critical, helpful, and encouraging comments on the annual reports of each project. Exchange visits between project scientists were started, and visits by consultants and specialists to many projects were arranged. Visits for oil crops project scientists in International Agricultural Research Centers (IARCs), and a strong oilseeds research program in other countries, were arranged.

An Oilcrops Workshop was held in Cairo, 3-8 Sep 1983, for the Project Leaders. Four specialists on sesame, sunflower, groundnut, and *Brassica* oilcrops also attended. The value of this workshop was recognized by all participants.

Objectives of Phase II (1984-87)

The general objectives remained as for Phase I. The emphasis shifted from establishing the Network to servicing and operating the Network. Specifically, the Project Advisor aimed to continue working with the Ethiopian Highland and Lowland Oil Crops Projects, to visit each project of the Network, to keep program officers in good touch with the situation, to publish an annual newsletter, to arrange for interchange of visits between scientists, to help in germplasm exchange, and to organize small workshops.

Achievements of Phase II

The Advisor was continuously helping the research activities of the Ethiopian Lowland and Highland Oilcrops and offered courses in statistics/experimental design to research officers/technicians of Institutes of Agricultural Research and to graduate students of Alemaya University of Agricultural Sciences.

The Network distributed cover pages of the most important international journals to all stations and sent back photocopies of requested papers for oilseed and nonoilseed crops. Also, computer printouts of references, abstracts, and papers for the use of oilseeds researchers were arranged and classified.

The Network, with the help of the IDRC program officers concerned, arranged a consultancy (Dr Hugh Doggett) for Ethiopia, the Sudan, Egypt, Nepal to advise and assess the project developments.

The Network helped to link together scientists from different projects who share the same crops and same problems; a visit of Dr Thangavelu (sesame, India) with Mr Yebio Wodemariam (lowland oil crops, Ethiopia) and Dr H. Ishag (oilseeds, Sudan) proved very fruitful in strengthening the links.

The Program Officer responsible for the Network in India arranged a visit for Dr Sawant (safflower, India) to visit safflower work in USA, Mexico, and Spain.

The Network contributed to a cooperative program with Agriculture Canada (Anther Culture Project) by sending the Network assistant and an Indian professor to work on the project for 2 years.

The Advisor visited non-IDRC supported projects and helped secure small research grants to ease the bottlenecks in ongoing research (Tanzania), to start germplasm collections (Somalia), and to help organize a National Oilseed Workshop (Kenya).

The Network organized a training course in India on sesame safflower for 15 junior research assistants/technicians from Africa and Asia. The Advisor participated in teaching and coordinated the course; with the Directorate of Oilseeds Research, Hyderabad.

Workshops. The Advisor coordinated two workshops and edited the proceedings, which were published in IDRC Manuscript Reports:

1. Second workshop held in February 1985 at Hyderabad, India, with participants from India, Ethiopia, Nepal, Sudan, Uganda, and Tanzania, with guest speakers from UK, Canada, USA, and the Philippines (IDRC-MR 105e).
2. Third workshop held in October 1986 at Addis Ababa, Ethiopia, with participants from Ethiopia, Egypt, the Sudan, India, Nepal, Pakistan, and the People's Republic of China, with guest speakers from Canada, UK, and Sweden.

Oilcrops Newsletter. The Advisor edited and published four issues: 1984, 1985, 1986, and 1987. More than 600 copies from each issue were dispatched to oilseeds workers around the globe.

The Present and Immediate Future (What Is and Will Be)

National program support

The Advisor will continue to devote 30–40% of his time working with the Ethiopian oilcrops program. More emphasis will go to supporting the lowland oilcrops and sunflower programs.

The Advisor will review annual technical reports from projects, and visit programs regularly to keep in touch with and discuss oilcrop improvement programs with the national oilcrops scientists.

More emphasis will be given to interacting with programs that do not have IDRC support.

In collaboration with the IDRC Program Officer, the Advisor will pursue possible further IDRC support for national programs. Where necessary, National Program Support funds will be allocated from the Project.

National scientists will be encouraged to visit each others' projects. The use of consultants from the Network region will be considered.

Germplasm exchange

The dialogue between Indian and Ethiopian germplasm officials will be followed up by the Advisor to ensure that bilateral exchange continues between these two countries.

Other network countries, with fewer constraints to exchanging germplasm, will be encouraged to exchange on a bilateral basis.

The collaborative nursery, as recommended at the third workshop, will be instituted using Ethiopia as a base for receiving the seed samples and distribution of the nursery. So far, only the following seed has been received:

- Niger seed from Ethiopia (Asmara) and Nepal,
- Sesame from Somalia, Nepal, Sri Lanka, the Philippines, Egypt, and the Food and Agriculture Organization of the United Nations (FAO),
- Groundnut from Nepal,
- *Brassica* from Nepal, Sweden, and India,
- Linseed from Nepal, and
- Safflower from Egypt.

The process of the nursery receipt and dispatch will be continuous. In some cases, seed will need to be multiplied in Ethiopia before dispatch. All Network members are now urged to participate.

The feasibility of three-way germplasm exchange, with a third country such as Canada involved to ensure that mutual and fair exchange occurs, will be pursued.

Information

The Network Advisor will ensure that flow of relevant information continues. This includes:

- compiling the annual Oilcrops Newsletter, in association with FAO,

- making sure that national programs receive oilseeds abstracts, computer profiles, and searches when needed,
- organizing a workshop at 1-2 year intervals,
- the books and journals received by the network will be reviewed for relevant articles for distribution,
- a multiauthored monograph on Niger seed, possibly followed by sesame or safflower monographs will be organized by the Network Advisor, and
- a bibliography on sesame diseases is negotiated for publication in 1988.

Training

- There will be emphasis on developing oilseed technician training. Training in one or more countries at a time, training of trainers as well as training in a single crop will be considered. The trainees at the recently concluded training in Hyderabad recommended a longer duration with more time for practical field-based training. This will be considered for the next training courses.
- The oilseed projects are advised as to where to send their trainees. Sudan needs to train one or two researchers for farming systems in Zimbabwe. Ethiopia needs to train the sunflower breeder; Canada is suggested as a possible place of training.
- As recommended by the *Brassica* Committee, Madam Zhang Yan suggested a training on quality in China. I handed this over to the Chairman and we think it can be done in 1988 because of the high cost which needs a special budget. More details will be presented by the *Brassica* Subnetwork Chairman.

ing this 4th Workshop:

1. Sesame Subnetwork (already formed Jan 1988)
2. Sunflower Subnetwork (already formed Jan 1988)
3. Other-oilcrops Subnetwork (linseed, Niger seed, safflower, castor) to be formed during or after the Sunflower Conference, India, 1989.

The four subcommittees can decide their activities and meetings. It is suggested that each can meet once a year and that the chairman and cochairman participate in the common Workshops with selected members from each subcommittee as relevant to the workshop themselves.

The sunflower Subnetwork can suggest that certain member countries be supported to attend the 12th International Sunflower Conference (Yugoslavia, 25-29 Jul 1988) to establish relations and coordination with the sunflower associations and to publish sunflower research papers/articles in 'Helia' and a sunflower year book.

The steering committee of the Network will include 10 members as follows:

2 members (Chairman and Cochairman of *Brassica* subcommittee)
2 members (Chairman and Cochairman of sesame subcommittee)
2 members (Chairman and Cochairman of sunflower subcommittee)
2 members (Chairman and Cochairman of other-crops subcommittee)
1 member (Network Advisor as General Secretary)
1 member (IDRC program officer responsible for the Network)

The Network Steering Committee can meet once between each of the two workshops. So the first meeting will be at the end of 4th Workshop in Kenya and the second before the end of 1988.

New network forms and activities

Several new approaches and activities were recommended at the Third Oilseeds Workshop. The following proposals were subject to discussions by the participants of the 4th Workshop held in Kenya, 25-29 Jan 1988.

Oilcrops Committees. Similar to the *Brassica* Subnetwork, it is suggested that the following three similar Subnetworks be discussed and formed dur-

Collaboration with FAO. FAO agreed to merge the "Oilcrops Newsletter" with their "Sesame and Safflower Newsletter". Dr Pineda and the Network Advisor will coordinate the collection of material and discuss the ways of publication to ensure wider distribution. For the present, articles on sesame or safflower should be forwarded to the FAO Newsletter.

FAO is formulating an international sesame project. The main objective is to support sesame-producing countries in their efforts to improve the agricultural production and the socioeconomic status of their populations through sesame improvement. The project aims at strengthening national institutes, building strong genetic basis for sesame, and building an efficient network for information and material exchange. Negotiations are going on between IDRC and FAO on how this project and the proposed Unit (described below) can be collaborated.

The Far Future or Maybe Phase IV of the Network. With the establishment of the Network Steering Committee and the four Subnetworks, the activities will be better organized. The project can be attached to the proposed Oilseeds Unit as a satisfactory base for the Network and to help the Unit in their regional activities. The Advisor can participate in research as a member of the Unit.

The Proposed Unit

As mentioned earlier, some oilcrops are receiving considerable attention from international organizations: these are oilcrops such as groundnut (International Crops Research Institute for the Semi-Arid Tropics) and soybean (International Soybean Program and International Institute of Tropical Agriculture). Oilcrops that are receiving moderate attention are those such as rapeseed/mustard (GCIRC) and sunflower (International Sunflower Association of Australia and of FAO). Yet some crops are receiving little or no attention such as sesame, linseed, Niger seed, safflower, and castor.

IDRC contacted several donors who showed interest. Then IDRC thought of building a nucleus for an International Oilcrops Research Unit. The objective is to develop a small, flexible, multidonor-supported research unit to provide scientific and technical back-stopping and coordination to researchers primarily in eastern and southern Africa and South Asia working on annual oilcrops.

Initially the Unit would concentrate its research activities on sesame, then Niger seed, sunflower, safflower, and others. Support for these, and other annual oilcrops will expand as additional resources become available.

In addition to the Coordinator, the Unit will comprise, initially, a full-time breeder and a postdoctoral fellow. Other positions, supported by additional donors, will be added later. The Unit would also employ short- and medium-term consultants.

The initial efforts will be:

a. To screen germplasm and to generate more variability for national projects;
b. To incorporate important resistances into good national material;
c. To distribute nurseries for testing, including to NGOs, where appropriate;
d. To develop male-steriles and breeding populations, and assess the practicability of hybrids in due course;
e. To develop and use tissue-culture technology as needed to facilitate the above;
f. To study the possibility of resistance breeding against *Orobanche* and *Cuscuta*; and
g. Training, one of the main activities, once the Unit is well established.

Appendixes

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Field Visits

Farmers' Fields and Chitala Research Station

The workshop participants spent Wednesday 16 March in the fields. They first visited smallholder farms in Lilongwe Agricultural Development Division. This administrative area includes the Lilongwe Plain (1100–1200 m altitude), which produces 70% of the Malawi groundnut crop, and where standards of farm management are generally good. The main variety grown is Chalimbana. The participants were shown several well-maintained fields where farmers had applied chlorothalonil (Daconil®) to control early leaf spot (ELS); in one field, the farmer had sprayed half the area, and comparisons could be made. The control of ELS was good. In view of the stimulating paper on the economics of ELS control by smallholders, interest was great and the farmers were asked many questions.

The participants then proceeded to the Chitala Agricultural Research Station, situated at about 600 m altitude in the Rift Valley. Here, warmer conditions prevail and the dominant foliar diseases are late leaf spot and rust. Because of heavy rain the participants were unfortunately unable to visit the Malawi national program or regional program experiments.

After lunch at the Farmers' Training Institute, the group visited many farmers' fields in the Chinguluwe Settlement Scheme. These fields were of particular interest, as they were sites of ongoing experiments concerned with economic evaluation of fungicidal control of foliar diseases and application of fertilizers in smallholder systems. Disease incidence in non-sprayed control areas of the fields was very low, but routine application of fungicide had nontheless been made. In general, the participants were critical of experiments where applications were made in apparent disregard of disease development. The discussions were lively.

The group ended the afternoon with tea at the Livingstonia Beach Hotel, on the shores of a tranquil Lake Malawi.

Chitedze Research Station

The workshop spent the morning of Thursday 17 March visiting the experimental fields of the Malawi national program and the SADCC/ICRISAT Regional Groundnut Improvement Program. Participants were shown the ICRISAT rosette disease nursery, where F_3s were being screened for resistance, the F_2 generation of ELS-tolerant intercrosses, and crop-loss experiments involving groundnut rosette assistor virus and groundnut streak necrosis disease.

The Malawi national team demonstrated their experiments in agronomy and pathology, and the group was given a resumé of the breeding program. The participants were given an overview of the ICRISAT field trials, and they returned to the waiting buses in time to avoid a torrential downpour of rain.

Recommendations of the Meeting

Chairpersons:
Dr D.L. Cole
Dr P.K. Sibale
Dr M.J. Mulila
Dr S. Sithanantham

Rapporteurs:
Dr S.N. Nigam
Dr J.A. Wightman

1. The meeting recommended that facilities for quality-factor analysis, particularly for oil and protein, be set up at the SADCC/ICRISAT Regional Groundnut Improvement Program for Southern Africa. The meeting further recommended that a position of a technician rather than a research assistant be created to carry out routine analysis work in assisting the national programs.
2. The meeting felt a strong need for financial assistance to national programs in purchasing equipment and expendable items needed in operations involving the regional yield trials. The Southern African Centre for Cooperation in Agricultural Research (SACCAR) suggested that scientists of national programs submit their proposals to SACCAR for possible financial assistance.
3. The meeting expressed its dissatisfaction with the contents of the training course at ICRISAT Center for technicians. The meeting suggested that this training be crop based. The meeting also felt that the age limit of 40 years for trainees is restrictive and precludes some fine technicians.

   The meeting further suggested that ICRISAT should publish a book on groundnut breeding on the lines of the existing book on sorghum breeding.

   The meeting also suggested that the SADCC/ICRISAT Regional Groundnut Improvement Program for Southern Africa should sponsor postgraduate training of research scientists.

4a. **Drought**: The meeting recognized the importance of making available drought resistant/tolerant material across the southern Africa region.

b. **Earliness**: The meeting noted that Lesotho, Botswana, and Mozambique, in particular required 90-day varieties. The meeting suggested that the SADCC/ICRISAT Regional Groundnut Improvement Program for Southern Africa attach high priority to breeding for earliness.

c. **'Pops'**: The meeting recognized the need to commence work on the 'pops' problem and urged the SADCC/ICRISAT Regional Groundnut Improvement Program for Southern Africa to screen its trials materials in problem areas so that tolerant/resistant material might be identified.

d. **Early Leaf Spot**: The meeting considered that the work on screening and development of early leaf spot resistant varieties be intensified in the SADCC/ICRISAT Regional Groundnut Improvement Program for Southern Africa. The meeting also felt that material of southern-African origin be made available from ICRISAT Center for re-evaluation at two sites in the southern Africa region.

e. **Breeding**: The national-program breeders requested that the SADCC/ICRISAT Regional Groundnut Improvement Program for Southern Africa prepare a list of all crosses available; clarify the purpose for which the crosses were made; and circulate this information to national programs.

5. The meeting felt that the workshop and group tours should be rotated among SADCC countries, a proposal endorsed by SACCAR. However, the meeting appreciated the problems of logistics and organization, associated with workshops and tours.
6. The meeting stressed the need for short-term consultancies by ICRISAT Center scientists. The meeting requested that the regional program arrange such consultancies, as necessary.

   The Botswana national program specifically wanted the services of a physiologist to assess the effect of low night temperature on groundnut.

   The meeting recommended that the ICRISAT Principal Groundnut Physiologist evaluate the performances of ICRISAT drought-resistant material in southern Africa during the 1989/90 season. The national programs agreed to plant the germplasm, to be sent by ICRISAT Center in advance for this evaluation.

   The Tanzanian national program requested the services of a cropping-systems scientist to advise generally on research associated with intercropping.

7. The meeting considered that additional research staff to the SADCC/ICRISAT Regional Groundnut Improvement Program for Southern Africa should consist of, in order of priority, a breeder, a pathologist (mycologist), and an entomologist. The meeting saw no need for a regional program agronomist.

   The meeting felt that the mycologist should direct attention to epidemiology and management of early leaf spot.

   Recent pest surveys by ICRISAT staff in southern Africa and the concomitant need for training in groundnut entomology indicated the need for a regional entomologist. One of the functions of the entomologist, the meeting noted, would be to plan and collate pest surveys. The meeting felt that the continuing need for this position be reviewed after 3 years.

8. The meeting recommended that the SADCC/ICRISAT Regional Program survey the requirements of the national programs for routine detection of aflatoxins.

9. The meeting recommended that ICRISAT consider the construction of self-contained flatlets at Chitedze Research Station for visiting scientists.

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