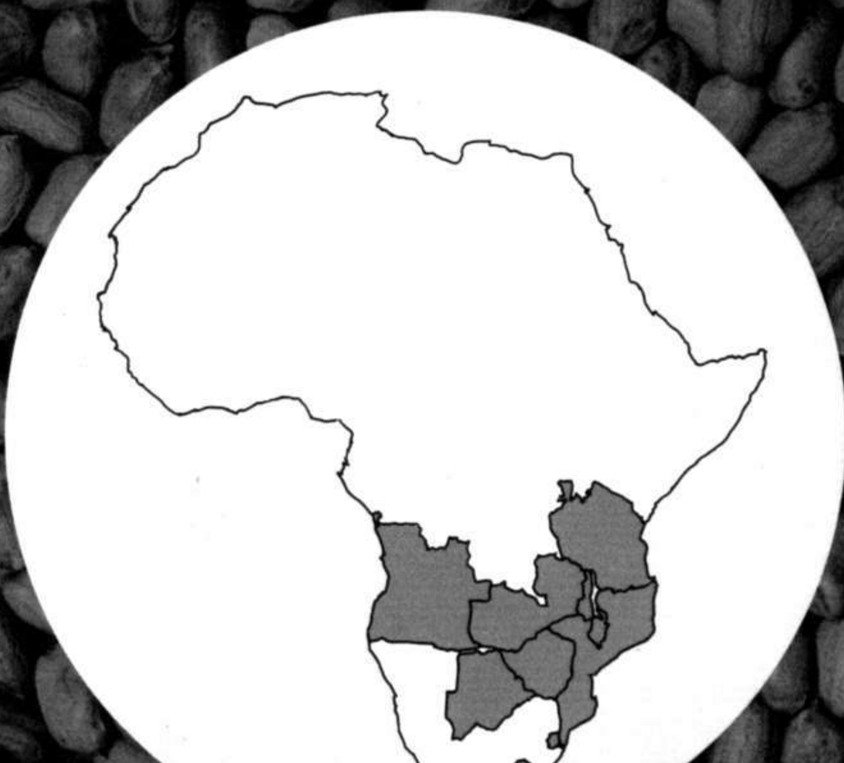
Proceedings of the

Regional Groundnut Workshop for Southern Africa



International Crops Research Institute for the Semi-Arid Tropics

Proceedings of the Regional Groundnut Workshop for Southern Africa

26-29 March 1984
Lilongwe, Malawi

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Contents

Inauguration

Welcome and Introduction of Chief Guest

H.K. Mwandemere*

Honorable Minister, District Chairman of the Malawi Congress Party, Your Excellencies, your Worship the Mayor of the City of Lilongwe, distinguished participants, ladies and gentlemen. It is with great pleasure that on behalf of the organizers of this first Regional Groundnut Workshop I welcome you to Lilongwe. We are honored today by the presence as Chief Guest of the Malawi Minister of Forestry and Natural Resources, the Honorable S. Demba who has very kindly found time from his busy schedule to attend our meeting and present the opening address on behalf of the Life President His Excellency Ngwazi Dr. H. Kamuzu Banda. I now request the Honorable Minister to open the proceedings.

Opening Address on Behalf of the Minister of Agriculture

The Hon. S. Demba*

District Chairman of the Malawi Congress Party, Your Excellencies, Your Worship the Mayor of the City of Lilongwe, Distinguished Participants, Ladies and Gentlemen.

On behalf of His Excellency the Life President, Ngwazi Dr. H. Kamuzu Banda, the Government and the people of Malawi, and on my own behalf, I wish to extend a very warm and hearty welcome to all our distinguished participants to the ICRISAT Regional Workshop on Groundnut Research and Improvement in Southern Africa. Please feel free to visit any part of the country and I hope that you will be able to enjoy your stay with us, and that you will have an opportunity to see something of the surrounding countryside to enable you to appreciate the efforts that Malawi is making in the field of agriculture in general, and groundnut production in particular.

I feel very honored to open this important workshop on behalf of His Excellency the Life President, Ngwazi Dr. H. Kamuzu Banda. In 1980 His Excellency the Life President directed that the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) could establish a Regional Groundnut Research Center for Southern Africa, at Chitedze Research Station in Lilongwe. While the memorandum of understanding between the Malawi Government and ICRISAT was signed in 1981, the Center became operational with the financial assistance of the International Development Research Center (IDRC) and the posting of the groundnut breeder and pathologist in 1982 and 1983, respectively.

The Center is developing a regional research program aimed at benefiting all the groundnut-growing areas of Southern and Eastern Africa. The Center, in collaboration with national research programs, will initiate trials to produce groundnuts with multiple disease resistance, earliness, high yield, good food quality, and increased seed size.

Groundnuts have been known to man as an important food crop for many centuries. However, they acquired economic importance only 130 years ago and even as late as 60 years ago in the developed and developing countries, respectively. Presently, because of an increased awareness of the protein shortage existing in the world, the use of groundnuts as a food and cash crop has increased substantially. Much of this increase is attributed to the high content of digestible protein (25-34%) and oil (44-56%), amino acids including cystine, and the vitamins thiamine, riboflavin, and niacin.

Groundnut is a multipurpose crop. The seeds are consumed in many forms (unshelled, shelled, roasted, peanut butter, candies, and confectionary), and in Africa groundnut flour is used in a large number of dishes. Groundnut oil is an excellent cooking oil because of its linoleic acid content. Groundnut cake, the by-product of oil extraction, is an excellent livestock feed because of its high protein content. The groundnut shells, besides being a source of a fuel are used in drilling-mud, as organic fertilizer, and in particle board.

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*Minister of Forestry and Natural Resources, Malawi.

Groundnuts are of great Importance in smallholder agriculture and in the national diet of Malawi. They provide a significant contribution towards dietary requirements in most parts of the country, they benefit farming systems through improving soil fertility and structure, and they provide between a quarter and a third of all small-holder agricultural cash income. Groundnuts are Malawi's fourth most important export crop after tobacco, sugar, and tea, and supply about half of the country's demand for edible oil.

Groundnuts are grown in all three regions of Malawi, the major share being contributed by the Central Region Plateau. Chalimbana and Mani Pintar are the major confectionary and oil cultivars respectively. Malimba and RG1 are grown in specific areas of the country. Through the National Research Program at Chitedze one large seeded confectionery cultivar (larger than Chalimbana), Chitembana, and one oil cultivar, Mawanga, have recently been released for commercial production.

Malawi groundnut production has undergone a marked decline since the late 1960s. Marketed output grew rapidly during the 1950s and 1960s from a negligible level to some 33 000 metric tonnes a year, but has tended to fall off since the late 1970's. The most recent National Sample Survey of Agriculture (NSSA) data suggest a drop in smallholder production of about 50% between 1968/69 and 1980/81, apparently as a result of a decrease in area planted coupled with a shift from mixed stands towards pure stands. The data from Agro-Economic Survey (AES) and project evaluation reports indicate that yields have indeed remained more or less static over the period. Sales to the Agricultural Development and Marketing Corporation of Malawi (ADMARC), representing about a third of total production, have also been declining.

Malawi confectionary nuts are very popular in Europe and fetch a premium price. It is the policy and hope of the Malawi Government to increase and encourage the production of good quality groundnuts to meet both domestic and export requirements. Where the major goal is to increase production per unit area, price incentive alone is not adequate. In order to lower production costs, farmers must be provided with the right type of good quality seed of cultivars that are pest- and disease-resistant. In turn, farmers should follow the recommended cultural practices of planting early, correct spacing, weeding on time, harvesting on time, and storing properly. Since groundnuts compete for labor with other crops like tobacco, cotton, and maize, mechanical groundnut shelling would go a long way towards increasing production.

Groundnuts have not been produced by estates in any appreciable quantity in the past, but are now being considered since they would make an excellent diversification and rotation crop, and could be profitably included in a tobacco/maize/fallow rotation on tobacco estates in most plateau areas of the country. Groundnuts play an important role if grown in rotation with crops such as maize, wheat, and tobacco in that they help to maintain soil fertility through their ability to fix nitrogen and improve soil structure, subsequently reducing the amount of mineral nitrogen that has to be applied to the following crop.

Export market prospects for the large-seeded Chalimbana and Chitembana cultivars are good, and there is also good potential for local oil extraction from the Mani Pintar and Mawanga cultivars. More urgent is the need to address the problem of low yields and declining production and sales of groundnuts in the smallholder sector. Improved cultivars such as Chitembana, Mawanga, and RG1 will only prove attractive to small-holder growers if seed is offered at prices which they can afford.

Malawi welcomes the efforts that ICRISAT is making towards improving groundnut production through its Regional Center and in collaboration with the National Groundnut Research Programs represented here today. For it is only through an exchange of germplasm and production technology at international, regional, and national levels that rapid increases in groundnut production can be achieved. This, we hope, is the beginning of the regional concerted effort to improve and encourage the production of groundnut in this part of Africa. Malawi is ready and willing to share her experience with other countries in the region just as much as we are ready to learn from other countries' experiences.

Groundnuts are the mainstay of our diet and all attempts must be made to increase their production to a stable level. We welcome the effort being made by ICRISAT through its Regional Groundnut Research Center for Southern Africa. Despite the prevailing number of problems constraining groundnut production in the region, this collaborative research program established by ICRISAT with financial assistance from IDRC should provide the technology for increased groundnut production.

I am confident that the experienced scientists from ICRISAT, from participating countries, and from Malawi herself, will use this week for the purpose of developing research strategies aimed at increasing groundnut production. I believe that the papers that will be presented and discussed here will be directed at meeting practical problems experienced by our farmers, large and small. And I hope that in your discussions you will take full account of the economic and sociological constraints and opportunities which arise from the nature of our societies, as well as the need to use modern knowledge for the benefit of our farmers. I am sure that all of you, participants to the workshop, will play a constructive role in improving and encouraging sound groundnut production strategies in your respective countries.

Distinguished participants, ladies and gentlemen, I now have much pleasure to declare this workshop open.

Thank you very much.

Response to Opening Address

R.A. Kirkby*

The Honorable S. Demba, Minister of Forestry and Natural Resources, Dr. Mwandemere, Chief Agricultural Research Officer, Your Worship the Mayor of Lilongwe, Distinguished Delegates and Scientists of the SADCC member States, Ladies and Gentlemen.

Honorable Minister, I should like to thank you personally, on behalf of the organizers and the participants of this workshop, for your thoughtful and most appropriate words of welcome and introduction. We appreciate your giving up your time this morning to distinguish us by your presence and, in so doing, to reconfirm the importance that the Government of Malawi evidently attaches to this program and to this first meeting of scientists dedicated to improving the production of groundnuts and well-being of groundnut producers and consumers throughout the Southern African Region.

The Malawi Government showed exemplary foresight, initiative and sense of regional cooperation when it agreed, some two years ago, to host this regional program which is being led by ICRISAT and with which I and my colleagues in IDRC are pleased to be associated. The importance of that foresight is shown by the fact that the Southern African Development Coordination Conference (SADCC) is proposing to expand this program to include other grain legumes of interest to SADCC member states. The spirit of regional cooperation fostered by your Government is demonstrated by the fact that this regional program, based in Malawi, has already in its second year of existence, contributed to the research efforts of neighboring countries through the distribution of regional variety trials and through visits made by the ICRISAT staff. Both ICRISAT and IDRC would like to extend to Dr. H.K. Mwandemere, Mr. D.R.B. Manda and to their colleagues in the Ministry of Agriculture and at Chitedze Research Station, their appreciation for the excellent cooperation received by the ICRISAT regional staff, Dr. S.N. Nigam and Dr. K.R. Bock.

In much of this region, the groundnut crop has not until recently received the research attention it might be expected to warrant from an appraisal of its importance for small farmer subsistence and cash generation, and for export earnings. Malawi appears to be an exception to this generalization, since this country has popularized the names "Chalimbana" and "Tambala King" far beyond its boundaries!

This program has been active now for less than two years, a period primarily of establishment and screening of germplasm introduced from ICRISAT, India. The objectives of this workshop are to provide you, the groundnut researchers of the region, with an opportunity to assess for yourselves the potential of this program to assist your own activities, to contribute to its evolution, and also to get to know something of one another's programs. Although the theme of the workshop is regional cooperation, this phrase means more than cooperation between the regional program and the various national programs: we hope that by getting to know one another here this week, you will be able to continue communicating directly among yourselves whenever you are aware of mutual interests.

*Program Officer, International Development Research Centre (IDRC) Regional Office for Eastern and Southern Africa. P.O. Box 62084, Nairobi, Kenya.

Southern Africa is a heterogeneous region in some respects. Ecological conditions for groundnut production vary from irrigated production in parts of Zimbabwe to production under very low rainfall conditions in Botswana and southern Mozambique. You are developing technology for farmers of very different socioeconomic circumstances, ranging from large scale commercial producers to some of the smallest and poorest farmers, who need lower input technology. The uses for which groundnuts are produced include consumption as oil or as a pulse by the producer's family, for cash, and for dry-season grazing of crop residues. For these reasons certain research needs differ from country to country, as do also the resources of trained manpower and support services presently available to national groundnut improvement programs. What, therefore, should the research priorities be at the regional level, and how can the regional program best take into account this diversity of needs? Some research administrators participating in last month's SADCC Agricultural Research Conference questioned whether a regional program based in one of the member states could become really effective in assisting the productivity of research programs in the other eight partner states. As the scientists responsible for implementing national programs, you have a unique opportunity this week to indicate, from your technical perspectives and in the light of the country presentations being made today, the most effective ways for the regional program to function. I know that both ICRISAT and IDRC will be listening intently to your suggestions, and seeking ways to respond during the next phase of the regional program to the needs that you identify.

Some crucial questions that we may want to think about this week are: what activities should each national groundnut improvement program strive to undertake itself using its own resources, what materials and services could the regional program more efficiently provide directly to national programs, and in what other ways could the regional program strengthen the effectiveness of national programs through facilitating cooperation among them?

Another national participant at last month's SADCC Conference commented on the possibility of competition for external funds between regional and national research programs. Perhaps we here are in the advantageous position of having made a modest start with this particular regional program, and of having at least two years' lead time over all other SADCC crop research programs. This is your opportunity to help determine the future course of this program and to make it your own, as well as perhaps to influence indirectly the organization of future regional programs. In doing this, you are likely to benefit many others in your countries.

I wish you a fruitful and enjoyable week of discussions.

Thank you for listening to me.

Welcome from ICRISAT

Curtis R. Jackson*

Participants of the Groundnut Conference, Colleagues, Ladies and Gentlemen:

I regret very much that ICRISAT's activities in Hyderabad have prevented me from being with you for this initial conference being held by ICRISAT's Groundnut Program. I have read the agenda and followed the development of this Workshop carefully so I am certain that it will be a most productive and rewarding undertaking for you.

It is ICRISAT's intention to hold such conferences and other forms of cooperative meetings as much as possible in the future. I call upon each of you to participate to the fullest extent and develop a sense of purpose and unity as a result of this workshop.

I am hopeful that next year or at some future year I will be with you for this most important event.

*Director of International Cooperation, ICRISAT.

Introductory Papers

The SADCC Regional Grain Legumes Improvement Program

D.R.B. Manda*

Summary

This paper provides background information on the Southern African Deveiopment Coordination Conference (SADCC) decision to consider the establishment of a Grain Legume Improvement Program. Groundnut would be an important crop in this program. Some information is provided on the scope of the proposed project and the crops, institutions, and countries involved.

Résumé

Programme régional de la SADCC pour l'amélioration des légumineuses à grain : *La communication donne des informations générales sur la décision de la Conférence de coordination du développement de l'Afrique australe (SADCC) de considérer l'établissement d'un Programme d'amélioration des légumineuses à grain. L'arachide constituerait une culture importante dans le cadre de ce Programme. Quelques détails sont fournis sur l'envergure du projet envisagé ainsi que sur les cultures, les institutions et les pays en question.*

The Southern African Heads of State at their Lusaka Summit in April 1980 directed that Agricultural Research be an area of cooperation between the Southern African Development Coordination Conference (SADCC) countries. The resolution gives priority to research related to the agricultural problems of the semi-arid areas.

SADCC with the help of ICRISAT identified research areas that would have regional foci. As a result, four regional research projects were identified:

- Land and Water Management — Botswana
- Sorghum and Pearl Millet Center — Zimbabwe
- Southern Africa Center for Cooperation in Agricultural Research — Botswana
- Regional Groundnut Research Center — Malawi

Assistance for the SADCC region has been pledged by Cooperation for Development in Africa (CDA) which was established in 1978 to coordinate programs and resources in order to promote agricultural development and productivity in Africa. CDA is a group of seven Western donor nations: Belgium, Canada, France, Italy, the United Kingdom, West Germany, and the USA. In March 1983, representatives of CDA made a reconnaisance visit to all SADCC countries to identify priority areas of agricultural research for financing by the group. In their report, they thought that the Regional Groundnut Research Program under ICRISAT sponsorship at Chitedze in Malawi was too narrowly based and recommended that it be expanded to also include other grain legume crops important in the region: beans, cowpeas, and pigeonpeas.

In April 1983 the SADCC Food Security Consultative Technical Committee (CTC) for Agricultural Research met in Harare, Zimbabwe to consider the CDA reconnaisance report. CTC is a committee of all Directors of Agricultural Research from SADCC countries. The CTC agreed with the recommendations of the CDA report and proposed that a six-person team be selected to prepare a comprehensive feasibility study for a Grain

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Legume Improvement Program (GLIP) for Southern Africa. This study would expand the existing Regional Groundnut Program now located in Malawi, financed by IDRC and implemented by ICRISAT. It was further agreed that support for this project be requested from France in order to exploit the expertise and experience which have been so beneficial to West Africa. SADCC countries could benefit from this experience in the short run, particularly in the areas of short duration, drought resistant varieties; and seed multiplication and seed exchange schemes for small farmers.

The CTC also recommended that the Headquarters of the proposed SADCC Grain Legume Improvement Program for Southern Africa remain in Malawi but that substations be established in Tanzania for cowpeas, in Mozambique lowland drier areas for groundnuts, and in Lesotho for beans.

The SADCC Council of Ministers Meeting held in Dar es Salaam, Tanzania on 5 May 1983 noted the title change from Regional Groundnut Program to Grain Legume Improvement Program (GLIP) in order to broaden the scope of the research. They also agreed to the suggestion that while the program headquarters remain in Malawi, substations be established in Mozambique, Lesotho, and Tanzania.

A seven-member team was assembled and from 14 Nov-20 Dec 1983, they prepared the Grain Legume Improvement Program Feasibility Study. One or more team members visited the SADCC countries except Angola.

The composition of the team was:

Dr. R.I. Jackson
Senior Agronomist
USAID, Washington DC, USA
Team Leader

Mr. D.R.B. Manda
Deputy Chief Agricultural Research
Officer, Malawi

Dr. J.F.M. Onim
Agronomist, CRSP for Small Ruminants
Winrock International, Kenya

Dr. J.D. Franckowiak
Assistant Professor of Agronomy
North Dakota State University
Fargo, ND, USA.

Dr. L Mosele
Freelance Consultant (Economist)
45010 Riva(Rovigo) Italy

Dr. R. Schilling
Assistant Director, Annual Oil Crops
Department, IRHO, Paris, France

Dr. B.J. Ndunguru
Professor and Head, Department of Crop
Science, University of Dar es Salaam,
Tanzania

The Feasibility Report has been written and will be discussed by the CTC for Agricultural Research in June before a design team is engaged to prepare the implementation document. The legumes which the team believes should receive due consideration for further research through the GLIP are:

Common beans
Cowpeas
Groundnuts/peanuts
Pigeonpeas
Bambara nuts
Soybeans
Chickpeas
Guar
Mung beans
Peas

The information available from the SADCC countries clearly indicates that if further research is undertaken there is a great potential to increase productivity and production of grain legumes in the region.

The situation which emerges from the analysis of the economic and social indicators of the SADCC countries is cause for much concern. Population is growing at an average rate of about 3% per year. Agricultural production growth is absolutely unable to meet the increasing needs. The importation of food products has been increasing; it is estimated that the region imports an average of at least 16% of its food consumption. The already critical food problem in the SADCC countries may be worsening. They may have to rely more and more on imports, further worsening the balance of payment situation. Statistics show that the roles of grain legumes in the agricultural systems and in the diet are far less important than they should be.

The goal of the GLIP is to increase grain legume production within the region and reduce the periodic food shortages due to low productivity caused by agricultural constraints such as diseases, insects, drought, low-yielding cultivars, and low quality. The purpose of the program is to assist in the development and introduction of new cultivars and improved cultural techniques. The transfer of this technology and its adoption by farmers will increase production and the availability of legumes for meeting future food requirements.

The development of the centers and the subcenters should be completed by the end of the first 5 years. At the end of the first 5-year phase of this program, it is planned that there will be research facilities located at headquarters in Malawi which will be fully equipped and staffed for conducting a regional grain legume research effort. During this phase it is proposed that assistance will be provided in the training of some 22 M.Sc. and 5 Ph.D. students, participation in on-the-job training within the region and special training for students and scientists from the region. Workshops and seminars will be held to develop better communications and interaction among scientists from within the region. Communication will be improved through the networking of screening trials wherein the research workers will be significantly involved. The research scientists of each country will visit and observe the trials throughout the region on an annual basis.

It is worth noting that the crops of this regional GLIP center fall under the mandate of three international institutions: CIAT (Centro Internacional de Agricultura Tropical), IITA (International Institute of Tropical Agriculture), and ICRISAT, as well as the Bean-Cowpea CBSP (Collaborative Research Support Program) of the United States. These institutions already have a wealth of expertise to help the SADCC region, and are active in the region. We hope the SADCC Grain Legume Improvement Program will become a better base for them to continue to help us. At this point I need to mention that the Sorghum and Millet project has already started in Zimbabwe under ICRISAT. This we appreciate very much.

It has been recommended that an independent Management Entity be established to effectively manage and administer the GLIP and at the same time not have any bias toward any of the participating centers or universities. All participating and collaborating research organizations would be treated equally and fairly.

The Management Entity would be the sole receiver of donor funds and would disperse these on contract basis to the participating institutions. At the same time, it would use discretion and provide operational support to national programs where funds and services were required. This could include funds for carrying out the proposed screening programs in the countries and other items requiring funds to effectively acccomplish the program objectives.

It is proposed that an International Advisory Panel be established soon after the beginning of the implementation of the program. The panel will be composed of seven members, three of whom will be from within the region and four from outside. The members from outside could be appointed by the donor(s) to the program. The panel will meet annually to review progress and make suggestions to the Management Entity for future planning.

The program can be justified on a number of grounds:

- Increased supply of vegetable protein in the SADCC countries.
- High returns on investments.
- Saving of foreign exchange.
- Increase in the level of income of small holders.
- Multiplier effect.

The cost for the first year phase of the program is estimated to be S18.0 million. This is all I can say at this moment. Remember this is a Feasibility Study Report. This report, once discussed, will be a major input for designing the project.

The ICRISAT Groundnut Program

D. McDonald*

Summary

In 1976 ICRISAT was designated a world center for the improvement of yield and quality of groundnut and to act as a world repository for the genetic resources of the cultivated Arachis hypogaea *and its wild relatives in the genus* Arachis. *About 67% of the world's groundnuts are produced by small farmers in the semi-arid tropics (SA T), but yields are low at around 780 kg/ha of dried pods. The potential yields are over 5000 kg/ha but cannot be attained because of such constraints as diseases, pests, and unreliable rainfall. This paper discusses these and other production constraints and outlines research being done on them by the ICRISA T Groundnut Improvement Program. The establishment of the ICRISAT Regional Groundnut Program in Southern Africa and our projected cooperative programs for Southeast Asia and West Africa will greatly increase the scope of the ICRISA T Groundnut Program to assist national programs in all aspects of research on groundnut problems.*

Résumé

Le Programme d'arachide à l'ICRISAT : *C'est en 1976 que l'ICRISAT a été désigné comme centre mondial chargé de l'amélioration des rendements et de la qualité de l'arachide, ainsi que de devenir un dépôt mondial pour les ressources génétiques de l'arachide cultivée (*Arachis hypogaea*) et de ses espèces sauvages du genre* Arachis. *Les petits paysans des zones tropicales semi-arides représentent environ 67% de la production mondiale arachidière, mais leurs rendements restent faibles, de l'ordre de 780 kg/ha de gousses sèches. Les rendements potentiels sont de 5000 kg/ha ou plus, mais les contraintes telles que les maladies, les ravageurs et la pluviosité aléatoire ne permettent pas la réalisation des niveaux pareils. L'article considère celles-ci ainsi que d'autres barrières à la production et donne un aperçu des travaux de recherche en cours au Programme de l'ICRISAT pour l'amélioration de l'arachide. L'établissement du Programme régional de l'ICRISAT pour l'arachide en Afrique australe ainsi que ses programmes coopératifs envisagés pour le Sud-Est asiatique et l'Afrique de l'Ouest, permettront au Programme de l'ICRISAT de mieux aider les programmes nationaux dans tous les aspects de la recherche sur les problèmes de l'arachide.*

The groundnut originated in South America but is now grown throughout the tropical and warm temperate regions of the world. Commercial production is largely within the limits of latitudes 40°N and 40°S. It is estimated that 67% of the world's groundnut production is grown in the semi-arid tropics (SAT), almost entirely by small farmers of limited means. The average yield of 780 kg/ha of dried pods compares unfavorably with the 2900 kg/ha grown in countries with developed agriculture. Yields of over 3000 kg/ha are common on research farms in the SAT, indicating good potential for improving farmers' yields. Constraints to groundnut production in the SAT include damage by pests and diseases, unreliable rainfall patterns with recurring droughts, lack of high-yielding adapted cultivars, poor agronomic practices, and limited fertilizer use. In many of the SAT countries there is a scarcity of well trained, specialized groundnut researchers available to solve the many problems affecting the crop. The need for an international program to strengthen research on

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groundnut was recognized when it became the fifth ICRISAT mandate crop in 1976. The Institute was required to serve as a world center for the improvement of yield and quality, and to act as a repository for the genetic resources of the cultivated groundnut, *Arachis hypogaea,* and its wild relatives in the genus *Arachis.* Research at ICRISAT has concentrated on breeding for resistance to production limiting factors. It is evident that breeding is of more value to the small farmer than solutions based on high technology.

Germplasm Base

During 1976—the first year after ICRISAT was designated as a world center for the collection, maintenance and documentation of the genus *Arachis*—2443 accessions were received. The total is now 10111 groundnut germplasm accessions, with over 1000 more awaiting plant quarantine clearance. There are also 171 accessions of 22 described and several undescribed *Arachis* spp., and 2 interspecific hybrids. Derivatives of interspecific crosses will be added to the groundnut germplasm collection when stabilized at the tetraploid level.

The germplasm collection is under the control of the ICRISAT Genetic Resources Unit. Germplasm botanists record a wide range of plant characters when evaluating the various germplasm lines. In consultation with the International Board of Plant Genetic Resources (IBPGR) a set of descriptors has been agreed and data are being entered into the computer.

Since 1976, 19625 seed samples have been supplied to cooperating scientists in many countries. The availability of the world collection has enabled ICRISAT scientists to screen a wide range of germplasm for resistance/tolerance to the various factors that reduce yield of groundnuts.

The Groundnut Improvement Program

The Groundnut Improvement Program has disciplinary Subprograms in Breeding, Cytogenetics, Pathology, Entomology, and Physiology. The Physiology Subprogram includes Microbiology which was previously a separate unit. Most of the research is multidisciplinary, with specific research goals of breeding for:

- resistance to major diseases and pests,
- resistance/tolerance to drought,
- increased biological nitrogen fixation,
- high yield and quality,
- earliness and seed dormancy, and
- adaptation to specific photoperiods.

The breeding work depends on identifying sources of resistance to stress factors, understanding basic physiological processes, elucidating disease epidemiology, etc. These data will be useful to develop cultural methods to minimize the adverse effects of stress factors if genetic options are not available or are inadequate.

The Program is involved in cooperative research with other ICRISAT Programs, especially Farming Systems and Economics, with many scientists in SAT countries, and with mentor institutes in developed countries. The establishment of the Regional Groundnut Program for Southern Africa has extended the range of research that can be done by ICRISAT and has improved opportunities for effective cooperation with groundnut research workers within the region.

Diseases

Foliar Diseases

The most important fungi-caused foliar groundnut diseases are the leafspots (*Cercospora arachidicola* and *Cercosporidium personatum*) and rust (*Puccinia arachidis).* At ICRISAT Center rust and late leafspot (C. *personatum)* occur each year in epidemic proportions. Together they have been shown to cause yield losses in susceptible cultivars of up to 70%, while each disease on its own is capable of causing up to a 50% loss. All released Indian cultivars are susceptible. Field screening of the world germplasm collection for resistance to these two diseases was started at ICRISAT Center in 1977, and over 9000 accessions have now been examined. Some 34 genotypes have been found to have good resistance to rust, 24 have resistance to late leafspot, and 17 of the genotypes have good resistance to both diseases (Table 1). The resistant genotypes have been listed in the ICRISAT 1981 Annual Report (ICRISAT 1982) and in research papers. Fourteen germplasm lines with rust resist-

Table 1. Rust early leafspot and late leafspot reactions of some groundnut genotypes in field screening trials at ICRISAT Center, rainy season 1983.

	Oisease scores[1]		
Genotypes	Rust	Early leafspot	Late leafspot
NC Ac 17090	2.7	8.7	5.7
PI 259747	2.7	7.3	3.0
PI 390593.	2.7	8.0	4.7
PI 393646	2.7	8.7	6.3
PI 405132	2.7	7.0	3.0
PI 414332	2.7	8.0	6.0
EC 76446(292)	3.0	7.7	3.0
PI 350680	3.0	7.0	3.3
PI 314817	3.0	8.7	6.3
PI 315608	3.0	7.3	6.7
PI 341879	3.0	8.7	3.3
PI 381622	3.0	8.0	3.3
PI 393517	3.0	7.7	6.7
PI 393527-B	3.0	8.7	6.7
PI 393643	3.0	7.3	6.7
PI 407454	3.0	8.7	6.7
PI 414331	3.0	8.7	7.3
NC Ac 17133-RF	3.3	7.7	3.3
NC Ac 927	3.3	8.7	3.3
USA 63	3.3	8.0	3.0
PI 390595	3.3	8.0	3.3
PI 270806	3.7	7.3	3.3
PI 393526	3.7	8.3	5.7
PI 393531	3.7	8.3	6.7
PI 393641	3.7	7.7	4.7
PI 215696	3.7	8.0	3.3
NCAc 17132	4.0	8.0	3.3
NCAc 17135	4.0	7.3	3.7
NCAc 17127	4.3	9.0	4.3
PI 298115	4.3	8.3	7.7
Krap St. 16	3.7	8.3	3.7
NCAc 17129	4.7	9.0	4.3
PI 393516	4.7	8.3	3.3
NC Ac 17506	4.7	8.3	3.7
NCAc 17142	5.0	8.0	4.3
C No. 45-23	6.3	8.3	5.3
NC Ac 17502	7.3	7.3	5.3
NC Ac 15989	8.3	7.0	3.7
RMP 12	8.3	6.7	4.0
NC 3033	9.0	8.0	9.0
EC 76446	9.0	8.7	9.7
TMV 2[2]	9.0	9.0	9.0

Continued

Table 1. *Continued*

Genotypes	Disease scores[1]		
	Rust	Early leafspot	Late leafspot
J 112	9.0	9.0	9.0
JL 24[2]	9.0	8.7	9.0
Robut 33 - 1[2]	9.0	8.6	8.3
SE ±	0.24	0.36	0.27
CV(%)	9.14	7.71	9.11

1. Mean of field disease scores on a 9-point scale; 1 - no disease and 9 - 50 to 100% foliage destroyed.
2. Foliar diseases-susceptible released high-yielding cultivars.

ance have been jointly released by ICRISAT and USDA (Hammons et at. 1982a, b, c).

Most of the rust and late leafspot resistant lines are low yielding and have undesirable pod and seed characters. Breeders have been crossing them with high-yielding, but disease susceptible cultivars, and are now well on the way to developing rust- and late leafspot-resistant cultivars with good agronomic characters (Table 2). In one field trial during the 1982 rainy season at ICRISAT four rust resistant lines yielded over 2200 kg/ha dried pods. The susceptible released cultivar JL 24 yielded only 870 kg/ha.

The stability of the resistance to rust and late leafspot has been checked by comparing screening results at ICRISAT over several seasons and by conducting an International Groundnut Foliar Diseases Nursery. The resistances appear to be stable. The biology of pathogens has also been investigated and resistance components have been measured. The physiological implications of disease resistance are now being examined and the findings may influence breeding and disease control strategies.

At ICRISAT the early leafspot disease caused by C. *arachidicola* does not normally become severe enough to permit reliable field resistance screening, but in the 1983 rainy season the attack by this disease was sufficiently severe to allow meaningful screening, and some genotypes showed significant resistance. Early leafspot is commonly present in epidemic form at Chitedze Agricultural Research Station, Lilongwe, Malawi, where an ICRISAT Regional Groundnut Program was established in 1982. ICRISAT germplasm is now being screened for resistance to this disease in Chitedze. Some lines reported resistant to early leafspot in the USA are susceptible in Malawi.

Near-tetraploid derivatives have been developed from crosses between wild *Arachis* species immune or highly resistant to the leafspots and rust diseases, and high-yielding groundnut cultivars. These derivatives have useful resistance to one or more of these important foliar diseases and are now used in the resistance breeding programs.

Pod Rot Diseases

Pod rots caused by a complex of soil inhabiting fungi cause serious reductions in both yield and quality of groundnuts in a number of countries. The extent of the damage is not always evident at harvest, and it is likely that the incidence of pod rots and the yield losses attributed to this problem have been considerably underestimated. Losses of over 20% have been recorded at ICRISAT for some genotypes. Field screening for resistance has been complicated by uneven disease incidence between and within fields, but 11 genotypes have been shown to have significantly lower incidences of rotted pods than susceptible check cultivars (ICRISAT 1982).

The most important fungi involved in pod rotting at ICRISAT are species of *Fusarium, Macrophomina phaseolina* and *Rhizoctonia solani.* Different fungi and varying combinations of fungi have been found associated with pod rots in different places. This variation may have implications for resistance screening and breeding.

Aspergillus flavus and Aflatoxins

Aflatoxins are toxic secondary metabolites produced by strains of fungi of the *Aspergillus flavus* group when growing on suitable substrates. Groundnut seed and groundnut products are very effective substrates for production of the toxins. Invasion of groundnut seeds by the toxigenic fungi is favored by damage to the developing pods by pathogenic fungi, insects, drought stress, and cultivations. Damaged harvested and stored pods and seeds, as well as wet seeds, are at increased risk from fungal invasion. Aflatoxin contamination can be minimized by adopting farming and produce

Table 2. Performance of some rust resistant advanced lines at ICRISAT Center, rainy season 1983.

Trial	Pedigrees	Yield (kg/ha) HP	Yield (kg/ha) LI[2]	Rust disease score[3]
$F_{6/7}$	(RMP-91 x Dht-200)-F6-B(S1)	4060	1970	3.2
	(RMP-91 x Dht-200)-F6-B(S2)	3730	2180	3.0
	(Robut 33-1 x PI 298115) F5-B	3650	2060	3.5
	NC Ac 1 7090 (Resistant check)	3890	1570	3.2
	Robut 33-1 (Susceptible check)	2810	1716	6.7
	JL 24 (Susceptible check)	2190	780	5.7
	SE ±	142	119	0.4
	Trial mean	3640	1610	3.9
	CV (%)	8	13	19.5
F_{10} (Selections from rainfed fields)	(NC-Fla-14 x NCAc 1 7090)F9-B	3150	1790	3.7
	(Tifspan x Nc Ac 1 7090) F9-B	3060	1320	3.0
	(Gang-1 x PI 259747) F9-B	2430	1930	4.0
	NC Ac 17090 (Resistant check)	3240	1750	3.2
	Robut 33-1 (Susceptible check)	2670	1490	7.2
	JL 24 (Susceptible check)	2290	840	7.0
	SE ±	197	94	0.3
	Trial mean	2520	1430	4.0
	(CV %)	13	11	14.3
F_9	(Ah-65 x NC Ac 1 7090) F8-B	4160	2200	3.3
	(NC Ac 2190 x NC Ac 1 7090) F8-B	4150	2020	3.2
	(JH 60 x NcAc 17090) F8-B	3340	2240	3.2
	NC Ac 17090 (Resistant check)	3290	2040	2.8
	Robut 33-1 (Susceptible check)	2410	1620	8.3
	JL 24 (Susceptible check)	2280	1010	7.7
	SE ±	165	148	0.4
	Trial mean	3160	1790	3.6
	CV (%)	9	14	20.8
F_{10}	(NC Ac 1107 x NC Ac 17090) F9-B	4070	2080	2.8
	(JH 60 x PI 259747) F9-B	3850	2530	2.8
	(Ah 65 x NC Ac 17090) F9-B	2740	2470	3.0
	NC Ac 17090 (Resistant check)	3670	1820	3.0
	Robut 33-1 (Susceptible check)	2560	1740	4.7
	JL 24 (Susceptible check)	2710	1080	4.7
	SE ±	182	144	0.3
	Trial mean	2890	1830	3.1
	CV (%)	11	14	16.5

1. HL= High input (60 kg/ha P_2O_5 with irrigation and insecticidal sprays).
2. LI = Low input (20 kg/ha P_2O_5 rainfed and no insecticidal spray).
3. Recorded from rainfed trials on a 9-point disease scale; 1 - no disease, and 9 - 50 to 100% foliage destroyed.

handling methods designed to avoid damage to pods and seeds. But unfortunately few farmers in the SAT follow the recommended procedure, so attention has therefore been concentrated on utilizing genetic resistance. Breeding lines with testa resistance to invasion of rehydrated dried seeds were reported from the USA. This resistance was confirmed at ICRISAT Center and several more dry seed resistant genotypes identified (Mehan et al. 1981). It is of interest that some of these genotypes were also found to be resistant to pod rots.

Several of the genotypes identified as resistant to colonization of the dried seeds by *Aspergillus fla-us* (J11, PI 337409, PI 337394F, UF 71513-1, Ah 7213, Var. 27, and U4-4-1) have been extensively crossed with susceptible but high-yielding cultivars. Derivatives of these crosses have been selected which have good yield and seed quality, and have levels of seed resistance to *Aspergillus flavus* colonization comparable to those of the resistant parents.

A number of germplasm lines have also been tested for resistance to aflatoxin production following invasion of seeds by toxigenic strains of *A. flavus.* All genotypes supported aflatoxin production but significant varietal differences in accumulation rates and total toxin produced were found (Mehan and McDonald 1984).

Virus Diseases

Virus diseases of groundnuts are common and can be serious, but it has often been difficult to estimate the losses caused by specific diseases because of confusion about their identification and distribution. Identification has too often been based only upon symptoms. At ICRISAT emphasis has been placed on the purification and precise characterization of groundnut viruses and on the production of antisera. This research has been accompanied by field and screenhouse evaluation of germplasm for resistance or tolerance to virus diseases such as bud necrosis, peanut mottle, and peanut clump. Some 7000 genotypes have been screened for resistance to bud necrosis (caused by tomato spotted wilt virus), but all were susceptible. Wild *Arachis* species are now being screened, and *Arachis chacoense* has been found resistant in mechanical and thrips inoculation tests. Almost 500 germplasm lines have been screened for resistance to peanut mottle using a field mechanical inoculation technique. All proved susceptible but four lines showed less than 5% yield loss compared with 12-60% losses from infected plants of other lines. Two genotypes were found to have no seed transmission of peanut mottle virus from infected mother plants. Resistance breeding using the tolerant and the no seed transmission genotypes has just started. Screening for resistance to the soil-borne peanut clump virus disease has been in progress for several seasons, but with conflicting results. These are probably due to virus strains with different virulence for different host plant genotypes.

Rosette disease is the best known and most important virus disease of groundnut in Africa south of the Sahara. High-level resistance to this disease was found in some West African germplasm, and breeders in Senegal, Nigeria, and Malawi have successfully bred rosette resistant cultivars with good agronomic characters (Gibbons 1977, Gillier 1978, Harkness 1977). Rosette resistant genotypes are being used in several ICRISAT Center breeding programs, and a program to breed for rosette resistance has now started at the ICRISAT Regional Groundnut Program for Southern Africa in Malawi. Although groundnut rosette has been known for several decades, the viruses involved have not been properly characterized. ICRISAT is now involved in coordinated international research to resolve this problem. Studies are in progress to characterize the two viruses involved in rosette and to develop reliable identification methods. These can then be used to clarify the situation in Southeast Asia where a "rosette" disease has been reported, but indications are that the disease(s) described are not identical to African groundnut rosette.

The groundnut virus disease situation differs considerably between Africa, the Indian subcontinent, and East Asia. Rosette seems to be confined to Africa, bud necrosis is most important in India, and witches broom (probably caused by a mycoplasma) is serious only in East Asia. Peanut mottle is worldwide. High priority should be given to establishing the identity and distribution of groundnut diseases caused by viruses and mycoplasmas. The need for immediate attention being given to this problem is highlighted by the recent report of peanut stripe virus disease being introduced into the USA in seed from East Asia (Demski et al. 1984).

Bacterial Disease

The only important bacterial disease of groundnut is the wilt caused by *Pseudomonas solanacearum.*

This disease is common and serious on groundnuts in East Asia and has been reported from South Africa and the USA, but because it has not been found so far in India, it has not been investigated at ICRISAT Center. Cooperative linkages will have to be established with national programs in East Asia so that ICRISAT germplasm can be screened for resistance to this important disease.

Pests

Over 300 insect and mite species have been recorded from groundnut, but most are of limited distribution. Yield losses worldwide have been assessed at 17% from field pests and 6-10% from storage pests. No research on storage pests has been done at ICRISAT although there are indications of genetic resistance to some important insect pests. Research has concentrated on problems caused by aphids, jassids, thrips, the tobacco caterpillar, leafminers, bollworms, and termites. Particular emphasis has been given to research on vectors of virus diseases.

Surveys

All major groundnut growing areas of India have been surveyed to identify pest problems and measure yield losses. The surveys have shown recent shifts in pest incidence, some insects becoming more damaging, and others less so. The overall trend is towards increased pest damage, and one factor that may be responsible for this is the recent increase in cultivation of irrigated groundnuts in the postrainy season. In 1968 there were only four important pests of the crop, but in 1984 nine pests are considered to be of major importance (Table 3). Leafminers have become a serious problem wherever irrigated groundnuts are cultivated on a large scale. The value of groundnuts lost by pest damage each year in India is estimated at US$160 million.

Table 3. Major field pests of groundnut in India (Rai 1976).

1968	1984	
Aphids	Leafminer	White grub
Leafminer	Thrips (vectors)	Thrips (pests)
Hairy caterpillar	Aphids	Tobacco caterpillar
	Jassid	Hairy caterpillar
Termite	Termite	

Virus Vectors

Insect pests may be important because of both the direct damage they do and their role in transmission of virus diseases. For instance, sap sucking by the groundnut aphid, *Aphis craccivora,* can cause severe damage or even death to young plants, particularly when large populations build up during early season droughts. However, of much greater economic importance is the spread of peanut mottle virus worldwide and groundnut rosette virus in Africa by these aphids. Similarly, thrips are more important as vectors of tomato spotted wilt virus in India than they are as direct foliage-feeding pests.

At ICRISAT the entomology research emphasis has been to effectively combine cultural practices and host plant resistance to develop integrated pest management systems.

For management of bud necrosis disease it was necessary to understand the epidemiology of the disease. Factors influencing buildup and migration of the vector thrips and associated spread of the disease were investigated. *Frankliniella schultzei* was identified as the major vector. It was found that by:

- early sowing,
- close plant spacing,
- intercropping groundnuts with pearl millet, and
- use of the high-yielding virus susceptible but "field resistant" cultivar Robut 33-1,

the incidence of bud necrosis disease could be reduced by 90-95%, and yields increased by 15-20 times. Although Robut 33-1 shows 50-80% lower field incidence of bud necrosis disease than commonly grown cultivars such as TMV-2, it is equally susceptible to the virus. Even lower field incidence of the disease has been recorded for progeny of the cross Robut 33-1 x NC Ac 2214. This line and similarly promising lines have been used in the resistance breeding program.

Field Pests

The effects of cultural practices on the incidence of other important pests are being studied with particular attention being given to the effects of intercropping. The high-yielding and multiple pest-resistant genotype NC Ac 343 has been used in developing a breeding line with good resistance to thrips, jassids, and termites.

Breeding for Pest Resistance

Breeding for pest resistance was started in 1980 to combine resistance to leaf hoppers, thrips, and termites into high-yielding genotypes. An extensive hybridization program was initiated and a large number of single and multiple crosses were made using NC Ac 2214, NC Ac 2232, NC Ac 2240, NC Ac 2242, NC Ac 2243, NC Ac 2230, NC Ac 1705, NC Ac 343, NC Ac 16940, and NC Ac 785 as sources of resistance to thrips, leafhoppers, and termites. The materials from these crosses are in different generations and are subjected to both natural and artificial infestation under field and laboratory conditions. Thrips populations are abundant in rainy and postrainy seasons, and material is screened in both seasons under natural field conditions. However, the leafhopper population in the postrainy season is very low and screening for resistance to this insect is done mainly during the rainy season. If natural leafhopper populations are too low, laboratory bred insects are released on the test material to ensure sufficient pest pressure.

Based on the amount of damage to the leaf at the time of maximum infestation, progenies resistant or tolerant to thrips and leafhoppers are selected for advancing. Through repeated testing and selection, several high-yielding progenies have been developed which have good resistance to thrips and leafhoppers (Table 4). The segregating material from crosses using lines such as NC Ac 343, NC Ac 2242, and NC Ac 1705, which are resistant to pod-scarifying termites, was screened for termite resistance in termite infested fields. Some termite resistant progenies were identified and further tests are in progress to confirm their resistance.

Observations indicate that presence of trichomes and thick leathery and waxy leaves were associated with leafhopper resistance in groundnut. The genetics of the different resistance mechanisms is under investigation.

Since it is suspected that insect resistance and high yield are negatively correlated, a two-stage breeding strategy is being followed to overcome this undesirable linkage. In the first stage, high-yielding lines with moderate resistance levels are developed, then in the second stage these lines are intermated to increase the levels of resistance to various insects. Intermating of early generation selections made on the basis of pest damage and/or on the basis of morphological traits such as thick leathery and waxy leaves with or without trichomes should increase the favorable genes for resistance.

Drought

Drought research is conducted mainly in the postrainy season because of lack of water control in the

Table 4. Some high yielding pest-resistant breeding lines.

High-yielding pest-resistant breeding lines	Pod yield (kg/ha)	
	High input	Low input
Manfredi 68 x NC Ac 343 (F7)	2604	1236
(Gangapuri x MK 374) x (Robut 33-1 x NC Ac 2214) (F7)	2583	1212
Robut 33-1 x NC Ac 343 (F9)	2536	1500
28-206 x NC Ac 10247 (F7)	2286	1361
Robut 33-1 x NC Ac 2214 (F7)	2286	1360
Robut 33-1 (Check)	2106	1149
NC Ac 343 (Check)	2020	1201
JL 24 (Check)	1552	531
J 11 (Check)	1627	430
SE ±	10.6	10.9
Mean (44 breeding lines)	1836	882
CV%	11.0	23.0

rainy season. Two simultaneous efforts have been made in drought research. One has been to develop a method to screen germplasm and breeders' lines, and to screen as much material as possible. The second has concentrated on examining in detail the physiological responses of groundnuts to drought stress, the factors which determine the use of water, water use efficiency, and the physical and physiological basis for genetic differences in drought responses.

The Physiology Subprogram has cooperated with other groups both within and outside ICRISAT. These collaborative efforts have been very fruitful and have accelerated progress by utilizing an expanded resource base to study the problem.

Drought Screening

Drought screening began in the 1980/81 postrainy season with a small range of treatments applied to 80 genotypes. Drought stress was induced at different stages in crop development but only two levels of stress were imposed: full irrigation for a control treatment and no irrigation for a dry treatment. Lines with 'tolerance' to drought were identified and the hypothesis that time of stress x genotype interactions existed was confirmed. Variability was substantial and an unexpected aspect of drought added a confounding factor because the crop was irrigated to facilitate harvest and one replicate was harvested each day. On the second day of lifting, pod rots were prominent and on the third day most pods had rotted. This observation is being exploited by the pathologists to improve their screening methods for pod rots resistance. Screening for drought resistance has been modified to overcome this factor.

In 1981/82 line source irrigation was used to create six levels of water application in each of four drought timings. Drought timings were selected to simulate the most commonly occurring droughts of the SAT and see if genetic variability existed in responses to them. One set of treatments represented variations of midseason drought, another set represented early drought, and a third represented environments where rainfall is always less than potential evaporation.

Lines from this screening were tested at Anantapur, a site in India where drought commonly occurs, and two of them were found to be significantly better than the local check cultivars (TMV-2 and Robut 33-1). In a season with no rainfall for 63 days after sowing and a total during the crop's life of only 220 mm, yields of 1.15 t/ha were produced.

In 1982/83 a drought screening evaluation of 25 lines selected from the previous drought screening used 12 patterns of drought stress, each with eight intensities of stress. These treatments were designed to examine the genetic variability and interactions of genotypes to multiple droughts, and variable durations and timings of drought. The trial provided 96 treatments differing mainly in the water component of the environment (temperature, photoperiod, and most other aspects of the environment were constant). The results of this trial are still being analyzed but preliminary analysis indicates that early stress definitely provides adaptive advantages in the event of a second drought at a later stage. Long droughts with occasional short periods of good water relations do not change the nature of the basic response to that drought pattern.

Lines have been identified from these trials which have consistently yielded better under drought than other cultivars.

Drought Physiology Studies

These have been conducted to investigate the effects of:

- drought intensity and time,
- plant population on water use and development of drought, and
- timing of stress on the drought recovery responses.

Research on the effects of timing of stress has shown that early stress can increase yield by 14-30% and that for Robut 33-1 late stress has a much greater impact on yield than midseason stress. For water management and efficiency, irrigation management to withhold water early and apply evenly deficient amounts during pod growth was better than utilizing the available water early, leaving no irrigation at later stages.

Investigations of population effects on water use and the development of drought stress have provided basic information on the development of root growth, leaf area development, stomatal resistance, and the interrelationship of these factors.

The detailed comparision of different genotypes in droughts utilized four contrasting genotypes identified by drought screening. Differences in water-use efficiency between drought tolerant and susceptible lines were demonstrated. Major differences in reproductive development during and after the drought were the reasons for differential performance.

Nutrient Stress

Biological Nitrogen Fixation

Although most cultivated soils of the tropics contain large populations of *Rhizobium* bacteria capable of forming nodules with groundnut cultivars, and although the groundnut is an efficient fixer of nitrogen, there is potential to increase nitrogen fixation by manipulation of *Rhizobium* strain, host genotype, and environment, as well as their interactions.

Inoculation with Rhizobium

There are several reports of *Rhizobium* inoculation increasing groundnut yields in fields where the crop had not previously been grown. In trials at ICRISAT Center over the past seven years, inoculation of groundnut genotypes with a very effective strain of *Rhizobium* increased nitrogen fixation and pod yield when the crops were grown in fields well populated with effective strains of *Rhizobium* (Table 5). The *Rhizobium* strain NC 92 was very efficient, particularly when in symbiosis with cultivar Robut 33-1. Field inoculation trials at ICRISAT Center with this strain and cultivar increased yields by 18-34% while a similar trial at Dharwad in Karnataka Stat͏e resulted in a 40% yield increase. Strain NC 92 was also very effective in combination with several other genotypes.

Method of inoculum application was important. Because groundnut seeds are fragile, direct application of *Rhizobium* inoculum can cause significant damage and actually decrease yields. It was better to apply the inoculum directly to the soil by the easy and cheap method of mixing peat containing *Rhizobium* with water and pouring the mixture into the furrow just before sowing the seed. This method also effectively reduces incompatibility problems of *Rhizobium* inoculum and fungicide seed protectants. An animal drawn seed planter has been modified for direct application of *Rhizobium* inoculum to the soil.

Studies of inoculum concentration indicated that a minimum of 10^8 rhizobia per seed was needed for good nodulation. Studies with strain NC 92 have shown that inoculation for a few years may be sufficient to establish a good soil population of a desired *Rhizobium* strain. This work was made possible by the use of enzyme linked immunosorbent assay (ELISA) for identifying *Rhizobium* strains in nodules.

Improving Host Genotypes

Over the past five years many germplasm lines were screened for nitrogen fixing ability. In general, the Spanish types were found to fix less nitrogen than the Virginia types, however, one Spanish line, X-14-4-B-19-B, showed high nitrogenase activity and will be used in the breeding program to increase the nitrogen fixation of Spanish types. The Virginia line, NC Ac 2821 showed high nitrogenase activity and some progenies of this line were high yielding. This suggests that it may be possible to increase yield potential by incorporating high nitrogen fixing lines in the breeding program. Inciden-

Table 5. Summary of responses of cv Robut 33-1 to inoculation with *Rhizobium* strain NC 92.

	Pod yield (kg/ha)		
Season trials	Uninoculated	Inoculated with NC 92	SE ±
Postrainy (1978/79)	3500	4500	291.2
Rainy (1979)	870	1160	24.3
Postrainy (1979/80)	4280	4400	104.7
Rainy (1980)	1350	1640	77.4
Postrainy (1980/81)	3210	3300	78.8
Rainy season (Site 1) (1981)	2350	2760	187.8
Rainy season (Site 2) (1981)	1100	1160	34.5
Rainy season (Site 3) (1981)	1530	2150	176.5
Mean	2274	2634	56.3

tally, this line also showed high nitrogenase activity when tested in fields in North Carolina, USA (Wynne, J.C. personal communication).

Nitrogen Fixation as Affected by Agronomic Practices

In collaboration with the Cropping Systems Program the effects of intercropping on nodulation and nitrogen fixation of groundnut were studied. Groundnut, when intercropped with nitrogen fertilized millet, maize, or sorghum, fixed less nitrogen than as a sole crop. This suggests that high nitrogen input on the cereal component reduces the advantage of the nitrogen fixation ability of groundnut.

Many farmers practice deep sowing to make use of residual moisture for germination. This results in the development of an elongated hypocotyl, poor nodulation, and reduced nitrogen fixation, especially in Spanish cultivars. Most Spanish types lack the ability to nodulate on the hypocotyl. Hypocotyl nodulation contributes substantially to the nitrogen fixation of the deep-sown crop. For example, in a deep-sown Virginia cultivar, Kadiri 71-1, hypocotyl nodules contributed around 50% of the nitrogenase activity at 70 days after planting. Hypocotyl nodulation in Spanish types could be beneficial where deep sowing is practised.

Measurement of Nitrogen Fixation

Nitrogen fixation was measured by estimating nitrogenase activity assayed by acetylene reduction, by nitrogen balance methods using nonnodulating groundnut, and by an isotope dilution technique using ^{15}N labeled fertilizer.

There is a marked diurnal variation in nitrogenase activity of field-grown groundnuts. Soil moisture, temperature, and light intensity also influence nitrogen fixation. Intercropping has a marked effect on groundnut nitrogen fixation.

During the 1978 rainy season some F2 progenies in a rust screening nursery segregated for nonnodulation. Some of these have been purified to obtain nonnodulating lines. Nitrogen fixation was estimated as the difference in nitrogen uptake of the parental lines and nonnodulating lines. Values ranged from 67-145 kg/ha N. The nonnodulating line utilizes soil nitrogen poorly, and the yield, even when supplied with 400 kg/ha N, was not equivalent to that of the nodulating crop grown without nitrogen fertilizer.

The 'A' value method of Fried and Broeshart (1975) was used to estimate nitrogen fixation using ^{15}N labeled ammonium sulphate and nonnodulating groundnut as the nonfixing control. A maize crop was grown in the previous season to deplete and even out soil nitrogen available for the groundnut crop. Estimates of nitrogen fixation ranged from 153 kg/ha N in Robut 33-1 to 100 kg/ha N in J-11.

Calcium Nutrition Research

Calcium deficiency is a major limiting factor for groundnut production in many parts of the world and gypsum application has been recommended for most areas.

Research was initiated to investigate reported genetic differences in calcium uptake 'efficiency' of pods of different genotypes. The work concentrated on the interactions of drought, gypsum, and genotype.

Consistent and significant genotype x drought x gypsum interactions were demonstrated in a series of three experiments. Gypsum applied at 500 kg/ha increased yields of groundnuts in droughts by as much as 30% in selected genotypes by enhancing early pod initiation and thus providing (or inducing) a drought 'escape' mechanism.

Development of Genotypes with Specific Attributes

High Yield and Quality

As an attempt to stabilize production over years and locations, breeding for resistance to various constraints has had the highest priority. But breeding for yield per se is also important, particularly for areas without constraints or where progressive farmers can afford inputs such as pesticides and fungicides. High-yielding lines are also needed in the constraint-based breeding programs and to counteract the rising cultivation costs.

Advanced breeding populations are evaluated in two different seasons at ICRISAT Center. In the rainy season they are evaluated under two management levels: high input (60 kg/ha of P_2O_5 with supplementary irrigation and insecticidal sprays when required) and low input (20 kg/ha P_2O_5 rainfed with no insecticidal sprays), but under high input only in the postrainy season. Very mild selection for yield is practiced in the early generations, but in later generations pod shape and seed size are also used as selection criteria. Most of the material is bulked into uniform groups for further evaluation and selection by cooperators in national programs.

Several high-yielding lines with acceptable pod and seed characteristics and a good shelling percentage have been developed. Based on consistently good performance, 62 lines have been entered in national trials in India.

In the early years of the program cultivars that yielded well in the rainy season did not necessarily yield well in the postrainy season and vice versa, indicating a strong genotype x environment interaction. It was therefore decided to make selections in the postrainy season to develop cultivars suitable for postrainy season irrigated cultivation. Several high-yielding lines suitable for this purpose have now been developed. Lines ICGS 30 and 21 have yielded over 6500 kg/ha of pods, which compares well with the 5500 kg/ha of the check cultivars J 11 and Robut 33-1 (Table 6).

High-yielding lines suitable for rainy season use have also been developed. ICGS 50, 30, and 1 did well under both low input and high input conditions at ICRISAT Center and several are under test in Indian national trials.

The research on quality has concentrated on oil content. The oil contents of 35 ICGS lines ranged from 42-50%, while protein was between 22 and 33%. Several lines have higher oil and protein content than the standard check cultivars J 11 and Robut 33-1.

Table 6. Performance of some high yielding ICRISAT selections during postrainy season trials at ICRISAT Center.

	Pod yield (kg/ha)	
Entry	1981/82	1982/83
ICGS 30	6600	7340
ICGS 21	6500	7040
ICGS 26	6430	6280
ICGS 16	6420	6550
ICGS 25	6300	6950
ICGS 23	6240	6680
ICGS 37	6150	7230
ICGS 35	6060	6770
ICGS 44	6060	6860
J 11 (Check)	5440	5440
JL 24 (Check)	4760	3860
Robut 33-1 (Check)	5450	6180
SE ±	289	297
CV (%)	10	10

Earliness and Dormancy

In the SAT, growing seasons can be very short because rains stop early. Earliness combined with good seed size and yield would provide stable production in poor rainfall years. Efforts are in progress to identify early-maturing groundnuts and to breed for increased yields. Use of early-maturing groundnuts increases the probability of rain on the crop at or after maturity, so it is necessary for early-maturing cultivars to have fresh seed dormancy.

In the initial years of this research two early Spanish types (Chico and 91176) and a mid-early Virginia line (Robut 33-1) were crossed with other high-yielding bunch and runner types. Recently L No. 95A, TG 1E, and TG 2E were identified as new sources of earliness and used extensively in crosses. Several hundred crosses have yielded selections for earliness and high yield, as well as lines with uniform plant growth habit, maturity, and pod and seed characters. Useful high-yielding early-maturing material has been generated. Results of a 1982 rainy season trial are presented in Table 7. Currently, 63 early progenies are undergoing yield testing in three different trials at ICRISAT Center. Twenty new early flowering lines have been identified from germplasm and will be used in the crossing program.

Seed dormancy has been difficult to introduce because of its almost complete absence from Spanish bunch types. However, dormancy screening methods have been evolved and several early-maturing, dormant lines have been identified from within populations derived from early nondormant types crossed with dormant long-season types.

Photoperiod Studies

Photoperiod studies have been made possible by GTZ support to the University of Bonn for collaboration with ICRISAT on this aspect of groundnut physiology.

Although photoperiod effects had been discounted as a major factor in the adaptation of groundnuts, the work was initiated because phytotron studies at North Carolina State University showed (in unrealistic daylengths) that major changes in reproductive development could result from daylength changes.

Table 7. Performance of early-maturing groundnut selections, ICRISAT Center, 1982 rainy season.

Entry	Days to flowering	Days to maturity	Pod yield (kg/ha)
(Ah 330 x 91176) F5-B1	18	93	2440
(NC Ac 2748 x Chico) F10B1	22	101	2120
(72-R x Chico) F9B	23	104	2130
(JH 89 x Chico) F9B	23	92	2000
(Chico x NC 344) F5	19	91	1980
Chico[1]	20	91	1780
J 11[2]	27	104	1920
JL 24[2]	27	108	2190
SE ±	0.6	1.4	116
CV(%)	5	3	13

1. Early maturity parent.
2. National check cultivars.

The ICRISAT objective was to establish the significance of photoperiods to groundnut yields within daylength ranges which occur in actual cropping environments. After preliminary experiments to examine the light intensity necessary to induce photoperiod effects, experiments were conducted under field conditions. Six genotypes were studied in long days (16 hours), and short days (11-12 hours), and large yield changes were observed for some cultivars. In some cultivars yield could be decreased by 50% by long days, while in others, long days resulted in slight yield increases. At present research is continuing in this field in order to develop a reliable method of screening.

Utilization of Wild *Arachis* Species

There are an unknown number of wild species of *Arachis.* Those that have been collected are maintained in major living collections in Brazil, USA, and at ICRISAT. There are about 100 accessions at ICRISAT; some are named species, others are collections whose identity and taxonomic status are not yet known.

All these accessions are screened for desirable characters as soon as possible after release from quarantine. Emphasis has been placed on disease resistance, especially resistance to leafspots and other diseases where resistance has not been found within *A. hypogaea.*

Not all resistances can be transferred. The most accessible genes are those in species closely related to *A. hypogaea.* These species are in the section *Arachis,* and can be crossed with *A. hypogaea* by conventional means, but the hybrids produced are partially or completely sterile. Species outside the section *Arachis* cannot be crossed with *A. hypogaea* by conventional means. Some intersectional hybrids have been produced in the USA, and their potential in bridge crosses explored, but with no success. All sections other than *Arachis* are therefore effectively isolated from *A. hypogaea,* but some accessions have characters that are of prime importance in groundnut improvment, such as resistance to viruses.

The emphasis in cytogenetics has therefore been on three fronts:

- to overcome the problems of gene transfer associated with sterility in section *Arachis* hybrids,
- to overcome intersectional barriers, and
- to develop the basic knowledge of the genomic constitution of the genus and the relationship between groundnut and potential gene sources.

The sterility in crosses within the section *Arachis* has been successfully overcome by ploidy manipulations. The initial hybrids were triploids. Chromosome doubling produced hexaploids, but subsequent backcrossing produced an unacceptable range of plant types, many of which were sterile.

Doubling the chromosome number of the wild species to produce autotetraploids or amphiploids, followed by crossing with *A. hypogaea* at the tetraploid level, produces a wide range of segregants with disease resistance and acceptable plant types. These segregants have arisen by backcrossing selections with *A. hypogaea* to allochromosome segregation and meiotic recombination to take place. The latter is especially important for elimination of undesirable characters. Cytogenetic analyses of chromosome complements of the newest collections indicate the presence o-new genomes in the section *Arachis.* These genomes may not recombine meiotically with *A. hypogaea* chromosomes (those from other sections almost certainly will not) and the elimination of undesirable characters will be impossible. In the meantime, we have made progress in using some wild species as sources of desirable characters, and have selected *A. hypogaea-like* lines with disease resistance, acceptable plant characters, and good yield.

Considerable progress has been made in overcoming barriers to intersectional hybridization. The major advance has been in the use of a simple technique to apply growth hormones to the flower at pollination time and at intervals thereafter. Careful attention to concentration, types, timing, and application sequence of hormones has enabled the development of ovules, which would otherwise degenerate, to the stage at which they can be successfully transferred to in vitro culture.

Tissue culture technology has been applied to the culture of young ovules from wide crosses. These grow successfully in culture, and develop roots and shoots but are difficult to transfer to soil. Most cultures have been of crosses between sections *Arachis* and *Rhizomatosae,* but other intersectional crosses have also been transferred to culture. The current emphasis is to investigate the causes for the difficulty in transferring cultures to soil.

The Future

We hope that over the next few years we can expand our cooperative efforts to Southeast Asia and West Africa by placing scientists or coordinators in these regions. This will enable us to better identify materials adapted to regional geographical areas. Materials developed at the ICRISAT Center in India will continue to be fed into the regional and national programs. While much of the material may be directly useable, other materials will have to be modified by crossing with locally adapted materials. Specific problems will also be identified in the regional programs where intensive work can only take place in situ because they are locale specific, e.g., bacterial wilt and witches' broom in Southeast Asia.

Our policy of supplying early generation breeding materials will also continue. This will give breeders and others the chance to select adapted material and advance it under their own agroclimatic conditions. This policy is already succeeding in India. Several cultivars which originated from ICRISAT crosses are now being entered by national breeders into national or state trials.

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Discussion on aper on the ICRISAT Groundnut Program

Taylor: Who grows minikit and other evaluation trials in India?

McDonald: Groundnut varietal evaluation is organized by the All India Coordinated Project on Oilseeds (AICORPO), a central government body, and trials are conducted in different zones of the country by State Research Institutes, Agricultural Universities, etc. Some AICORPO trials are carried out at ICRISAT Center.

Doto: Does ICRISAT Center offer a facility for identifying diseases on plant materials sent from countries outside India?

McDonald: No. Plant Quarantine regulations prevent us from importing diseased materials. However, we do make available antisera for identification of disease caused by viruses, and if funds were available we could assist other countries by sending specialist staff to cooperate in disease surveys. We are currently preparing information bulletins on important diseases.

Simons: Bud necrosis and other diseases occur at the same time. How do you arrive at a figure for yield loss from bud necrosis and other diseases and how reliable are the loss estimates?

McDonald: The severity of bud necrosis disease at ICRISAT Center can vary a great deal from season-to-season, from negligible to over 70%. Accurate loss estimates can be made by tagging diseased plants and measuring yield from healthy and diseased plants separately. Other diseases show much less seasonal variation, for instance rust and late leaf spot diseases regularly cause yield losses of around 70% on susceptible cultivars at ICRISAT Center in the rainy season.

A Regional Approach to Groundnut Improvement

S.N. Nigam and K.R. Bock*

Summary

The paper outlines in brief the objectives of the ICRISAT Regional Groundnut Program, describes the geographical diversity in the region and summarizes the constraints to increased groundnut production. It further discusses the breeding strategy adopted in the program and the results obtained so far.

Résumé

***Une approche régionale de l'amélioration de l'arachide :** Les auteurs donnent un aperçu global des objectifs du Programme régional de l'ICRISAT pour l'arachide. La diversité géographique constatée dans la région, ainsi que les contraintes à l'accroissement de la production de l'arachide sont résumées. L'article expose en détail la stratégie de sélection adoptée dans le programme et les résultats des trevaux obtenus jusqu'à présent.*

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Regional Groundnut Program for Southern Africa, established in July 1982, at Chitedze Agricultural Research Station near Lilongwe, Malawi and funded by the International Development Research Center, Canada, became effectively functional with the arrival of a groundnut breeder in September 1982. Subsequently a groundnut pathologist joined the program in December 1983, thus completing the senior staff.

This action was taken by ICRISAT in response to a 1980 request for such regional assistance by Heads of State of the nine Southern African Development Coordination Conference (SADCC) member countries.

Goals and Objectives

The goal of the program is to increase groundnut production, mainly by small farmers throughout Southern and Eastern Africa, particularly in SADCC member countries. To achieve this goal, three general objectives are being pursued with the cooperation of the national programs in the region:

- To develop and introduce high-yielding breeding lines and populations adapted to the region's different agroecological zones and containing resistance to the main factors presently limiting production at the small farmer level.
- To train scientists from the region and thus help to establish strong national groundnut research and development programs in conjunction with ICRISAT scientists in Hyderabad and other centers and programs in the region.
- To organize workshops and symposia to evolve regional research strategies and disseminate up-to-date research information in the region.

SADCC Region

The region covered by SADCC member countries, Angola, Botswana, Lesotho, Malawi, Mozambique, Swaziland, Tanzania, Zambia, and Zimbabwe is very large and diverse. It lies between the Atlantic

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(11°E) and Indian Oceans (41°E) and stretches from near the equator to about 30° S and has a total area of 4.9 million km^2. The elevation of the region ranges from sea level to mountains over 3500 m, with the major area on a plateau between 900 and 3000 m.

Although 95% of the region is in the tropics, the whole of Lesotho and Swaziland, one third of Botswana and a small portion of Mozambique lie outside the tropics. These differences in location and physiography are reflected in the wide range of climates, soils, and photoperiods found within the region. Well over 75% of the region is semi-arid as defined under ICRISAT's mandate.

Groundnut Production in SADCC Member Countries

Groundnut is an important cash and food crop in the region. Table 1 shows the FAO estimates of area and production of groundnut in the SADCC member countries. Malawi and Zimbabwe are the biggest producers, but the crop is not grown in Lesotho. Mozambique also has a substantial area under groundnuts but total production is low.

Table 2 gives the average yield of groundnut in SADCC member countries. Almost the entire groundnut crop is grown on small farms with low average yields.

Yields of over 4 t/ha have been grown on research stations and large scale farms in the region. The record groundnut yield (9.6 t/ha) was reported from Zimbabwe from the cultivar Makulu Red grown on a large farm (Hildebrand 1975).

There is great potential for increasing yields and total production in the region provided existing constraints are reduced.

Table 2. Average yield of groundnut (kg/ha) in SADCC countries.

Countries	1981	1982
Angola	500	N/A
Botswana	395	N/A
Malawi	720	720
Mozambique	471	471
Swaziland	481	N/A
Tanzania	596	604
Zambia	600	600
Zimbabwe	955	479
SADCC Region	710	--
Africa	804	738
North and Central America	2573	2630

N/A=Figure not available. Source: FAO Production Year Book, Volume 35, 1982 and FAO Monthly Bulletin of Statistics. 1983:6(1).

Constraints to Increased Groundnut Production

Constraints to groundnut production in the region have been identified at all stages from sowing

Table 1. Area and production figures for groundnuts in SADCC countries.

	Area ('000 ha)		Production (*000 t)	
Countries	1981	1982	1981	1982
Angola	40	N/A	20	N/A
Botswana	4	N/A	2	N/A
Malawi	250	250	180	180
Mozambique	170	170	80	80
Swaziland	3	N/A	1	N/A
Tanzania	94	96	56	58
Zambia	50	50	30	30
Zimbabwe	240	240	239	115
SADCC Region	851	--	608	--
Africa	6470	--	5201	--

N/A- Figure not available. Source: FAO Production Yearbook, 1982; FAO Monthly Bulletin of Statistics, 1983 6(1).

through marketing. The constraints and their order of importance vary with the countries. The major constraints to increased production in the region are:

- Low soil fertility.
- Poor cultural practices.
- Nonavailability of good quality seed.
- Lack of suitable cultivars for different agroecological areas.
- Lack of labor and draft power.
- Damage from diseases and insect pests.
- Drought stress.
- Low prices.

Of the various constraints listed, only those which fall within the competence of the regional ICRISAT team are elaborated further. This, however, does not belittle the importance of other constraints.

Damage from Diseases and Insect Pests

Disease spectra vary not only from country to country but also within countries. For example, rosette and early leafspot (*Cercospora arachidicola)* are important in the central region of Malawi, whereas in the southern region rust (*Puccinia arachidis)* and late leafspot (*Cercosporidiumpersonaturn)* are important in addition to rosette.

Of the fungal diseases, leafspots (early and late), rust, web blotch (*Phoma arachidicola*), pepper spot and leaf scorch (*Leptosphaerulina trifolli*), pod rots, and *Aspergillus flavus* are important on a regional basis. Recent studies in Tanzania have shown 37.6% yield loss caused jointly by rust and leafspot and 26.1% by rust alone (Anon 1983). Similarly, at Chitedze Research Station yield increases ranging from 31-75% were obtained in a 1982/83 experiment on economic evaluation of fungicides for control of foliar fungal diseases. Rust has become so serious in southern Mozambique that it has almost destroyed the groundnut crop there.

Among the virus diseases, groundnut rosette virus (GRV) is the most important and is capable of causing almost 100% loss in late-planted crops grown with wide spacing. Peanut mottle virus (PMV) is another common disease, however the extent of losses caused by it are not known.

Among the insect pests, Hilda (*Hilda patruelis),* aphids, and termites are frequently encountered and sometimes cause serious damage to the crop. Aphids also act as vectors for GRV and PMV. Other insect pests such as jassids and thrips can also occur in serious proportions in some fields. No efforts have been made to quantify losses caused by these insect pests.

Lack of Suitable Cultivars

With the exception of Malawi and Zimbabwe, the varietal picture in the region is not very encouraging. Even in these two programs, development of improved short-season cultivars has received little attention. Disease resistance breeding, with the exception of Malawi, has only very recently been started in the region. The Malawi Program successfully developed a rosette resistant cultivar, RG1, but did not make much progress in developing cultivars resistant to important foliar fungal diseases.

Drought Stress

The importance of drought as a factor limiting groundnut production varies within the region. In Malawi and Zambia, it is less important, but in other countries uneven rainfall is a major problem. Mid-season droughts of 2-3 weeks are common in the region.

Research Program

Because the mandated area of the Regional Program is very large and diverse, so are the problems associated with groundnut production. For a regional program to function effectively in cooperation with national programs, present activities are concentrated on:

- Breeding for resistance to the diseases of regional importance, and
- Breeding for increased yields, seed quality, and earliness.

Breeding Strategy

Breeding strategy depends on the nature of available breeding material and the specific breeding objectives. The breeding material is obtained either from germplasm lines and breeding populations imported from ICRISAT Center and other organizations, or material generated at the Regional Center.

In the first season exotic material undergoes preliminary evaluation either In replicated trials or In observational plots. In the first season of evaluation or selection, emphasis is placed on characters such as disease resistance, seed size, and quality. Selection pressure for yield per se is not kept high. This is mainly done to give the exotic material at least a season to "tune in" to the local conditions. Experience has shown that quite often exotic lines improve their performance under local conditions as time passes. From the second year onwards, selection pressure based on yield per se is generally kept high, although the intensity of this pressure varies from early to advanced generations.

The breeding material generated at the Regional Center passes through rigid selection pressure for yield and other specific characters from the F2 generation onwards. Sometimes, depending upon the population size in F2 or F3, it might be slightly relaxed.

Most of the time the bulk pedigree method is followed to retain enough variability in the selected populations to permit in situ selection at other locations by cooperating scientists. Occasionally highly promising individual plant selections are also made. Quite often phenotypically similar sister lines are bulked.

Selected populations are supplied to the national programs for further selection under local conditions. Advanced breeding lines are included in Regional Yield Trials for evaluation under different agroecologjcal conditions. These trials are intended to be kept fairly dynamic and flexible, permitting easy deletion or addition of test entries for rapid dispersal of breeding material.

Introduction, Evaluation, and Documentation of Germplasm

Introduction or "reselection" in the introduced germplasm has played a significant role in the development of new groundnut cultivars in the region (Hildebrand and Smartt 1980). Of the seven cultivars released in Zimbabwe, five are the result of introduction or of "reselection" in the introduced material, as were five of the six cultivars released in Malawi.

1982/83 Season. Introducing varietal improvement either directly or indirectly by enriching the available variability is important. The Regional Program acquired new germplasm from the beginning. In the 1982/83 crop season, 488 germplasm lines, mostly of South American and African origin, and 111 elite parental lines of proven good combining ability and resistance to diseases and insect pests were evaluated in 6 m long by 60 cm wide unreplicated one-row plots. Nine important cultivars of the region were included as controls.

All 599 lines were evaluated for various morphological characters, reaction to early leafspot, and yield. These lines have been assigned ICRISAT Groundnut Malawi Numbers (ICGM) and have been documented in the Germplasm Accession Register. Performance of some of the promising germplasm lines and selected controls is presented in Table 3. From the preliminary evaluation it appears that some of the Valencia types (*Arachis hypogaea* subspecies *fastigiata* var. *fastigiata),* particularly those of South American origin, perform well under Chitedze conditions. With the exception of Zimbabwe, where they are now being phased out, it seems that Valencia types have not received the attention they deserve.

During the first season, Dr. P. Subrahmanyam, ICRISAT Center Groundnut Pathologist, was seconded to the Regional Program from January to April 1983 to assist the breeder in evaluating the germplasm and breeding material for disease resistance. His observations on disease reaction are included in this paper.

None of the lines tested showed any appreciable level of resistance to early leafspot. All of them were rated 9 on a 1 -9 scale (1 = no disease, and 9 = extensive damage to foliage) with defoliation ranging from 80 to 100% when assessed some 10 days before harvest. In some cases of severe defoliation, the lesions on the retained leaflets were small with sparse sporulation (Table 4). One such germplasm line was ICGM 189, which was selected independently on the basis of yield performance.

Some of the lines [NC 3033, ICG 6340 (PI 350680), ICG 4747 (PI 259747), and ICG 7882 (PI 270608)] reported resistant to early leafspot in the USA (Sowell et al. 1976, Hassan and Beute 1977) did not maintain their resistance under Chitedze conditions.

The germplasm lines could not be screened for rust and late leafspot at Chitedze because these diseases appeared very late in the season, by which time early leafspot had already caused severe defoliation.

1983/84 Season. In the current 1983/84 season, two plantings of germplasm material have been made.

Table 3. Performances of some promising germplasm lines compared with selected control cultivars, Chitedze, 1982/83 (unreplicated trial).

ICGM No.[1]	Origin	Final stand	Pod yield (kg/plot)	Seed yield (kg/plot)	100 seed weight (g)	Cultivar group[2]
336	Bolivia	34	1.41	0.83	58.3	Nambyquarae
471	--	32	1.12	0.83	34.9	Spanish/ Valencia
437	Brazil	39	1.09	0.80	41.7	Spanish
48	Brazil	41	1.16	0.79	35.0	Valencia
197	Bolivia	30	1.25	0.78	36.3	Valencia
177	Brazil	35	1.13	0.78	35.2	Valencia
189	Brazil	34	1.03	0.73	34.4	Valencia
Control						
Chalimbana	Zambia	33	0.62	0.38	75.9	Virginia
Mani Pintar	Bolivia	35	0.90	0.65	50.9	Nambyquarae
Egret	Zimbabwe	23	1.09	0.56	48.2	Virginia
Spancross	USA	40	0.70	0.48	29.4	Spanish

1. All the ICGM's and control Spancross took 124 days to mature as compared to the 139 days of the other 3 controls.
2. As per Gibbons et al. 1972.

Table 4. Reaction of groundnut genotypes to early leafspot (*C. arachidicola*), Chitedze, 1982/83.

	Components of resistance			
Genotypes	Defoliation (%)	Infection frequency (lesions/cm^2)	Lesion diameter (mm)	Sporulation[1]
Germplasm				
ICGM 189 (ICG 5216)	80	15.1	2.0	1.8
ICGM 291 (ICG 8528)	85	19.2	2.2	2.0
ICGM 292 (ICG 8529)	80	20.5	2.5	1.5
Breeding populations				
F_4 (NC Ac 17133-RF x TMV2) F2-B1-B1	90	1.2	9.2	5.0
F_7 (TG 3 x NC Ac 17090) F2-B2-B1-B2-B1-B1	55	2.3	9.0	5.0
Control Chalimbana	85	3.0	8.5	5.0

1. Scored on a 5-point scale where 1 = no speculation and 5 - extensive sporulation.

Germplasm Yield Trial

Fifty-one of the germplasm lines selected on the basis of 1982/83 performance and 13 control cultivars have been planted in an 8 x 8 simple lattice design with 6 m long two-row plots.

Preliminary Germplasm Evaluation

Single 6 m rows of 270 germplasm lines (108 new and 162 old acquisitions of large seed size) along with 9 control cultivars have been planted in an augmented plot design.

Breeding for Disease Resistance

Foliar Fungal Diseases. Of the various fungal diseases prevalent in the region, only rust and early and late leafspots merit our present attention.

Chitedze provides an ideal location to screen for early leafspot resistance, but it is not suitable to screen for rust or late leafspot due to their restricted and very late occurrence. To overcome this problem and to combine resistance against these pathogens, rust- and late leafspot-resistant populations derived from stable resistance sources (Subrahmanyam et al. 1983) are obtained from ICRISAT Center in Hyderabad. These populations are then screened for early leafspot resistance at Chitedze.

The major emphasis in selection is yield and seed quality under severe and uniform disease pressure (artificial or natural). This should ideally result in three kinds of selected populations:

- high yield and a high resistance level,
- high yield and a moderate or low level of resistance, and
- low yield and a very high resistance level.

The latter populations usually end up in hybridization blocks, but the other two are advanced further and evaluated in diverse environments. That is the ideal: let us now see how far we have gone in Malawi.

1982/83 Season

Breeding Material. In the 1982/83 season a total of 338 breeding populations (F1-F9 generations) were planted in varying numbers of rows. Early leafspot caused extensive defoliation (75-100%) of all populations except one, resulting in a maximum disease score of 9. Only two populations, one with somewhat less defoliation and another with a low infection frequency were identified as possessing any degree of resistance (Table 4). The breeding population, TG3 x NCAc 17090, though sustaining less than average defoliation, had large lesions with extensive sporulation. The other population, NCAc 17133-RF x TMV 2, had severe defoliation and large lesions with extensive sporulation, but its infection frequency was low. It is hoped that by intercrossing these populations and germplasm lines such as ICGM189, ICGM291 and ICGM292, populations with high levels of early leafspot resistance can be developed by combining the various components of resistance.

On the basis of yield and pod and seed characteristics 161 bulk selections were made. Of these only six were rated as good (Table 5) and a further 27 as average to good. The rest were average or below average. The average and below average selections were retained for further evaluation at Chitedze and other locations where rust and late leafspot are the predominant diseases.

Yield trial. Twenty advanced rust-resistant breeding lines were evaluated along with nine control cultivars. The highest yield was from the control cultivar, Mani Pintar (A *hypogaea* subspecies *hypogaea*), which matured in 132 days (Table 6). Among the breeding lines, Nc-Fla-14 x PI 259747 yielded highest, but it was not a significantly different yield than that from Mani Pintar. It took only 118 days to mature. Many breeding lines, when compared with Spancross, a control cultivar of similar growth habit (*A. hypogaea* subspecies *fastigiata*), had higher yields but the differences were not sig-

Table 5. Pedigree of six good selections made in the Foliar Fungal Disease Resistance Program, Chitedze, 1982/83.

Generation	Number of selections	Pedigree
F_1	1	(ICGS 21 x (SM 1 x EC 76446 (292)) (F2-B2-B1-B2-B1-B1)
F_4	1	(EC 76446 (292) x 87/4/7 (2))F2-B1-B1
F_6	2	(Robut 33 - 1 x NCAc 17506) F3-B1-B1
F_6	1	(Starr x NCAc 17090) F2-B1-B1-B1-B1
F_8	1	(HG 1 x NCAc 17090) F2-B1-B1-B2-B1-B1-B1

Table 6. Performance of some of the high-yielding breeding lines and control cultivars in the Rust Yield Trial, Chitedze, 1982/83.

Identity	Branching pattern	Days to maturity	Yield (kg/ha)	Shelling (%)	100 seed weight (g)
Mani Pintar	A[1]	132	2939	72	51.3
(NC - Fla - 14 x PI 259747)	S[2]	118	2596	75	26.7
(TC x EC 76446 (292))	S	118	2471	71	35.9
(NCAc 2190 x NCAc 17090)	S	118	2408	63	40.7
(Florigiant x NCAc 1 7090)	S	118	2323	62	31.2
Spancross[3]	S	118	2254	75	30.0
NCAc 17090[4]	S	118	1902	68	37.0
Chalimbana[3]	A	137	1565	68	82.3
SE ±			131		
CV (%)			12.5		

1. Alternate branching (*A. hypogaea* subspecies *hypogaea var. hypogaea).*
2. Sequential branching (*A. hypogaea,* subspecies *fastigiata),*
3. Control cultivar.
4. Control, rust resistant parent.

nificant. At Chitedze, however, the advantage of these rust resistant lines could not be exploited fully because of the severity of early leafspot and the very late and restricted rust occurrence. Under conditions of heavy rust attack they should significantly outyield Spancross. Four of these breeding lines, ICGMS Nos. 27, 28, 29, and 30, were further purified and included in the Regional Yield Trials.

New Crosses. Twenty-three new crosses were made between the important cultivars of the region and lines resistant to rust and late leafspot.

1983/84 Season

Breeding Material. A total of 274 breeding populations starting from F_1 to F_{11} generations have been planted in plots of varying sizes. They are selections made in the 1982/83 season, newly acquired populations from ICRISAT Center, 20 *Phoma* resistant populations obtained from Zimbabwe, and 23 new F_1 hybrids developed at the Regional Center.

Yield Trials. Three yield trials are currently being conducted to evaluate performance and reaction to early leafspot.

- Interspecific material yield trial. Forty newly obtained interspecific lines and nine control cultivars are being evaluated. The interspecific lines have shown high yield potential and high levels of resistance to rust and late leafspot under Indian conditions.
- Rust yield trial (F_6-F_{11} generations). Sixteen newly obtained populations are being evaluated along with four control cultivars.
- Rust yield trial. A total of 18 entries from the 1982/83 yield trial and selected breeding populations are being evaluated with seven control cultivars.

Virus Diseases

Groundnut rosette is the most devastating virus disease in the region. The Malawi national program has successfully developed and released a resistant cultivar, RG1. There are many more breeding lines in the pipeline. However, all of these are of long duration and belong to the subspecies *hypogaea.* No efforts have been made to incorporate rosette resistance into the short-season cultivars belonging to the subspecies *fastigiata.* The regional program intends to develop short-season rosette resistant cultivars and to incorporate resistance to the important foliar fungal diseases. Successful screening for rosette resistance at Chitedze can be carried out by planting disease nurseries late in the season.

1982/83 Season

Rosette Screening. In the 1982/83 season 300 advanced interspecific lines were screened for rosette resistance by planting them late in January. A total of 48 selections, mostly single plants, were made which did not have typical rosette symptoms.

West African germplasm. Resistance of the West African germplasm lines such as RMP 40, 48-37, 48-36, and 48-21 was reconfirmed under field conditions in Malawi.

F_1 Crosses. Seventy-one new F_1 crosses were made for rosette and multiple disease resistance.

1983/84 Season

Plant Selections. Forty-eight plant selections were sown at the normal time for seed increase. Some of them have already gone down with rosette.

F_1 Crosses. Seventy-one F_1 crosses were planted in the field. They are being regularly sprayed against aphids to avoid rosette.

Rosette resistance. A 6 x 6 diallel (48-36, RMP 40, and RG1 as resistant parents and JL 24, ICGM 48, and Mani Pintar as susceptible parents) for studying inheritance of rosette resistance has been completed in the field hybridization block.

Breeding for Increased Yield, Seed Quality and Earliness

Development of early-maturing high-yielding breeding lines with good seed quality is an important activity of the program. These lines do not possess disease resistance and are intended principally for areas where some of the diseases may not occur or could be contained by other means. However, since these lines are selected and evaluated under nonprotected conditions, they apparently have the ability to yield well under disease pressure without possessing any obvious disease resistant characteristics. These lines are also useful parents! material to use in disease resistance programs.

1982/83 Season

Breeding material. Some 645 populations representing F_1 to F_{10} generations were grown in varying plot sizes under nonprotected conditions. Days to 75% flowering ranged from 21-35 and to maturity from 108-138. All the populations were highly susceptible to early leafspot. Selections were made visually on the basis of yield and pod and seed characteristics, and 219 populations were rejected. Of the remaining 426 populations, 443 selections, mostly bulks, were made. A total of 58 good selections were identified. Three of these selections, ICGMS Nos. 31, 32 and 47, were included in the Regional Yield Trials. Various station trials also included 102 other selections with good or average performance. The remaining were replanted for further selection.

Yield trials. Seven yield trials with entries ranging from 19-64 were planted in appropriate experimental designs. The mean yield of trials varied from 1710-2277 kg/ha. The control cultivar Mani Pintar, wherever it was included, generally performed the best, and few lines exceeded its yield. However, Chalimbana, the predominant confectionary cultivar of Malawi, did not fare well in any of the trials. Tables 7 and 8 give the performance of some of the breeding lines vis-a-vis the highest yielding control cultivar of the same botanical type.

Of the 226 test entries 121 were retained because they performed as well or better than the control cultivars of similar botanical types. ICGMS numbers were assigned to 37 high-yielding breeding lines which were included in the Regional Yield Trials. The remaining entries were included in various station trials according to their botanical types.

F_1 crosses. Ninety-three F_1 crosses were made among the important high-yielding cultivars of the region and exotic material of good combining ability.

1983/84 Season

Breeding material. In addition to the 93 F_1 crosses, 547 populations (F_2 to F_{11}) were planted in the field in varying plot sizes under nonprotected conditions. These include 117 newly acquired populations, many of which include African cultivars in their parentage.

Yield trials. Nine yield trials with entries ranging from 16-64 are being conducted in appropriate experimental designs. These include two Regional Yield Trials, one each for Spanish and Virginia

Table 7. Performance of some of the selected entries in various yield trials, Chitedze, 1982/83.

Trial	Identity	Yield (kg/ha) Unadjusted	Yield (kg/ha) Adjusted	Shelling (%)	100 seed weight (g)
Early Population	(JH 89 x Chico) F2-B1-B1-N1B1-B2-B1-B1-B1	2775	--	77	32.1
	Malimba[1]	2463	--	75	32.7
	SE ±	189	--	--	--
	CV(%)	18	--	--	--
High yield and quality F9. (S.B.)	JL 24	2389	2368	74	40.6
	(Tifspan x Robut 33-1) F2-E-B1-B1-B1-B1-B1-B1-B1	2345	2336	72	38.3
	Malimba[1]	2113	2104	65	32.2
	SE ±	106	--	--	--
	CV(%)	10	--	--	--

1. Control cultivar belonging to subspecies *fastigiata* cultivar *vulgaris.*

Table 8. Performance of some of the selected entries in various yield trials, Chitedze, 1982/83.

Trial	Identity	Yield (kg/ha) Unadjusted	Yield (kg/ha) Adjusted	Shelling (%)	100 seed weight (g)
HYQF 10 (VB)	(Robut 33-1 x NCAc 316) F2-B1-B1-B1-B1-B2-B1-B1-B1	3382	3302	72	41.6
	Mani Pintar[2]	2852	2788	72	51.0
	SE ±	267	--	--	--
	CV(%)	25	--	--	--
HYQF 11	(USA 20 x TMV 10) F2-P3-B1-B1-B1-B1-B1-B1-B1-B1	3456	3393	73	64.0
	RG 1	2236	2116	66	46.2
	JL 24	2606	2572	74	36.3
	Spancross[1]	2345	2252	71	29.2
	SE ±	120	--	--	--
	CV(%)	12	--	--	--

1. Control cultivar belonging to subspecies *hypogaea* cultivar *hypogaea.*
2. Control cultivar belonging to subspecies *fastigiata* cultivar *vulgaris.*

bunch groups, an F2 yield trial and an F2 line x tester yield trial.

A set of 54 crosses between six released cultivars of the region and nine high-yielding exotic cultivars has been completed in the field hybridization block.

Looking Ahead

No major shifts in the program's goal and objectives are seen in the near future. However, activities will be intensified in these areas:

Germplasm Acquisition. Sources of rosette- and drought-resistance from Senegal and Burkina Faso (formerly Upper Volta), early leafspot resistant sources from the USA and Zimbabwe, and other promising lines from the region will be acquired.

Crosses. More new crosses will be attempted as workers' hybridization expertise improves. This will considerably increase the proportion of self-generated breeding material in the program.

Disease Resistance. Search for stable sources of resistance to early leafspot will be intensified. Development of breeding populations with multiple disease resistance will continue to receive our prime attention.

Regional Tests. With the cooperation of national programs, the regional network of testing for yield and disease reaction will be further strengthened. National programs will be encouraged to make more use of the breeding material generated at the Regional Center.

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Discussion on Paper on a Regional Approach to Groundnut Improvement

Gausi: Are you looking for vertical or horizontal resistance in your breeding for resistance to diseases?

Nigam: It depends upon the disease in question. In the case of rosette virus disease it is vertical resistance whereas for the foliar diseases it is horizontal resistance.

Edje: What is the relevance of breeding for easiness for Malawi conditions given that the cultivar Chalimbana can attain maturity under the existing conditions?

Nigam: In some areas of Malawi and in other countries of the region the growing season is 110-120 days. Chalimbana takes 140-150 days to reach maturity in Malawi. This justifies breeding for earliness.

Pasley: What are the chances of breeding high-yielding cultivars given that there are at least five diseases reducing yield?

Nigam: Work at ICRISAT Center has shown that it is possible to combine multiple disease resistance with high yield. There are several lines with moderate resistance to late leaf spot, rust, and rosette.

Chiteka: It is known that there are two types of groundnut rosette, chlorotic rosette, and green rosette. Which of these is most prevalent in Malawi? Is the inheritance of resistance similar for both types?

Nigam: Chlorotic rosette is predominant in Malawi. The inheritance of resistance to the two types of rosette is not known.

Bock: There are a few isolated areas where green rosette occurs but by and large the chlorotic rosette is predominant.

Ramanaiah: Rosette resistant cultivars are needed for Mozambique.

Monjana: Groundnut rust is a problem on research stations in Mozambique but not on farmers' groundnuts in normal years.

Nigam: I have seen severe rust damage on crops near Maputo.

Sandhu: Some of the ICG lines have resistance to rust and late leaf spot but they are of a different botanical type from the agronomically acceptable cultivars commonly grown. What are the possibilities for successful transfer of the resistance across the botanical types?

Nigam: The transfer of resistances from fastigiata to hypogaea and vice versa is possible but it is easier if both parents belong to the same botanical groups.

Amin: You seem to have based your conclusion that rust is important in Mozambique on one visit, is this sufficient?

Nigam: More visits are needed to establish the importance of rust and other diseases in Mozambique.

Doto: What criteria are used in selecting disease-resistant material from ICRISAT Center for use in your Regional Program?

Nigam: Many factors are considered in the choice of material. Special consideration is given to the findings of Hildebrand and his coworkers in Zimbabwe that Bolivian groundnut germplasm is well adapted to the Central Africa region.

Country Reports

Groundnut Production in Botswana

A. Mayeux*

Summary

This paper provides some information on the climate of Botswana and on the position of groundnuts in the agriculture of the country.

Résumé

La production de l'arachide au Botswana : L'article fournit des informations sur le climat du Botswana et sur l'importance de l'arachide vis-à-vis des autres cultures dans le cadre de l'agriculture du pays.

Botswana lies between latitudes 17° and 27°S and has a semi-arid climate with average annual rainfall ranging from 600 mm in the northeast to less than 200 mm in the southwest. Rainfall figures for five regions are shown for three probability levels in Table 1. Most of the rain falls in the summer months (Oct-Apr). For the main arable areas the annual rainfall varies from 350-550 mm, but the variation is very high. It has been estimated that the potential evaporation of freely watered crops is 1400 mm per annum with daily maximum of 5.5 mm.

Table 1. Annual rainfall totals for different regions of Botswana.

	Annual rainfall (mm)		
	Probability		
Region	75%	50%	25%
Gabarone	214.5	453.1	612.6
Central	344.6	523.4	663.1
Francistown	318.5	453.2	562.1
Maun	345.0	473.9	580.2
Western	304.0	432.5	536.7

The cultivation of groundnuts in Botswana is small in comparison with that of cereal crops (sorghum, maize, millet) and beans. Areas of important crops harvested and production figures are given in Table 2. More detailed data on traditional groundnut cultivation and production are given in Table 3. Traditional farm yields are generally very low. There has been a limited commercial production of groundnut with 25, 20 and 10 farms being involved in the 1980,1981 and 1982 seasons respectively. Commercial farm yields are also low

Table 2. Areas harvested and total production of important crops in Botswana, 1980-82.

	1980		1981		1982		Average	
Crops	Area ('000 ha)	Production ('000 t)	Area ('000 ha)	Production ('000 t)	Area ('000 ha)	Production ('000 t)	Area ('000 ha)	Production ('000 t)
Sorghum	130.4	29.1	122.4	28.3	37.3	3.9	96.7	20.0
Maize	46.5	11.6	59.3	21.4	23.9	12.4	43.2	15.1
Millet	14.3	2.3	12.7	1.9	3.4	0.5	10.1	1.5
Pulses	12.6	1.8	14.7	2.7	3.6	0.5	10.3	1.7
Sunflower	6.7	1.4	2.9	1.2	1.9	0.7	3.8	1.1
Groundnut	3.8	1.4	4.3	2.0	0.7	0.5	2 9	1.3

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International Crops Research Institute for the Semi-Arid Tropics. 1984. Regional Groundnut Workshop for Southern Africa, 26-29 March 1984, Lilongwe, Malawi. Patancheru, A.P. 502324, India: ICRISAT.

Table 3. Groundnut cultivation and production in traditional farming in Botswana 1980-1982.

	No. of groundnut farms			Area of groundnut harvested			Production (t)			Average yield (kg/ha)		
Region	1980	1981	1982	1980	1981	1982	1980	1981	1982	1980	1981	1982
Southern	200	500	1000	0.2	0.7	0.3	50	440	75	250	629	250
Gaborone	100	400	400	0.1	0.1	0.1	15	25	5	150	250	50
Central	1000	300	800	0.8	0.6	0.1	56	120	30	70	200	300
Francistown	1000	1700	2200	0.3	0.3	-	42	70	-	140	233	-
Maun	200	-	100	-	-	-	-	-	-	-	-	-

at 508-533 kg/ha for the 1980-1982 period. Attention should be given to improving agronomic practices and to selecting cultivars suited to Botswana conditions.

Groundnut Improvement in Malawi

Patricia Ngwira*

Summary

This paper discusses the importance of groundnuts in Malawi, the average and potential yields, and the constraints that limit the groundnut yields in the country. It reviews both past and current research work aimed at improving the yields and quality of groundnuts in the country.

Résumé

***L'amélioration de l'arachide au Malawi :** Cette communication donne un bref aperçu de l'importance de l'arachide au Malawi, les rendements moyens et potentiels, et les facteurs limitant la production et le rendement dans ce pays. Elle fait le point sur les travaux effectués jusqu'ici comme les recherches en cours visant à l'amélioration des rendements et de la qualité de l'arachide au Malawi.*

Groundnuts, *Arachis hypogaea* L, have been grown in Malawi since the middle of the 19th century. The crop is Malawi's fourth most important export crop after tobacco, sugar, and tea. Groundnuts also supply about half the country's edible oil. The crop is particularly important in smallholder agriculture. Groundnuts contribute significantly to the diet and provide between a third and a fourth of smallholder cash income.

Groundnuts are exported as confectionary nuts at a yearly average of 130001 (1978-83 average). Groundnut production has declined since the late 1960s due to a combination of factors.

Farmers average yields are very low (500-700 kg/ha) as compared to over 3000 kg/ha at research stations. It remains the policy of the Government to increase yield and quality of the crop as rapidly as possible.

The Groundnut Improvement Program in Malawi started early in the 1960s under the Grain Legume Unit of the Agricultural Research Council of Central Africa. The two main problems under investigation were rosette virus disease and cercospora leafspots of groundnuts. The objective was the production of disease-resistant or immune strains of groundnuts through breeding, and finding ways of reducing the disease incidence by using various chemicals in order to control the diseases.

Constraints that Limit Groundnut Yields and Production

It is conceivable that some of the factors which limit groundnut yields and production today are of long standing occurrence, although more is now known about what should be done to grow a good crop of groundnuts. But again, new problems are being born all the time.

Previously, lack of improved cultivars was among the constraints, but now good improved cultivars have been developed and released to farmers. Poor crop husbandry has been a major limiting factor.

There are four main cultivars recommended and grown in Malawi. Chalimbana, a large, pink-seeded, long-season (140-150 days) cultivar of runner habit is recommended for altitudes of 1000-1500 m. Chalimbana forms the basis of the confectionary export trade. It has a yield potential of over 4000 kg/ha. Mani Pintar has medium-sized red and white variegated seeds, is of medium- to long-season (130-140 days), and has a spreading bunch habit. It is recommended for altitudes of 500-750 m and has a yield potential of over 3000 kg/ha. Malimba has small seeds with light tan testas and a Spanish bunch growth habit. It is short

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season (110-120 days) and recommended for altitudes of 200-300 m. RG1 is a long-season (130-140 days) spreading bunch cultivar with medium large russet-brown seeds. It was bred by the Grain Legume Unit of the Agricultural Research Council of Central Africa, is resistant to rosette, and is recommended in areas where rosette is very serious. It has a lower yield potential than either Chalimbana or Mani Pintar.

Even though these four cultivars are improved forms with very high yield potentials, they generally give only low yields (500-700 kg/ha) when grown by farmers. The reasons for these low average yields include droughts, unreliable rainfall, poor crop management, attacks by pests and diseases, and the low calcium content of some soils.

Pests and diseases are major constraints limiting groundnut yields in the country. Pests of groundnuts include termites, white grubs, *Aphis craccivora* (which is more important as a vector of rosette disease than a direct damage pest), aphids, thrips, jassids (damage not yet evaluated), and *Hilda patruelis* which is said to be responsible for the groundnut disease known as 'slow wilt'.

Fungal diseases of groundnuts in Malawi include early leafspot, late leafspot, rust, Phoma leafspot, Leptosphaerulina scorch and pepper spots, 'slow wilt' due to *Fusarium* and *Hilda patruelis,* pod and collar rot due to *Aspergillus niger,* and stem rot and leaf blight due to *Sclerotium rolfsii.* Several virus diseases have been identified including those caused by groundnut rosette virus (GRV), peanut mottle virus (PMV), tomato spotted wilt virus (TSWV), and cowpea mild mottle virus (CMMV). Of all these diseases the most economically important are rosette and early leafspot. These two diseases are present throughout Malawi's groundnut regions, and are particularly devastating in the Central Region where the bulk of the crop is produced (Ngwira et al. 1983). Rust and late-leafspot diseases occur towards maturity of the crop and are not serious in the Central Region but are extremely important in the Southern, Northern, and Lake Shore areas of the country. 'Slow wilt' caused by *Fusarium* and *Hilda patruelis* has become extremely important in some areas over the past two years.

The four cultivars grown in the country differ in their disease susceptibility. Chalimbana, Malimba, and Mani Pintar are susceptible to all the diseases, while RG1 is resistant to rosette but susceptible to all the other diseases mentioned.

Witchweed, *Alectra* sp., a parasitic flowering plant, is becoming an important problem. It may be controlled to a limited extent by hand pulling but this is labor demanding and time consuming.

Groundnut Improvement in Malawi

The groundnut improvement program is aimed at finding ways to increase yields and improve groundnut quality. To achieve this objective a multidisciplinary team comprising a breeder, a pathologist, and an agronomist carry out the following programs.

Groundnut Breeding

Varietal Improvement

The standard methods of introduction, selection, and breeding have been used for varietal improvement. Introduction from outside has been an effective tool. Three of the recommended cultivars have been introduced from outside: Chalimbana from Zambia, Mani Pintarfrom Bolivia through Australia and then Zambia, and Malimba from the Gambia. There is no doubt that this tool will continue to play an important role in the future.

Breeding for Resistance

Because the three cultivars mentioned above are susceptible to all the important diseases, a breeding program to combine desirable characteristics into one cultivar was necessary. RG1 was the result of efforts to breed a rosette resistant cultivar. The rosette resistance for this cultivar was obtained from Cultivar No. 48-14, which is highly resistant to rosette virus. Because RG1 is small seeded, breeders worked to incorporate rosette resistance into the existing Malawi groundnut cultivars. This involved back crossing/intercrossing the high-yielding but susceptible Malawi groundnut cultivars and other cultivars reported to carry resistance to rosette. This program was successful and several rosette resistant cultivars have been produced. These are now being tested all over the country, especially in the areas where rosette is most serious.

Breeding for cercospora resistance has not been done because there are no resistance sources in the cultivated tetraploid *Arachis hypogaea.* We hope to take advantage of any useful material coming out of ICRISAT's interspecific work. Although we have some lines reputed to carry resistance to aflatoxin, to date no work has been done on this problem.

Since increasing yield and seed size are major objectives, a breeding program produced the cultivar E879/6/4, which has an extra large pod and a seed count of 68/100 g. It is a Chalimbana hybrid and is now on limited release. Also on limited release is SAC 58, a variegated red- and pink-seeded cultivar designed for oil production, and to compliment Vlani Pintar.

Groundnut Protection from Pests and Diseases

Groundnut protection covers the control of weeds, diseases, and pests in order of decreasing importance.

Weed Control

There are several problem grasses early in the season but the broad-leaved weeds of various types become dominant later in the season. But of ail the weeds the most important and tough weed is the witchweed, *Alectra* sp. This parasitic weed is widespread on groundnuts in Malawi.

Weeds are generally controlled by hand weeding with a traditional hoe, although chemical weed control with Lasso is useful. Hand pulling is effective for the broad-leaved weeds and *Alectra* sp. Crop rotation has also been found to help with weed control.

Disease Control

Although the disease situation for groundnuts has changed drastically since 1974 with the new importance of rust and 'slow wilt', the scope of the research work on disease control has remained virtually the same: to monitor the diseases on groundnuts, study their epidemiology, and most importantly, find the best fungicide to use for disease control.

The guiding principle in the search for chemical disease control has been to find a suitable broad spectrum fungicide: of low toxicity, cheap to use, but effective. It is from these investigations that Daconil 2787 has now been recommended to replace the previously recommended sulphur dust. Daconil 2787, a chlorothalonil product, is a contact fungicide which controls most of the important foliar fungal diseases effectively and economically. Table 1 shows some yield increases over 13 years when Daconil was used for foliar disease control.

Pest Control

Since the economic importance of insect pests has not been evaluated so far, no routine spraying of insecticides in conjunction with fungicides is done. If serious infestations occur occasional spraying is worthwhile.

Pirimiphos methyl or carbaryl is used to control leafeaters when they assume destructive proportions. Dimethoate is used for aphid control.

Agronomy

Most of the work to establish good cultural practices for groundnuts started in the early 1950s. As a result, groundnuts are known to grow well under a wide range of soil and climatic conditions in the country (Fig.1) provided good crop husbandry practices are followed. Planting early, using good

Table 1. Effects of Daconil spray treatment on kernel yields of cultivar Chalimbana over 13 seasons. (Daconil 2787 at 1.6 kg/ha in 100 l water on 8 occasions).

	Kernel yield (kg/ha)		
Season	No spray	Daconil sprays	Increase (%)
1970/71	1773	3159	78
1971/72	1703	2860	68
1972/73	2344	3828	55
1973/74	1364	2133	56
1974/75	1589	2207	39
1975/76	1200	2797	133
1976/77	2118	2964	40
1977/78	1707	3670	115
1978/79	2510	3609	44
1979/80	1613	2507	55
1980/81	1085	1859	71
1981/82	1472	2011	37
1982/83	1774	3101	71

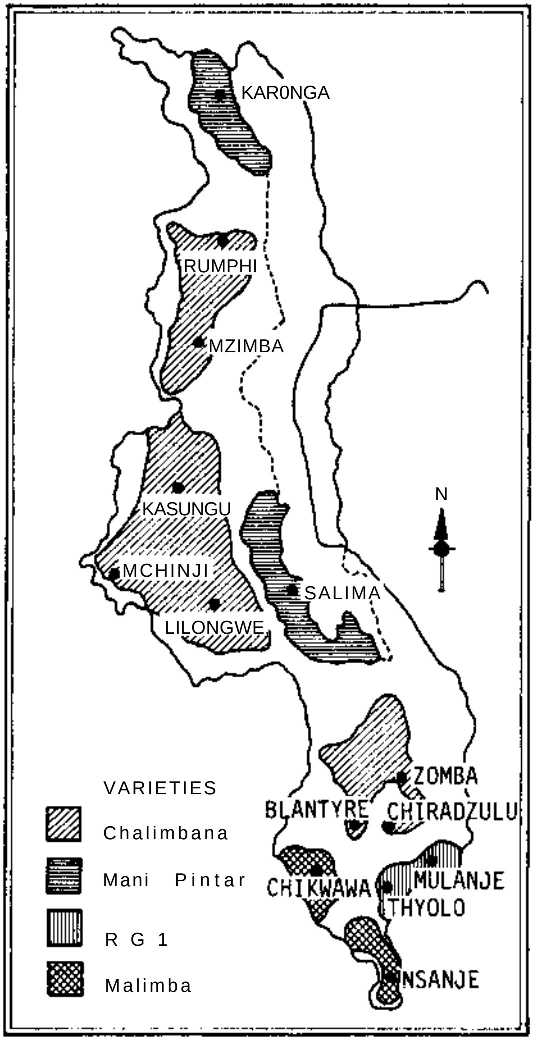

Figure 1. Areas of groundnut production and varieties grown in Malawi.

quality seed sown at recommended spacings, early and regular weeding, banking up ridges at the onset of flowering, and harvesting at optimum maturity have long been recommended to farmers, and some progressive farmers are now following these practices.

The only breakthrough resulting from fairly recent research work has been on ridge spacing. It has now been shown with Chalimbana and E879/6/4 that early planting on 60 cm ridges at 15 cm plant spacing with one seed per hole gives higher yields (Table 2) than when the previously recommended 90 cm ridge spacing is used. At the 60 cm ridge spacing high plant populations in the range of 90000-120000 plants/ha are produced. This plant population provides quicker ground cover and hence better weed control, lower rosette incidence, and higher yields. Other cultivars of the bunch type such as RG1, Mani Pintar, and Malimba are best grown at 10 cm plant spacing on 60 cm ridges.

There is as yet no fertilizer recommendation for groundnuts, because fertilizer experiments have often produced erratic responses. But it is generally recommended that for high yields groundnuts should follow a well-fertilized crop such as maize in the rotation.

In certain parts of the country groundnuts are prone to a disorder known as "pops" (poor pod filling), a symptom of calcium deficiency. In such areas a dose of 300-500 kg/ha of agricultural gypsum at flowering is recommended in the absence of a cultivar resistant to pops. Screening for pops tolerance and resistance is being conducted.

Future Development of Research Programs

Malawi must aim to satisfy part of the growing demand for large confectionary nuts indicated by the major groundnut buyers, as well as satisfy the increasing domestic markets for edible oil.

The best strategy, therefore, would be for Malawi to ensure high yields per unit area of both the confectionary nuts (for export) and oil nuts (for the domestic market). Research has shown yield potentials under good management of over 4 t/ha for the confectionary cultivars and 3 t/ha for oil cultivars.

However, to increase average yields, efforts are required in breeding, pathology, and agronomy to remove production constraints.

A study is in progress to determine the physiological aspects of yield of Malawi groundnut cultivars. Breeding for resistance to fungal diseases is already in progress in the ICRISAT Regional Program, which remains the source for resistant materials.

With the increasing importance of groundnut slow wilt, there is an urgent need for research into immediate control measures. High-yielding varieties with oil contents greater than 50% are also urgently required.

Table 2. Effect of ridge spacing on groundnut yields, (kg/ha kernels), and percent yield increase average of three seasons.

	Spacing between ridges (cm)			
Cultivar	90	75	60	45
Chalimbana	1698	1831 (7.8)[1]	1981(17.0)	2244(33.0)
E 879/6/4	1821	2055(13.0)	2067(14.0)	2178 (20.0)
E 885/1/4/B	1278	1995(57.0)	2201(73.0)	1339(5.0)
Mean	1599	1960(25.9)	2083(34.7)	1920(19.3)

1. Percentage increases in yield.

Acknowledgments

I would like to extend my sincere acknowledgements to Mr. T. Chibwana and Mr. C. Phangaphanga for their valuable contributions on the breeding and agronomy aspects of the crop. I also extend my sincere gratitude to Mr. M.M. Chikonda for his valuable advice on the paper, as well as that offered by Dr. S.N. Nigam.

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Groundnut (*Arachis hypogaea* L.) Seed Quality Control in Malawi

J.H. Luhanga*

Summary

The Seed Technology Unit of the Ministry of Agriculture is responsible for seed quality control in Malawi. In this paper the seed quality control procedures are detailed, including certification and testing. A review is also given of the constraints to groundnut seed production, and preliminary research project findings.

Résumé

***Contrôle de la qualité des semences d'arachide (Arachis hypogaea L.) au Malawi :** Le contrôle de la qualité des semences, au Malawi, est assuré par l'Unité de la technologie de semences au sein du Ministère de l'Agriculture. La communication décrit en détail les diverses procédures du contrôle de la qualité des semences, y compris la certification et l'essai. On fait le point, brièvement, sur les contraintes de la production arachidière, et expose quelques résultats des travaux de recherche.*

Agriculture is the most important sector in the Malawian economy: 90% of the population is employed in this sector, which contributes about 88% of the total domestic foreign earnings. Rural development through increased agricultural productivity is one of the government's primary objectives (Anon 1978). Farm inputs, including good quality seed, are vital for the success of the country's agricultural development efforts. Consequently a steady supply of seed is a prerequisite to sustain agricultural productivity.

There have been several attempts in the past to organize seed production in Malawi, but the success of such efforts in some instances was short lived. For example, the multiplication program of LH 11 (a locally bred maize hybrid) was successfully launched but eventually the program was abandoned because of lack of pure parent lines (Anon 1973). Sometimes multiplication programs succeeded, but the supply of seed could not cope with demand, such as for Mani Pintar. Seed requirements were at times met through imports, as was the case of hybrid maize.

These previous seed production efforts were inadequate because of seed importation problems, and the demand for seed far outstripped the supply because intensified extension efforts successfully encouraged more farmers to use good seed.

These circumstances made it necessary to reorganize the national seeds program in 1976 into the Seed Technology Unit (Anon 1978b). It is responsible for seed quality control in Malawi.

Quality Control

A continuous supply of seed can be produced through certification, the legally sanctioned system for seed production quality control. Its primary objective is to maintain and make available to the farming community high quality (i.e., viable and disease-free) propagating material. The Seed Technology Unit is the designated certification authority in Malawi. It prescribes, in consultation with a National Seed Technical Committee, the conditions under which seed is to be produced and the standards to be attained. The procedure for certification in Malawi is outlined below with special reference to groundnuts.

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Eligibility of Cultivars

The establishment of seed quality control systems presupposes the availability of improved cultivars generated from plant breeding efforts. The future of a seeds program is therefore based on an on-going plant improvement program. There are special regulations in Malawi which govern the eligibility of new groundnut cultivars for entry into the certification scheme. The new cultivar must be approved by the National Variety Release Committee, and has to be backed by a sound maintenance program (conducted by the breeder) in order that "fresh" seed can be introduced into the production cycle periodically. Two newgroundnut cultivars (Chitambana and SAC 58) have been released recently in accordance with these procedures. These cultivars were developed at Chitedze Research Station by the Groundnut Breeding Section.

Registration of Growers

Inherent in the certification concept is a generation system whereby the pedigrees of superior cultivars are maintained through subsequent seed production (Copeland 1976). In Malawi a three-generation scheme of internationally acceptable nomenclature is recognized (Feistritzer et al. 1975):

1. Breeder's seed is produced directly by the breeder, providing the source for the increase of the subsequent generation i.e., basic seed.
2. Basic seed is produced under the responsibility of the breeder or his authorized agent. There are standards to which the seed must conform. The fulfilment of these conditions is checked by official Seed Technology Unit inspectors;
3. Certified seed is grown from basic seed and is intended to be used for food.

Growers wishing to produce seed choose which class of seed (or generation) they want to multiply. The National Seed Company of Malawi (NSCM) is responsible for organizing the seed production program. The bulk of the seed is grown on estates under contract. The NSCM makes the necessary arrangements for the identification and registration of growers with the Seed Technology Unit each year. This season some 25 farmers,, representing 30 ha of Chitambana, have been registered with the Seed Technology Unit. The General Farming Company plans to grow 80 ha of SAC 58.

Table 1. Field standards in use for groundnut seed production.

	Class of Seed	
	Basic	Certified
Parent seed (source)	Breeder's seed	Basic seed
Isolation	100 meters	100 meters
Previous cropping history	1 season	1 season
Off-type plants	0.1%	0.2%

Note: When the seed crop is so severely infected with any disease or otherwise damaged so as to prejudice seed production, the seed certification authority rejects the crop. This condition is applicable to both classes of seed.

Field Inspection

Government inspectors examine all registered groundnut crops. Inspections are timed so that varietal off-types, or rogues, are easily identified. Field standards for basic and certified groundnut seed are shown in Table 1. These are based on the code of the Association of Official Seed Certifying Agencies (AOSCA), an international certification authority. Seed crops that fail to meet field standards are rejected.

Seed Inspection

Groundnut seed has to be processed in order to meet the purity standards for certification purposes. The National Seed Company undertakes the cleaning operation. The sample tested to determine seed quality and acceptance for certification is obtained by a government seed inspector after final processing. The sample is then submitted to the official Seed Testing Laboratory at Chitedze Research Station. The laboratory is equipped according to international standards as prescribed

Table 2. Seed standards for basic and certified groundnut seed production.

Germination	70.0%
Insect damaged seed (by weight)	2.5%
Off-types	1.0%
Pure seed (analytical purity)	98.0%
Defects (e.g. mechanical damage)	2.5%

by the International Seed Testing Association (ISTA) to which it is an accredited member. The standards for purity, germination, and other seed quality attributes are based on the Association's rules. The minimum standards for groundnut seed are shown in Table 2.

Monitoring Seed Quality

Certified seed in Malawi is marketed by the Agricultural and Marketing Corporation (ADMARC) and NSCM. The Seed Technology Unit monitors seed quality during distribution and storage by annually resampling all carryover seed stocks in ADMARC and NSCM depots. Germination tests are conducted and substandard seed is rejected.

Regulatory Control: the Seeds Act

Legislation is required to enable the Seed Technology Unit to perform its quality control functions effectively. Farmers and seed institutions would also benefit because their interests would be legally protected. A draft Seeds Act has been prepared and is being reviewed by the Ministry of Agriculture. It is hoped that in the near future seed legislation will be covered by an act of parliament.

Factors Limiting Seed Production

Although the groundnut seed certification scheme outlined in this paper is operational, the quantity of seed produced does not meet the demand. A number of constraints have been identified:

- Shelling. There is an urgent need to mechanize the shelling operation for Chalimbana, a confectionary cultivar which has large kernels. The existing equipment damages the kernels. Due to this setback, large-scale production of Chalimbana is not feasible.
- Mani Pintar, an oil nut is highly susceptible to seed-borne fungal diseases e.g. *Fusarium* spp. and *Aspergillus* spp. Shelled seed does not store well.
- These two cultivars are easily damaged (split) during processing and transportation, especially over earth roads.

In view of these problems, the Seed Technology Unit has launched a research project aimed at overcoming some of these constraints. Preliminary results from one of the trials show that:

- Seed treatment (fungicides) effectively check fungal development on seed, which improves field establishment, especially in the oil nut cultivar SAC 58 (Table 3). However, there is no appreciable improvement in field establishment of Chalimbana (Table 4).

Table 3. Mean percentage establishment of cultivar SAC 58 seedlings in a field seed dressing trial at Chitedze.

	% establishment			
	Seed dressed with			
Seed source	Prentasan	Thiram	Captafol	No seed dressing
Seed shelled 3 days before sowing	87	91	87	80
Seed shelled 5 months before sowing	68	70	94	39

Table 4. Mean percentage establishment of cultivar Chalimbana seedlings in a field seed dressing trial at Chitedze.

	% establishment			
	Seed dressed with			
Seedsource	Prentasan	Thiram	Captafol	No seed dressing
Seed shelled 3 days before sowing	87	90	96	94
Seed shelled 5 months before sowing	89	87	84	82

- There is no need to treat the seed with fungicide if it is stored in the pod and shelled three days prior to planting.

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Discussion on Malawi Papers

Kelly: Close plant spacing does result in increased yield but it also has the disadvantage of increased seed input, and it is more difficult to prepare narrow ridges and to carry out inter-row cultivations.

Ngwira: We have had no difficulty in making 60 cm wide ridges instead of 90 cm wide ones, and there have been substantial gains in yield. Weeding has not posed a problem and the more rapid attainment of land cover has helped in suppressing weed growth.

Doto: The parasitic weed alectra is a serious problem in cowpeas, what is the situation in groundnuts?

Manda: Alectra is clearly increasing in importance in groundnuts and research needs to be initiated.

McDonald: Have the economics of foliar diseases control with Daconil (chlorothalonil) been fully worked out?

Ngwira: The original recommendations for foliar diseases control was to use sulphur dust. Daconil is now recommended because it gives superior control of rust. The economics have yet to be fully worked out. The large volume of water required might discourage some farmers from following the recommendation.

Edje: Some farmers have suggested that application of daconil increased attack by *Hilda patruelis.*

Amin: You have mentioned that the economic importance of groundnut pests have not been assessed, however, pests like *Hilda patruelis* and termites can do considerable damage and *Aphis craccivora* is important both as a direct pest and as the vector of rosette.

Ngwira: Insect pest problems will be investigated in the future.

Cole: Where are the various cultivars grown in Malawi?

Ngwira: Cultivars are recommended for specific environments. Mani Pintar is grown near the lake at low altitude while Chalimbana is grown at higher altitudes.

Manda: Pops are a serious problem in some regions of Malawi. What are the prospects for genetic variability in respect of this situation? It has been reported that cultivar MB 662 is not sensitive to the condition.

Nigam: The cultivar TMV 3 from India also appears to have some resistance to pops. Good work on this problem has been done in Zambia and research is being done at ICRISAT Center on effects of calcium nutrition on pops and interaction of calcium and drought stress. Genetic variability has been found.

Doto: What are the effects of shelling method on seed viability?

Luhanga: Method of shelling is very important in relation to testa damage and seed viability. Seed of cultivar Chalimbana retained good viability over a period of 5 months following hand shelling.

Factors Affecting Groundnut Production in Mozambique

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Summary

Groundnut is cultivated mostly by small farmers as a rainfed Crop. The average yield of dried pods is 500 kg/ha. Short-season erect cultivars are grown in the south while long-season prostrate types dominate in the north.

The main production constraints are: 1. poor cultural practices, 2. pests, diseases, and weeds, 3. lack of good quality seeds, 4. irregular rainfall, 5. lack of marketing opportunities, 6. lack of suitable implements and farm power, 7. growing unimproved landraces, 8. low soil fertility, and 9. lack of technical and extension personnel. The Groundnut Impovement Project is working with farmers to find solutions to these constraints. Promising results have been obtained and are being applied at the farm level.

Résumé

***Les facteurs limitant la production arachidière au Mozambique :** L'arachide est cultivée au Mozambique principalement par les petits paysans comme culture pluviale. Les rendements sont médiocres, la moyenne étant d'environ 500 kg/ha. Les cultivars érigés à courte saison sont cultivés dans le sud du pays, alors que les types rampants à longue saison sont préférés dans le nord.*

Les contraintes principales liées à la production sont : 1. pratiques culturales peu adaptées; 2. parasites, maladies et mauvaises herbes; 3. manque de semences de bonne qualité; 4. pluviométrie aléatoire; 5. peu de possibilités de commercialisation; 6. non disponibilité d'outils adaptés et de traction suffisante; 7. utilisation des souches locales non améliorées; 8. fertilité réduite du sol et 9. insuffisance en matière de personnel technique et de vulgarisation. Le Projet d'amélioration de l'arachide étudie actuellement, en étroite collaboration avec les paysans, les moyens de surmonter ces contraintes. Des résultats favorables ont été obtenus et sont introduits en ce moment au niveau rural.

Groundnuts are grown in all parts of Mozambique, but mainly in the coastal zones of the northern provinces of Nampula, Zambezia, and Cabo Delgado, and in the southern provinces of Inhambane, Gaza, and Maputo (Malithano 1980, Malithano and Ramanaiah 1983). They are an important food and cash crop grown mainly by small-scale farmers as a rainfed crop. Yields are generally low and average about 500 kg/ha.

The potential for groundnut production in Mozambique as both rainfed and irrigated crops is enormous. Listed in order of importance are production constraints:

1. Poor cultural practices
2. Pests, diseases, and weeds
3. Lack of good quality seed
4. Irregular rainfall

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5. Lack of marketing opportunities
6. Lack of suitable implements and farm power
7. Growing unimproved groundnut landraces
8. Low soil fertility
9. Lack of technical and extension personnel

The Groundnut Improvement Project, financed jointly by the Government of the People's Republic of Mozambique (PRM) and the International Development Research Centre (IDRC) is making efforts to overcome these problems through research and extension services. A brief explanation of the constraints to groundnut production in Mozambique and their potential solutions follow.

Poor Cultural Practices

Poor cultural practices seriously limit groundnut production in Mozambique. Despite farmers' intimate knowledge and traditional experience, cultural practices have remained static mainly because rural men have migrated to the cities and mines, leaving only women to grow crops. The women have social and family assignments, so they farm only part time. The few men who remain on the land usually consider groundnuts as a crop that concerns women and children. Therefore, very little attention is given to improving crop production methods.

In most groundnut growing areas, land fallowing is either decreasing or is not practiced at all because of population pressure. As a result, the soil nutrients are depleted and since farmers do not apply fertilizers to groundnuts, yields are steadily decreasing. In the southern province of Gaza, for example, high populations leave very little opportunity for farmers to fallow their land. In northern Mozambique, forests are being cut down and bush cleared as a result of increasing population. Heavy rains in the north where no soil conservation measures are practiced has led to wide-spread soil erosion and low fertility.

To solve these problems, old cultural practices need to be replaced by new ones. Cultural practices requiring attention are:

- planting date,
- plant density,
- soil and moisture conservation, and
- intercropping and crop rotation.

Planting Date

Farmers are aware that they will have low yields if they plant late, but lack of farm power and erratic rainfall force them to plant late. Also, groundnuts are planted late because first priority is given to the major staple crops of maize, cassava, sorghum, and rice.

Plant Density

The most expensive input in groundnut production is the seed. Farmers cannot afford to increase the seed rate in order to achieve optimum plant density because groundnut seed is expensive and is usually in short supply. Therefore, yields are low because farmers plant at low plant density since they are interested in getting maximum yield per plant rather than per hectare. On commercial and state farms, maximum yield per hectare is the goal, and therefore their seed rate is higher than that of the small-scale farmers. The big enterprises can afford to buy expensive seed.

Soil and Moisture Conservation

In southern Mozambique the rains are erratic and the moisture holding capacity of the soil is very low. In the north, high rainfall causes soil erosion. Because of poor cultural practices to conserve moisture and soil, the yields of groundnuts are decreasing.

Intercropping and Crop Rotation

Intercropping is a very popular cultural practice in Mozambique and, almost invariably, groundnuts are interplanted with such crops as maize, cassava, and sorghum. The cropping patterns and different planting dates of the intercrops are not very well defined and yet these factors greatly influence the yields of the component crops. Systematic rotation is not practiced although farmers sometimes grow pure crops adjacent to each other. Thus, crop yields are affected by not rotating crops.

Pests, Diseases, and Weeds

Farmers do not use control measures against pests and diseases. Termites and rosette virus disease are major problems and cause heavy losses. Termites are a very serious problem all over the country, but the degree of termite damage varies from place to place and from season to season. In the north, e.g., in the province of Nampula, termite damage to groundnuts is extensive and serious. Literature on termite damage to crops is lacking but according to the work of Carvalho (1972), in Mozambique termites even attack living plants.

The effect of rosette on groundnut yields has been well documented (Davis 1976, Mercer 1977). In Mozambique, rosette is very common, especially in late-sown and second season crops in the south. Rosette incidence also appears to be related to rainfall: high during prolonged dry weather and low when rainfall is frequent. Heavy rainfall washes away the vector aphids from the plants.

Rust is a common disease and occurs everywhere in Mozambique, but there is no information available on the extent of crop losses due to this disease.

Weeds are quite a serious problem on farmers' fields. Although farmers weed their crops, weeding is usually done late and inefficiently causing reduced yields. The weeding problem is related to a farm labor shortage due to rural migration to the cities.

Lack of Seed

Preindependence seed buying and redistribution services do not now exist. Farmers became accustomed to being supplied with or buying groundnut seed at planting time, and ate or sold whatever they produced. Obtaining seed has been difficult because consecutive and severe droughts have caused complete crop losses. There is a critical seed shortage. To make things worse, there are no efficient structures to produce good quality groundnut seed and distribute it to the farmers. Lack of seed is a problem that requires immediate attention if production of groundnut is to increase.

Irregular Rainfall

Annual Rainfall

The total annual rainfall is sufficient to raise a good crop of groundnuts, but in some parts of Mozambique, especially in the south, rainfall is very erratic and not evenly distributed.

Drought

Prolonged dry spells during the growing season cause groundnuts to suffer from severe drought. Since there is little or no irrigation for groundnuts, droughts can cause complete crop loss.

Heavy Rains

Intensive rains falling within a few days cause erosion, soil nutrient leaching, and hence low yields. A more serious effect of heavy rains is frequent and serious floods which damage crops and livestock.

Lack of Marketing Opportunities

Unless farmers are given incentives, including prices that cover production expenses, groundnut yields will continue to be low. Because current groundnut prices are very low, farmers produce groundnuts only for home consumption.

Groundnut marketing should be linked with farm inputs and essential consumer goods in line with rural community needs. In Mozambique, well organized marketing facilities are lacking in the rural areas.

Because transportation is a problem, it is difficult to move agricultural produce from rural areas to the cities. Thus, most production is consumed locally (Malithano and Ramanaiah 1983).

Lack of Farm Power

There is a severe shortage of improved agricultural implements. The hand hoe is the only implement the farmers use for land preparation, sowing, weeding, and harvesting. Those farmers who have an animal-drawn plow can only use it for land preparation and sowing. There are no other animal-drawn implements for hoeing, weeding, harvesting, carting, etc.

Lack of draft animals is a general problem in Mozambique, and during the dry period, they are weak from lack of feed. Because of tsetse fly in the north, the cattle population is concentrated in the south, but a beef shortage has intensified the shortage of draft animals.

On large farms, in addition to shortages of trained manpower and agricultural implements, fuel is in very short supply and will remain so as long as the world recession continues.

During the farm surveys conducted by the Groundnut Improvement Project, farmers rated lack of farm power as the main constraint to groundnut production in Mozambique.

Growing of Unimproved Groundnut Landraces

No improved cultivars suitable for local conditions have been developed. Colonial practices of introducing unsuitable and untested seed have resulted in genetic erosion of local genotypes and degeneration of introduced cultivars. (Malithano and Ramanaiah 1983). During Project surveys, farmers wanted improved groundnut cultivars that were potentially high yielding and adapted to their cultural practices. There is an urgent need to develop cultivars resistant to rosette.

Low Soil Fertility

Intensive cultivation as a result of population pressure depletes soil nutrients with consequent low production because there is no land fallowing. Generally, farmers do not apply fertilizers to groundnuts although surveys have shown that in the south, the soils are low in phosphorus and zinc and, in the north, calcium is lacking.

Lack of Technical and Extension Personnel

There is a severe shortage of trained personnel and extension services do not exist.

Groundnut Improvement Project Efforts

Poor Cultural Practices

Through the surveys conducted by the Project, the farmers' situation is quite well understood and experiments on planting dates, plant density, intercropping, etc. are performed to raise low crop production. The criterion for designing experiments is need-based and influenced by the farmers' situation. Some problems farmers face have been solved through direct transfer and application of information and experience of farmers from one region to those of another. For example, farmers in Nhacoongo have developed a very complicated but scientifically sound and well integrated farming system involving intercropping of groundnuts and maize which follows a logical sequence of planting dates of groundnuts and maize, and a pattern of the component crops.

The Project is screening both local and exotic germplasm for disease and insect pest resistance genes to breed into potentially high-yielding cultivars. Some high-yielding groundnut cultivars have been identified and these will now enter a hybridization program for disease resistance at the ICRISAT Groundnut Regional Centre, Lilongwe, Malawi, where good facilities for this kind of work exist.

Farmers are advised to plant early to avoid diseases. On-farm trials have shown regular weeding to be necessary if good yields are to be achieved.

Lack of Seed

The Groundnut Improvement Project is closely linked with seed multiplication and is advising the National Seed Enterprise on the importation of cultivars that have been tested in Mozambique. The Project also trains agricultural administrators concerned with groundnut seed multiplication and distribution.

Lack of Marketing Opportunities

The Groundnut Improvement Project, through its contacts with the producers, obtained information on the marketing situation in the country. The information on marketing problems faced by farmers was passed through the normal channels to the authorities concerned with marketing of agricultural produce. The Project also advised farmers on suitable groundnut storage and to sell unshelled rather than shelled groundnuts because scarce facilities for storing shelled groundnuts result in heavy storage losses.

Lack of Farm Power

The Project is planning to improve animal-drawn implements by testing farm implements developed by French scientists and ICRISAT under Mozambique conditions. Bamboo tubes used by Indian farmers to plant groundnuts and place fertilizers have been successfully tested in Mozambique.

Growing Unimproved Groundnut Landraces

Potentially high-yielding local and exotic groundnut cultivars have been identified and recommended to the Ministry of Agriculture for multiplication and eventual distribution to growers. Evaluation and selection of superior cultivars to replace landraces is in progress. Short-season cultivars of local origin perform well in the south and exotic long-season cultivars from Senegal are excellent in the north.

Low Soil Fertility

Soil nutrient deficiencies have been identified in different parts of the country. In the south, zinc is deficient in the groundnut soils in the province of Inhambane and phosphorus is lacking in the soils of the provinces of Gaza and Maputo. In the north, calcium is deficient in the soils of the province of Nampula. Based on this information, fertilizer trials were conducted in these provinces. On agricultural research stations and state farms the response of groundnuts to fertilizers was small or even negative because of high soil nutrient levels on these sites. However, on farmers' fields the response of groundnuts to fertilizers was 50-300% more than in the control plots indicating high potential for fertilizer application to increase groundnut yields.

Lack of Technical and Extension Personnel

The project has been very successful in training national research scientists, technicians, and field assistants. Farm laborers have also been trained so that they do their work more efficiently.

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Effect of Fertilizers on the Yield of Groundnut in Mozambique

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Summary

Symptoms of phosphorus, calcium, zinc, and nitrogen deficiencies were noticed in groundnut grown in Mozambique. Based on this observation, field experiments were conducted on research stations along the coastal belt. Very little response to fertilizers was obtained on research stations and state farms because soil fertility was high, varying from 0.09-0.14 % total N and 60-175 ppm P. Thus, on-farm trials were conducted on farmers fields with lower soil nutrient levels. High yields of groundnut were obtained when 40 kg/ha P_2O_5 of 16% single superphosphate were applied, with yields ranging from 50-300% higher than in the control plots.

Résumé

L'effet des engrais sur le rendement de l'arachide au Mozambique : *Des symptômes de manques en éléments nutritifs, notamment le phosphore, le zinc, le calcium et l'azote, ont été constatés chez l'arachide cultivée au Mozambique. Ces observations ont amené les chercheurs à entreprendre des essais aux champs, effectués aux stations de recherche dans la région côtière. La fertilité du sol étant très élevée sur les stations de recherche et les exploitations de l'Etat—taux de l'azote total de 0,09 à 0,14% et celui du phosphore de 60 à 175 ppm—on n'a obtenu que des réactions peu notables aux traitements. Les essais ont été repris, par conséquent, sur les champs ruraux des paysans, sur les sols à niveaux inférieurs d'éléments nutritifs. L'application de 40 kg/ha de P_2O_5 (16% de superphosphate simple) a permis des rendements élevés d'arachide, de 50 à 300% supérieurs aux rendements constatés sur les parcelles témoins.*

Groundnuts have been grown in Mozambique for many years, mainly in light soils along the coastal zone. These soils yield poorly because mineral nutrients are low, especially in areas adjacent to towns where population pressure is high and the land is intensively cultivated without fertilizer application or fallowing. During field surveys conducted by the Groundnut Improvement Project, farmers stressed the problem of decreasing groundnut yields due to droughts and low soil fertility. Observations of continuously cropped groundnut fields confirmed nutrient deficiencies of phosphorus, calcium, zinc, and nitrogen. In southern Mozambique, in the district of Macia in Gaza Province, groundnuts showed symptoms of nitrogen deficiency characterized by poor vegetative growth and pale yellow foliage. Nitrogen deficiency was severe on plants growing in coarse sandy soils. These plants produced very few nodules, most of which were not effectively fixing nitrogen.

Phosphorus deficiency symptoms were observed in many groundnut growing areas, whereas calcium deficiency, characterized by pops, shriveled and small seeds, was observed mainly in the north where long duration and prostrate groundnut types are grown.

Zinc deficiency was observed on young leaves of groundnuts which were a bronze color and became powdery when pressed.

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Based on these observations, fertilizer trials were conducted both on research stations and on farmers' fields.

Materials and Methods

The trials were carried out at Umbeluzi Agricultural Research Station, Marracuene State Farm, and on farmers' fields in southern Mozambique very close to the capital city of Maputo, and on a seed multiplication farm at Namialo in the north. The trials lasted two growing seasons, 1981/82 and 1982/83 at Umbeluzi and 1982/83 and 1983/84 on the farmers' fields. Two sites had trials during only one growing season: 1981 /82 at Namialo and 1982/83 at Marracuene, but those at Marracuene, Namialo, and all the sites on the farmers' fields were rainfed except one irrigated site. Ten sites on farmers' fields were selected during 1982/83 and six during the 1983/84 crop growing seasons.

On the research station and on state farms the experimental design used was a split plot with fertilizer as the main treatment and cultivars as subplots. Several cultivars were tested on the research station and on the state farms. Short-season cultivars were tested in the south, while long-season ones were tested in the north.

On the research station and state farms two fertilizer treatments and one control treatment were used:

Fo - control
F_1 - 40 kg/ha P_2O_5 as 16% single superphosphate
F2 - 40 kg/ha P_2O_5 as 16% single superphosphate and 20 kg/ha N as urea.

On the farmers' fields, the experimental design used was of a demonstration type with one treated plot and one control plot:

Fo - control
F1 - 40 kg/ha P_2O_5 as 16% single superphosphate.

The total area varied from 2000-4000 m^2 and the net plot varied from 50-100 m^2.

The low doses were applied so that farmers could afford to buy fertilizers to use at these rates should the tests show economic gains.

The fertilizers were applied at the time of planting using a placement method. Planting was by hand and spacing was 45 cm between rows and 10 cm within rows. All the operations were done by the farmers themselves.

Results

Groundnut yields on research station and state farm on treated and untreated plots are presented in Tables 1-3. Application of fertilizers did not increase yields of groundnut.

The yields at Marracuene were very low because the crop was not irrigated and suffered from a very severe drought during the growing season. However, at Namialo the yields under rainfed conditions, were higher than those at Umbeluzi. This yield difference is related to the performance of the cultivars themselves.

In general, soil nutrient levels on research station and state farms are very high (Table 4), and as a consequence, the groundnuts did not respond to fertilizer treatment.

Table 1. Dry pod yield of irrigated groundnut at Umbeluzi Research Station.

Year	Treatment	Yield (kg/ha)
1981	FO	2644
	F1	2596
	F2	2591
1982	FO	1883
	F1	1744
	F2	1779

Table 2 Dry pod yield of groundnut at Marracuene state farm, 1982.

Treatment	Yield (kg/ha)
FO	413
F1	562
F2	676

Table 3. Dry pod yield of groundnut at Namialo state farm, 1982.

Treatment	Yield (kg/ha)
FO	3328
F1	3526
F2	3586

Table 4. Soil analysis, Umbeluzi Research Station.

Total N	0.09%
Organic matter	2.0-3.0%
Available P	60-1 75 ppm

On-farm trials were conducted on farmers' fields with poor soils especially deficient in nitrogen and phosphorus, with only medium levels of potassium, and a neutral pH The data in Table 5 show that groundnut responded well to phosphorus yielding up to 4000 kg/ha on treated plots as compared to 50-2000 kg/ha on control plots.

Conclusions

Yields were well above average for the south when fertilizer was used on coarse sandy soils in farmers' fields. Groundnut yields were high even when only small quantities of fertilizers which farmers can afford to buy were applied. Therefore, higher fertilizer levels should increase yields even more. In the nutrient deficient soils in southern Mozambique, application of single superphosphate gave very high yields.

If conclusive results are to be obtained, fertilizer trials should be conducted on farmers' fields with low soil nutrient levels and not on research stations and state farms where soil nutrient levels are higher.

Table 5. Dry pod yield of groundnut on farmers' fields, 1982 and 1983 seasons.

		Yield (kg/ha)	
Year	Site No.	Control	Treated with 40 kg/ha P_2O_5
1982	1	1000	3600
	2	900	3500
	3	1200	4000
	4	200	1000
	5	80	900
	6	900	3600
	7	1500	3500
	8	2000	3800
	9	1000	3400
	10	900	1900
	Average	968	2920
1983	1	750	2500
	2	1000	2500
	3	950	2500
	4	900	1500
	5	486	607
	6	1636	3771
	Average	954	2230

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Local and Exotic Groundnut Germplasm Collection and Evaluation

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Summary

In an effort to establish a Groundnut Breeding Program in Mozambique, a large number of accessions of both local and exotic germplasm were collected in the major groundnut production zones of southern and northern Mozambique where a valuable source of genetic variability in this crop exists. The local accessions are a valuable asset to Mozambique which has suffered from consecutive droughts and flooding, resulting in genetic erosion of groundnut and other crops. Introductions of exotic germplasm have been made. These accessions are being screened and evaluated for yield and other agronomic characters so that their potential for breeding and commercial production can be established and recommendations for their utilization made. Preliminary data indicate that yields of exotic germplasm are higher in the north than in the south and that local germplasm has the same yield potential as the exotic germplasm.

Résumé

La collection et l'évaluation du germplasme local et exotique de l'arachide : *L'article porte sur la constitution d'une collection importante de ressources génétiques, tant locales qu'exotiques, dans le but d'établir un Programme de sélection de l'arachide au Mozambique. Il s'agit d'un grand nombre d'introductions prélevées sur les zones majeures de production arachidière dans le sud et le nord du pays, où il existe des sources très intéressantes de variabilité génétique de cette culture. Les introductions locales seront d'une grande utilité au Mozambique : les phénomènes consécutifs de sécheresse et d'inondations ont eu pour effet d'y provoquer l'érosion génétique de l'arachide et des autres cultures. On a effectué des introductions de germplasme exotique. Les essais sont en cours pour cribler et évaluer ces accessions pour le rendement et d'autres caractéristiques agronomiques. Cela permettra d'établir leur potentiel de sélection et de production commerciale, et facilitera l'élaboration des recommandations pour leur utilisation. Les premières données montrent que les rendements obtenus sur le germplasme exotique sont plus importants dans le nord que dans le sud, et que le potentiel de rendement reste identique pour les germplasmes locaux et exotiques.*

In order to establish an active groundnut improvement program in Mozambique, work on germplasm introduction and collection was initiated by the Faculty of Agronomy and Forestry. This work started only a few years ago. However, the number of accessions obtained is quite large so that a base for a research program and technology development has been established. The local germplasm was acquired through expeditions to the major groundnut growing areas in the country and through official contacts. The exotic germplasm was sent to us on request by national and international research organizations working with groundnut. The germplasm is being maintained, multiplied, evaluated, and documented. Some cultivars that show high yield potential have been recommended for multiplication and distribution to farmers. Thus, practical application is made of the gene bank being developed by the Groundnut Improvement Project.

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Introduction of Germplasm

Breeding programs at their inception can fulfill their objectives through introductions of cultivars from other countries. (Hildebrand and Smartt 1980, Norden 1980). The Groundnut Improvement Project has exploited this possibility by introducing exotic cultivars from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Southern and West Africa (Table 1). These cultivars were evaluated in southern and northern Mozambique. Preliminary data indicate that cultivars from West Africa and the USA perform well in northern Mozambique, but poorly in southern Mozambique (Tables 2 and 3).

Table 1. Introduction of groundnut germplasm into Mozambique.

Year of Introduction	Donor Country	No. of samples
1976	Senegal	5
1976	U. S. A.	2
1979	Malawi	5
1979 & 1980	India (ICRISAT)	86
1980	Burkina Faso (IRHO)	4
1981	Tanzania	7
1983	Malawi (ICRISAT)	48

Collection of Local Germplasm

Local germplasm is a valuable source of genetic variability from which selections of genotypes with specific attributes can be made. Thus, much importance is attached to its collection by planned expeditions to the main groundnut growing areas in the southern provinces of Inhambane, Gaza, and Maputo, and in the northern privinces of Nampula, Zambezia, and Cabo Delgado. In the north, the germplasm collection was made in collaboration with ICRISAT and the International Board for Plant Genetic Resources (IBPGR). Table 4 gives data on the local accessions. In the province of Inham-

Table 2. Yield of local and exotic cultivars in northern Mozambique.

		Yield of dried pods (kg/ha)			
		Namialo		Napai	Rabaue[1]
Cultivar	Origin	1981	1982	1982	1983
57-422	Senegal	3611	1982	--	1600
Florunner	USA	3333	--	650	--
RMP 12	Burkina Faso	3259	--	1780	770
Early Runner	USA	2963	2963	770	--
59-127	Senegal	2796	--	600	--
69-101	Senegal	2333	--	930	1130
Napalala	Mozambique	2278	--	360	--
Mani Pintar	Malawi	2206	--	560	--
Senegal	Senegal	1556	--	--	650
Local	Mozambique	1500	--	380	--
Jonca[2]	Mozambique	--	1230	--	--
Tamnut[2]	Mozambique	--	1060	--	--
Starr[2]	USA	--	900	--	--
Maquiiovilha	Mozambique	--	880	--	--
Local	Mozambique	--	660	--	--
AC 207	Mozambique	--	660	--	--
Ah 175	Mozambique	--	--	--	720
Ipala local	Mozambique	--	--	--	680

1. Shelled groundnut.
2. Short-season cultivars.

Table 3. Yield of local and exotic cultivars in southern Mozambique, 1980/81.

Cultivar	Origin	Yield (kg/ha) dried kernels
Bebiano Branco	Local	262
Tamnut[1]	USA	219
55.437	Senegal	212
Malimba[1]	Malawi	210
Bebiano Encarnado[1]	Local	182
Starr[1]	USA	155
73.301[1]	Senegal	187
RMP 12	Burkina Faso	87
69.101	Burkina Faso	78
57.422	Burkina Faso	60
Florunner	USA	59
73.33[1]	Senegal	48
Mwitunde	Malawi	31
Mani Pintar	Malawi	18

1. Short-season cultivars.

bane, especially in the districts of Inharrime, Inhambane, Massinga, and Morrumbene, very high genetic variability was observed in the groundnut landraces grown by the farmers (Malithano 1980). Selections from these landraces are also very high yielding (Table 5). In northern Mozambique, the variability in the groundnut samples collected was also very high. All the three different habit groups belonging to var. *hypogaea* (70%) and var *vulgaris* (30%) were found but var. *fastigiata* was not observed (Rao 1981). The high genetic variability observed in groundnut landraces grown in Mozambique may be attributed to introgression of local landraces introduced from neighboring countries or to introductions made over hundreds of years during the colonial era.

Field collections were made at numerous sites to obtain germplasm that was as genetically diverse as possible. Single plant sampling and collection "en masse" were both practiced.

Genetic Erosion

Genetic erosion has reduced genetic variability of Mozambique groundnuts significantly in recent years. The degree of genetic erosion varies from place to place, but it is most severe in the southern provinces of Inhambane, Gaza, and Maputo, in that order of importance. Two factors contributed to genetic erosion: consecutive droughts causing complete crop failure, followed by distribution of imported seed. Droughts have wiped out groundnut landraces in many parts of southern Mozambique, and in those areas where farmers were able to raise any groundnuts at all, collection was not possible due to scarcity. In some parts of the north where there were no droughts it is still possible to collect groundnut germplasm. However, collections made prior to the droughts are of great significance to Mozambique in that the Groundnut Improvement Project has, among its accessions, genotypes and landraces that have been lost by farmers.

Germplasm Evaluation

All accessions pass through a sequence of evaluation procedures which are still being perfected. In general, the accessions are screened, the best cultivars are tested at different sites with and without inputs, and finally, on-farm trials of the best cultivars are conducted.

Rapid Screening

Seed increase is necessary before extensive evaluation because the original seed sample of many accessions is very small. As a result there is a delay of 2-3 years before the accessions are thoroughly screened. The first seed increase allows an identification based on a limited number of characters. Systematic evaluation, studying several characters in order to allow an exact identification of the accessions and to determine possible duplicates, was carried out at Umbeluzi Agricultural Research Station (Table 5). One hundred accessions of groundnut cultivars, pure lines, and segregating materials were evaluated in a randomized complete block with two replicates.

There were significant differences in many agronomic characters such as yield, disease resistance, maturity, plant habit, number of pods per plant, number of seeds per pod, etc. (Table 5). The yields of the local accessions, especially landraces from Inhambane, were quite high. The exotic germplasm showed resistance to diseases such as early and late leafspots, (*Cercospora arachidicola* [Hori] and *Cercosporidium personatum* [Berk, and Curt.] Deighton) and to rust, (*Puccinia arachidis* [Speg]). The yield of the early-maturing cultivars

Table 4. Local germplasm collected in Mozambique.

Date Collected	Place	Province	No. of samples
Nov 1978	Nampula	Nampula	93
April 1981	Corane	"	7
"	Lirnpo-Naula	"	9
"	Napai	"	
"	Amperini	"	
"	Namiropera	"	
"	Namilero	"	
"	Itoculo	"	
"	Kaleni	"	
"	Mendazi	"	
"	Natikiri	"	
"	Mativase	"	
"	Matamande	"	
"	Lallawa	"	
"	Mupase	"	
"	Malema	"	
"	Mutuari	"	
"	Lurio	"	
"	Mecanhelas	Niassa	
"	Natakine	Nampula	
"	Namahitu	Zambezia	
"	Livia	"	
"	Rombe	"	
"	Tavela	"	
"	Chaenda	"	
"	Guereguere	"	
"	Bive	"	
"	Maecuia	"	
1973-74	Mocuba	"	14
April 1981	Celula do Mapira	"	
"	Mutange	"	
"	Ceracero de Mocubela	"	
"	Vila do Mocubela	"	
"	Mucubela	"	
"	Oualivia	"	
"	15 km de Mucubela-Mana	"	
"	Mani	"	
"	Mucheba	"	
"	Chalapla	"	
"	Momba-Alto Molucue	"	
"	Namuja	"	
"	Gile	"	3
"	15 km Gile-A Molucue	"	

Continued

Table 4. *Continued*

Date Collected	Place	Province	No. of samples
"	Celula Namucha	"	1
"	Naniope	"	2
"	Naheje	"	1
"	Mahegua	Zambezia	2
"	Nahavara	Nampula	2
"	Marelo	Zambezia	1
"	Celula Magodone	"	1
"	Celula Nusseia	"	2
"	Mocurrugue	"	1
"	Mualama	"	1
"	Celula Gigiebe	"	1
"	Celula Namaroi	"	1
"	Majiga	"	1
"	Metelani	"	1
"	Mucubela	"	1
"	Celua Magene	"	1
"	9 km from Namegonia	"	1
"	Paevounha	Nampula	1
"	Luluti	"	1
"	Mulessari	"	2
"	2 km from Nametil Muatua	"	1
"	Namecunta-Meconta	"	1
"	Marcia	"	3
"	Nicarroa	"	1
"	Nampula	"	1
"	Namialo	"	2
"	Nacivara	Cabo-Delgado	1
"	Tuane	Gaza	4
"	Incaia	"	1
"	Mahungu	"	5
"	Chihissa	"	1
April 1974	Inhambane	Inhambane	2
		Total	216

was higher than that of the late-maturiftg ones. There is, therefore, a need to conduct multi-location trials in order to accurately evaluate the germplasm.

Variety Yield Trials

These were conducted in the north and south. Long-season cultivars were tested only in the north where the rains are regular and prolonged. The introductions from West Africa and the USA yielded over 3000 kg/ha without chemical application (Table 2).

Short-season cultivars were evaluated in both the north and south. Yields were higher in the north (Tables 2 and 3).

Advanced Variety Yield Trials

Cultivars that performed well in the variety yield trials were tested further at different locations under various farming systems. Soil nutrients were

Table 5. Evaluation and characterization of groundnut germplasm at Umbeluzi, 1982/83 crop season.

Cultivar	Origin	Days to 50% flowering	Days to maturity	Growth habit	Pods/ plant	Seeds/ pod	Yield (kg/ha)
Chinjinguiri	Mozambique	29	120	SE	43	2	2186
NAc 2748 x Chico	ICRISAT	28	102	E	21	2-3	1897
Seleccao Homoine	Mozambique	28	105	E	27	2	1875
2.5 x Chico	ICRISAT	35	104	E	61	2	1858
Te 3	Burkina Faso	31	117	E	42	2	1811
Ah 202	Mozambique	32	104	E	29	2	1797
Ah 134	Mozambique	29	104	E	35	2	1725
Matimule	Mozambique	33	102	SE	41	2	1719
Ah 192	Mozambique	30	105	P1	26	2	1685
CN 115B	Burkina Faso	29	104	E	28	2	1669
MH1 x SM5	ICRISAT	33	103	E	22	2	1653
Inhambane	Mozambique	32	102	E	48	2	1639
796	India	26	114	E	14	2	1637
69 63 2.5	Tanzania	32	100	E	26	2-3	1625
Morrumbene	Mozambique	28	110	SE	36	2	1606
Ah 8254 x MH2	ICRISAT	30	104	E	21	2	1597
Argentina x Chico	ICRISAT	33	104	E	36	2	1592
Valencia	USA	33	110	SE	53	2	1576
Ah 229	Mozambique	28	105	E	45	2	1561
15714	Senegal	30	109	E	39	2	1558
White Spanish	USA	40	106	E	33	2	1525
Spanish 18-38	USA	29	106	E	45	2	1519
Gaug 1 x Starr	ICRISAT	28	110	E	--	2	1508
RPM 68	Mozambique	28	110	E	41	2	1503
MH1 x MH2	ICRISAT	32	102	E	39	2	1494
Robut 33-1	India	35	120	VB	18	2	1486
Ah 6279 x Spancross	ICRISAT	36	100	E	--	2	1481
Virginia R 26	USA	32	100	E	46	2	1472
AM/665	USA	30	98	E	38	2	1456
Ah 139	Mozambique	33	114	E	26	2	1447
69 62 2.5	Tanzania	30	106	E	29	2	1447
Janjuro	Mozambique	29	112	E	28	2	1406
Natal Common	South Africa	28	112	E	30	2	1400
Chibututuine	Mozambique	32	104	E	40	2	1397
CN 94C	Burkina Faso	32	104	E	23	2	1392
Starr	USA	33	110	E	38	2	1376
Tamnut	USA	33	110	E	37	2	1376
Ah 140	Mozambique	28	119	SE	35	2	1362
Jouca	Mozambique	31	105	E	28	2	1357
Bebiano Branco	Mozambique	32	112	E	43	2	1340
RPM 128	Mozambique	35	110	E	26	2	1339
72-R x Chico	ICRISAT	29	103	E	39	2	1303
Southeast	USA	36	103	E	48	2	1303

Continued

Table 5. *Continued*

Cultivar	Origin	Days to 50% flowering	Days to maturity	Growth habit	Pods/ plant	Seeds/ pod	Yield (kg/ha)
FESR-8P 12-B1-B1-B1	ICRISAT	--	114	E	--	2	1300
69.29.2	Tanzania	34	110	E	--	2	1272
668/73	Zimbabwe	30	104	E	36	2-3	1272
Ah 223	Mozambique	32	103	E	14	2	1272
Inhambane A	Mozambique	32	103	E	53	2	1225
Ts 18-1	Burkina Faso	29	103	E	24	2	1180
Ah 188	Mozambique	34	110	E	32	2	1178
Guipombo	Mozambique	28	100	E	42	2	1172
Comet x MH2	ICRISAT	33	102	SE	36	2	1161
FESR-8P 12-B1+B1+B1+B1	ICRISAT	34	104	--	26	2	1161
PI 337407	ICRISAT	29	104	E	32	2	1117
Malimba	Malawi	34	117	E	30	2-3	1094
Tatui	USA	33	116	SE	49	2	1089
Ah 126	Mozambique	35	--	P1	--	2-3	1075
KH 197A	Burkina Faso	36	105	E	29	2	1064
2.5 x P1 259747A	ICRISAT	30	120	SE	5	1-3	1064
CHONGOENE 57A	Mozambique	39	104	E	53	2	1033
57-422	Senegal	36	104	D3	17	2	1011
Ah 6279 x TG-16	ICRISAT	29	105	E	18	2	972
CN 1 16A	Burkina Faso	32	100	E	31	2	950
Ah 168	Mozamque	--	--	D3	6	2-3	942
69.99.1.2.4	Tanzania	32	104	E	22	2	911
JH 60 x PI 279748	ICRISAT	32	110	E	22	2	908
69.17.6	Tanzania	37	110	E	22	2	906
TMV4 x Chico	ICRISAT	--	--	E	--	2	878
Ah 65 x Chico	ICRISAT	32	110	D1	6	3	875
Ah 123	Mozambique	30	110	D1	13	2	861
JH 171 x Chico	ICRISAT	32	102	SE	34	2	806
69.351	Tanzania	35	104	E	37	2	800
FESR 5P 12-B1+B1+B1	ICRISAT	28	100	P1	10	2	786
TS 32-1	Burkina Faso	33	110	E	21	2	766
Ah 143	Mozambique	36	117	D2	7	2	693
KH 241 D	Burkina Faso	34	118	SE	36	2	680
Mafassane	Mozambique	37	121	SE	39	2	667
Ah 195	Mozambique	37	115	E	10	2	661
Ah 209	Mozambique	38	113	D1	8	2	627
Ah 196	Mozambique	39	110	P1	--	2	603
FESR-8P 11+B1+B1+B1	ICRISAT	40	113	D2	19	2	581
Marracuence A	Mozambique	32	110	SE	40	2	558
FESR-P11-B2+B1+B1	ICRISAT	32	110	E	24	2-3	544
AH 151	Mozambique	35	117	D1	6	2	542
Ah 138	Mozambique	31	115	D1	6	2	454
Ah 181	Mozambique	37	115	D1	34	2	439
Ah 207	Mozambique	37	150	P1	25	2	407

Continued

Table 5. *Continued*

Cultivar	Origin	Days to 50% flowering	Days to maturity	Growth habit	Pods/ plant	Seeds/ pod	Yield (kg/ha)
Ah 137	Mozambique	32	116	D3	10	1-3	404
Ah 147	Mozambique	34	116	–	5	2-3	344
Marracuence B	Mozambique	32	104	SE	49	2	333
Ah 232	Mozambique	36	105	D1	15	2-3	281
Napalala	Mozambique	29	130	D3	7	2-3	264
Ah 150	Mozambique	35	116	D1	–	1-3	260
Tomo	Mozambique	41	130	D1	50	2-3	253

D = Decumbent, E - Erect, P - Procumbent, VB - Virginia Bunch, SE - Semi-erect.

very high at the research stations and there was no yield response to fertilizers. However, where zinc and phosphorus were deficient, treated plots yielded higher than the controls (Ramanaiah et al. 1984). In southern Mozambique where light and sandy soils are predominant, groundnuts intercropped with cassava yielded better than groundnuts intercropped with maize (unpublished data).

On-farm Trials

This is the final stage where cultivars are tested on the farm under actual growing conditions. The cultivars were tested on State and Cooperative farms using high input technology such as machinery, irrigation, and fertilizers. The first of these trials was conducted during the 1982/83 growing season on Timor Leste farm located in the valley of the River Umbeluzi. Only two local cultivars, Bebiano Branco and Murrumbene were tested. A tractor prepared the land and the crop was fertilized and irrigated. The season was very dry and elsewhere the groundnut crop failed completely. The yield on this farm averaged only 1000 kg/ha since irrigation was very irregular because the river was very low. These cultivars were further tested during the 1983/84 growing season on 20 ha at Sabie. The soils were light to sandy and both irrigation and fertilizers were applied. Yields averaged 2000 kg/ha.

Two exotic cultivars, RMP-12 and Natal Common, were tested at Chokwe under high input technology on medium to heavy soils. Useful information on the use of the seed drill was obtained. For example, it was easy to drill the small seeds of Natal Common, but was difficult with the large seeds of RMP 12. Data on the performance of these cultivars are not available since the crop has not yet been harvested.

Cultivars tested on cooperatives yielded better than on State farms. Single superphosphate at 40 kg/ha P_2O_5 yielded 3500 kg/ha of unshelled groundnuts, three times the yield of control plots (Ramanaiah et al. 1984).

Testing the low input technology of the small farmer has not yet begun because this requires a well organized extension service, trained personnel, and transport, all of which are lacking at the moment. Future variety testing will also investigate consumer acceptability.

Acknowledgement

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Discussion on Mozambique Papers

Mtika: How are groundnuts sown in Mozambique, and how is the weeding operation carried out?

Ramanaiah: Sowing is done by hand. Weeding may be done by hand hoe or with animal-drawn or tractor-drawn equipment. Herbicides are not used.

Doto: It appears that your varietal evaluation trials are carried out in one area of Mozambique, while most groundnuts are grown in other areas. Could you please comment on this?

Ramanaiah: Your statement is not strictly accurate. Due to shortage of seed of introduced cultivars these are multiplied in one place and initial observations made. Experiments are later carried out in both north and south of the country. Security problems currently restrict access to certain parts of the country.

Doto: I recognize that the trials were carried out at a number of sites but these tended to be on more fertile soils and it is necessary that the material should also be selected on other soils.

Taylor: The responses to phosphate on the on-farm trials are as large as I have seen anywhere. Do you think that any element other than phosphorous, e.g., calcium or sulphur, could have influenced the results? Were any other factors involved?

Ramanaiah: In trials on farmers' fields the responses to phosphate and gypsum were striking. Soil moisture was optimal on the sites.

Kelly: How were cooperative farmers chosen? What problems were encountered in running trials on farmers' fields?

Ramanaiah: Three years ago there was resistance from farmers as they suspected the Program was attempting to take over their land. Confidence was gradually developed and the Ministry of Agriculture initially donated the seed and fertilizer. Small plot trials are now readily accepted in the villages. Farmers now purchase their own materials but the Ministry of Agriculture covers the risk of crop failure.

Riley: From the data presented it would appear that cultivar RMP 12 is a low yielder. Why did you persist in importing and multiplying it?

Ramanaiah: On the basis of advice from the French adviser the cultivar RMP 12 was imported from West Africa for multiplication.

Nigam: How serious a problem is rust disease? Leaf spots have not been mentioned. Are they important?

Monjana: Rust disease is common on groundnuts in Mozambique but not serious. No loss evaluation has been attempted. Leaf spots occur but have not been found to be serious. The most important disease problem is rosette.

Edje: Why do farmers prefer high yield per plant to high yield per unit of land area?

Monjana: Yield per plant is important because seed is in very short supply in the country.

Groundnut Breeding and Improvement Programs in Tanzania

F.F. Mwenda*

Summary

This paper indicates constraints in groundnut production in Tanzania and describes past and present breeding programs for groundnut improvement Data on germplasm evaluation trials are provided.

Résumé

***Programmes de sélection et d'amélioration de l'arachide en Tanzanie :** L'auteur souligne les contraintes à la production arachidière en Tanzanie et décrit les programmes de sélection de l'arachide, programmes actuels ainsi que les programmes antérieurs. Les résultats des essais d'évaluation de germplasme sont présentés.*

In Tanzania groundnuts are grown by the small farmer and are one of the major raw materials for edible vegetable oils in the country. Yields are low because fertilizer and other chemical inputs are rarely used and seed of improved cultivars is not available. Diseases are another factor limiting yield, e.g., leafspot and rust together accounted for 35% yield loss at Naliendele in the 1982/83 season.

The two main groundnut growing zones have different rainfall amounts and distribution during the growing season. One zone covers the Mtwara, Ruvuma, Kigoma, Shinyanga, and Mwanza regions, where rainfall is unimodal from October/ November to May/June, with a brief dry spell of from a few days to a few weeks in January or February. The second zone has a bimodal rainfall distribution, with short rains in November/December and long rains suitable for most crops from March to May/June. This zone covers the Morogoro, Central, and northeastern parts of the country.

Although there is no conclusive evidence of cultivar x site interactions, breeding objectives are to identify cultivars suitable to the two zones. The overall objectives of the breeding program at Naliendele are:

- To assemble a large number of local and exotic genotypes and thus expand the genetic base.
- To identify and develop high-yielding cultivars suited to the main groundnut growing areas of the country.
- To incorporate genes for resistances to major diseases, e.g., leafspots, rust, and rosette.
- To identify and incorporate genes for drought tolerance.

This report gives a brief summary of previous breeding work, the current program, and progress made so far at Naliendele.

Previous Breeding Work

Groundnut breeding in Tanzania started in the late 1940s at Nachingwea in southeast Tanzania at the time of the Groundnut Scheme. Records of early research are scanty, but Red Mwitunde and Natal Common were recommended to farmers. Then as

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International Crops Research Institute for the Semi-Arid Tropics. 1984. Regional Groundnut Workshop for Southern Africa, 26-29 March 1984, Lilongwe, Malawi. Patancheru, A.P. 502324, India: ICRISAT.

now, the short-season Spanish group did better than the long-season Virginia types (Table 1). Red Mwitunde is still the cultivar most widely grown in Mtwara and Lindi regions of southern Tanzania. (A new cultivar has now been released and recommended to be grown along with Red Mwintunde for the same regions). Most groundnut breeding work ceased with the collapse of the Groundnut Scheme and did not begin again until the late 1960s when the Ministry of Agriculture initiated groundnut research work at Mwanza in western Tanzania.

The emphasis then was on national collection, evaluation, and maintenance of local cultivars as well as selection from inherited cultivars. Records of that research are also very scanty. Many of the local cultivars collected were lost when groundnut research work was transferred from Mwanza to Naliendele in southern Tanzania in the early 1970s. Most of the material eventually recovered at Naliendele was Natal Common, Red Mwitunde, and selections from short-season cultivars of the Spanish and Valencia groups, including selections from Natal Common (69.62.2.5 and 69.63.2.5). Except for Red Mwitunde the material used for groundnut research at Naliendele up to 1978 was selections from short-season cultivars which are still not favored by most small farmers in Tanzania.

This may explain in part why none of the selections had been recommended although most of them outyielded both Red Mwintunde and Natal Common. Table 2 summarizes preliminary yield tests of some promising selections for the 1974/75 and 1975/76 seasons, and of an advanced yield test of the more promising selections for the

Table 1. Groundnut variety trial. Namanga (southern province) 1948-49 season.

Cultivars	Plants per hectare ('000)	Kernels (kg/ha)	Oil content (%)	Oil (kg/ha)
Long-season runner types				
Kongwa Pink	87.3	1059	43.3	459
Kalandi Kwanza	51.0	938	42.1	394
Tanganyika X	47.4	903	43.2	390
Kutembaa	78.4	757	43.8	331
Tanganyika Y.	50.8	749	43.3	324
Mean	68.0	881	43.1	380
Long-season bunch types				
Wima	72.2	733	43.7	321
Kanyoma	37.9	725	43.5	315
Mwitunde Ukiri	70.4	673	45.1	302
Mgongo Nzega	48.6	609	41.2	172
Virginia	34.5	416	41.2	172
Mean	53.1	632	43.0	272
Short-season bunch types				
Barberton	102.7	1463	46.4	679
Spanish	99.9	1401	45.8	642
Natal Common	74.2	1396	45.4	634
Kidang	101.4	1309	43.7	572
Manyema Tabora	85.8	1248	45.2	564
Manyema Tanganyika M.	102.2	1215	43.7	531
Manyema Nzega	101.2	1157	43.7	531
Valencia Tabora	107.6	1102	45.4	501
Valencia Ukiriguru	101.9	1022	43.8	437
Valencia 2	82.1	912	44.4	405
Mean	76.1	1223	44.6	547

Table 2. Preliminary yield trials 1974/75 and 1975/76 seasons, advanced yield trial 1977/78 season, all at Naliendele.

		Kernels (kg/ha)		
Entry	Botanical group	1974/75	1975/76	1977/78
69.35a. 1.4	SP	1184	629	928
69.99. 1-2.4	Va	1139	267	821
69. 15.3	SP	865	629	959
69. 29. 2	SP	946	600	1092
70. 1. 1. 1	Va	833	545	777
69. 17. 1	SP	931	840	1042
69. 17.5	SP	833	378	1042
69. 62. 2. 5	SP	824	883	1179
Red Mwitunde	Va	667	153	391
69. 63. 8. 5	SP	787	576	713
76.7.3	SP	821	465	743
Natal Common	SP	762	265	852
NWS 7	Va	672	136	--
NWS 11	Va	527	207	--
69. 13a. 4	SP	536	289	--
69. 48. 1		547	272	--
70. 16.3	Va	545	265	--
69.87. 1	SP	449	554	--
69.25.2	SP	428	251	--
69.99. 1-2.6	Va	303	222	--
Mean		730	455	877

1977/78 season at Naliendele. No selection consistently outyielded all others, but over the three seasons a selection from Natal common, 69.62.2.5, seemed on average to do better than the rest.

Current Programs

A major thrust in groundnut breeding and improvement began in 1978 when the Oilseeds Research Project was started. With better funding and more staff, major improvements became possible:

- Acquisition of breeding material by importation and selection.
- Expansion of the regional variety trials network.
- More extensive evaluations of cultivars.
- Collection of local cultivars grown in Tanzania.

New Accessions and Selections

Table 3 lists groundnut genotypes collected locally and imported between 1978 and 1983. The material provides a wide range of useful characteristics from high-yielding lines to those reported to have resistances to important diseases. Most of these accessions are still in the observation and multiplication stages but some which have shown promise have been included in preliminary yield tests at Naliendele or in regional cultivar trials. Table 4 shows observations on 21 accessions in the 1982/83 season. From these accessions, Spancross (from the USA) was released and recommended to farmers in Mtwara and Lindi regions in 1983 after 3 years in replicated trials.

Scarce germplasm limited selection work in the early years of the program, but more selections are currently being made, especially from ICRISAT

Table 3. New groundnut accessions received between 1978 and 1983.

Country	Growth Habit			Total
	Runner	Spanish bunch	Virginia bunch	
USA	11	9	27	57
Bolivia	0	1	0	1
Brazil	0	0	1	1
India (ICRISAT)	85	154	295	534
Indonesia	0	0	1	1
Kenya	2	4	8	14
Malawi	0	1	0	1
Mozambique	0	3	5	8
Senegal	1	4	3	8
Zambia	2	7	19	28
Zimbabwe	0	17	14	31
Selections	-	-	30	30
Local cvs.	22	43	52	117
Others		ICRISAT crosses		45
Total	123	243	465	876

Table 4. Evaluation of groundnut accessions at Naliendele 1982/83 season.

Entry	Growth habit[1]	Kernels (kg/ha)	Shelling (%)	100 Kernel weight (g)
Pronto	EB	1966	75.2	40.8
MGS 8 x Robut 33-1	EB-SB	1723	70.0	50.4
Rasawanira	SB	1570	66.9	48.6
Madi	EB	1551	70.5	31.8
MH-2	EB (DWARF)	1382	72.0	31.5
Njombe 3	R	1377	67.5	49.0
Virginia bunch	SB	1282	71.2	55.3
Sootm Basi Runner 56-15	R	1282	65.4	43.4
280/71	EB	1251	73.6	35.0
Miptaye	EB	1212	68.1	39.0
Tifspan	EB	1209	73.7	34.9
Robut 33-1 x NCA 2698	SB x EB	1208	74.8	46.3
Chihangu	R	1208	67.1	41.5
57-422	SB	1180	66.3	52.5
Chaiu	EB	1175	66.0	46.1
Texas Peanut	EB	1170	65.0	38.8
310/66	EB	1165	71.9	34.3
73-30	EB	1559	69.0	37.5
Sigaro Pink	SB	1159	66.1	43.5
Chico	EB	1141	72.2	28.2
Dixie Runner	R	1094	63.6	40.3
Red Mwitunde	SB	850	58.5	42.9
Spancross	EB	1310	74.5	35.6

1. EB = Erect bunch; SB = Spreading bunch; R = Runner.

segregating materials, for lines with high yield and resistance to leafspot and rust.

Evaluation

Evaluation of new material is done first in small unreplicated plots. Promising cultivars and lines are included in preliminary yield tests at Naliendele and its substation at Nachingwea. Results of preliminary yield tests in 1983 are given in Table 5. Elite materials from these tests are included in the regional variety trials. Because there are indications of cultivar x site interaction, preliminary yield tests have been extended this season to cover locations representative of the different agroecological zones of the country in an attempt to identify cultivars suitable to these zones.

Regional Variety Trials

The network of regional variety trials has been greatly extended in the past 5 years and test sites now cover most of the groundnut growing areas of the country. The number of cultivars that have gone into these trials has varied from year to year, but has always included promising cultivars from the three major botanical groups: Spanish, Valencia, and Virginia. Tables 6 and 7 give kernel yields from some of the sites for the 1979/80 and 1982/83 seasons respectively. At all sites where tests were conducted the short-season cultivars of the Spanish and Valencia groups outyielded the long-season Virginia types.

National Collections

Efforts to collect local germplasm have been hindered by lack of transport. Table 3 lists the current collection of 117 local cultivars which are mainly from the southern regions of the country. This collection indicates that all major botanical groups are grown in the country. Table 8 summarizes the performance of representatives of each group compared to the local control Red Mwitunde, and Spancross, the best yielder of the Spanish group.

Table 5. Preliminary groundnut variety trials 1982/83.

	Naliendele			Nachingwea		
Entry	Kernels (kg/ha)	Shelling (%)	100 Kernel weight (g)	Kernels (kg/ha)	Shelling (%)	100 Kernel weight (g)
Robut 33-1	1324	66.8	45.7	1638	71.4	49.8
Spancross	1310	74.1	35.1	1838	74.1	36.9
6/77	1139	66.2	38.7	1488	68.5	42.6
69.62.2.5	1039	68.1	37.6	1740	72.6	40.3
69.99.1.2.6	1006	65.8	45.1	1468	66.7	44.4
70.1.1.1	930	66.5	41.4	1455	66.8	45.1
JACNA	822	54.7	45.1	1505	70.5	54.2
668/73	822	58.0	38.9	1398	66.3	45.2
Valencia R2	767	63.0	42.9	1456	67.0	41.3
9/7/26	657	55.0	38.5	1353	66.1	47.2
183/66	505	45.3	44.3	1344	62.8	59.9
Mani Pintar	503	58.4	54.8	1361	69.4	57.0
Red Mwitunde	486	54.0	42.8	1394	64.6	49.8
Lindi	466	50.6	50.4	1230	60.1	63.1
Apollo	398	47.8	49.2	1302	65.5	62.5
Egret	347	44.2	50.1	1572	64.1	63.7
Mean	783	58.7	48.8	1471	67.3	50.2
S.E. ±	55.6	2.98	1.66	92.0	1.21	1.42

Table 6. Kernel yields (kg/ha) of 1979/80 groundnut variety trials.

Entry	Ndengo	Suluti	Utengule	Mtowa	Entry mean
69. 62. 2. 5	903	798	808	1600	1027
69. 15.3	1005	584	967	1520	1019
70. 1. 1. 1	1190	514	696	1600	1000
69.99. 1.2.4	935	770	879	1300	971
69. 29. 2	855	818	866	1140	920
69. 63. 2. 5	880	484	788	1160	903
Natal Common	1013	790	861	-	888
69.35a. 1.4	827	588	467	1560	861
69. 17.6	834	610	867	1120	858
Local	-	280	409	-	345
Site Mean	938.0	762.6	976.8	141.2	
S.E ±	76.6	71.6	94.8	-	

Conclusions

It is evident from this paper that considerable progress has been made in assembling and evaluating both local and exotic material. This provides scope for further improvements through breeding as our germplasm resources expand.

The present objective of identifying cultivars suitable for different agroecological zones will involve extensive evaluation of a large number of cultivars in several locations representative of the major zones, but is limited at present by the distances involved. Another area of importance is the collection of local cultivars. Major constraints to this have been mentioned above, but cooperation with the Crop Science Department of the University of Dar es Salaam in assembling local materials will be encouraged, and our own efforts increased.

Table 7. Kernel yields (kg/ha) of 1982/83 regional groundnut variety trial.

	Sites							
Entry	NAM	NAC	NAN	NAL	NAR	MSI	ISM	CHA
Spancross	1838	1838	1784	1310	555	397	1965	583
69.62.2.5	1888	1740	1634	1039	504	304	1788	743
69.99. 1.2.6	1826	1468	1434	1006	573	242	1738	720
70. 1. 1. 1	1728	1455	1262	9930	526	267	1433	417
Valencia R2	1613	1456	1056	7777	342	172	1587	330
Red Mwitunde	1750	1394	874	486	274	136	1560	213
Lindi	1878	1236	636	466	122	95	1175	137
Mani Pintar	1695	1361	754	503	219	22	1080	217
Egret	1970	1572	-	347	-	41	1240	93
Mean	1800	1502	1179	762		186	1508	384
S.E. ±	183.2	92.0.	-	55.6		65.9	141.8	89.5

NAM - Nam jani NAR = Narunyu
NAC - Nachingwea MSI = Msijute
NAN - Nangomba ISM = Ismani
NAL - Naliendele CHA = Chambezi

Table 8. Kernel yields (kg/ha) of 1982/83 regional groundnut variety trials.

Place of origin		Growth	Kernels	Shelling	100 Kernel
Town	Region	habit[1]	(kg/ha)	(%)	(g)
Ntombe	Tringa	EB	1039	71.9	34.1
Isman	Iringa	EB	1007	71.7	35.8
USANGU	Mbeya	EB	930	66.2	37.8
Mbinga	Ruvuma	EB	940	65.7	42.7
Ukiriguru	Mwanza	EB	1057	70.0	38.5
Mombo	Tanga	EB(V)	1021	62.4	52.4
Chiumbati	Lindi	SB	800	65.3	48.2
Tunduru	Ruvuma	SB	944	62.3	48.3
Songea	Ruvuma	SB	987	63.7	50.3
Bwanga	Mwanza	SB	847	68.6	39.1
Moshi	Moshi	SB	871	57.8	47.4
Chiumbati	Lindi	R	965	63.3	54.8
Igurusi	Mbeya	R	846	61.3	50.3
Iringa	Iringa	R	955	61.0	54.6
Mbinga	Ruvuma	R	859	61.4	53.5
Songea	Ruvuma	R	1003	66.4	49.9
Red Mwitunde[2]		SB	781	59.3	47.3
Spancross[2]		EB	1272	73.4	36.6

1 EB = Erect bunch (Spanish), EB(V) = Erect hunch (Virginia), SB = Spreading hunch, R = Runner (Virginia).
2. Mean of six plots.

Among our major achievements has been the release, the first in over 30 years, of a groundnut cultivar of the Spanish group, Nyota (= Spancross), in 1983 for the Mtwara and Lindi regions. The cultivar has been released under the name Nyota.

Groundnut Production, Farming Methods, and Research in Tanzania

F.F. Mwenda, A.L. Doto, B.R. Taylor, and J.H. Simons*

Summary

*This paper considers the main areas of groundnut cultivation in Tanzania, farmers' yields, production, and marketing. The crop is grown almost entirely by small scale farmers who have access to a limited range of local cultivars and who practice groundnut farming at a very low input level. There is no certified seed multiplication. Past research on groundnuts is briefly reviewed and the research program of the Oilseeds Research Project is outlined. Collection and evaluation of groundnut germplasm is given high priority, and agronomic and crop protection investigations are being made. Testing of exotic materials has led to the release of the Spanish type cultivar Nyota (*Spancross) to growers in the Mtwara and Lindi Regions.*

Résumé

***La production, les méthodes de culture et la recherche sur l'arachide en Tanzanie :** La communication porte sur les principaux domaines de la culture de l'arachide en Tanzanie, notamment les rendements obtenus par les paysans, la production et la commercialisation. La quasi-totalité de la production de cette culture est faite par les petits paysans qui n'ont accès qu'à un choix limité de cultivars locaux. Ils ont peu d'intrants à leur disposition et, à l'heure actuelle, il n'existe pas de multiplication de semences certifiées.*

L'article présente les points saillants des travaux de recherche effectués jusqu'à maintenant et donne un bref aperçu du programme du Projet de recherches sur les oléagineux. Un accent particulier est porté sur la collecte et l'évaluation du germplasme d'arachide; sont également en cours, des études agronomiques et de défense de cultures. Des essais sur le matériel végétal exotique ont abouti à la vulgarisation du cultivar Nyota (=Spancross) du type spanish, dans les régions de Mtwara et Lindi.

Production

Groundnuts are grown in most parts of Tanzania below 1500 m altitude. The most important groundnut growing regions are Mtwara, Tabora, Shinyanga, Kigoma, Dodoma, and Mwanza, where rainfall varies between 500 and 1200 mm/yr. Soils are derived from sandstone, granite, and gneiss and range from sandy to loamy.

The total area sown to the crop in Tanzania increased from below 50000 ha in the early 1960s to nearly 100000 ha in 1980 (Table 1). Yields have been estimated at 600 kg/ha of dried pods but it is doubtful if the majority of small farmers achieve this. Over the past 20 years total production has shown a gradual upward trend, reaching a peak of over 70000 t in 1976 and 1977 (Table 1).

Oilseeds for processing are purchased by the General Agricultural Products Export Corporation (GAPEX), and later resold to mills. Since the formation of GAPEX in 1971, purchases have fallen to only a few tonnes in 1981 and 1982 (Table 2). Although there have been large fluctuations in pur-

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Table 1. Groundnut production in Tanzania.

Year	Area ('000 ha)	Dried pod yield (kg/ha)	Dried pod production ('000 t)
1961-65	45	1002	45
1969-71	49	662	32
1971	63	603	38
1972	63	546	34
1973	60	893	54
1974	70	887	62
1975	77	597	46
1976	124	597	74
1977	125	591	74
1978	118	593	70
1979	88	591	52
1980	92	587	54
1981	94	596	56

Source: FAO Production Yearbooks 1973-1981.

chases of the other annual oilseeds, sesame and sunflower, quantities have been more or less maintained. Because groundnut is both a food and cash crop, large quantities are sold in informal markets. In recent years groundnut exports have fallen considerably, mills are underutilized, and there is a domestic shortage of refined vegetable oils.

Farming Methods

Most groundnut production in Tanzania is by small-scale farmers who grow several other annual crops which compete with groundnut for their limited resources. Groundnuts are generally intercropped, particularly with cereals or cassava, but often with several other crops when groundnut is of secondary importance.

Several local groundnut cultivars are grown in Tanzania (Table 3), and many have become contaminated since they were first identified as cultivars, e.g., the runner admixture to Red Mwitunde. There is at present no certified seed multiplication of groundnuts, so that where seed is produced, the crop is not inspected and seed quality is suspect. The low multiplication rate of groundnuts, and the specialized equipment needed to process the seed, make this crop unattractive to Tanzania's parastatal seed company. With the release of new cultivars, field and postharvest inspections will have to be enforced, perhaps by the Tanzanian Official Seed Certification Agency if true-to-type cultivars are to reach farmers.

Groundnuts are generally grown without fertilizers, which are not readily available to small farmers, and are sown either on the flat or on ridges. Populations of 30000-100000 plants/ha have recently been recorded in the Mtwara and Lindi Regions. Although a dual purpose seed dressing (MCH + thiram) is available in Tanzania, it is not widely distributed and is rarely used by farmers. Small farmers do not use chemical crop protection, primarily because equipment and materials are not available, rather than through ignorance. While initial cultivations may be by hired tractor, most work is done by hand, and weeding and harvesting are done exclusively by hand.

Table 2. Official purchases of sesame, groundnut, and sunflower 1971-83, (t).

Year[1]	Sesame	Groundnut	Sunflower
1971-72	8170	3295	6199
1972-73	7336	3454	9464
1973-74	6641	1363	6252
1974-75	5820	509	7032
1975-76	5891	510	6894
1976-77	5941	417	5912
1977-78	6596	1448	7167
1978-79	6564	2615	12011
1979-80	4317	6676	17408
1980-81	7528	1738	10798
1981-82	3669	227	9373
1982-83	5499	129	5563

Source: GAPEX.
1. May to April.

Research

Groundnut research by the Overseas Food Corporation in the late 1940s and early 1950s led to the recommendation of Red Mwitunde and Natal Common cultivars to farmers. Some variety trials were carried out in the early 1970s by the Ministry of Agriculture. More recently, groundnut research has been the responsibility of the Oilseeds Research Project which was set up in 1978 at Naliendele, Mtwara; and the Pulses and Groundnut Project, set up in 1980 at the Faculty of Agriculture, Forestry and Veterinary Science of the University of Dar es Salaam, Morogoro. The former project is funded by the British Overseas Development Administration and the Tanzanian Government, and the latter by the Canadian International Development Research Centre.

Table 3. Common groundnut types grown in Tanzania.

Name	Region	Type
Red Mwitunde	Mtwara, Lindi	Mixture of spreading bunch and runner
Dodoma Bold	Ruvuma	Mainly runner
Amani	Ruvuma	Mainly runner
Mongo mongo	Mtwara	Mixture of spreading and runner
Kasalagara	Mwanza	Mainly upright bunches
Bwanga	Mwanza	Mixture of spreading bunches and runner
Mwanjelwa	Mbeya	Mainly runner
Malawi	Ruvuma, Dodoma	Upright bunches

The Oilseeds Research Project initially worked mainly on sesame and sunflower, but in 1981-82 the groundnut program was greatly expanded following the collection of a wide range of local and exotic materials. Based on evaluations at Naliendele and regional trials, the Spanish type cultivar Nyota (=Spancross) was released in 1983 for multiplication and distribution in the Mtwara and Lindi regions. This cultivar has produced outstanding yields in trials and is recommended to farmers who use improved practices (primarily sowing early at close spacing and timely harvesting).

Because many small farmers are likely to continue growing Virginia type cultivars, which although lower yielding, can be grown at wider spacings with less seed than Spanish types, it is essential that improved cultivars of this group are found. Several interesting lines have been identified during the last two seasons, but further evaluation and regional testing are necessary before recommendations can be made. Much promising material of both Virginia and Spanish types is available from ICRISAT with whom good links have been established.

Groundnut agronomy has covered spacing and intercropping. More recently the husbandry requirements of the two groundnut types have been compared to find out how farmers' practices will have to change if they adopt new cultivars. The response of high-yielding cultivars to different levels of fertility and to different intercropping situations has not yet been assessed.

Yield losses from cercospora leafspots and rust are estimated at over 35% at Naliendele (Simons, J.H. 1983 personal communication). Resistant germplasm is becoming available from ICRISAT and from locally collected material currently under evaluation in Tanzania. Seed and seedling disorders have been observed but are not well understood. These disorders may be an important cause, perhaps in combination with soil factors, of empty pods or pops which are a major problem in southeast Tanzania.

Rosette virus disease is of considerable importance in certain areas of the country, but is considered unimportant in others. Farmers may plant Virginia type cultivars in most areas because they think they are less susceptible to rosette than Spanish type cultivars. New cultivar releases, particularly Spanish types, will have to be closely monitored for rosette. The large groundnut collection at Naliendele includes materials reported resistant to rosette in East and West Africa, and these are ready for resistance breeding should this become necessary.

Termites cause serious damage to groundnut. Spraying insecticide on the soil around the collar of plants was necessary to safeguard breeding material and trials at Naliendele. Thrips cause some scarring and distortion of the leaves of most plants, and are potentially serious vectors of tomato spotted wilt virus. A jassid (*Empoasca* sp.) may also infest plants causing extensive chlorotic patches on leaves and leading to some foliage rotting during periods of frequent rain.

Rats can be very damaging to planted seed before emergence, and to maturing pods if harvesting is delayed. Crows often cause similar damage.

The main centers for oil seed research in the country are at the Naliendele Research Station in southern Tanzania and at the Faculty of Agriculture, Forestry, and Veterinary Science in Morogoro in east central Tanzania. However, both these centers have outreach trials throughout the country in areas where groundnut is an important crop. With the recent release of the Project's first improved groundnut cultivar from the Oilseeds Research Project at Naliendele, more regional trials are planned, especially of Spanish types commonly grown in Dodoma and Mwanza regions.

Groundnut Crop Protection Work in the Tanzania Oilseeds Research Project

J.H. Simons*

Summary

The first two years work of the crop protection section of the British government-assisted Tanzania Oilseeds Research Project is described as it relates to groundnut. Work on groundnut is limited, and initial emphasis has been on cataloging practical field problems, particularly to aid resistance screening; to quantify yield losses caused by cercospora leaf spots and rust, which together or singly seem to be the most serious problems; and to obtain and test resistant materials found elsewhere.

Phytotoxicity by fungicides seems to be responsible for some peculiar results in the yield loss study, but for the cultivar Natal Common the combined kernel loss to rust and late leaf spot is about 40% at Mtwara. Some cultivars and lines from ICRISA T are highly resistant to rust and/or late leafspot in Tanzania.

Other important problems are pops, several seedling diseases, rosette virus disease complex (possibly including other virus diseases), suspected fusarium wilt, termites, jassids, thrips, field rats, and crows. Their approximate incidences in the south are given, along with some possible practical control methods. In the next year or two similar information should be available for the central and northern groundnut areas.

Résumé

Travaux de défense des cultures de l'arachide au sein du Projet de recherches sur les oléagineux de la Tanzanie : *Les travaux effectués dans les deux premières années à la section de défense des cultures du Projet de recherches sur les oléagineux de la Tanzanie, subventionné par le gouvernement de la Grande-Bretagne, sont passés en revue puisqu'ils concernent l'arachide. Cependant, la recherche sur l'arachide est limitée, et au préalable, l'accent a été mis sur l'établissement d'un catalogue des problèmes de nature pratique rencontrés sur le terrain afin de : faciliter le criblage pour la résistance; quantifier les pertes de récoltes provoquées par les cercosporioses et la rouille, qui posent seules ou ensemble, les plus graves problèmes; et obtenir ainsi qu'évaluer les matériels résistants dépistés ailleurs.*

La phytotoxicité due aux fongicides a apparemment entraîné des résultats très singuliers dans l'étude sur la perte des récoltes. Quant au cultivar "Natal Common", cependant, la perte combinée d'amandes causée par la rouille et la cercosporiose tardive est de 40% à Mtwara. Certains cultivars et lignées provenant de l'ICRISAT s'avèrent très résistants à la rouille ou à la cercosporiose tardive en Tanzanie.

D'autres problèmes importants qui sont abordés incluent le pauvre remplissage de la gousse, plusieurs maladies de la plantule, le complexe de la rosette (comprenant probablement d'autres viroses), le flétrissement dû au Fusarium, *les termites, les jassidés, les thrips, les rats et les corbeaux. Leur incidence approximative au sud de la Tanzanie est présentée, et certaines méthodes pratiques de lutte sont suggérées. Dans le proche avenir (un ou deux ans), de tels renseignements seraient disponibles pour les zones centrale et septentrionale de culture d'arachide.*

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International Crops Research Institute for the Semi-Arid Tropics. 1984. Regional Groundnut Workshop for Southern Africa, 26-29 March 1984, Lilongwe, Malawi. Patancheru, A.P. 502324, India: ICRISAT.

In the first two years of the crop protection program of the Tanzania Oilseeds Research Project, work on groundnut pests and diseases has been mostly in two areas:

- Cercospora leafspots and rust study and control. Early leafspot (*Cercospora arachidicola*), late leafspot (*Cercosporidium personatum*), and rust (*Puccinia arachidis*) seem to be the most important crop protection problems of groundnut throughout Tanzania.
- Assess other problems, determine their causes, and note variations between different cultivars and growing conditions. This information is necessary to increase screening work.

Work on the Cercospora leafspots and rust has been mainly to assess yield losses and to identify resistant cultivars and lines. Work on other crop protection problems has included observations on empty pods ("pops"), and seedling disorders, as well as fungal diseases, virus diseases, insect pests, and rats.

Most of this work has been done at the project's base at Naliendele, Mtwara region, in the southeast corner of Tanzania. Pest and disease observations have frequently been made on trials at the edge of the major groundnut growing area of Masasi, 150 km inland at Nachingwoa, also in the southeast. Many groundnut disease specimens have been collected by a project agronomist based at Suluti-Songea in the southwest.

A gap in the work has been the failure to visit the major groundnut growing areas in the center of the country, mainly due to great difficulty in traveling out of the southeast. However, some information from other parts has come in reports on cultivar trials carried out for the project by other agricultural research stations. And recently, a Tanzanian crop protectionist joined the project, so it should be possible to remedy the deficiency soon.

Foliage Diseases

Early leafspot, late leafspot, and rust appear to be the most damaging diseases of groundnut in Tanzania. Every season practically every plant is heavily infected and usually defoliated by one or more of these. The relative importance of the three diseases varies from place to place. At Naliendele late leafspot and rust are always severe, while early leafspot usually is slight to moderate. Inland in the southern zone, early leafspot becomes as important as late leafspot, but rust seems less severe than in the coastal zone.

The only other foliage disease noticed was probably Phoma leafspot at Naliendele, but on only a few plants shortly before harvest.

Assessment of Yield Losses Caused by Cercospora Leafspots and Rust

Field trials in 1982 and 1983 at Naliendele assessed the yield losses caused by leafspots and rust, jointly and separately, copying a selective fungicides trial used by ICRISAT. The selective fungicides were carbendazim to control leafspots, and tridemorph for rust control, while chlorothalonil was used to control both diseases together. There was a water-sprayed control.

Three groundnut cultivars, all highly susceptible to leafspots and rust, were used: Red Mwitunde (spreading bunch Virginia), Natal Common (Spanish), and Ukiriguru 70.1.1 (Valencia). Judged on check plots in both seasons, late leafspot and rust attacks were severe and early leafspots attack slight.

The mean percentage kernel yield losses caused by the leaf spots and rust separately and jointly (Table 1) were highly variable from year to year, especially for Red Mwitunde. With Natal Common the losses to joint leafspots and rust damage were closer with an average yield loss of about 40%.

Losses caused by the two diseases separately were as large or larger than losses from joint attack, so despite controlling the disease the selective fungicides may have depressed yields. The non-selective chlorothalonil apparently depressed the yield of the Valencia cultivar.

Expressing the fungicide effects as percentage increases over the control (Table 2) confirms that yields were depressed, presumably due to fungicide phytotoxicity. This is being investigated in a pot trial and another field trial.

Screening for Leafspot and Rust Resistance

So far, the only specific screening was in the 1983 ICRISAT international groundnut foliar diseases nursery at Naliendele. It is being repeated this year. In 1983 the nursery was exposed to abundant rust and late leafspot disease pressure, but there was little early leafspot, as is usual at Naliendele. The

Table 1. Yield losses from rust and leaf spots at Naliendele.

Cultivar	Year	Mean % loss of kernels from		
		Leaf spots	Rust	Leaf spots and rust
Red Mwitunde	1982	39	34	38
	1983	13	33	17
Natal Common	1982	37	20	34
	1983	25	25	44
Valencia 70.1.1	1983	2	(11)	5

( ) = increase in yield relative to yield when both are controlled.

1983 nursery contained 44 entries: 39 cultivars and lines from ICRISAT, and 5 Tanzanian cultivars, all replicated twice. They were scored just before harvest for late leafspot and rust using the 1 -9 scale devised by ICRISAT.

The nursery confirmed that at least some materials resistant to rust and late leafspot elsewhere were also resistant in Tanzania. Several lines showed immunity to rust and two contained plants with high resistance to late leafspot. Although yield was not of primary concern, it was interesting to find that resistance was not necessarily associated with high yield. Most of the resistant materials yielded poorly, because of very high levels of pops (shelling percentage as low as 20%). On the other hand several susceptible Indian and South American cultivars were among the highest yielders, along with the best Tanzanian cultivars (Spanish and Valencia type). Some of the best exotics were the Virginia types traditionally grown in southeast Tanzania, which yielded much better than the standard Tanzanian Virginia.

The crop protection section also assisted the groundnut breeder in scoring his considerable collection of foliar disease resistant material, most of which comes from ICRISAT.

Seed and Seedling Diseases and Disorders

Pops

Pops are empty, otherwise perfect pods, in which the kernel has failed to develop. Pops are believed to be due to a calcium deficiency, and have long been rated a major problem of groundnut in southern Tanzania. Incidence of pops is always recorded in Oilseeds Project trials. Virginia type cultivars often show high levels of pops at Nalien-

Table 2. Yield increase from controlling rust and leaf spots at Naliendele.

Cultivar	Year	Mean % increase in kernel yield from spraying		
		Carbendazim (controls leaf spots)	Tridemorph (controls rust)	Chlorothalonil (controls leaf spots and rust)
Red Mwitunde	1982	8	(D	62
	1983	(21)	(12)	18
Natal Common	1982	21	(5)	50
	1983	33	34	77
Valencia 70.1.1	1983	17	4	6

( ) = decrease in yield relative to water-sprayed check.

dele, and some recently acquired Valencia type lines from ICRISAT have shown up to 80% incidence. Naliendele soil is very low in calcium, but liming it generally has not reduced the level of pops. The crop protection section has started looking closely at pods and kernels for any pathogen associated with empty pods.

Seedling Stub Leaf and Pale Dwarf

Seed-borne stub leaf of seedlings, due to calcium deficiency, is very common at Naliendele and is especially severe in Virginia type cultivars, resulting in gappy plots of plants of all sizes. Pale dwarf, due to boron deficiency, is less common, but plants do not recover as some stub leaf affected plants do. Presumably, these are a result of the seed having been produced on Naliendele's sandy deficient soil, and has important implications for seed multiplication and distribution. The solution should be to add appropriate nutrients to the deficient soil, or move major seed multiplication to more fertile sites. Meanwhile crop protection is attempting to identify affected seed to intercept bad lots.

Crown Rot and Seed Decay

All project seed is dressed with athiram-HCH seed dressing and this apparently keeps sown-seed losses from *Aspergillus flavus* and *Rhizopus stolonifer* to low levels. But farmers generally do not dress their seed and therefore suffer considerable losses. Crown rot (*Aspergillus niger*) incidence is generally low in the southeast.

Suspected Fusarium Wilt

Bright yellowing of all leaves, soon followed by wilting and death, affects some plants in most plantings of Spanish and Valencia type cultivars in the southeast. At Nachingwea substation the disease kills at least half of the short-season cultivar plants each season. In most other places the incidence is much lower. Virginia type cultivars are less severely affected: their leaves turn pale green, wilt, and death is slow, or the plants may not die. The tap root of affected plants invariably is rotten, and sometimes there are pink streaks in the xylem of root and stem, suggesting a Fusarium wilt. Material has been sent to the Commonwealth Mycological Institute, London, for identification.

Some evidence shows that yellow wilt causes some pops. Equal numbers of dark green leaved and pale green leaved Red Mwitunde plants from one plot gave 41% and 81% pops respectively. Virginia type groundnuts, infected but not killed quickly by yellow wilt may be harvested along with healthy plants, whereas infected plants of Spanish and Valencia types are usually dead and decomposed by harvest time.

Strict rotation of crops on research land at Naliendele seems to be effective to keep yellow wilt incidence low, while in nearby haphazardly cropped gardens the incidence is high.

Rosette Virus Disease

A low incidence of chlorotic rosette occurs in most groundnut plantings in the southeast, and has been rare at Naliendele, Nachingwea, and Suluti-Songea during the last three seasons. The vector, *Aphis craccivora,* is abundant in Naliendele, infesting most plants early in the season until rains become more frequent. In the major groundnut growing district of Masasi, the disease can be locally serious but generally is not common. What is probably green rosette virus disease seems to have a similar incidence, but other, unrecognised virus diseases may be included. There have been no reports of serious rosette outbreaks in the other major groundnut growing areas.

A major factor in the generally low incidence of rosette in the southeast may be the exclusive growing of Virginia type cultivars by farmers, especially of Red Mwitunde, which has long been recommended as a rosette-resistant cultivar. The situation could change if the recently produced new Spanish type cultivar, Nyota, becomes widely grown by farmers.

In addition to distinctive chlorotic rosette, groundnuts in southeast Tanzania show a range of other virus-like disease conditions comprising some stunting and chlorosis. In most plots they are not frequent, but in one relatively large Red Mwitunde planting on the edge of Masasi town this season, over 50% of the plants showed tiny yellow spots and/or small yellow rings on some young leaves, while older plants had a stiff, compact, inverted cone appearance, usually with little or no chlorosis of the upper leaves. Using crude sap it was possible to transmit the disease mechanically to groundnut. It probably is a form of rosette, but the chlorotic spots and rings raise doubts. It is evident that virus diseases can and do occur on groundnut in Tanzania.

Insect Pests

In addition to the aphid vector of rosette, three insects appear to be important groundnut pests in the southeast.

Termites usually kill some plants in most plots by hollowing out the hypocotyl and main stem anytime from germination to harvest. At Naliendele, insecticidal sprays are applied routinely to the soil around the collars of plants to safeguard valuable breeding materials and trials.

Jassids (*Empoasca* sp.) infest most plants and cause chlorotic patches on leaves which often become rotten during very wet spells. Spanish type cultivars appear to be the most susceptible, local Virginias the least.

Thrips (unidentified) infest the shoot tops of most plants causing some scarring and distortion of most leaves. As vectors of tomato spotted wilt virus disease they are potentially important.

Rats and Crows

Field rats (mostly *Mastomys* spp.) frequently take a large proportion of seed after sowing and pods at maturity in plots close to bush. Plots grown close to pied crow colonies suffer similar damage. Accordingly, in trial work it is often necessary to set rodenticide bait, and employ labor to scare birds.

Groundnut Agronomy Research in Southeast Tanzania

B.R. Taylor

Summary

The objectives of agronomic research on groundnuts within the Tanzania Oilseeds Project are listed and the difficulties stressed. Emphasis is placed on finding out what farmers are currently doing and why. Past agronomic research on groundnuts in Tanzania is summarized and future research considered.

Résumé

Recherches agronomiques sur l'arachide au sud-est de la Tanzanie : *L'article présente les divers objectifs de la recherche agronomique sur l'arachide dans le cadre du Projet de recherches sur les oléagineux de la Tanzanie, et met en relief les contraintes à sa réalisation. On souligne l'importance des renseignements sur les pratiques agricoles actuelles des paysans et leurs motifs. Enfin, on fait le point sur les recherches agronomiques sur l'arachide effectuées jusqu'à présent en Tanzanie et donne un bref aperçu des orientations futures de recherches.*

This paper will not describe results of agronomy trials in detail, which would be applicable only to the area in which the trials were done, and only to the level of husbandry at which the trials were aimed. Instead, objectives are listed, a brief summary of findings given, and considerations for future work are discussed.

Groundnut agronomy research has two objectives:

- to find optimum husbandry practices for specific areas and farming systems to form the bases for extension service recommendations, and,
- to determine changes necessary for farmers to adopt a new cultivar or improved practice.

It is difficult to understand current cultural practices, but this is a necessary prerequisite before recommendations for changes in sowing dates, plant spacing, etc. to suit a new and potentially higher-yielding cultivar are made. What appear to be bad practices probably are justified. For example, farmers in some areas may plant low-yielding but drought-resistant cultivars and use late or phased plantings without inputs in order to reduce drought risk (Ruthenberg 1980).

Agronomy Research: Past and Present

Groundnut research in southeast Tanzania before 1978, including that done by the Overseas Food Corporation, has been summarized by Bennett et al. (1979). They concluded that relatively high plant populations (above 150000 plants/ha), early sowing, and application of P-containing fertilizers are necessary for high yields. Responses to lime, organic manure, and nitrogen applications were inconsistent.

Since 1978 groundnut agronomy research has been carried out by the Oilseeds Research Project in southern Tanzania, although the crop receives less attention than the project's other crops, sesame and sunflower. In plant density trials the advantages of close row spacing (40 cm compared to 60 cm) have been demonstrated (Bolton 1980).

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International Crops Research Institute for the Semi-Arid Tropics. 1984. Regional Groundnut Workshop for Southern Africa, 26-29 March 1984, Lilongwe, Malawi. Patancheru, A.P. 502324, India: ICRISAT.

Spanish cultivars have responded to populations of up to 250000 plants/ha, while Virginia cultivars (spreading bunch and runner) have given yields close to maximum at 50000 plants/ha. Sowing date trials have demonstrated the importance of early sowing for Virginia types, with slightly more flexibility for Spanish types.

Only two trials have examined groundnut/cereal intercropping. The mixture outyielded pure stands when groundnut was mixed with short, early sorghum (land equivalent ratio greater than unity), but there appeared to be no advantage from groundnut/maize combinations (Bolton 1980). More recent intercropping trials with groundnut and cassava did not include pure stands, and results suggested that yield responses to husbandry practices and possibly to cultivar were similar in mixture to those expected in sole crops.

Recent fertilizer trials have shown responses to P up to 22 kg/ha (50 kg/ha P_2O_5). Where elemental sulphur was applied at 20 kg/ha, there was no significant yield response. Long term experiments are now examining responses to combinations of lime, P and K (Ngatunga, 1983). Nutrient effects on empty pod percentages are of particular interest in these trials.

Considerations for Future Research

Problems encountered in agronomy research are not unique to southeast Tanzania, nor to this crop alone. Apart from nonuniform sites and differences in error variances which preclude combined analyses, results are rarely as consistent, and trials rarely as numerous, as might be wished. Therefore generalizations are necessary to formulate recommendations. Moreover, the husbandry methods which produce the highest yields in trials may be beyond the farmer's capabilities or may represent unacceptable or unattainable changes from traditional farming practices. A recommendation of 100 kg/ha triple superphosphate is unrealistic if fertilizer is not available.

It may be better to look at changes farmers must make If they are to use new cultivars with different characteristics, or if they adopt, perhaps one at a time, so-called improved practices such as fertilizer or insecticide use, or close spacing. For example farmers who traditionally grow Virginia cultivars will have to use much higher plant populations, perhaps 200000 plants/ha in southeast Tanzania, if they are to realize the potential yield of Spanish cultivars (Fig. 1). However, this will treble the farmer's seed requirement, and consume potential food at a hungry time of year. Where land is plentiful, as it is in much of Tanzania, the farmer may be more interested in yield per plant or per kilogram of seed sown, rather than yield per hectare. Certainly increasing the population decreases the yield per plant, especially in local cultivars (Fig. 2).

Where land is plentiful, output may be limited by labor availability, particularly labor needed for weeding (Moody 1975). Perhaps more concern should be shown over the amount of extra labor needed to implement improved practices. High plant populations need more labor at sowing and at harvest. Fertilizer, particularly where applications are placed in the soil, uses more labor, and nontraditional sowing and harvest dates may coincide with other important labor peaks.

The study of intercropping is complicated because there are as many intercropping systems as there are farmers who grow mixed crops. In Tanzania, groundnuts are found in the first intercropping situation recognized by Willey (1979) "Where intercropping must give full yield of a 'main' crop and some yield of a second crop". Groundnut is a second crop to cassava or cereals or both. A survey done in Lindi region found groundnut mixed with up to seven other crops, but most commonly with three others, when it occupied on average

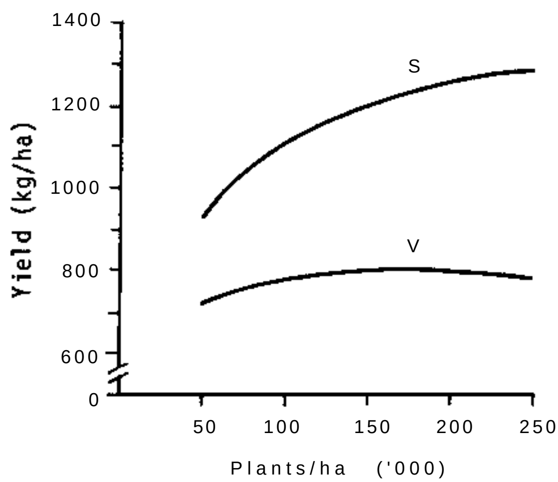

Figure 1. Kernel yield response of Spanish (S) and Virginia (V) groundnuts to increasing plant population at Naliendele.

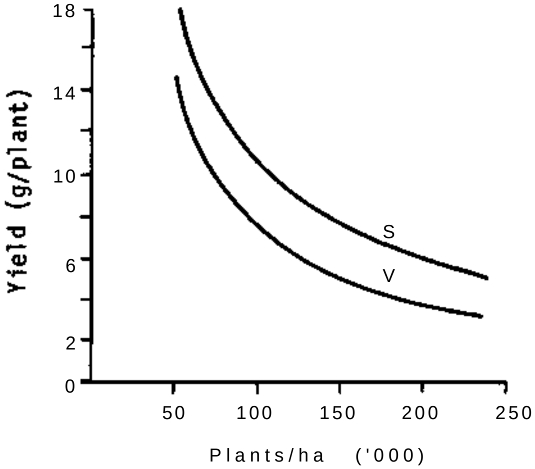

Figure 2. Plant kernel yield response of Spanish (S) and Virginia (V) groundnuts to increasing plant population at Naliendele.

one-sixth of the land area (P.M. Oates personal communication). The problem of the research agronomist is to know where to start. Work in southeast Tanzania has examined only two crops at a time and has used alternate rows for simplicity whereas local systems can have several randomly-sown crops. Because groundnut tends to be a secondary crop in a mixture, usually sown after food crops when time allows, no sole crop plots have been included in recent intercropping trials. The trials were not intended to support recommendations for or against intercropping, but to determine how best to grow mixed crops (Mead and Stern 1980).

The starting point to determine what will happen when the farmer introduces changes is a thorough knowledge of what the farmer is doing already, and why. To find out what is happening, systematic surveys are possible, but difficult and expensive. To find out why the farmer acts as he does is more difficult still.

Conclusions

Groundnut is grown in southeast Tanzania primarily by small farmers using traditional practices. It is not difficult to formulate packages of improved practices which will greatly increase yields on research stations. At present little is known about local farming methods, particularly intercropping, and the reasons for them. Until there is a better understanding of what the farmer is doing, it will be difficult to suggest ways in which he can increase production.

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Groundnut Improvement in Tanzania: Progress and Future Orientation

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Summary

Data are presented on groundnut production in Tanzania with emphasis on the continuing demand for the commodity. The aims of the Pulses and Groundnuts Project to develop high-yielding cultivars with resistance or tolerance to the various yield-reducing factors, and to develop agronomic packages to match local conditions are described. Future research is outlined with particular attention to cuitivar x site x season interactions. Introduction, selection, and hybridization will all be used in crop improvement.

Résumé

Amélioration de l'arachide en Tanzanie—les progrès et les perspectives : *L'article présente les données sur les divers aspects de la production arachidière en Tanzanie, mettant en évidence, en particulier, la demande toujours importante pour ce produit. Sont également exposés les objectifs du Projet arachide et légumineuses, notamment la création des cultivars à haut rendement et présentant une résistance ou une tolérance aux divers facteurs affectant le rendement, ainsi que la mise au point de techniques agronomiques adaptées aux conditions locales. Les perspectives de la recherche sont examinées, et surtout celles des études sur les intéractions entre les cultivars, sites et saisons. L'amélioration des cultures fera appel à la fois à l'introduction, à la sélection et à l'hybridation.*

To date groundnut history in Tanzania has been closely associated with the collapse of the ambitious Tanganyika Groundnut Scheme of the 1940s. In spite of the collapse of this scheme, the country has continued to produce a substantial volume of groundnuts for both local and export markets. Recently groundnut production in Tanzania has been estimated at 58000 tonnes (Nigam 1983), almost all produced by small scale farmers and consumed locally. Thus accurate production figures are difficult to get, but these have been highlighted (Mwenda et al. 1984).

Groundnut yields in Tanzania are generally low, averaging about 600 kg/ha (Nigam 1983). The increase in groundnut production is mainly from increased area under the crop. In 1971 for example, 63000 ha were under groundnuts while the figure rose to 96000 ha in 1982 (FAO 1983).

In spite of increased production, the domestic demand for groundnuts and groundnut products still far outstrips the supply. Several factors have been identified as important in limiting groundnut production in southern Africa (Nigam 1983), for example lack of suitable cultivars in the area. Cultivars such as Natal Common, Red Mwitunde, Dodoma Bold, and Amani are grown in various parts of Tanzania, but are generally mixed and until now there has been an acute shortage of pure seed.

The Pulses and Groundnuts Project

Because of these production limitations the Canadian International Development Research Centre

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(IDRC) funded a project in May 1980 at the Faculty of Agricuture, Forestry and Veterinary Science, Morogoro with a large breeding component. This groundnut project aims to develop:

- high-yielding cultivars with high oil and protein contents resistant to drought, insects, and diseases;
- early- and late-maturing cultivars to suit the various agroecologicai zones; and
- suitable agronomic packages for groundnuts to match local conditions.

Base-line Data and Future Considerations

Work at Naliendele has indicated the importance of cultivar x site interactions (Preston 1982). The nature of these interactions is, however, not clearly resolved. It is important to note that the role and place of both long- and short-season germplasm has been recognized by both the Morogoro and the Naliendele projects.

While the presence of significant cultivar x site interactions points to the need for extensive testing, the importance of properly planned and coordinated testing cannot be overemphasized. Such coordinated efforts at country level or even at regional level could pay dividends by:

- allowing cross-reference across sites, years, and cultivars, and
- generating a bank of information which could finally throw light on the nature of cultivar x site, cultivar x year, and cultivar x site x year interactions.

In addition, thorough data analysis could, if superimposed on the above system, be able to identify sources of potentially useful genetic material. The role of introductions in our project at Morogoro has been recognized. For example, in our previous work a number of outstanding introductions have been identified (Table 1). On the other hand, it is also true that a good number of the locally available materials have considerable potential, but there is still a need to have a clearly defined path on which to concentrate scarce resources.

Our colleagues in Zambia and Zimbabwe, with a long history of groundnut breeding, acknowledge the unique value of genetic material of Bolivian origin. The performance in Tanzania of genetic material from Zimbabwe and Zambia has been encouraging (Preston 1982). It may be premature at present, but the ICRISAT Regional Groundnut Program could be requested to facilitate the acquisition of materials from neighboring countries and those of Bolivian origin.

Farmers in Tanzania are currently aware of the potential for groundnuts and the search for improved seed is on. Surprisingly, uniform, viable seed is hard to obtain in the country and breeders and seed producers are now exploring short-cuts to satisfy the rising seed demand.

Table 1. Mean kerne! yield (kg/ha) for cultivars in evaluation trials at Morogoro in 1981 and 1983.

Cultivar	1981 season	1983[1] season
1/30	1206	512
Starr	1116	599
Tarapoto PI 350680	986	721
NC 343	1001	883
1/69	1031	764
1/88	1020	573
Ex-Njombe	765	870
Dixie Runner	914	895
lleje (Ex-Ulambia)	784	477
Ex-Chimala	838	554
Mbeya	1089	670
Makambako	658	672
Tabulaya	905	436
Karayaga Kibwa	482	200
Comet	1068	633
Ex-Chunya	905	570
Spanhoma	1228	1018
Spancross	966	651
Virginia 72R	880	507
2/108	336	222
KH 149A	774	385
Tamnut - 74	1316	679
Mamboleo	1033	790
Natal Common	1097	853
1/94	992	544
1/21	--	967
Asilia Mamboleo	--	958
Mean	938	--
S.E. ±	54.2	--

1. The 1983 trial was not replicated.

Our project has three components in the search for Improved cultivars: introduction, selection, and hybridization. The Naliendele project released a cultivar in 1983 which resulted from the intensive evaluation of existing established cultivars. As a short-term measure, existing lines/cultivars are under evaluation and selection. Given the limited resources available, this approach seems to be the most desirable one in the urgent search for improved material.

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Discussion on Tanzania Papers

Ramanaiah: In Mozambique we also find short- and long-duration cultivars mixed in the field. Could the participants from Tanzania comment on the problems involved?

Doto: In most cases a long-season crop is grown but this is a population with a range of maturity dates rather than a pure cultivar.

Simons: In southeast Tanzania the seed distributed to farmers has been a mixture of runner and spreading bunch cultivars.

Ramanaiah: In Mozambique we have a 'yellowing' disease of groundnut but the plants recover after some time. Is this the case with the disease in Tanzania?

Simons: In Tanzania groundnuts that become yellowed do not recover, and in most cases they die.

Amin: Our experience in India has been that a high plant population could lead to drought stress and increased attack by insects. Such interactions should be borne in mind.

Simons: I agree, this may be why some farmers use low plant populations.

Riley: I am interested in time-of-planting trials. Perhaps a long-season cultivar would do better than early-maturing types planted after commencement of the rains?

Taylor: In our trials short-season cultivars were as high yielding as long-season cultivars planted early. Short-season types are more flexible and give good yield. If long-season cultivars are planted late their yields are much reduced.

Diga: How do the various countries of the region maintain purity of cultivars?

Hildebrand: In Zimbabwe there has for some time been a sophisticated seed production and certification scheme. All cultivars grown were put into this scheme. Breeders' seed was produced by the breeders. Seed was then sold to seed firms who were responsible for maintenance of purity.

Sinvula: In Zambia the breeders take care of maintenance of seed purity. There is a National Seed Company which multiplies and distributes seed.

Groundnut Production and Research: Problems and Priorities in Zambia

R.S. Sandhu, G. Kelly, and J. Kannaiyan*

Summary

While national demand for groundnuts has been increasing in Zambia, production has declined, contributing to a serious shortfall. This is reflected in high prices paid by urban consumers, reduced exports, and a negligible supply for processors. For both the small-scale rural farmer and the major producer, groundnut is an important food as well as a source of cash. In this paper critical management factors are outlined and major yield reducing factors are discussed. Cultivars currently in use are described and breeding procedures and objectives outlined. Serious diseases and pests of groundnut are listed. Agronomic research in Zambia is briefly reviewed and future needs considered.

Résumé

La production arachidière et les problèmes et priorités de la recherche en Zambie : *Face à une demande nationale toujours en croissance, la production arachidière de la Zambie a marqué une forte régression, ce qui a occasionné un manque important de l'arachide. Par conséquent, ce manque se traduit par des prix élevés offerts par les consommateurs urbains, des exportations réduites et des quantités trop faibles de matière première pour les transformateurs. L'arachide constitue une denrée principale et une source importante de revenu aussi bien pour le petit paysan que pour le grand exploitant. Cette communication donne un aperçu des facteurs d'exploitation critiques et étudie les principaux facteurs limitant le rendement. Sont également décrits les cultivars faisant l'objet de l'exploitation actuelle ainsi que les procédés et les objectifs de sélection. Les maladies et les insectes ravageurs les plus importants de l'arachide sont examinés. On présente un bref résumé de la recherche agronomique en Zambie, tout en considérant les besoins futurs.*

Zambia lies between latitudes 8° and 18° S and longitudes 22° and 34° E, and has a land area of 752615 km^2. The widest part of the country is 1280 km east to west. The country is mainly a plateau with an altitude range of 900-1350 m. Some valleys lie below 310 m and are relatively hot and dry.

Rainfed groundnut is grown during the wet season, which starts in November and ends in March/April. Rainfall in the central and eastern regions (800-1100 mm) is adequate for growing long season groundnuts, while the comparatively drier south and west (below 800 mm) are suitable only for short-season types. High rainfall in the north and northwest (1100-1525 mm) has resulted in leached acid soils with associated pops problem in groundnuts.

Production

The officially marketed national production of groundnuts reached a peak of 14 8101 in 1967. The total production probably far exceeded this figure because large quantities of groundnuts are consumed locally. In 1968 sales through official channels dropped to 5390 t. Later production has fluctuated, but reached a lower peak in 1976 when 9467 t were officially marketed. Table 1 shows the

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Table 1. Groundnuts officially marketed in Zambia, 1976-83.

Year	Groundnut production (t)	
	Zambia	Eastern Province
1976	9467	7330
1977	7462	3062
1978	2234	1672
1979	2737	2241
1980	2028	1455
1981	1320	912
1982	794	741
1983	983	948

Source: 1982 Agricultural Statistical Bulletin, and Namboard Report as of 14/10/83.

marked decline in marketed production from 1976 to the present. The volume of sales dropped to a low of 7941 in 1982 but picked up again slightly in 1983 to approximately 983 t (preliminary estimates). During this period the eastern province provided most of the groundnuts marketed.

The decline in production is also reflected in the quantity of groundnuts available for export (Table 2) and the value of foreign exchange earned from sales abroad.

Utilization

It is nearly impossible to arrive at true groundnut consumption demand figures because of limited information on the total marketed production, the volume moving through informal channels, and the quantity groundnut producers retain for their own consumption.

Table 2. Groundnut exports from Zambia, 1971-1982.

Year	Quantity (t)	Year	Quantity (t)
1971	4171	1977	990
1972	4431	1978	378
1973	1997	1979	465
1974	2145	1980	26
1975	2880	1981	Nil
1976	1289	1982	Nil

Source: Eastern Province Co-operative Union 1983.

Domestic consumption has taken an increasing share of the groundnut production. In 1971, approximately 80% of all groundnuts marketed by the Eastern Province Marketing Union went to export markets, but by 1976 only 17.8% of the Eastern Co-operative Union's marketed production was exported.

While Zambia's population has been increasing at a rate in excess of 3%/yr, groundnut production has fallen by 20-30%, resulting in a shortage of edible groundnuts for both home consumption and export.

Prices offered on the world market for exported Chalimbana cannot compete with what the urban consumer is willing to pay for edible nuts during the current shortage. Any production increase will have to first satisfy this demand before groundnuts become available for export.

The shortage is likely to persist as long as the relative profitability of maize over groundnuts remains high. Since 1978, there has been a steady decline in the value of groundnuts compared with maize, making groundnuts less profitable to grow. There seems to have been a positive response by farmers to this trend leading to a reduced groundnut hectarage grown by fewer farmers.

National vegetable oil demand was approximately 332751 during 1984. For the 2-year period 1979-80, of 29 7001 of edible oil sold by Refined Oil Products (1975) Limited, only 37% was produced locally (MacFarlane 1983). During 1981, edible oil production by this company was 12.5% of the national demand. Very little of this came from groundnuts.

Yield Potential

Most groundnuts are grown by small-scale farmers and are important as a source of protein as well as cash. According to a recent study on marketing in the Eastern Province, more than 50% of the groundnut growers farm less than 4 ha, of which only 0.6 ha is groundnuts.

At research stations groundnuts yield 1.5-3.0 t/ha depending upon the cultivar. With proper management under farmers' conditions, 1.0-1.6 t/ha should be an easily attainable yield. Actual mean yields by small farmers do not exceed 560 kg/ha.

The large fluctuations in national groundnut production may be due in part to a labor shortage, especially at planting, weeding, and harvesting times, which coincide with those of maize.

Farmers prefer to use their own seed saved from the previous year's harvest. The price of improved seed is a major deterrent, and farmers still need to be convinced that the use of this seed will provide adequate returns for the added investment. There is a common tendency among farmers to skimp on seed, and thus not have an optimal plant population. Another major problem is the use of nonviable or damaged seed which is prone to infection by soil fungi.

Variety Improvement

Background

Early work (1955-63) compared local traditionally grown cultivars with new introduced selections. Both Makulu Red and Mani Pintar gave considerably higher yields than other cultivars, including Chalimbana. Since Mani Pintar showed varietal instability, Makulu Red was accepted as the most suitable high-yielding cultivar.

During 1963-68 a large germplasm collection of 1000 cultivars and selections was grown and classified according to the system of Bunting (1955).

Studies on Chalimbana in the late 1960s showed a preponderance of two-kernel pods irrespective of their origin from seed of one-, two-, or three-kemeled pods. Large seeds tended to produce a large proportion of two-kernel pods without affecting total yield. Planting large seeds for the off-take of larger kerneled nuts was justified.

A series of trials was conducted to grow uniform plant types and large seeds of Sigaro Pink, and also to determine its yield performance. Though it was superior to Chalimbana, it was lower yielding than Makulu Red. Sigaro Pink was considered to be a dual purpose cultivar, suited as a smaller seeded quality groundnut for export as well as for oil. As a long term measure, crossing it with Chalimbana was suggested.

Sarmezey (1978) screened cultivars for pops tolerance in leached acid soils from 1973-77. Of the four cultivars found relatively tolerant, three belonged to the Kongwa Runner group. Copperbelt Runner (a selection from TMV-1) had 26.9% pops and a shelled yield of 1120 kg/ha. The control, Makulu Red, produced 69.5% pops and yielded 718 kg/ha.

Multilocation trials with 16 short-season exotic cultivars were conducted in the 1970s but no cultivar was superior to Natal Common.

Cultivars Grown

The above findings provided a basis for recommending the following three cultivars for growing by Zambian farmers in a range of different conditions.

1. Chalimbana: A Virginia jumbo runner type of long standing in the Eastern Province for export as a premium nut. This was the only cultivar allowed to be grown in the Eastern Province until this ban was lifted in 1975. The cultivar is also popular for home consumption, especially in urban areas.

   Leaves are large and dark green. The crop matures within 140-160 days of planting. Pods are very large to large and predominantly two-seeded. Seeds are very large, round-ended, pink, and have a dormancy period of 30 days.
2. Makulu Red: Belongs to the Nambyquarae Bunch Group, probably an outcross of Mani Pintado (Mani Pintar) selected by Smartt in 1960. The cultivar has excellent yield, high oil content, and uniform pod size. It is suitable for machine shelling.

   Leaves are large and medium green. It matures in 135-145 days. Pods are large, strongly beaked, slightly constricted and strictly two-seeded. Seeds are large, red, and often flat ended. Recommended for growing in high rainfall areas.
3. Natal Common: A short-season cultivar with a growing period of 110-120 days. Belongs to the Sequential Spanish Bunch Group. Leaves are light green, and pods are small, unconstricted, and two-seeded. Seeds are small, pale buff, nondormant, and are suitable for oil. Recommended for growing in dry, short-season areas.

Production Problems

Since the release of these three cultivars, a number of production problems have arisen that need to be resolved through further research. No single cultivar is entirely satisfactory under Zambian conditions; all have shortcomings.

While Chalimbana remains the most popular cultivar for home consumption and export of high premium kernels, its yield potential is well below that of Makulu Red. Its indeterminate runner growth habit produces pods of varying size. Pods are also thick shelled. The extra large kernel has a thin testa and splits easily when dry if handled carelessly The cultivar is moderately susceptible to cercospora leaf spots and rust. It gives up to 50% pops on acid soils (below 4.5 pH).

Makulu Red performs well as an oil seed under all levels of farming systems. Even so, it has never been popular as a food protein source in Zambia because of its unattractive kernel flavor, color, and appearance. Again its high vulnerability to pops (70%) limits its production capacity in the high rainfall zone for which it has been selected.

Natal Common is highly susceptible to cercospora leaf spots and bears non-dormant and flat-ended small kernels. There is scope for improving yield, kernel size, and disease resistance in this cultivar.

Breeding Objectives

Deficiencies noted in the existing groundnut cultivars are being reduced by appropriate breeding technology. The objectives of the present program (1980-84) are to develop genotypes with one or more of the following features:

1. High yield potential (under either poor or advanced management).
2. Uniform, well-filled pods (thin shells and suitable for machine shelling).
3. Excellent kernel quality (acceptable for export, home consumption, and/or oil).
4. Acceptable agronomic characters (ideal plant spread or maturity period, close placement of pods, high pod retention at harvest, and easy stripping).
5. Disease resistance (cercospora leaf spots, rust, Aflaroot disease, fusarium wilt and rhizoctonia root/pod rot).

Because Chalimbana nuts are so important for domestic food use and export earnings (70-80% of groundnut production), high research priority is given to improvement of this cultivar. Local Chalimbana land races grown by small farmers (Mayoba, Nsenga, Kayowa, etc.) are reported to have a fair amount of variability for plant type, growth habit, maturity period, and pod and kernel characteristics. To exploit possible variability for higher yields, a sizeable collection (150 entries) from farmers' seed lots in the major groundnut growing areas of the Eastern Province was made (1980). Visits by IBPGR/FAO missions to specific agricultural areas of Zambia during successive years (1980-82) further enriched the collection. The entries were grown in observation rows and the most promising were entered in preliminary trials for yield assessment, either directly or after putting them through progeny evaluation for true-breeding lines. Even though a small number were advanced to large scale multi-location trials, the yield increases noted among them so far were not very impressive. A few predominantly three-seeded lines showing uniform pod size were identified. Some large-seeded introductions with reduced lateral spread were tried but none gave as good a kernel quality as Chalimbana.

To further improve the high oil production cultivar Makulu Red, which produces approximately 10% of the country's groundnuts, high-yielding, superior quality pink-seeded selections developed from the cultivar Sigaro Pink (selection from Makulu Red) in Zimbabwe were introduced. Along with others, these were compared in multilocation trials. Although no significant yield improvement over Makulu Red was noted, a positive gain in seed quality was obvious. Makulu Pink, an inconsistent yielder, matures early and bears attractive small sized pink seed. The pops tolerant Copperbelt Runner (TMV 1 selection) yields poorly on non-acidic soils and shows moderate susceptibility to leaf spots.

In an effort to identify a suitable replacement for the short-season Natal Common, about 15% of the total groundnut production, a series of adaptation trials were conducted with improved introduced cultivars. The cultivar Comet consistently yielded higher (increases of 7-10%). The kernel size and leaf spot resistance of this cultivar require improvement.

To diversify seed materials, a large number of introductions have been made from Africa, America and Asia, most in cultivated forms. The collection, inclusive of the local land races, is now over 850 entries. These are grown each year in single observation rows, maintained, evaluated, and catalogued for important agromorphological characters, including resistance to important pathogens. It serves as a useful reservoir of donor genes for the hybridization program.

To generate variability, deliberate breeding is an important component of the groundnut improvement program. During the past two years a number of planned crosses have been attempted to remove deficiencies in the existing cultivars. Some early- and advanced-generation cross bulks with desired combinations have been received from ICRISAT (Hyderabad and Lilongwe). Segregating progenies are screened using the modified pedigree selection method (Brim 1966). A very wide spectrum of variability has been observed and possibilities of securing potentially promising genotypes are quite high.

Production of breeders' seed of released cultivars is an integral part of the breeding work. Upgrading and renovation of the cultivars is a regular feature. The crop is grown in isolation to avoid outcrossing and rogue plants are removed twice during the growing season and at harvest. Any doubtful looking kernels are removed at shelling. The selected seed goes to produce the prebasic seed.

Future Breeding Plans

The broad objectives of breeding for high yield (under both poor and top management), acceptable seed quality (for home consumption, export, and oil), and disease resistance, will be met by an intensified hybridization program. We look forward to a free flow of new improved cultivars and seed materials, especially among neighboring countries. Considerable reliance is placed on the very useful cooperation already being extended to us by the ICRISAT Regional Program, Lilongwe, in readily undertaking suggested crosses, supplying cross bulks (in various generations), and in putting out regional trials of promising fixed lines for local evaluation.

Plant Protection

Diseases

Diseases are a major constraint to groundnut production in Zambia. Angus (1966) reported 16 diseases on the groundnut crop. In recent years some new diseases like rust (*Puccinia arachidis* Speg.), Phoma blight (*Phoma* sp.), pepper spot (*Leptosphaerulina* sp.), and peanut mottle virus have been observed in the Eastern Province.

Leaf spots (*Cercospora arachidicola* Hori and *Cercosporidium personatum* (Berk & Curt.} Deighton), rosette virus disease, rust, aflaroot, and aflatoxin *(Aspergillus flaws* Link ex. Fr.) are the most widely distributed and economically important groundnut diseases in Zambia.

Leaf spots

Of the leaf spots, early leaf spot (C. *arachidicola*) is the most serious. It causes almost 100% defoliation of susceptible cultivars like Natal Common with high yield losses. Investigations by Smartt (1966) on leaf spots indicated that application of fungicides to the cultivar Spanish 809 increased yields 40-100% and doubled the number of large kernels. The cultivar Makulu Red showed no such response to fungicide application because of its tolerance to leaf spots.

Screening for leaf spots resistance in Zambia began during the 1981 /82 season at the National Irrigation Research Station, Nanga. During the subsequent year this work was undertaken at Msekera Regional Research Station, Chipata, Eastern Province. The natural occurrence of early leaf spot at the station is fairly uniform when susceptible lines are planted during late November to early December. This allows for useful field screening of materials under test in the foliar diseases nursery, germplasm, and breeding trials. Late leaf spot (C. *personatum)* is less common and seldom causes serious yield losses.

During the 1981/82 and 1982/83 seasons, 43 ICRISAT Groundnut Foliar Disease Nursery entries and three local cultivars (Natal Common, Chalimbana, and Makulu Red) were screened at Nanga and Msekera. Of these, only 13 ICRISAT entries showed a disease score of 4 or below on the 9 point scale (1 = no disease and 9 = extensive damage to the foliage) against the leaf spots at both locations. The susceptible control Natal Common scored as high as 7.

During 1983/84, 58 entries (28 ICRISAT entries and 30 other cultivars) are being tested in two replications at Msekera. Two spreader rows of Natal Common were planted after every four test entries with two spreader guard rows planted around the trial. Ten weeks after planting, Natal Common, Argentine, and Sellie gave a score of 7 for early leaf spot. Forty-four entries/cultivars showed a rating of 4 or below and the lowest disease Incidence was recorded in Puerto Rico 62, Ch. 148/80, RG 8, ICG 4790, ICG 6322, ICG 7884, and ICG 7897. Final observations will be recorded 2 weeks prior to harvesting.

Table 3 summarizes leaf spot resistance during three seasons (1981 -1983) for 12 promising ICRISAT entries.

Rosette

Groundnut rosette virus disease has been reported from most countries in Africa south of the Sahara, including Zambia. Chlorotic rosette is widespread

Table 3. Reaction of 12 ICRISAT foliar disease resistant lines to leaf spots at 3 sites in Zambia.

	Reaction to leaf spots[1]		
Genotype	Nanga (1981/82)	Msekera (1982/83)	Msekera (1983/84)
ICG 1705	4	4	4
ICG 1707	4	4	3
ICG 2716	4	3	4
ICG 4747	4	3	4
ICG 4790	4	3	3
ICG 6022	4	4	4
ICG 6330	4	3	3
ICG 6340	4	3	4
ICG 7881	2	4	4
ICG 7013	4	3	4
ICG 7888	2	4	3
ICG 7897	4	4	3
Natal Common[2]	9	7	7

1. Leaf spots scored on a 9-point rating scale (1 = no disease, 9 - 50 to 100% foliage destroyed)
2. Standard susceptible cultivar.

and destructive on late planted crops and on crops with sparse plant stands. The rosette virus is transmitted by *Aphis craccivora* Koch. Not much work has been done on rosette in Zambia except on the effect of time of sowing (Smartt 1966). Late planted groundnuts (cv. Mani Pintar) with poor plant stands showed higher incidence (36-85%) than earlier planted crops with full stands (2-6%). Two possible reasons are:

- the isolated plants act as more efficient "combs" for aphids borne in air currents than plants in a continuous mass, and
- destruction of aphids by predators may be more efficient in full stands.

In limited screening done under natural field conditions in recent years four entries were resistant to rosette: RG 8, RG 11, RMP 12, and KI PR 19 BUS. Extensive screening and breeding for resistance will begin during the 1984/85 season.

Rust

This disease was first observed in Zambia during the late 1970s. The disease is most serious on long-season local landraces of the Chalimbana type in the Eastern Province. During the current season, field screening of germplasm and breeding materials has been undertaken. The most promising entries will be further screened in the rust nursery next season.

Aflaroot and Aflatoxin

Aspergillus flavus causes both aflaroot and aflatoxin problems in groundnuts. Aflaroot symptoms on groundnuts were observed both at research stations and in farmers' fields. The incidence is more severe on Chalimbana than on other cultivars. A preliminary study of yield loss caused by this disease in Chalimbana cultivars will be conducted during the 1983/84 season.

The same fungus, *A. flavus,* can produce aflatoxin in groundnuts during storage.

Pests

In general, insect pests have received little attention in Zambia. Although relatively less important than disease damage, more severe damage may occur than is recognized at present. Aphids (*Aphis craccivora),* leaf hopper (*Empoasca* spp.), thrips, lepidoptera caterpillars, and termites are common groundnut pests in Zambia.

Severe infestation by aphids was noticed at the Experimental Station and in farmers' fields during mid-January 1984 when there was an extended drought of 2-3 weeks. The pest caused stunting and drying of plants over an extensive area.

Leaf hoppers caused characteristic distortion of foliage during the first two months of growth. Some tolerant lines were found in the germplasm and breeding materials. Both aphids and leaf hoppers can be effectively controlled by the application of commonly used insecticides.

Termites have been observed to cause sporadic withering of plants during the reproductive stage of the crop under conditions of extended drought. Termites can be controlled by the application of Aldinel 48 EC or Furadan 41 EC.

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A Review of Agronomic Work in Zambia, and Prospects for the Future

G. Kelly*

Summary

This paper reviews agronomic research in Zambia from 1954 to the present. Data are presented on effects of dates of sowing and harvest, plant populations, cultivations and weed control, and fertilizers on crop production. The problem of pops is extensively reviewed. Current work is described and future research priorities listed.

Résumé

Le point sur les travaux agronomiques effectués en Zambie, et des perspectives d'avenir : *L'article fait le point sur les recherches agronomiques effectuées en Zambie à partir de 1954 jusqu'à présent. Les données sont présentées sur les effets de divers facteurs sur la production : dates de semis et de récolte, populations des plantes, labours et lutte contre les mauvaises herbes, et engrais. Le problème du pauvre remplissage de la gousse est étudié en détail. Les travaux actuels sont décrits et les orientations futures de la recherche sont précisées.*

Sowing and Harvest Time, Plant Populations, and Weed Control

Records of agronomic trials on the groundnut crop go back to the 1954/55 season. At that time, simple time-of-planting trials were established at the Central Research Station, Mt. Makulu, Lusaka. Similar, but more sophisticated trials were laid out in the 1958/59 season at a number of sites, including Mt. Makulu, Eastern Province, and Southern Province.

Yields were substantially reduced by delayed sowing after the first rains. Later sowings were severely affected by rosette and subjected to high inoculum potentials of leafspot throughout their life. Emergence and establishment were also very poor in later sowings. The yield per plant was also much reduced for both early- and late-maturing cultivars, while the yield of large high grade kernels was higher from early rather than late sowings. These trials included local runner types, GB-1, Mani Pintar, and Makulu Red.

The merits of dry planting were also investigated. As the optimum period for planting groundnuts coincided with that of maize, groundnut would tend to take second place in the farmer's planting calendar. Dry planting, although possibly leading to delayed and uneven seedling emergence, was still considered to be useful as late planting would lead to yield losses.

Early investigations into optimum time of lifting for the crop sought to determine the time needed to produce the maximum crop yield, and also to measure the effects of delayed harvest on yield and quality. Trials from 1959-1961 at three sites found that delayed lifting (i.e., after about 150 days for long-season cultivars and 130 days for Spanish types) was responsible for heavy losses from pod shedding caused by disintegration of the plant and termite attacks.

The first trials to test variations in plant populations and spacing were initiated at three sites in the 1958/59 season using the local runner types Mani Pintar and Makulu Red. Fixed spacings between ridges (or rows) of 60 cm and within-row spacings of 7.5,15, and 30 cm, were used. These trials were

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continued in subsequent seasons with these conclusions:

- Ridging practices per se did not improve yield but were associated with harvesting ease and soil conservation practices.
- Rows should be as close together as practical, consistent with ease of ridging (where used).
- Use of plant populations in excess of the recommendations for each cultivar served no useful purpose: yields were not increased, kernel quality was depressed, and the cost of seed nuts rose to an unacceptably high level.

Current agronomic work is confirming ideal plant populations for each cultivar presently grown in the country.

Cultivation and weed control regime trials were also started at three sites during the 1958/59 season. Yields increased substantially at some sites from each successive interrow and intrarow cultivation. The effects of weed competition were important even in the later stages of growth. Current recommendations are for two and preferably three hoe weedings during the season at approximately 20, 40, and 60-80 days after planting, followed by hand pulling of weeds thereafter.

Nutrition

A considerable amount of fertilizer response work has been done on the groundnut crop in Zambia. Early work looked at the effects of gypsum application at the flowering stage, and this was found useful at some sites but not others. The 1958/59 season saw the initiation of basic nutrition trials on the crop, with significant responses to nitrogen at two sites and to phosphorous at one site. It must be admitted that responses to directly applied fertilizers in Zambia have been inconsistent. The groundnut is known as the "unpredictable legume" for good reasons.

Zambian recommendations for the crop have drawn on American experience and practice. The cereal component of the rotation is fertilized adequately to ensure sufficient residual nutrients are present at the correct depth in the soil profile where they may be exploited by the deep-rooting groundnut plant forming the next course in the rotation.

Maize has a relatively shallow root system and can efficiently utilize superficially applied fertilizer which is then translocated deeper in the soil profile for use by the groundnut plant. Such recommendations presuppose application of compound fertilizer to the preceding crop (which is generally maize, but could be tobacco, sunflower, cotton, or sorghum).

In virgin land or land of inherently low fertility the Ministry of Agriculture recommendation is a basal dressing of 200 kg/ha of TV compound to be applied (analysis 10-20-10-10 [S]). There is certainly scope for more work to be done on fertilizer response, but for the moment, the recommendation to adequately fertilize other components of the rotation is sensible.

Pops Problem

Low soil pH tends to restrict groundnut production in Zambia, particularly in the northern belt of the country where high rainfall over a long season leaches soils. The problem area in Zambia is north of latitude 13°30' S which includes the area north of Zambezi, Mkushi, and Chipata, where seasonal rainfall is normally in excess of 900-1000 mm. The problem also occurs in pockets elsewhere in the country.

Most of the better Virginia groundnut cultivars are affected by pops under such conditions. The phenomenon is characterized by early seed abortion, and although pods remain apparently normal, they contain either no seeds or only minute shriveled remains. Investigative work relevant to this problem has occupied researchers in Zambia for nearly 20 years.

Formative work on the problem in Zambia was done by Henrickson, Herbert, Beringer, and Taha. Herbert drew on Henrickson's observations and his own, and made these conclusions:

- The level of calcium in the soil is crucial. When calcium is in the region of 1.0-1.5 meq/100 g soil as leached out by neutral ammonium acetate solution, pops occur. Moreover, when leaf calcium drops below 1% or when shell calcium drops below 0.1%, pops occur.
- If the level of exchangeable calcium falls below the critical level of 1.0-1.5 meq/100 g soil then as the ratio of K/Ca increases to above 0.2, then pops occur with increasing severity.
- Small-seeded cultivars are less susceptible to pops than large-seeded cultivars.
- Pops can occur in soils where the calcium status is above the critical level when unfavorable growth conditions prevail, such as a drought. Under such conditions, the root hairs are unable

to absorb their nutrients from the surrounding soil.

- Aluminium levels In the soil are also implicated in the problem. As soil pH drops below 4.5, exchangeable aluminium increases tremendously. Addition of calcium in the form of gypsum has been found relatively ineffective in either lowering aluminium levels or raising pH, compared to the same amounts of calcium added as lime.

Excessive aluminium can inhibit the uptake of nutrients by the root hairs, resulting in pops. The recommendations following Herbert's report were to:

- Confirm the critical level of calcium and its relationship with potassium levels.
- Investigate the economic aspects of gypsum and/or lime applications to ameliorate pops soils.
- Breed cultivars suitable for use in the more leached-soils areas of Zambia.

Beringer and Taha used nutrient solutions (Ca labeled with ^{45}Ca) when they compared Makulu Red and Natal Common cultivars. They found that the translocation of calcium from shells to seeds was greater in the small-seeded sequential Natal Common. It also showed less susceptibility to pops than Makulu Red, and hence a better calcium supply from the shells to the seeds inhibited pops in this cultivar.

Research on Pops since 1970

Trials confirmed the critical level of calcium as 1.0-1.5 meq/100 g soil. In the National Lime Trials (MN-1944 series) it was clearly demonstrated that the level of soil calcium was related to shelling percentage and yield.

Most trials showed that on soils with a pH less than 4.6, the response to lime or gypsum application was sufficient. Lime had a positive residual effect over at least 9 years after an initial application of finely ground limestone at 1 -2 *Xl* ha. Gypsum, although easier to apply (it was simply dusted over the plants at flowering), had the drawback of being less available locally in quantity and giving erratic results in soils of pH less than 4.5.

Lime application at the above rates remains the current recommendation. There are a number of lime deposits located in the pops problem areas in Zambia which have yet to be exploited. As added evidence to justify their exploitation, we can refer to the MN-1944 series of trials (National Lime Trials). These were carried out at six different low pH sites for several seasons and at one site (Misamfu in Northern Province) for 10 years. At this site, the residual effect of a single basal dose of 1 -2 t/ha of lime was *still measurable* some 9 years after initial application, on a maize-groundnut rotation. If the initial cost of exploitation, transport, and application of lime pays off over a decade with increased production for both components of the rotation, then the original expenses may be justified.

Present Agronomy Program

The groundnut team (breeder and agronomists) is based at Msekera Research Station outside Chipata in Eastern Province. The team has a national responsibility which involves extensive touring, and placement of locally relevant trials at other regional research stations and substations in the country.

The present program is geared to a thorough investigation of agronomic production aspects of three important groundnut cultivars released in Zambia (Chalimbana, Makulu Red, and Natal Common). Two other cultivars not yet released but considered promising by the Breeder are also being studied (Comet and MgS-1).

Spacing and plant population studies have been carried out over two seasons to confirm present recommendations for the first three cultivars, and to see if the two new cultivars must be treated differently. Farmers' field trials on spacing, at 18 sites around Chipata, have also been planted. Fertilizer response work on the cultivars Chalimbana and Makulu Red, including possible differences in effectiveness of single and triple superphosphates and a range of phosphate levels, is being examined.

A large *Rhizobium* inoculation trial on six cultivars is laid out this year in cooperation with the Microbiology Department at Mt. Makulu Research Station. This features six basic inocula, mixtures of them, and four nitrogen levels for comparison purposes.

Future Direction of the Agronomy Program

The scope and standard of past agronomic work in Zambia has had to be carefully reviewed so as not to repeat previous work. Some areas have been well covered, others less so.

- Even if there has been exhaustive work done on old cultivars, new cultivars emerging from the breeding program must be included in agronomic trials to establish whether or not their growth behavior is similar to that of existing cultivars, and if not, what changes must be made in recommendations to the farmer. This is an ongoing task of the program.
- The place of groundnut in the rotation will also be more closely examined to help answer these questions: What possible nitrogen contribution will benefit succeeding crops in the rotation, and how little fertilizer is needed to sustain both cereal and groundnut components of the rotation? In some parts of Eastern Province, farmers are encouraged to undersow pasture legumes (such as *Desmodium* and *Siratro)* in their maize crop. We need to establish whether there will be deleterious effects on groundnut cultivation from this practice.
- Intercropping studies involving groundnut, presently managed by the farming systems agronomist at Msekera Research Station, will also be handled by the groundnut agronomists in subsequent seasons.
- *Rhizobium* inoculation studies are valuable if transport and refrigeration of cultures can be efficiently managed. Such studies must form part of ongoing work to seek low input methods of increasing yields.
- For the more enterprising small-scale commercial farmer, we shall be looking at more sophisticated production packages which will cover all operations from planting to shelling. This implies (for example) work to be done on economic costing of various fungicide spray regimes against leaf spots and development of village-level machinery.
- An important brief of the agronomy program is to develop simple ox-powered machinery to ease the tasks of:

    - weeding the crop (a labor bottleneck coincident with maize cultivations),
    - lifting the crop, and
    - shelling the pods (hand operated shelters).

Some preliminary work on these problems was done by a succession of engineers based at Magoye Research Station in the south of the country. It is planned to continue this work next season with the assistance of an agricultural engineer, based in Chipata, who is to work with the Swedish-funded Integrated Rural Development Program in Eastern Province.

Discussion on Zambia Papers

Kirkby: How is groundnut sowing done in Zambia?

Kelly: Dry sowing is done approximately 10 days before the expected arrival of the planting rains. Soil temperatures are quite high at this time. If sowing is delayed yields may be poor. Agronomic practices are being developed to get round this problem.

Kirkby: Could this form a breeding objective?

Sandhu: Short-duration cultivars fit well with late sowing requirements.

Doto: *Rhizobium* strain x host genotypes interactions are important in soybeans and IITA is looking for similar interactions with cowpea. What is the situation with groundnuts?

Kelly: Research on symbiotic nitrogen fixation is being done in Zambia in collaboration with NifTAL

Amin: ICRISAT also works in cooperation with NifTAL and research is being carried out at ICRISAT Center on many aspects of nitrogen fixation in groundnuts. Collaborative research with scientists in Zambia could be developed.

Pests, Diseases and Weeds in Groundnuts in Zimbabwe

Desiree L. Cole*

Summary

Many of the weeds, pests, and diseases of groundnuts in Zimbabwe are problems in other groundnut growing areas in Southern Africa, but their relative importance obviously varies from country to country. The main weed problems in Zimbabwe are grasses such as "rapoko"and "shamva"and a few broad leaved species such as Commelina benghalensis *and* Nicandra physalodes. *The weeds are controlled by preplant herbicide treatment and subsequent hand cultivation.*

A vast array of pests feed on groundnut foliage, the most conspicuous of which are leaf eaters such as loopers, semi-loopers, and bollworms. Routine insecticide sprays are necessary to keep the pests in check. More serious damage is done by a stem sap feeder, Hilda patruelis, *which has proved difficult to control.*

Cercospora arachidicola *and* Phoma arachidicola *are the main foliar diseases, and their interaction is discussed.* Cercosporidium personatum *and* Puccinia arachidis *are relatively minor pathogens affecting plants usually 3-4 weeks prior to harvest.* Botrytis cinerea *is a potentially serious disease but most of the commercial cultivars have a fair degree of resistance. Poor stands in communal areas make rosette an annual problem and sporadic outbreaks are seen even in well managed field trials. Aflatoxin levels are carefully monitored in all batches of groundnuts received by the Grain Marketing Board.*

Résumé

Les ravageurs, les maladies et les mauvaises herbes de l'arachide au Zimbabwe : *La plupart des insectes et parasites, des maladies et des plantes nuisibles aux cultures d'arachide au Zimbabwe constituent également des problèmes dans d'autres zones arachidières de l'Afrique australe; il est évident, bien sûr, que leur importance relative varie d'un pays à l'autre. Les graminées telles que le "rapoko" et le "shamva", ainsi que des espèces à feuilles larges (*Commelina benghalensis, Nicandra physalodes*) sont des mauvaises herbes les plus importantes au Zimbabwe. Le traitement chimique avant le semis associé à un désherbage manuel permet de lutter contre celles-ci.*

Une grande diversité des ravageurs s'alimentent sur les feuilles et la tige de l'arachide, dont les plus importants : des rongeurs de feuilles tels que les chenilles arpenteuses et les vers de la capsule. Une pulvérisation régulière des insecticides est nécessaire pour limiter les attaques. Hilda patruelis, *qui se nourrit de la sève des plantes, occasionne de plus graves dégâts et les mesures de lutte se sont révélées peu efficaces.*

Cercospora arachidicola *et* Phoma arachidicola *constituent les maladies principales foliaires, et les auteurs examinent les intéractions entre celles-ci.* Cercosporidium personatum *et* Puccinia arachidis *sont des agents pathogènes relativement mineurs qui atteignent les plantes généralement 3 à 4 semaines avant la récolte.* Botrutis cinerea *peut s'avérer très grave, mais nombre de cultivars commerciaux y présentent une bonne résistance. L'établissement pauvre dans les zones communales font de la rosette un problème annuel; des attaques sont constatées même dans des essais bien contrôlés aux champs. Un contrôle rigoureux des niveaux d'aflatoxines est effectué sur tous les lots d'arachides livrés à la Grain Marketing Board.*

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Much research has been done in Zimbabwe on pests, diseases, and weeds in groundnuts, yet only on commercial farms have we seen dramatic yield increases as a result of pest management (including diseases and weeds). In the communal areas, yields are still abysmally low. Why? It is obvious that the dissemination of information and education of the peasant farmer is or should be our top priority. Only then will their yields increase.

Weeds

Groundnuts are planted in closely spaced rows and weeds must therefore be largely controlled by the use of herbicides. These, however, do not provide complete weed control and a certain amount of hand and machine cultivation is necessary (Richards 1981). Some of the main weeds affecting groundnuts are:

- Grasses. *Rottboellia exaltata* (shamva grass) on heavier soils and *Eleusine indica* (rapoko grass) on all soil types.
- Broadleaf weeds. *Acanthospermum hispidium* (Starbr) is a frequent problem, as is *Bidens pilosa* (Black jack), *Nicandra physaloides* (Apple of Peru) and *Commelina bengalensis* (Wandering jew).

Pests

Hilda patruelis (Hemiptera: Tettigometridae), a hopper, can be devastating to groundnuts and in recent years many of our disease and breeding trials have had to be abandoned because of severe infestation. Control is very difficult and, to date, no practical method has been devised. The life cycle of the hopper will give some insight as to why control is difficult.

The hopper is aided by black ants which help it to penetrate the soil. These small insects, adults are about 5 mm long, may be seen in disturbed soil. The first symptoms are wilting, but at this stage the plant has already been severely infected and is unlikely to recover. Even more frustrating is that by the time the symptoms are seen, the hoppers will have moved to neighboring plants and so the areas surrounding wilting plants must be treated in the hope of reaching the hoppers. The only effective way to reach them is by drenching, but on a large scale this is uneconomical and impractical.

Batches of small, elongated, white eggs will be found fixed firmly and flat against the underground parts of the stems and pods, often within chambers evacuated by the associated ants (Broad 1966).

In summer (Sep to Apr), one generation can be completed in 6 weeks and breeding continues, although more slowly, throughout the winter on alternate hosts or overwintering volunteer plants (Weaving 1980). The ants probably protect *Hilda* from predators and in turn feed on honeydew secretions of the hopper. The combination of hoppers feeding on the sap of plants and ants exposing the roots to desiccation through their working, cause the plants to wilt. Wilting is particularly severe in drought years.

Pests that transmit diseases can also be a problem. The damage from rosette virus disease is particularly serious. It was virtually eliminated from Zimbabwe more than a decade ago by the use of improved cultural techniques in the commercial sector. Volunteer plants were eliminated, all seeds were treated with a suitable seed dressing, and with even germination a full plant population grew on well prepared soils.

In recent times, the disease has once more invaded the crop and a large section of the communal sector has reduced groundnut production because of this disease (Maramba 1983). Even the commercial sector has experienced an increase in rosette incidence. Important outbreaks occur a few weeks after planting, even when very few aphids are to be found. Because they have numerous leguminous secondary hosts it is highly probable they arrive already infected even when there are no local infected volunteer plants, When the aphids (*Aphis craccivo)* are seen, spraying with dimethoate is essential for control. A program to breed cultivars resistant to rosette is under wav.

Leafspot Diseases

The major foliar diseases are cercospora leafspot (*Cercosporaarachidicola)* and web blotch (*Phoma arachidicola)* (Cole 1981). A certain amount of interaction between the two diseases makes them very interesting to study. Cercospora leafspot colonizes leaves earlier than web blotch and these leaves are not susceptible to web blotch (Cole 1982). Where there is no competition for leaf area, the two diseases develop independently, but when leaf area becomes limiting, cercospora usually increases at the expense of web blotch.

If cercospora leafspot is controlled chemically, then the plants rapidly become infected with web blotch. Until recently, no fungicide controlled web blotch effectively and spray programs were so designed as to allow a certain amount of cercospora leafspot to develop before initiating the spray program, to delay the onset of web blotch. With recent advances in fungicide formulations, both diseases can be controlled and this practice is no longer necessary. It was suspected that the host-pathogen interaction when cercospora spores infected leaves triggered some biochemical changes in the leaves. So far we have identified three phytoalexins formed in response to cercospora infection which are also formed in response to web blotch infection but to a lesser extent. As cercospora is the earlier colonizer, this explains why web blotch cannot infect cercospora-infected leaves, and cercospora is rarely seen on web blotch-infected leaves. However, statistical tests have not revealed that cercospora spread is in any way inhibited by web blotch, although there is clear statistical evidence that the opposite occurs. The work in this area has only just begun.

Stem Diseases

Most of the commercially grown cultivars in Zimbabwe have a high *Botrytis cinerea* tolerance. This led to an air of complacency that botrytis was not really a problem, and consequently little research has been directed to botrytis control. It was not until several breeding lines with resistance to foliar pathogens, but not to botrytis, were grown in trials that it was realized what a potential threat botrytis could pose. Even in dry years, botrytis has severely damaged susceptible plants.

Sclerotinia can be serious in irrigated groundnuts, but occurs only sporadically. *Sclerotium rolfsii* is occasionally seen.

Pod Rots

To a large extent pod rots reflect the general health of the plant. Plants with little stem or foliar disease have very little pod rot, while badly defoliated plants can be seriously affected by pod rots (Cole 1981). We measure both total yield and harvested yield. Harvested yield is represented by the pods that are attached to the plant and total yield is obtained by gleaning all the loose pods from the plots as well. In fungicide sprayed healthy plants, harvested yield represents 90-95% of the total yield. In diseased, defoliated plants, harvested yield can be less than 50% of the total yield.

Aflatoxins

All groundnuts delivered to the Grain Marketing Board (GMB) are analyzed for the presence of aflatoxins (du Toit 1977). The tolerance limits are: 0.005 mg/kg for aflatoxin B_1 and 0.004 mg/kg for aflatoxin G_1.

There is appreciable season-to-season variation in the level of aflatoxin contamination in the groundnut crop. In seasons where end-of-season rainfall is low, aflatoxin contamination is high, while in more favorable seasons the levels are low. There are indications that groundnuts grown in the cooler, high rainfall areas along the watershed have less aflatoxin contamination than those grown in the hotter and drier parts of the country.

Methods of Pesticide Application

Pesticides are applied on commercial farms by tractor-drawn equipment, either through high pressure, high volume conventional sprayers or through ultra low volume (ULV) applicators attached to a boom. On small-scale farms, pesticides are applied with knapsack or motorized knapsack sprayers or by hand-held ULV applicators (Cole and Chingombe 1981).

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The Present and Future Status of Groundnut Breeding and Research in Zimbabwe

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Summary

This paper discusses groundnut production patterns and marketing trends in Zimbabwe. Groundnut is widely grown, mostly by peasant farmers, and it is the most important pulse legume crop. It is principally grown for home consumption and as a cash crop. The main environmental factors determining the nature and type of production are outlined.

The major constraints to yield are low and unreliable rainfall often poorly distributed over the growing season, unadapted cultivars, diseases, and pests. Breeding is the major component of research on groundnuts in Zimbabwe and the objectives are discussed in the light of the production problems. Various other aspects of groundnut production e.g., agronomy, nutrition, mechanization, pathology, and entomology are currently under investigation.

Frequently, research recommendations are not adopted by farmers. A farming systems research program has been initiated in conjuction with the Extension Department to bridge this gap.

The future trends in groundnut research are outlined in the light of the present status and projected production trends.

Résumé

Travaux actuels et futurs de la recherche et de la sélection de l'arachide au Zimbabwe : *Cette communication étudie les types de la production de l'arachide et les tendances à la commercialisation au Zimbabwe. L'arachide reste la première culture oléagineuse du pays cultivée surtout par des paysans ruraux, principalement pour la consommation directe mais aussi comme culture commerciale. Les facteurs déterminants de la nature et du type de production sont esquissés.*

Une pluviométrie basse et aléatoire, le plus souvent mal répartie sur la période de végétation, des cultivars peu adaptés, les maladies et les ravageurs constituent les contraintes principales aux rendements élevés. La sélection est un composant majeur de la recherche sur l'arachide au Zimbabwe; les objectives de celle-ci sont examinés, par conséquent, à la lumière des problèmes de la production. D'autres aspects de la production arachidière, notamment l'agronomie, la nutrition, la mécanisation, la pathologie et l'entomologie, font l'objet des travaux actuels.

On constate souvent que les recommendations faites par les chercheurs ne sont pas adoptées par les paysans. Afin de surmonter ce problème, un programme de recherches sur les systèmes de production a été mis en place en collaboration avec la Direction de la vulgarisation. Enfin, les orientations de la recherche sur l'arachide pour le futur sont définies à la lumière de l'état actuel ainsi que des projections de la production.

Geographically, Zimbabwe lies between latitudes 16° and 22°S, with an altitude range of 160-2000 m above sea level. The altitude has a marked effect on cropping patterns and on this basis the country falls into three zones, the highveld (> 1200 m), the middleveld (900-1200 m), and the lowveld (< 800 m). Rainfall generally declines with decreasing altitude. The highveld has the highest rainfall and lowest temperatures while the lowveld is hot and dry with commercial crop production only possible with irrigation. Climate data for sites typical of the three altitude zones are shown in Table 1. There are

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Table 1. Climatic data for selected sites in Zimbabwe (means for 5 month period November-March).

	Meterological stations (with altitude in m)			
	Marondera (1628)	Kadoma (1157)	Tuli (765)	Triangle (421)
	Highveld	Middleveld	Lowveld	
Mean max. temperature (°C)	24.4	28.4	30.4	32.2
Mean min. temperature (°C)	14.2	17.0	17.9	19.3
Mean hours sunshine/day	6.5	6.8	7.3	7.3
Mean evaporation/month (mm)	152	175	198	200
Duration of rainy season (days)	135	125	80	105
Rainfall for November-March (mm)	840	706	394	539
Annual rainfall (mm)	936	776	455	622

distinct wet and dry periods and rainfall fluctuates between and within seasons. The rainy season is from Nov-Mar but the effective growing season averages about 130 days.

Types of Production

Production of groundnuts falls into two distinct types, the commercial sector and the peasant sector. In the latter group, there is a small section of farmers whose holdings average 120 ha and who are referred to as small-scale commercial farmers. The remainder are referred to as communal area producers. These two groups have not been separated for the purposes of this paper. Some production figures are shown in Table 2 and deliveries to the Grain Marketing Board (GMB) are shown in Table 3. Up to 90% of the national crop is grown by communal area farmers who retain most of their produce for home consumption and seed, and sell the surplus. They mostly grow short-season Spanish and Valencia cultivars under rainfed conditions.

Table 2. Shelled groundnut production in Zimbabwe 1976/77 to 1981/82.

Season	Commercial sector ('000 t)	Peasant sector ('000 t)
1976/77	4.3	93.5
1977/78	4.0	74.8
1978/79	5.2	73.6
1979/80	7.4	50.0
1980/81	10.7	76.0
1981/82	9.9	--
Average yield	2.02 t/ha	0.5 t/ha

Source: Agricultural Marketing Authority.

Table 3. Shelled groundnuts delivered to the GMB. 1976/77 to 1981/82.

Season	Commercial sector ('000 t)	Peasant sector ('000 t)
1976/77	5.2	26.6
1977/78	3.1	6.0
1978/79	3.3	8.5
1979/80	4.3	4.1
1980/81	6.5	4.9
1981/82	9.1	3.1

Source: Agricultural Marketing Authority.

The commercial farmers produce about 10% of the national crop and grow mostly long-season Virginia cultivars with supplementary irrigation. In recent years, groundnut production has declined and at present more than 90% of deliveries to the GMB are from the commercial sector. Average yields vary considerably with altitude and type of production, and are about 0.5 t/ha for the peasant sector and 2.02 t/ha (shelled basis) for the commercial sector.

A survey is currently under way to establish why production has fallen so drastically. The low price to groundnut producers in comparison to other crops is probably the major factor. Groundnut is a controlled crop with government prescribed producer prices and is marketed through the GMB.

Utilization

Groundnuts have been superceded by soybeans and cotton as a source of vegetable oil. Over 90% of the country's vegetable oil is from the soybeans and cotton, while 10% is from groundnut, sunflower, and maize. Groundnut, however, still remains the major legume crop grown for food and as a cash crop by communal area farmers who make up more than 70% of the population.

The fresh or dried kernels are eaten raw, cooked, or roasted, while the dry kernels are used to make peanut butter that is blended into various food preparations and is a major protein source. The haulms are fed to animals. Some of the deliveries to the GMB are marketed as confectionery nuts, a valuable foreign exchange earner, and some for oil. The cake is used in animal feeds.

Varieties

Production is predominantly under dryland conditions using short-season Spanish and Valencia cultivars (110-150 days to maturity). Planting is done at the onset of the rains in November or early December and the crop is harvested in March to early April.

A smaller crop of irrigated long-season Virginia cultivars (150-200 days to maturity) is grown by commercial farmers. These are high-yielding cultivars, with high quality large-seeded nuts suitable for the confectionery trade. They are planted under irrigation before the rains in Sep-Oct and harvested in Mar to Apr. Planting early under irrigation has produced very high yields (Metelerkamp 1967).

Production Constraints

Low Yield

A common problem with the groundnut production in Zimbabwe is the low seed yield. The low producer price in relation to alternative crops has reduced plantings. A number of factors may be responsible for the low yields.

Drought

Groundnut yields are poor because of the low, unreliable rainfall, often with midseason drought. This is the single most important factor contributing to the low average groundnut yields in Zimbabwe.

Cultivars

Many of the farmers in communal areas tend to grow only traditional cultivars, some of which have a low yield potential. Yields are reduced even further as a result of low and poorly distributed rainfall. Although better adapted short-season cultivars were released by the Department of Research and Specialist Services in 1979, these have not been widely adopted by the majority of growers in the peasant sector.

Groundnuts show very rank growth in the hot low altitude areas, especially under irrigation (Hildebrand 1980). Nutrients are lost and yields reduced. Better adapted cultivars are therefore needed for these areas.

Diseases

The major diseases limiting yield are early leafspot (*Cercospora arachidicola)* and web blotch *(Phoma arachidicola)* (Cole 1981). Stem rot *(Sclerotica sclerotiorum)* is becoming increasingly important. Work has been done on these diseases, but control recommendations are uneconomic for short-season crops. Groundnut rosette disease is prevalent on crops grown by communal area farmers and is a major factor reducing yields.

Pests

The groundnut aphid *(Aphis craccivora)* is a major pest of groundnuts which not only reduces the growth by feeding on the plant, but also spreads the groundnut rosette virus. In recent years the groundnut hopper *(Hilda patruelis)* has been on the increase. It feeds on groundnuts causing premature senescence and has a wide range of alternative hosts.

Aflatoxin

The national groundnut crop contains appreciable levels of aflatoxin (Bushnel 1965). Work by Du Toit (1977) elucidated the factors leading to aflatoxin contamination. A routine system of monitoring aflatoxin in groundnut crops was formulated and this is carried out by the Soil Chemistry Branch of the Department of Research and Specialist Services on behalf of the GMB. Seed dormancy at physiolgical maturity has a bearing on the incidence of aflatoxin. Some cultivars tend to sprout and thereby encourage the growth of the toxin-producing *Aspergillus flavus.*

Agronomy

Standard recommendations on plant populations have been made following the work by Metelerkamp (1967). The populations grown by communal area farmers are frequently below optimum and produce reduced yields. One of the biggest limiting factors is the inherent low fertility of soils in most communal areas, especially the low level of nitrogen and phosphorus (Mashiringwani 1983). Many of the fields produce poorly because of a suboptimal pH. A lack of draft power is a factor leading to delayed plantings and drastically reduced yields (Shumba 1983).

The limited work on nitrogen fixation has shown a marginal response from inoculating groundnuts. The crop generally nodulates profusely with indigenous rhizobia. Recent work with inoculants has shown occasional benefits, but some groundnut yields were depressed when inoculated with certain rhizobia strains. Further investigations are needed to understand better the response of groundnuts to inoculation and the interaction of the inoculum with indigenous rhizobia present. The nitrogen benefit to a crop grown after groundnuts has yet to be quantified.

Research

Breeding

The biggest research input into groundnut production has been variety improvement. This was started in the early 1960s with collection and evaluation of cultivars grown by peasant farmers. The distribution of the various cultivars was investigated. Many introductions were made, and up to 1970 work concentrated on screening these for adaptability. Crossing was started during 1970/71 and since then the emphasis has been on selecting superior genotypes from locally bred material.

Genetic Resources

The genetic base is both introduced germplasm and material generated from crosses. The first introductions date back to 1939, and since then many more have been made from East Africa, Latin America (through the United States Department of Agriculture (USDA), South Africa, Australia, West Africa, India, and Taiwan. Many materials have been introduced from ICRISAT. Although no wild species have been used in the program, stable lines derived from crosses with wild species were obtained from ICRISAT and are currently being evaluated. Bolivian germplasm introduced from the USDA has shown particular promise (Hildebrand and Smartt 1980).

Breeding Objectives:

The objective of the program is to develop superior cultivars in both the long- and short-season groups with these requirements:

- Short-season cultivars of Spanish and Valencia types for production under rainfed conditions in the high altitude, high rainfall areas.
- Short-season cultivars for rainfed production in the drier, warmer areas of the country.
- Long-season Virginia type cultivars for production under irrigation in the middle and highveld areas.

Emphasis for the long-season crop is on quality and yield to maximize export returns for foreign currency, while for the short-season crop the aim is to maximize productivity under rainfed conditions. In all cases, the attributes to look for are good yield, drought resistance, disease resistance, dormancy at maturity, good peg attachment, acceptable growth habit, good seed size, good quality, good pod shape, pest resistance, acceptable seed color, and good shelling characteristics.

Although groundnuts are not important as a source of vegetable oil, routine monitoring is done to ensure acceptable oil and protein levels.

Methods and Techniques Used

Crosses are made in the greenhouse. Artificial light is switched on at 1600 hrs and off at 0200 hrs. This alters the time of bud formation and enables crosses to be made between 0800 and 1100 hrs (Hildebrand 1975). The advantage of this method is that it takes only 3-4 minutes per pollination because emasculation and pollination are done together during a part of the day when staff are readily available. The target is to make at least 20 cross combinations per year with at least 50 pollinations per cross. The female parents are moved into the greenhouse to the extended light period at the onset of flowering. Flowering occurs about 3 days after the start of the treatment. The actual crossing is done by hand using forceps and the method is as described by Norden (1980).

The F_1 plants are grown in pots in a heated greenhouse during winter along with the male parents to confirm successful crosses.

From the F2 onwards, most of the material is handled by the modified pedigree method (Brim 1966). Selections are made in the F_5 or F_6 generations for preliminary screening. Where appropriate, for example, when screening for disease resistance, pedigree selections may be made from the F3 or F_4 generations.

Introductions and selections are screened in progeny rows. These are single 3m rows, nonrepli-

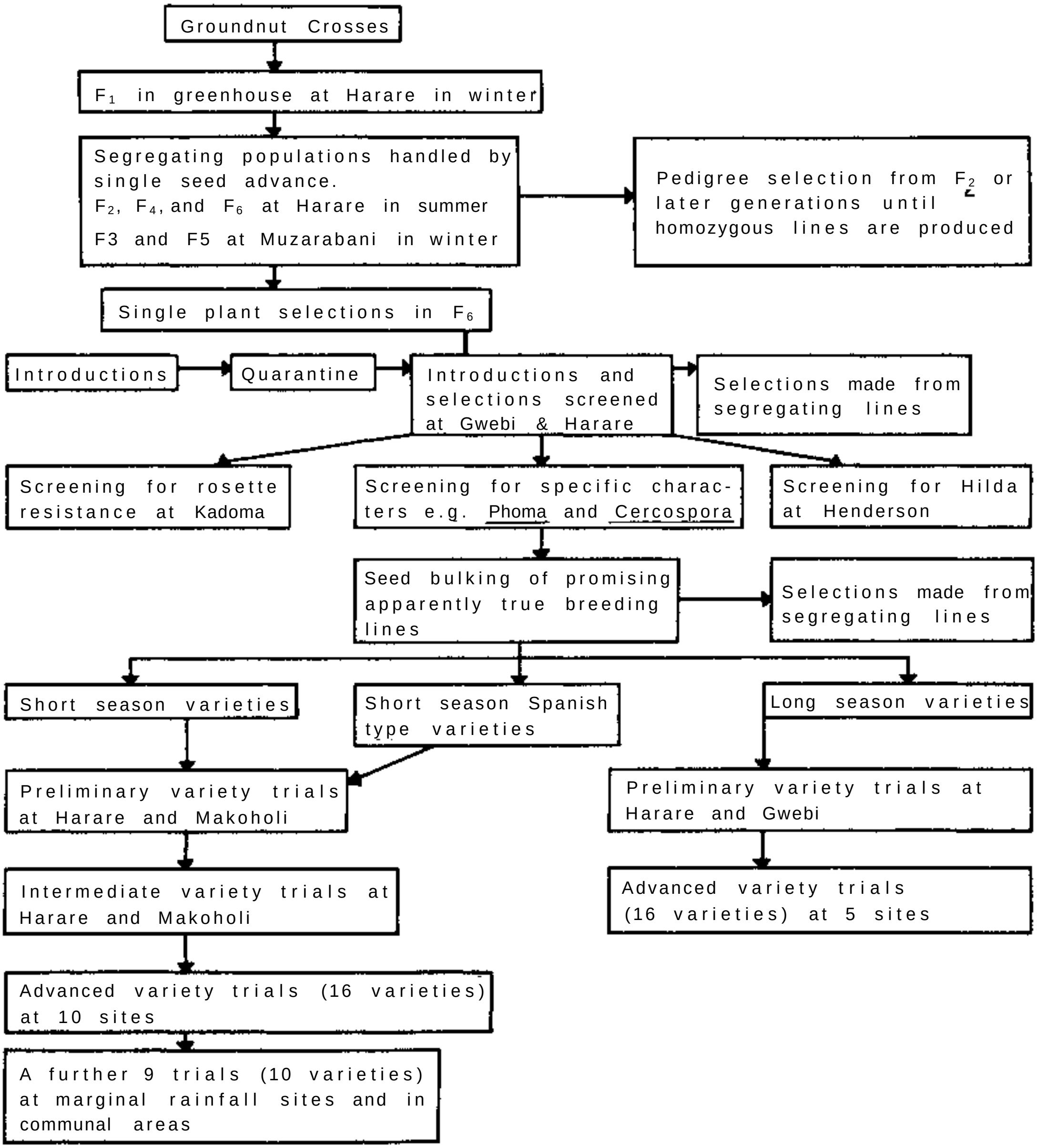

Figure 1. The organization of the groundnut breeding program in Zimbabwe, 1983/84 season.

cated, with random controls, and spaced 90 cm apart. Promising uniform materials are selected for further testing and further selections are made from materials that still show segregation. Long- and short-season lines are identified and further testing is conducted separately in preliminary trials at different sites. Promising materials are then tested in intermediate variety trials and finally in advanced variety trials on a national scale for at least two seasons before they are considered for release.

There are separate screening programs to identify material resistant to Phoma, rosette, and Hilda. During the various testing stages materials with resistance to cercospora leafspots and other diseases are identified. The schematic diagram in Figure 1 summarizes the breeding program.

Table 4. Groundnut cultivars released in Zimbabwe as of 1982.

Short season	Long season
Natal Common	Egret
Valencia R2	Makulu Red
Swallow	Flamingo
Plover	

Some Research Results

Commercial cultivars that have been released from the breeding program and are currently available are shown in Table 4.

Table 5 shows the yields for the 1982/83 long-season advanced variety trials, while Table 6 shows the short-season data. Differences in yield levels for the two variety groups are highlighted. The past three seasons have been characterized

Table 5. Long-season groundnut advanced variety trials, 1982/83 season.

	Yield (t/ha) of air-dried kernels				
Variety	Harare	C.R.T.	Matopos	Gwebi	R-Arnold
C347/5/6	4.67	3.39	3.10	5.43	544
6/12/4	5.10	2.86	2.12	5.93	5.20
P4a/11/1	4.72	3.45	2.28	5.50	5.24
Flamingo	5.05	3.11	1.49	5.48	5.76
38/7/20	4.36	3.48	1.96	5.82	4.96
32/6/1	4.49	2.72	1.99	5.31	5.79
P 105/3/7	4.99	3.32	1.63	5.89	4.49
34/6/1	4.63	2.54	1.84	5.38	5.75
12/7/16	4.56	2.51	1.56	5.52	5.40
Makulu Red	3.68	2.69	2.08	5.15	5.75
12/7/10	3.92	3.13	1.94	5.15	5.23
C351/5/2	3.14	2.97	2.43	5.22	5.32
Egret	3.47	2.30	1.91	5.32	5.71
P84/5/500	3.24	2.63	1.46	4.36	5.14
P84/5/112	4.03	1.68	1.68	3.84	4.65
P84/5/344	2.57	1.57	0.90	3.39	4.02
Mean	4.16	2.77	1.90	5.17	5.24
SE mean ±	0.22	0.37	0.24	0.11	0.15
LSD 5%	0.66	0.93	0.69	0.31	0.43
Significance of F	***	**	***	***	***
CV(%)	11.3	21.3	15.2	3.3	6.5
Efficiency gain	2.7	41.8	12.7	46.0	--

Table 6. Short-season groundnut advanced variety trials, 1982/83 season.

	Yield (t/ha) of air-dried kernels					
Variety	Harare	CRT.	Matapos	Makoholi	Gwebi	R-Arnold
31/6/13	3.73	0.87	0.30	0.64	3.47	2.70
10/7/36	3.53	0.87	0.22	0.39	3.13	3.22
Plover	3.02	0.68	0.13	0.31	3.63	3.62
Val R2	2.79	0.61	0.13	0.46	3.41	3.73
31/7/19	3.44	0.44	0.12	0.48	3.49	2.89
31/8/10	3.40	0.71	0.16	0.48	3.31	2.84
31/6/18	3.21	0.66	0.22	0.51	3.22	2.90
47/7/20	3.28	0.74	0.13	0.60	3.12	2.76
Swallow	2.18	0.42	0.11	0.27	3.05	3.77
31/7/24	3.18	0.79	0.19	0.50	3.06	2.50
31/6/8	3.26	0.58	0.21	0.35	3.14	2.43
145/79	2.57	0.72	0.22	0.47	3.16	2.79
P1/7/3	2.89	0.36	0.04	0.33	2.73	3.40
Natal Common	2.89	0.80	0.14	0.39	2.87	2.64
31/7/34	3.02	0.60	0.18	0.35	3.14	2.25
31/8/2	3.19	0.71	0.12	0.30	2.62	3.22
Mean	3.10	0.66	0.16	0.43	3.16	2.98
SE mean ±	0.11	0.12	0.04	0.06	0.14	0.13
LSD 5%	0.33	0.26	0.09	0.18	0.40	0.34
Significance of F	***	**	**	**	***	***
CV (%)	7.7	24.1	35.4	31.6	6.8	7.3
Gain in efficiency	-1.84	59.6	54	-1.71	56.6	31.8

by drought. The long-season cultivars yielded well because of the high temperatures, high solar radiation, and supplementary irrigation. The very low yields at Matopos and Makoholi for the short-season trials were due to drought. The crops at Matopos and Makoholi received 237 and 315 mm of rainfall respectively.

Other Research

Mechanization

Work on the mechanization of groundnut production continues. Emphasis is on appropriate technology for lifting, picking, and cleaning. Investigations on solar drying techniques, curing methods, and the effect of growing conditions on shelling ability are under way. The GMB encourages in-shell marketing of groundnuts. It is important that the shelling done centrally by GMB be effective and without damage to the seeds.

Farming Systems

In the peasant sector, by far the greatest yield increases are expected from adoption of already existing groundnut production technology. Given the necessary input resources and a competitive producer price, groundnut production could increase tremendously. The farming systems research team examines the available production technology and investigates its appropriateness and cost effectiveness under typical peasant farmers' field conditions. The farmers' priorities are taken into consideration and group activity is encouraged with the hope of achieving maximum utilization of available draft power. There are crop and livestock components in this effort since the two are closely related.

This approach involves the farmer and research and extension workers in planning, execution, and evaluation of research projects, and encourages adoption of research recommendations. The program examines ways of facilitating earlier planting, achieving optimum plant stands, and effective fertilizer use.

Future Research Needs

Variety Improvement

Variety improvement work to produce better adapted cultivars consistent with the stated objectives must be continued. More emphasis must be put on breeding for resistance to drought, early leaf spot, groundnut rosette virus disease, Hilda, and web blotch, and for higher yield potential with better quality. Germplasm with good disease resistance and acceptable agronomic characteristics is limited. Screening for drought resistance is limited to sites with low rainfall and there is no control over the timing and intensity of drought. A regional drought resistance testing facility with a controlled environment would be beneficial.

Pest and Disease Control

Work on screening pesticides for effectiveness and economy in the control of diseases and pests should be continued. Further studies on the biology and control of the pest *Hilda patrueiis* should be undertaken. Many soils in the communal areas are light sandy types and harbor nematodes. The effect of nematodes on groundnut yields, and possible control measures, should be investigated.

Agronomy

Inadequate work has been done on groundnut fertilizer requirements, particularly in the communal areas. Further work needs to be done on potential benefits from *Rhizobium* inoculation. The amount of residual nitrogen from fixation by a groundnut crop in Zimbabwe needs to be quantified to form a sound basis for fertilizer recommendations for succeeding crops. The physiology of drought resistance in groundnuts in relation to plant population and nutritional requirements needs further study.

Farming Systems

The farming systems research effort must be intensified and taken to many more communal farming areas in all the different altitude zones. More emphasis must be given to livestock since this still provides the major form of draft power available to the majority of peasant farmers.

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Discussion on Zimbabwe Papers

Saka: Seed availability does not seem to be a problem in most countries for small-scale farmers. Why is it a problem in Zimbabwe?

Chiteka: In Zimbabwe most small-scale farmers save their own seed and this can be in very short supply.

Kelly: The same is true in Zambia where seed can be very expensive.

Ngwira: Seed availability and production go hand in hand. Seed supply is a major constraint on production of groundnuts in Malawi.

Saka: In Malawi 'slow wilt' has many of the characteristics of fusarium wilt.

Cole: The interaction of *Fusarium* spp. and *Hilda patruelis* has not received in-depth study in Zimbabwe. Hilda is most serious in dry seasons but in some areas it is serious in both wet and dry seasons.

Hildebrand: Hilda is particularly serious on research farms.

Amin: It is still not known if toxins produced by Hilda are involved in the wilting, but experiments could readily be designed to investigate this.

Ngwira: I note that Daconil (chlorothalonil) is effective for control of phoma and cercospora leafspots at Chitedze but not in Zimbabwe. Could this be due to different application methods?

Saka: Concerning mechanisms of resistance to cercospora, are phytoalexins produced only after infection of the groundnut leaf by the fungus?

Cole: Phytoalexins are produced as a response to infection. Phoma infection is restricted to the areas between the cuticle and epidermal cells and this possibly is why less phytoalexins are found after phoma infection than after cercospora infection.

McDonald: Phytoalexins are also produced in groundnut seed following invasion by *Aspergillus flavus,* ICRISAT is collaborating with Dr. Richard Strange of University of London in studies on this.

Special Reports

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Use of the Single-Seed Descent Method of Selection in Groundnut Breeding in Zimbabwe

G. L. Hildebrand*

Summary

The single-seed descent method of selection has proved successful in Zimbabwe where two new cultivars have been released after 10 and 8 years of development. The ease of handling segregating populations and rapid generation advance are two of the more important benefits. This method could be appropriate for groundnut breeding in developing countries. In addition, lesser developed programs could benefit from selection, in their own environments, within duplicate populations provided by more developed programs.

Résumé

Exploitation de la technique de sélection dite "single seed descent" pour l'amélioration de l'arachide au Zimbabwe : *L'introduction de la technique "single seed descent" de sélection s'est avérée très intéressante au Zimbabwe où deux nouveaux cultivars ont pu être vulgarisés, après 10 et 8 ans de sélection. La facilité de manipulation des populations en ségrégation, ainsi que l'avancement rapide des générations sont deux grands avantages qu'offre cette technique, qui serait appropriée à l'amélioration de l'arachide dans les pays en voie de développement. En outre, les programmes moins développés pourraient ainsi profiter de la sélection, dans leurs propres environnements, à l'intérieur même des populations doubles fournies par les programmes plus développés.*

The single-seed descent method of selection has been used successfully in Zimbabwe during the past 14 years. The method is based on the proposal by Brim (1966) of a modified pedigree selection method for soybeans. The theory and genetic basis for this method in groundnuts has recently been adequately discussed by Isleib and Wynne (1980).

Single-seed descent has been used successfully in North Carolina, USA to transfer southern corn rootworm resistance to lines with suitable agronomic qualities (Wynne 1976) and to develop CBR-resistant groundnut lines (Wynne and Gregory 1981).

The object of this paper is to discuss the practical use of single-seed descent in Zimbabwe and to highlight its advantages and disadvantages. Finally, the use of this method in the development of two new cultivars is illustrated.

Procedure

The initial step in any groundnut breeding program is to generate genetic variability by creating hybrid populations. The next phase is to advance the populations to a homozygous state by inbreeding.

Brim's method is to advance each F2 plant in a population to the desired level of homozygosity by taking a single seed from each plant to provide the F_3 population. This procedure is repeated on each F3 plant to produce the F_4 population and so on. Selection in the segregating generations is restricted to removing obviously undesirable genotypes. Once the desired level of homozygosity is reached, single plants are selected for further testing.

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Advantages

- Since little or no selection is practiced in the segregating generations there is no need to grow the population in the environment where it is likely to be used. Populations can therefore be grown in greenhouses or in winter nurseries.
- Less space is required for each generation.
- Time and effort in harvesting and record-keeping is reduced to a minimum.
- Because less space, time, and effort is required for each generation, more crosses and populations can be carried in the program.
- Because greenhouses and winter nurseries can be used, two or more generations can be grown each year, reducing the time to reach the desired level of homozygosity.

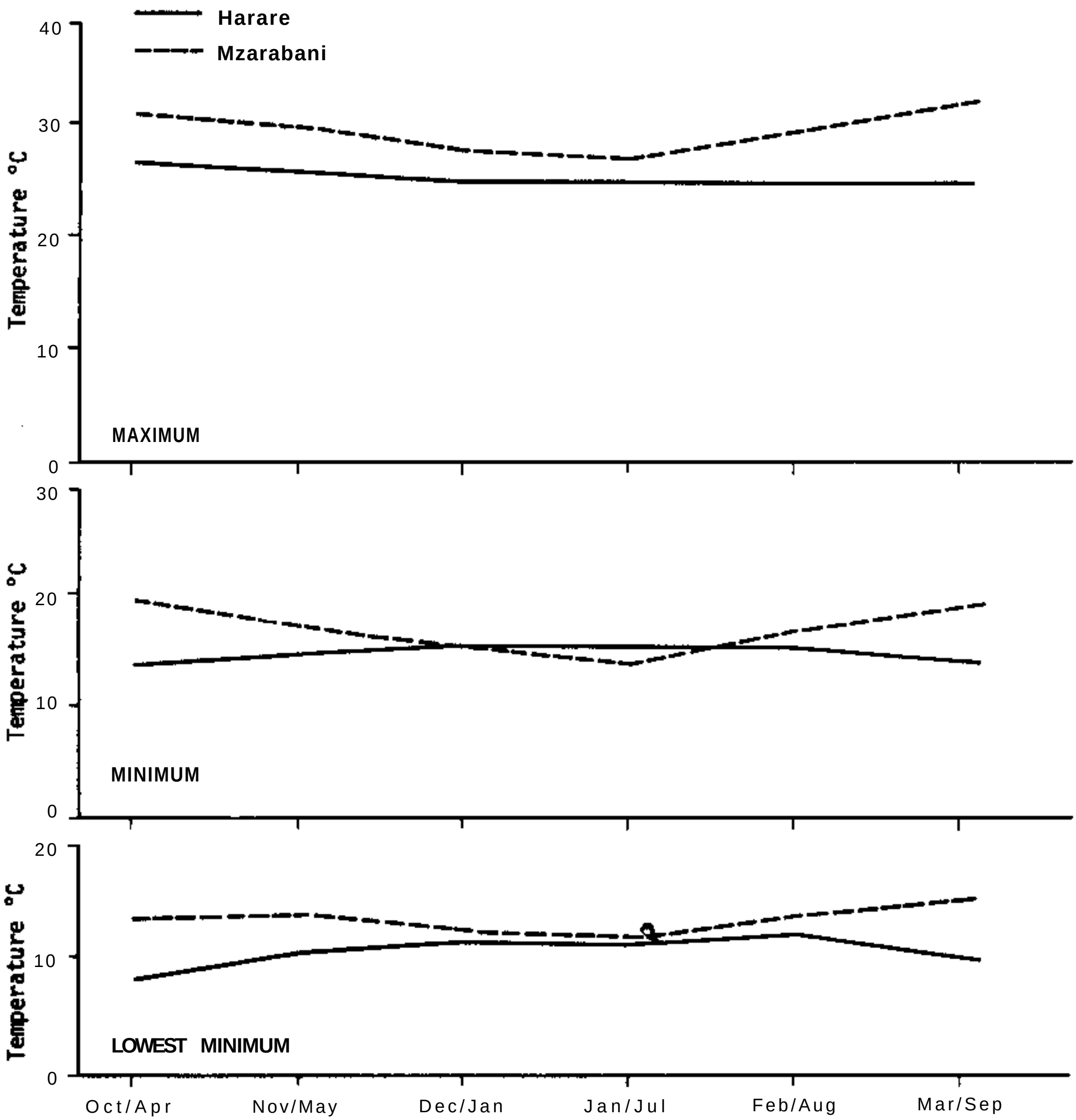

Figure 1. Mean monthly temperatures for Harare Research Station and ARDA Mzarbani Estate.

Disadvantage

One slight drawback is that a few inferior lines are retained. A certain amount of relatively useless material is carried through the segregating generations. Although these are soon eliminated in preliminary trials, it may be necessary to select a larger proportion of plants for initial screening.

Practical Use of the Method in Zimbabwe

Crosses are generally made in a greenhouse during summer using artificial light to manipulate the time of bud development (Hildebrand 1974). Each year 12-18 crosses are made. The F_1 plants are grown in a greenhouse during winter together with the parents to aid identification of hybrid plants. The F2 population is grown during the following summer at Harare and subsequent generations are grown alternately in winter and summer with the final F_6 population being grown in summer for the selection of single plants. Duplicate samples of all generations are maintained in cold storage as insurance against loss and also for exchange with other breeders.

Winter nurseries have been grown at Chiredzi, but recent results indicate that sites in the Zambesi valley are more suitable. Populations planted at the ARDA Mzarabani Estate in Apr 1982 were well developed when harvested in late August. Preliminary observations during the 1983 winter at Charara near Lake Kariba indicated that viable seed could be produced in about 120 days. Comparative temperatures for summer and winter at Harare and Mzarabani respectively, are presented in Figure 1. The summer generation is generally grown from Oct-Mar and the winter generation from Apr-Sep. After drying, seed is heated in an oven at 50°C for 12 days to break dormancy.

During the segregating generations the populations are identified only by a cross number and generation number. When single plants are selected from the F_6 population, the generation number is advanced and each plant is numbered from 1 upwards, e.g., 32/7/1, 32/7/43.

A single nonreplicated progeny is grown from each selected plant for initial screening and classification. The parents are grown as random checks. Some performance data are collected which allows selection of progenies worthy of further testing in replicated yield trials.

Sufficient seed is usually available from the more productive progenies to enable four replicates of a yield trial having 3-row plots 3 m long to be planted. Such trials at Harare Research Station have been sufficiently precise to allow large numbers of new selections to be evaluated on limited land area.

Advanced trials having 16 entries are usually conducted at between 6 and 10 sites each year. An

Table 1. Development of Flamingo and Swallow groundnut cultivars.

	Flamingo	Swallow
Pedigree	N. Common x 183/66	183/66 x PM. 1 7/4
Cross	1971/72	1973/74
F1	Greenhouse W 72	Greenhouse W 74
F2	Chiredizi W 73	Harare 74/75
F3	Harare 73/74	Chiredzi W 75
F4	Chiredzi W 74	Harare 75/76
F5	Harare 74/75	S. P. S. -
Selections	28 selections from F5, Harare 74/75	2 in F4 Harare 75/76 2 in F5 Chiredzi W 76
Progeny rows	1975/76 (F6)	1977/78 (F6)
Preliminary yield trials	1976/77	1978/79
Advanced yield trials	1977/78 5 sites 1978/79 8 sites 1979/80 8 sites 1980/81 7 sites 1881/82 6 sites	1979/80 4 sites 1980/81 19 sites 1981/82 17 sites
Release	1982	1982
Commercial availability	1984/85?	1985/86?

attempt is made to include eight promising genotypes from the preliminary trials in advanced trials each year. The eight most promising genotypes from the previous year are included in advanced trials a second year, and since seed supply of these is generally not limited, they may be included in additional trials, often conducted in communal farming areas.

After a minimum of 2 years of testing on a national scale new genotypes may be considered for release for commercial production.

What Success?

Three new cultivars have recently been released for commercial production (Hildebrand 1980a, b, c). Two of these, Flamingo and Swallow, were developed using single-seed descent. The development of these two cultivars is illustrated in Table 1.

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The Oilcrops Network and Groundnut Improvement in Northern East Africa

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Summary

Research support from IDRC for annual oilcrops has steadily increased over the past decade. In northern East Africa and South Asia, there is IDRC support for rapeseed, mustard, and safflower, and sesame improvement in India, while projects in Sri Lanka, Egypt, Sudan, and Ethiopia cover three or four oilcrops each. IDRC has supported projects in Tanzania and Mozambique, and now gives support to ICRISA T for its Regional Groundnut Program in Malawi. This paper describes the IDRC oilseeds network and groundnut improvement programs in northern East Africa.

Résumé

Le réseau oléagineux et l'amélioration de l'arachide en Afrique de l'Est septentrionale : *Au cours des dix dernières années, le Centre de recherche pour le développement international (CRDI) a apporté un soutien de plus en plus important en matière de recherche sur les oléagineux annuels. Par exemple, en Afrique de l'Est septentrionale et en Asie du Sud, le CRDI aide l'amélioration du colza, de la moutarde et du carthame, ainsi que du sésame en Inde; les projets d'amélioration portent sur trois ou quatre oléagineux chacun au Sri Lanka, en Egypte, au Soudan et en Ethiopie. Le CRDI a également aidé des projets en Tanzanie et au Mozambique. A présent, il soutien le Programme régional de l'ICRISAT pour l'arachide au Malawi. Dans cette communication, l'auteur décrit le Réseau oléagineux du CRDI ainsi que les programmes d'amélioration de l'arachide en Afrique de l'Est septentrionale.*

The Oilcrops Network

Some sort of link between the various IDRC-funded projects on annual oilcrops has been identified as a useful way to increase the interaction and communication among scientists. Projects could also benefit from having better access to the world literature on oilcrops, and from having better links with leading research institutions and International Agricultural Research Centers (IARCs).

The oilcrops network project started in 1981, with the broad objective of creating such links among the IDRC-supported oilseed improvement projects in northern East Africa and South Asia. Initially, the form or model for the network was left flexible. The network advisor was posted in Ethiopia. At first, most of his time was spent in providing support to the Highland and Lowland Oilcrop Projects in Ethiopia with one or two introductory visits made to each oilcrop project in the region.

An oilseed workshop, held in Cairo in Sep 1983, helped establish the emerging network. The workshop provided the opportunity for participating scientists from projects in the network to get to know each other, to present and discuss their research programs, and to see for themselves oilseed research and production in Egypt.

During the final session of the workshop, a consensus was reached on many aspects of the network itself. It was agreed that the network should facilitate the exchange of germplasm among projects by making information available on the correct channels to be used for such exchanges. It was decided that regional nurseries would not be established, instead, germplasm and elite material

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International Crops Research Institute for the Semi-Arid Tropics. 1984. Regional Groundnut Workshop for Southern Africa, 26-29 March 1984, Lilongwe, Malawi. Patancheru, A.P. 502324, India: ICRISAT.

could be exchanged and evaluated as part of the regular program of each project. This would avoid the risk of requesting projects to test material in which they really had no interest.

Methods of making information more available to project scientists were discussed. It was agreed that a newsletter, containing research summaries from projects, short research articles, and information on germplasm, should be published annually and distributed to the projects by the network advisor. Annual workshops are to be held, each one hosted by a different project in the region, and the proceedings published. Each workshop will concentrate on some aspect of the improvement of not more than two or three oilcrops. The project hosting the workshop will have the opportunity of showing its research in the field.

The advisor is essential in that he often needs to initiate and encourage interaction within the network. However, once it has been initiated, much of the interaction will continue directly among the scientists in the network.

Most agricultural research networks have an IARC as a base. The Oilcrops Network however, is different in that the Ethiopian oilcrop projects serve as the network advisor's base. Developing a base for a network may be slower in a national program than in an IARC, but a base in a national program benefits the advisor, as he can keep his feet firmly grounded in research, and the national program benefits from the special attention and support from the network advisor.

Excellent cooperation has also been established with prominent oilcrop scientists located in institutions outside the network. For example, ICRISAT has given support by providing nurseries to the projects working on groundnuts and Dr. Nigam's contribution to the Cairo oilcrops workshop was greatly appreciated by the participants.

Groundnut Improvement Programs in Northern East Africa

The oilcrops network includes three projects in Egypt, Sudan, and Ethiopia, which are working on groundnut improvement. It may be of interest to present some highlights of these projects in northern East Africa.

Egypt

Groundnuts in Egypt are grown for confectionary purposes, both for export and for domestic consumption. Fortunately, no aflatoxin has been reported in Egyptian groundnuts, and leafspots and rust are unimportant. The project leader, Dr. Bach Elahman has tested 100 local collections and introductions and has found four local lines that have up to 30% higher yields, heavier seed weights, and a higher percentage of exportable kernels than Giza 4, the established cultivar. Giza 4, which is almost the only cultivar grown in Egypt, is a Virginia bunch, medium-maturing type. Further work is concentrating on testing improved cultural practices, small-scale mechanized digging and threshing equipment, and evaluating the economic benefits of the new technology on farmers' fields.

Sudan

Groundnuts are an important crop grown for food, oil, and export on approximately 750000 hectares. Up to 25% of the crop is grown under irrigation. The main irrigated area is in the Gezira, where Dr Hassan Ishaq, the project leader, is carrying out research on agronomic improvement and management under irrigated conditions on heavy soils. The Virginia bunch cultivars Ashford and NH383 are grown under irrigation.

The principal rainfed area of groundnuts is in the western Sudan, where the crop is grown on light soils. The introduced, early maturing upright bunch type Barberton has largely replaced the runner type land races. A strong breeding and selection program for rainfed conditions is under way to identify drought resistant early lines with good resistance to *Aspergillus flavus* infection. Material from Senegal, USA, and ICRISAT is being tested. Several sets of crosses are being made to find a sequential runner type to better utilize soil moisture, which is both synchronous in flowering and early maturing.

Ethiopia

Groundnuts are grown under rainfed conditions in the lowland areas of the eastern, western and northern regions of the country. The crop is grown for oil extraction, for confectionary purposes, and as a pulse crop. A significant portion of the crop is exported.

Both early and late leafspots can be severe, causing yield losses of up to 65%. Rust is a problem in eastern Ethiopia, but has not yet spread to the western groundnut areas. Rosette virus disease is not a problem.

The Virginia bunch cultivars NC2 and Shulamit have been recommended, based on past research conducted on irrigated conditions. The present research program was started two years ago, with emphasis shifting to testing in the rainfed groundnut growing areas.

There has been good cooperation with ICRISAT, which has provided germplasm lines, segregating material, and the International Groundnut Foliar Disease Nursery (IGDFN). Ethiopian scientists have visited the groundnut program at ICRISAT, and Dr. Subrahmanyam recently spent a few days in Ethiopia discussing aspects of groundnut pathology with Ethiopian scientists.

All introductions must first be grown in quarantine before they can be evaluated. Results are now available from testing 110 germplasm lines in replicated plots at three locations in the country in 1983. Dr. Yebio Woldemariam, the project leader, has kindly provided the data in Table 1 which lists the five top yielding germplasm lines at each of the three locations. It would appear that there is specific adaptation of a particular plant type in the different areas of the country where the tests were carried out. Virginia bunch types from African countries performed best under irrigation; fast-maturing Valencia and Spanish types, mainly from South America, were best in the low rainfall areas in the east; and longer-maturing Virginia runner types gave highest yields in the high rainfall site in western Ethiopia.

Leaf disease reaction of lines from the IGFDN and other introductions were scored at Babille in eastern Ethiopia. Five lines out of 130 were reported with a score of 1 or less for rust and 2 or less for leafspots on a 0 to 9 scale.

The Ethiopian groundnut program is expanding, with more work to be carried out on cultivar testing and agronomic research for the rainfed areas. Further details on these and other projects in the Oilcrops Network can be found in the Proceedings of the Cairo Workshop.

The IDRC Network Approach

In addition to the Oilcrops Network, IDRC has helped support several agricultural research networks. Perhaps the most successful has been the Asian Farming Systems Network (AFSN), which has the International Rice Research Institute (IRRI) in the Philippines as its base. The AFSN provides support to national farming systems programs to

Table 1. Pod yields (kg/ha) of the five highest-yielding germplasm lines from ICRISAT at each of three locations in Ethiopia, 1983.

Location:	Melka Wera (center)				Babille (east)				Dicless (west)			
Altitude:	750 m				1650 m				1400 m			
Rainfall:	Irrigation				770 m				1200 m			
	ICG No.	Plant type	Origin	Yields (kg/ha)	ICG No.	Plant type	Origin	Yields (kg/ha)	ICG No.	Plant type	Origin	Yields (kg/ha)
	7484	Vi B	Burkina Faso	8725	273	Val	Argentina	3250	1008	Vi Run	India	5250
	8742	Vi B	Egypt	7800	7287	Val	Brazil	2313	9262	Vi Run	Chad	4583
	7673	Vi B	Nigeria	7800	724	Val	Brazil	2344	7273	Vi Run	USA	4383
	9222	Vi B	--	6645	7845	Span	India	2219	2471	Vi Run	India	3917
	7974	Vi B	Zimbabwe	6575	314	Val	Brazil	2188	2518	Vi Run	India	3583

Plant Type: Vi B = virginia bunch
Vi Run = virginia runner
Val = valencia
Span = spanish bunch

identify and establish improved cropping patterns on farmers fields.

Many of the aspects of the AFSN have been incorporated into the Oilcrops Network. These include the central role of a network advisor or coordinator, and the emphasis on support to the national programs to help carry out more effective research. Germplasm exchange, regular workshops, and information exchange are other aspects common to both networks.

The involvement of an IARC in a network has many advantages. Perhaps the most important is that the national programs can evaluate the technology that the IARC generates, and provide feedback on its usefulness so that the IARC can refine and adapt the technology to better meet the needs of national programs.

Toward Comprehensive Sector Studies of Groundnuts in Countries of Southern Africa, with Specific Reference to Malawi

D. W. Pervis and F. Nyondo*

Summary

The authors point out that new technologies, e.g., the introduction of new cultivars, require complementary government policies if their potentials are to be realized. They list factors likely to inhibit the spread of new technology and, using data collected in Malawi, present a country framework within which groundnut input, production, and marketing systems may be studied, and potential bottlenecks identified and eliminated before they become critical.

Résumé

Vers des études sectorielles plus exhaustives sur l'arachide dans les pays de l'Afrique australe, avec une référence particulière au Malawi : *Les auteurs soulignent, dans cette communication, que les nouvelles technologies, notamment l'introduction de nouveaux cultivars, exigent des politiques gouvernementales complémentaires pour que leurs potentiels soient mis en valeur. Les facteurs susceptibles d'empêcher la diffusion de nouvelles technologies sont énumérés. Grâce aux renseignements obtenus au Malawi, on a pu élaborer un cadre qui permet d'étudier les systèmes d'intrants, de production et de commercialisation de l'arachide d'un pays, de repérer les goulots d'étranglement potentiels et, enfin, d'éliminer ceux-ci avant qu'ils ne deviennent critiques.*

The biological scientists at the International Agricultural Research Centers (IARCs), in cooperation with national research organizations, are making important contributions to improving the production potential of crops in the Southern African region. The potentials of new cultivars and other technologies in developing countries usually require complementary government policies in order to be realized. The experiences of the "green revolution" in Asia have indicated that such policies are often slow in coming. Of the green revolution, Wharton (1969) says, "Others see this development as opening a Pandora's Box: its very success will produce a number of new problems which are far more subtle and difficult than those faced during the development of the new technology".

Two general kinds of difficulties have been identified by Wharton: (1) those related to the implementation of technological change and, (2) those related to the effects of the change if and when it is successfully implemented. In the first category, six general problem areas may be identified and in the second category, 8 problem areas. The importance of each will vary from one country or part of the world to another, and one crop to another, but when considering a specific crop in a specific country it is necessary to examine all possible problem areas so they may be eliminated from further consideration or put forward for additional study.

Factors Inhibiting the Spread of New Technology

- Availability of other necessary inputs such as irrigated land, fertilizers, timely labor availability, etc.

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- The size of existing markets, and the possibility that people may not accept the new cultivar because it does not satisfy their tastes and preferences.
- Risk aversion, particularly if the crop is a staple one on which the family depends for survival.
- The need for new farming skills and expertise of a higher order than was needed in traditional methods. Obtaining such skill will take time and effort on the part of extension workers and farmers.
- Different harvesting times may require additional processing (e.g., drying of early-maturing maize) or result in heavy pest damage because only one cultivar matures early and birds are drawn to it in large numbers.
- Needed institutional and policy changes may be slow in coming or not to be implemented at all.

Problems Arising After the Acceptance of a New Technology

- The possibility that if the new cultivar is genetically vulnerable to disease and infestation, large areas planted to one new cultivar will aggravate the situation and the vulnerability will be apparent.
- The pressures on the entire complex of services and industries required to realize the potential of the new technology.
- The capacity of the market system will become a major bottleneck if planning has not allowed for timely expansion.
- The effect on prices of a major production increase can be devastating if sufficient storage, transport, or export markets are not available. Unless adequate attention is given to price policy, there is a real danger that the disincentives of a resulting low price will cause farmers to abandon the new technology as unprofitable.
- Even if the increased food production is available in the market, people cannot increase their nutritional standards unless they can buy the food. General development of the country is needed to increase incomes if most of the extra food is not to be exported.
- If the technological change is implemented primarily for food self sufficiency, the result may be an international allocation of resources which are contrary to the comparative advantages of trading countries.
- Once the technological advance is implemented, will another one occur before population increase overtakes the first?
- The introduction of early-maturing cultivars will give the first acceptors a market advantage at harvest time. This will be a problem if equity questions are important.

Purpose of this Paper

The problems noted above occur in different parts of the system where market signals are seldom clear or do not exist. As a result, one part of the system will not adjust quickly enough to events in another.

The purpose of this paper is to present a framework within which the groundnut input, production, and marketing system of a country may be studied and potential bottlenecks identified and eliminated before they become critical. The discussion is in the context of Malawi, but a similar study could be conducted in each Southern African country. It is hoped that the paper will form the basis of discussion among workshop participants regarding specific problems in Malawi and other countries in Southern Africa.

The System Components

Qualitative information about the structure of the system is available from participants in the system, the Agricultural Development Divisions (ADDs), the Ministry of Agriculture, and research stations. Figure 1 presents the currently defined structure of the system consisting of nine components connected by 14 partial marketing channels. A full understanding of the system would involve a multidisciplinary effort to quantify the channel flows, and understand the relationships within each component which determine the rates of flows and their values. The degree of detail to which a specific system should be described and analyzed will depend on a number of factors, including the expected potential importance of groundnuts to the national economy, the funds available to do the study compared to the complexity of the system, the ease of obtaining data, and the components where the most severe bottlenecks are expected to occur. If large amounts of data are available it will depend also on the data processing facilities available. If the computer facilities and expertise are

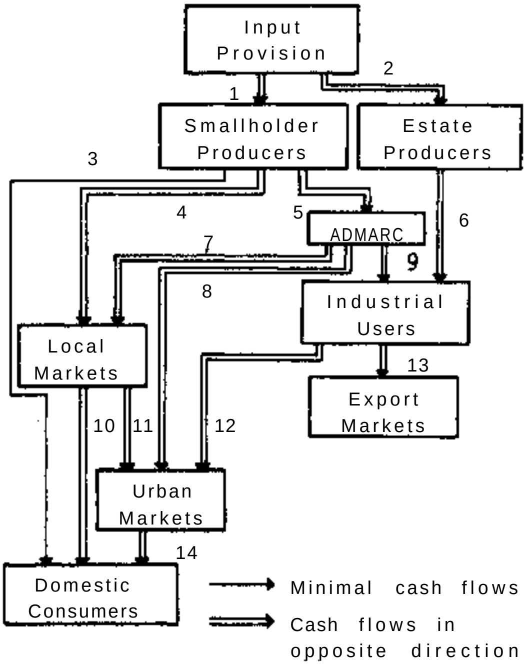

Figure 1. Groundnut production and marketing system of Malawi.

available, it is possible to develop a full computer-based simulation model of the system, but this is not a recommendation of this paper.

Input Provision

The goal of an input delivery system is to provide the right amount, of the right product, in the right form, in the right place, at the right time at the lowest possible price which covers all expenses.

The primary source of commercially obtained inputs to small holders is the Agricultural Development and Marketing Corporation (ADMARC). In the case of groundnuts, fresh seed is the main input supplied; however, farmers do not buy fresh seed every year but save some from the previous year or obtain them from neighbors. Currently Daconil (Chlorothalonil), to control ieafspot, is the only chemical used in the production of groundnuts, and it is supplied directly from Shell Chemicals, Ltd. on an experimental basis only. Other inputs such as transportation may be provided by neighbors or own resources. When labor is hired, neighbors and relatives are the main resources. In the case of groundnuts for home consumption, labor is seldom, if ever, hired.

Since ADMARC is an important source of inputs to smallholders growing groundnuts (particularly new seed), the factors within it which affect the flow of inputs are important. ADMARC is a parastatal organization with the dual function of input supply and crop purchase. As an input procurement and distribution system, the factors affecting the product quality and timely flows into and out of the component can be identified as:

- Management of the timing of orders for material from suppliers.
- The frequency distribution of lag times between order placement and shipment arrival.
- Capacity of initial storage facilities as well as regional and local storage facilities.
- Transportation systems including capacity, type, and road conditions.
- Management and timing of shipment requests from the regional storage facilities to the local selling points.
- The price charged, a function of product cost, marketing costs, and government policy.

In 1980 ADMARC reported a fully utilized storage capacity of 2900001 for both inputs and products. ADMARC serves the country in three regions, Northern, Central, and Southern. Each region has a number of stores and markets. Since Malawi is a landlocked country (as are four other Southern African countries) the proper management of imported inputs is difficult.

Estates normally obtain their inputs from the private sector, not ADMARC.

Smallholder Producers

The work of the IARCs and national research organizations concentrates on problems within this component. Smallholder production is perhaps the most complex of the seven defined components. Although the concern here is with the smallholder as a producer, an examination of production decisions cannot be isolated from household consumption decisions. No attempt will be made here to present a full discussion of the relationships within a smallholder production and consumption unit (Wharton 1970), but some factors influencing the flows of groundnuts out of the component can be identified. Groundnuts are used within the household in various forms depending on the family's tastes and preferences. Groundnuts may be bought and the land used to produce something else, or just enough land may be planted to groundnuts to satisfy the family needs. Perhaps a field will be planted (as a pure stand or intercropped) which is expected to supply the home needs for groundnuts. If it does not, some may be purchased. If there is a surplus it will be sold either on the local market or to ADMARC, depending on the prices and the distances to the markets. Some of the factors involved in determining the amounts grown for consumption, cash, and actually sold for cash are:

Amount Grown for Home Consumption

- Family size, obligations and tastes.
- Prices of other crops.
- Cost of groundnuts if they were to be bought.
- Value of having own assured supply of groundnuts.
- Amount of resources available, including seed availability.
- Suitability of land and climatic factors for growing groundnuts.

Amount Grown for Cash

- Expected profit from groundnuts.
- Expected profit from other possible cash crops.
- Resources available after providing for home consumption of maize and groundnuts.
- Market proximity and size.

Amount Actually Sold for Cash

- Discrepancies between actual and expected yields.
- Ability to store groundnuts adequately.
- Preference for cash now versus groundnuts later.

Some factors within the production component which affect the flow of inputs can be identified. While it is true that in the long run over many years no input is entirely fixed in its availability, a farmer can obtain or lose land, he can increase his family size to provide more labor or he can take a part-time job off the farm to increase working capital. However, at the time that he must make decisions regarding resource allocation for a specific growing season, there are inputs whose availabilities are fixed for the duration of the season. The level at which these resources are fixed, and the costs of and expected returns to applying other variable inputs are the underlying factors determining what a farmer wants to grow for cash and the inputs he wants to use. The amount of cash and credit a farmer has available will be a strong determinant of the quantities of inputs a smallholder is financially able and willing to purchase.

As shown in Table 1 yields on farmers' fields have fallen since 1978/79 and the reason is not entirely clear. A full explanation may be part economic and part agronomic. Further research at the farm level is needed.

Estate Producers

The estate production of groundnuts has not been fully explored. It is known that they do produce groundnuts and at least some of them are sold to Lever Brothers (Malawi) Ltd. (They may also sell to ADMARC but this has not been confirmed.)

Local Markets

Local markets refer to places where a number of local rural-based buyers and sellers come together to trade their products for cash.

Groundnuts are sold through local markets in several forms: unshelled, shelled, and salt coated.

Table 1. Yields of groundnuts. Malawi, 1978/79 - 1982/83.

	Farmer[1]		Research[2]
Year	Chalimbana (MK3/kg)	Chalimbana (MK/kg)	Mani Pintar (MK/kg)
1978/79	494	N/A	1160
1979/80	515	170	1030
1980/81	245	518	1400
1981/82	189	80	800
1982/83	N/A	N/A	1040

1. LADO Evaluation Office.
2. Chitedze Research Station.
3. Malawi Kwacha.

There may be a certain amount of informal grading in such markets, but they are not consistent from one market to the next nor from year to year. The prices on these markets are free market prices and fluctuate seasonally in response to supply and demand. There are few, if any, adequate facilities for long-term storage of groundnuts in local markets.

Chipeta (1981) describes three types of local markets: the home market, the ceremonial market, and the institutional market. The home market is characterized by customers approaching producers at their homes or perhaps producers searching out customers at their homes. Trading on a ceremonial market takes place when people gather for dances, feasts, or other occasions. The institutional market is described as an established market place where barter is almost absent. A wide range of commercial and social activities are centered in these markets and larger volumes of produce can be sold through them than the other two. There are a number of private middlemen operating in the groundnut system who buy on the local institutional markets and sell on the urban markets. However, their significance in terms of volume and efficiency is not known.

Since groundnuts must be harvested quickly and require certain storage conditions to prevent dangerous molds from growing, smallholders may sell on the local markets shortly after harvest as long as the price is at least as high as the ADMARC price, plus the difference in transportation costs. Additional surplus production will be sold to ADMARC.

Urban Markets

Urban markets refer to those markets in which buyers are predominantly urban dwellers. Two types of such markets can be identified: the traditional open air type and the more modern shop or supermarket type. Generally, the sellers on the traditional urban market will obtain their groundnuts from local markets in the rural areas and bring them to the urban areas (or buy them from middlemen who perform this service), or they may buy directly from ADMARC. The modern urban market will normally have all groundnut products available for sale which may be obtained from any or all sources, notably including industrial users.

ADMARC

ADMARC purchases groundnuts and other smallholder crops at predetermined and annually fixed prices. in effect ADMARC activities set floor prices for products, including groundnuts. The two types of groundnuts handled by ADMARC are the Chalimbana cultivar, which is generally used for confectionary consumption, and Malimba or Manipintar cultivars which are mainly used for oil. ADMARC has maintained a grading system for groundnuts. From 1971 (or earlier) to 1983 there were three grades for Chalimbana. Until 1977 they were designated as (1), (2), and (3), with (1) commanding the highest price. From 1978-82 the grades remained much the same but were designated GDA, GDB, and GDX. With the 1984/85 buying season the Chalimbana Grades GDA and GDB were combined into a single grade GDA. The GDX grade (splits and shrivels) became GDB. Malimba and Manipintar cultivars do not have grades based on quality, only on the degree of processing (shelled or unshelled).

The quantities of groundnuts flowing into ADMARC are affected by few factors within ADMARC itself. The prices charged act as floor prices for the free market. Depending on the yields in a particular year the prices on the local market after harvest may drop quickly (or slowly) resulting in a high (or low) volume being offered for sale to ADMARC. Quantities and prices of ADMARC purchases and exports during 1979-84 are shown in Table 2.

Industrial Users

The groundnut processing industry in Malawi is two firms, Sales Services Ltd., an affiliate of Guthrie (Malawi) Ltd., and Lever Brothers (Malawi) Ltd.

Sales Services Ltd. of Blantyre buys Chalimbana groundnuts from ADMARC and processes them into three brands of fried nuts and a groundnut butter product. "Tambala Kings" is the brand name of a fried confectionary nut with the skins removed. "Tambala Redskins" are also a fried confectionary nut but with the skins left on. The fried nut product consists of splits and shrivels. The groundnut butter product is marketed as two lines, one labeled "Peanut Butter" the other "Tambala Nut Butter". Splits and shrivels are also used as feed rations.

Lever Brothers (Malawi) Ltd. purchases groundnuts (Malimba and Manipintar) from both ADMARC and estates, to produce cooking oil which is sold under the brand names "COVO" and "Kazinga". During shortages of oil-type nuts, Lever Brothers buys Chalimbana nuts (not normally an oil nut) to make cooking oil.

Table 2. Quantities and prices of ADMARC purchases and exports of groundnuts, Malawi. 1979-1984.

	ADMARC domestic purchases				Exports			
Year	Qty. (t)	Value[3] (MK' 000)[4]	Implied price (MK/kg)	Implied real price (MK/kg)	Qty. (t)	Value[3] (MK'OOO)	Implied price (MK/kg)	Implied real price (MK/kg)
1972	39273	4376	.111	.099	NA	7123	NA	NA
1973	29981	3694	.123	.104	NA	5922	NA	NA
1974	28794	4543	.158	.116	NA	5202	NA	NA
1975	32807	5221	.159	.101	NA	6490	NA	NA
1976	32553	5577	.171	.104	NA	11243	NA	NA
1977	18497	3383	.193	.107	NA	8861	NA	NA
1978	11130	2230	.200	.108	6830	4673	.684	.484
1979	24296	7331	.302	.147	13697	8866	.647	.345
1980	31418	9689	.308	.126	25556	15937	.624	.316
1981	19494	5976	.307	.115	11121	10622	.925	.648
1982	10432	3408	.327	.111	7228	4634	.641	.314
1983	10495[1]	5215[1]	.497	.147	10312	726[2]	.704	.207
1984	NA	NA	.54[1]	NA	NA	NA	NA	NA

1. Estimated.
2. To September.
3. Deflated by the Blantyre Low Income Retail Price Index (1970 = 100) •
4. Malawi Kwacha .
Source: Malawi Monthly Statistical Bulletin, Dec 1983

Domestic Consumption

Domestic consumption refers to the consumption of groundnuts and groundnut products within Malawi, not just by the household producing the crop. On the supply side, domestic consumption is served by three sources: home production, local markets, and urban markets. On the demand side, groundnuts in some form are consumed by all sections of Malawian society with the various supply channels tending to serve certain sections. The rural section of Malawian society obtains most of its groundnuts from their own production and through local markets. Urban based industrial workers and professionals obtain most of their groundnut products through the traditional urban markets and retail stores. Also, the urban population may obtain groundnuts from local markets and even through informal transfers from friends and relatives in the rural areas.

In many rural areas where cooking oil is not purchased, groundnuts are often ground finely and added to leafy vegetables, or meat. Sometimes groundnuts are locally fried, ground, and mixed with warm water to form a relish, but this is not common.

Export Markets

In the past most exported groundnuts were sold to the UK in the form of fried confectionary nuts. However, in recent years the world price has deteriorated and it is no longer profitable to sell to such a distant market. Currently, the only groundnut products exported are Tambala Kings and Tambala Redskins sold to Botswana, Zimbabwe, and South Africa.

Values and Quantities of Flows

Much work has yet to be done to quantify the volumes and values of material flowing through the groundnut system of Malawi. Figure 1 identified each flow of material by a number. These numbers are used in Table 3 as a flow identification. Table 3 indicates the current status of quantification and the expected sources of further data. The table presents the 14 currently defined flows by numbers along the top and the expected sources along the left side. An "X" indicates that data from the source regarding a particular flow has been obtained and is as complete as that source can provide; it does

Table 3. Sources of data for flows through the groundnut system of Malawi.

Sources	Flows 1	2	3	4	5	6	7	8	9	10	11	12	13	14
ADMARC	0				0		0	0						
ADD's	0			0										
Monthly Stat. Bulletin					x								x	
Lever Bros						0			0			0	0	
Sales services									0			0	0	
PTC											0			0
Kandoda											0			0
Estates		0												
Dar	0				0									
Planning (Ag)	0				0				0				0	
Estimates		0	0	0						0	0			0
Spec. Surveys			0	0						0	0			0
Produce Export Co.													0	
Malawi Expt. Prom. Counc.													0	
National Seed Co.			0	0										

Notes. X - All data available has been obtained. 0 - Not all data available has been obtained, some may have.

not necessarily mean that it is fully adequate for the purposes of this study. An "O" indicates that the source of data has not been completely explored. Some data may have been obtained but more are available.

The remainder of this section is a discussion of the volumes and values of flows as determined to date.

Input Provision to Smallholder Producers (1)

Initial information indicates that a large proportion of groundnut seed originates on the smallholding itself or on neighboring farms. ADD reports that in the Dedza Hills Rural Development Project, most smallholders (87% of sample) plant groundnuts saved from the previous year. The second most frequent source was "other sources" (8%) followed by ADMARC (5%).

Smallholder Producers to Domestic Consumption (3)

This is a very difficult quantity to measure but may be estimated if the total production and flows to local markets and ADMARC are available. A special survey may also provide an estimate.

Smallholder Producers to Local Markets (4)

There is no monitoring of local markets but the ADDs may have estimates of this flow. Alternatively, a special survey could provide an estimate.

The Agro-Economic Survey surveyed 19 local markets throughout the country in 1982 (Table 4) and reports that on average, shelled groundnuts were priced at MK 1.02755/kg while the price of unshelled groundnuts was MK 0.746/kg; a MK 0.2755/kg (36%) increase in value per unit weight (MK is the Malawi Kwacha). If this type of survey continues yearly for entire years, further analyses may be done to identify the three components of a time series (long-term trend, seasonal cycles, and random fluctuations). This type of analysis could assist greatly in determining appropriate floor prices.

Smallholder Producers to ADMARC (5)

The data available are total ADMARC purchases by quantity and value (Table 2). Figures 2-4, present the total domestic purchases of groundnuts by ADMARC by quantity, value, and price from 1972-83. As shown in Figure 2 there is a general downward trend in the volume of ADMARC purchases of

Table 4. Groundnut prices on local markets, Malawi, Jan - Jun 1982.

Market	Jan		Feb		Mar		Apr		May		Jun	
	Shelled (MK[1]/kg)	Unshelled (MK/kg)	Shelled (MK/kg)	Unshelled (MK/kg)	Shelled (MK/kg)	Unshelled (MK/kg)	Shelled (MK/kg)	Unshelled (MK/kg)	Shelled (MK/kg)	Unshelled (MK/kg)	Shelled (MK/kg)	Unshelled (MK/kg)
Karonga Boma	1.43	0.80	1.50	.58	.76	.83	1.43	.53	1.00	.68	.83	.57
Kopaka	--	.16	--	.16	.40	.16	--	.67	--	.67	--	.67
Kaseye	--	.145	--	.15	--	.14	--	.20	--	.26	1.00	.80
Chilumba	--	.96	--	.83	--	1.09	--	.67	--	.70	1.00	.67
Chitipa	.778	--	.80	--	.755	--	1.00	--	1.00	--	1.00	--
Mtaktaka	.50	--	--	--	--	--	--	--	.61	.35	--	--
Nkhotakota	.923	--	.991	--	1.094	--	1.296	--	.985	.667	1.072	.50
Nkhata Bay	.85	--	.889	--	.881	--	.947	--	1.56	--	1.288	--
Mzuzu	.797	--	.78	--	1.202	--	1.241	--	1.112	--	--	--
Chimbiya	.483	.211	--	--	--	--	--	--	--	.20	--	.254
Nsanje Dist.	--	--	--	--	--	--	.575	.51	--	.676	.403	.843
Mwanza	--	--	--	--	--	--	.641	--	--	.676	4.03	.843
Mkande	.894	.125	2.083	1.679	.756	2.326	.767	.538	1.191	.581	.633	.559
Ngabu	.943	2.003	2.083	1.679	1.425	2.326	.767	.538	.879	.581	.756	.559
Chikwawa	1.22	.839	1.266	.658	1.312	.636	1.109	.714	1.515	.945	1.042	.735
Bangula	1.291	--	1.601	--	.98	.526	1.601	--	2.222	--	1.042	.735
Chiradzulu	--	--	--	--	--	.	--	--	--	--	--	.287
Migowi	--	--	--	--	--	--	--	--	--	--	--	.40
Thyolo	--	.978	--	--	--	--	--	--	--	--	--	--

1. Malawi Kwacha.

Source : Agro-economic survey. An analysis of agricultural commodity prices at local markets in Malawi. Working paper No. 4. A.E.S. Lilongwe, 1983.

Figure 2. ADMARC purchases of groundnuts.

groundnuts. The value and price of groundnuts are shown in Figures 3 and 4 in two ways. The nominal value and price are the prices reported in current Kwacha. The real value and price are the nominal measures deflated by the Blantyre Low Income Price Index (1970 = 100) (Table 6). The changes in these deflated values give a better indication of the significance of the changes in relation to price changes in the economy generally. Figure 3 indicates that while the nominal value of groundnut purchases shows little trend, it has fluctuated from almost 10 MK to a little over 2 MK. The real value of purchases has shown a fairly definite downward trend. Figure 4 indicates that the nominal price paid for groundnuts has shown a persistent, but not steady, increase over the years 1972-83 but the real price has been fairly constant.

Industrial Users to Urban Markets (12)

The main products flowing through this part of the marketing system are the fried nut products, the groundnut butter products, and groundnut cooking oil. From personal observation it would appear that the industrial users are able to fill the domestic demand for all items except cooking oil. Sometimes there is a shortage of domestically produced oil and imports must be obtained. (The oil sold by Lever Brothers under the brand name "Livio" is imported from South Africa).

Industrial Users to Export Markets (13)

The importance of groundnuts, tobacco, rice, pulses, and other exports in the total value of exports from 1972-84 is shown in Figure 5 (see also Table 5). The data show that groundnuts have never been of major significance as an export and the relative importance has been falling.

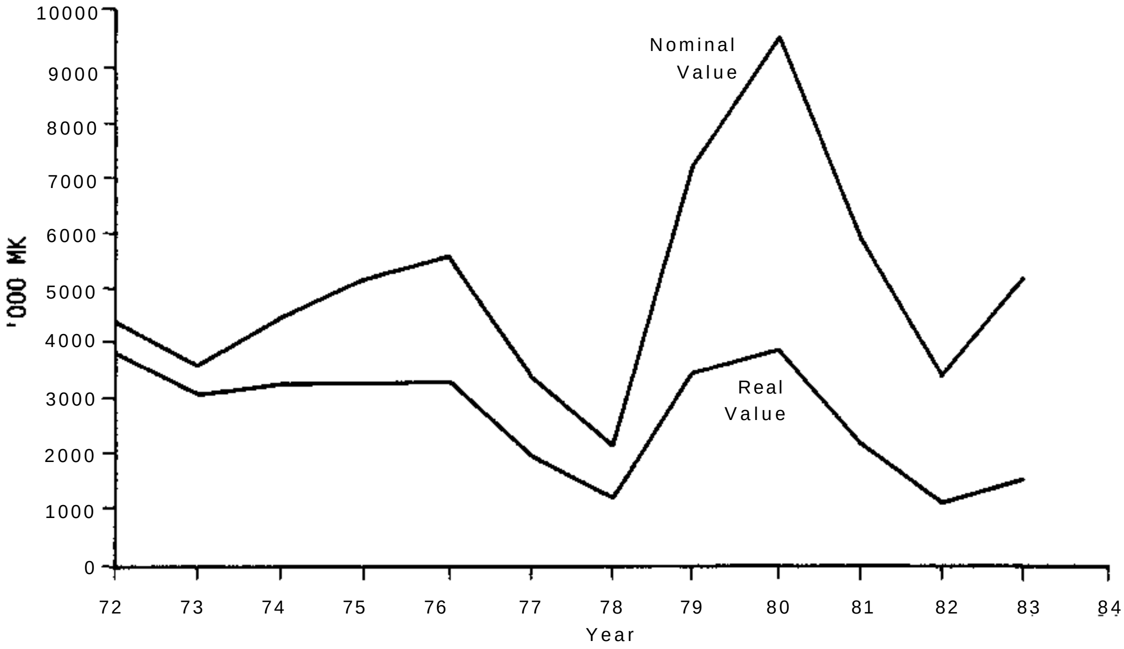

Figure 3. Nominal and real value of groundnut purchases by ADMARC (Malawi: Kwacha).

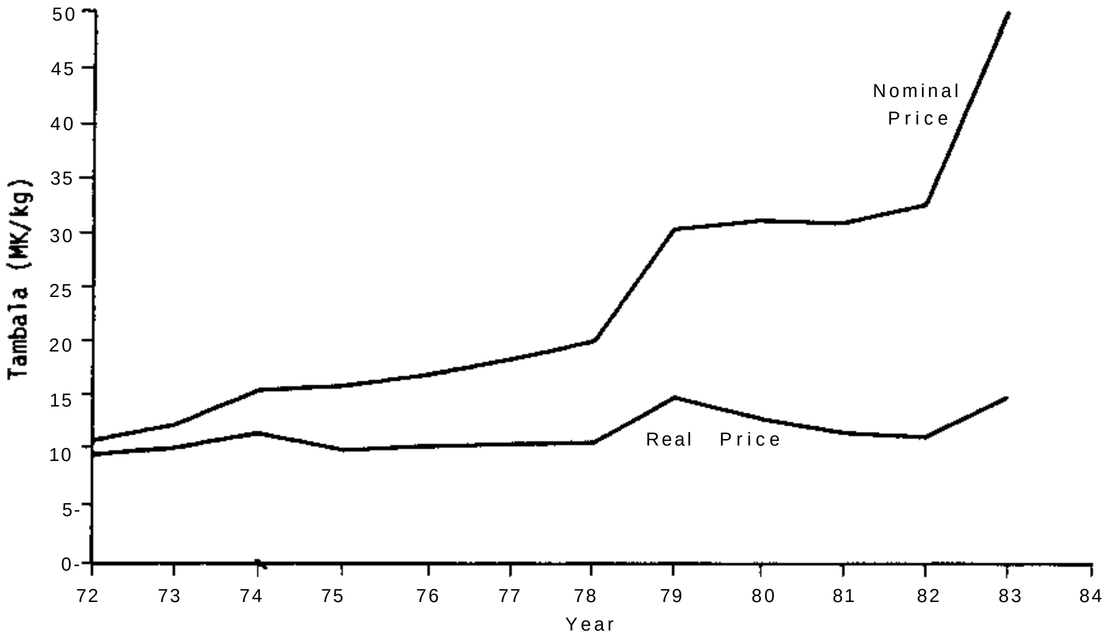

Figure 4. Average price of shelled groundnuts paid by ADMARC (Malawi Kwacha).

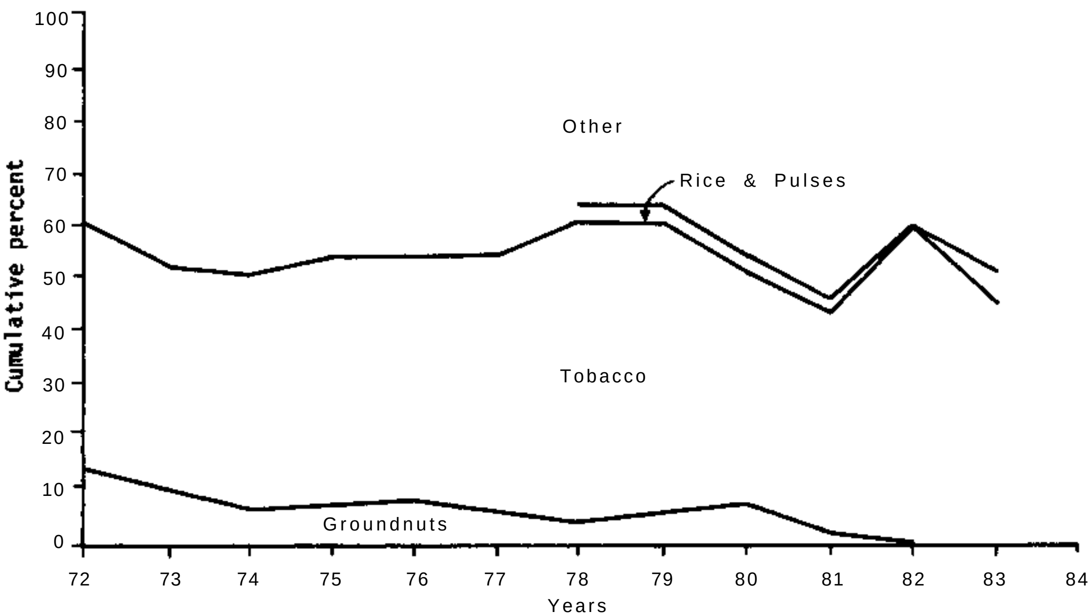

Figure 5. Cumulative percent shares of exports.

Table 5. Value of commodity exports, Malawi, 1979-83.

Year	Groundnuts[2] Value (MK '000)[3]	Groundnuts[2] % of Total	Tobacco Value (MK '000)	Tobacco % of Total	Rice Value (MK '000)	Rice % of Total	Pulses Value (MK '000)	Pulses % of Total	Other exports Value (MK '000)	Other exports % of Total	Total domestic exports Value (MK '000)
1972	7123	12.9	24968	45.3	NA	NA	NA	NA	23051	41.8	55142
1973	5922	8.6	30259	44.0	NA	NA	NA	NA	32621	47.4	68802
1974	5202	5.8	39269	43.9	NA	NA	NA	NA	45063	50.3	89534
1975	6490	6.1	51132	48.1	NA	NA	NA	NA	48661	45.8	106283
1976	11243	8.0	64930	46.0	NA	NA	NA	NA	64857	46.0	141030
1977	8861	5.1	86651	50.4	NA	NA	NA	NA	76458	44.5	171970
1978	4673	3.1	86146	57.9	2130	1.4	2338	1.6	53494	36.0	148781
1979	8866	5.0	98638	55.9	2235	1.3	1943	1.1	64623	36.6	176305
1980	15937	7.3	100796	46.2	3023	1.4	1766	0.8	96785	44.3	218307
1981	10622	4.3	101589	41.3	3086	1.3	2244	0.9	128413	52.2	245945
1982	4634	1.8	145777	55.6	1705	0.7	2006	0.8	111085	42.4	262207
1983[1]	982	0.4	118799	44.8	140	0.05	11880	4.5	133302	50.3	265103

1. Estimated. 2. Products not specified. 3. Malawi Kwacha.
Source: Malawi Monthly Statistical Bulletin, Dec 1983.

Table 6. Blantyre all item retail price index for low incomes, 1972 - 1983.

Year	Index
1972	112.1
1973	117.8
1974	135.9
1975	157.0
1976	163.8
1977	170.7
1978	185.2
1979	206.1
1980	243.9
1981	267.2
1982	292.4
1983	337.5

Source: Monthly Statistical Bulletin, Dec 1983 P. 18.

In order to obtain some indication of the profitability of groundnut exports, the marketing margin between the average implied price paid to farmers and received for exports has been examined. Figure 6 indicates that this margin has narrowed every year since 1979 except in 1981 when it widened phenomenally due to a particularly high implied average price received for exports. In 1983 the margin was 57% less than it was in 1978. This narrowing margin is making it progressively less attractive to export and if the trend continues groundnuts may disappear from Malawi's list of exports.

Observations and Conclusions

Although the model is far from complete, some observations and tentative conclusions may be drawn.

Observations

- The export market for fried nuts has been deteriorating.
- Yields on smallholder fields are low and appear to be falling relative to potentials (see Table 5).
- Domestic market demand is currently being met by domestic production for all groundnut products except cooking oil.

Tentative Conclusions

Without an increase in exported products, any technological advances to increase the yields of

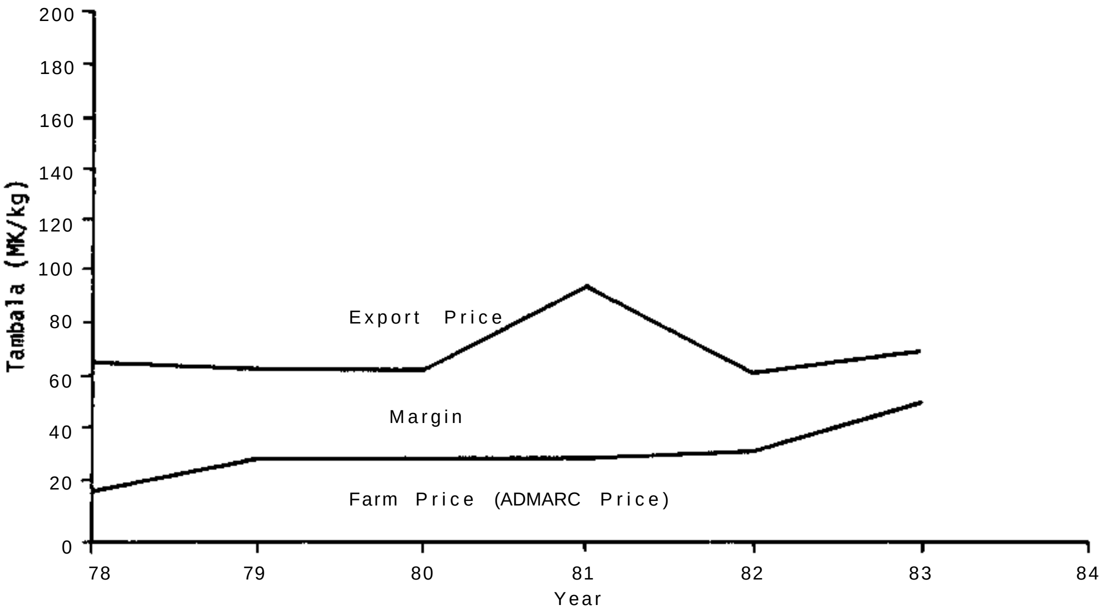

Figure 6. Implied farm and export prices for groundnuts and groundnut products, Malawi (Malawi Kwacha).

groundnuts should be directed at two goals:

- Releasing some smallholder land from the production of eating-type groundnuts to production of other crops.
- Increasing the amount of oil-type groundnuts so that Malawi may be assured of its own supply. Processing capacity may have to be increased also.

If exports are to be increased to utilize the additional production, then market studies must be done to determine where those markets are and what products and qualities are required to compete. Currently, a small amount of fried nuts are exported to nearby countries. A search for additional products utilizing groundnuts should be made. There are a number of confections not currently produced in Malawi which utilize groundnuts in conjuction with popcorn, chocolate, sugar, etc. Perhaps some of these could be produced to utilize additional groundnut production. Some of the groundnut products currently produced for domestic consumption could be exported if more were produced.

The actual adjustments which will have to be made in response to an increased groundnut yield will depend on the type of nut to which the new technology is applied and assumptions about exports. Logically, there are six possible situations:

- technological improvement in the production of eating-type nuts
  - with no increase in exports, and
  - with increased exports;
- technological improvement in the production of oil-type nuts
  - with no increase in exports, and
  - with increased exports; and
- technological improvement in both oil and eating nuts
  - with no increase in exports, and
  - with increased exports.

Improvement in the Production of Oil-Type Nuts

Without Increased Exports. Indications are that Malawi barely produces enough cooking oil for its own needs. More could probably be produced for domestic consumption but further study should be done to determine the cause of this shortfall. If the shortage is because they are not profitable to grow, then the problem is one of price and/or yield. A technological change which will increase profitability by increasing yieid with a modest increase in input costs can be expected to reduce this shortfall without having to increase prices.

The fact that the effective demand for cooking oil is barely satisfied has a nutritional implication which should be investigated. It can be expected that nutritional need is greater than the effective market demand. A study of the nutritional adequacy of fat soluble vitamins (A, D, E, and K) in the diet may indicate a need for additional fats and oils. Vitamin A is essential to the development and healthy maintenance of the eyes, skin, and bones. Vitamin D is necessary for calcium and phosphorus to be absorbed by the bones, teeth, and blood. It helps maintain proper child growth and is essential for the eruption of teeth. Vitamin E is needed to absorb certain fats and is necessary for premature and low-birth-weight infants to prevent a form of anemia common in these infants known as hemolytic anemia. Vitamin K is necessary for blood to coagulate in the event of wounds. Groundnuts do not provide all of these oil soluble vitamins but they are rich in vitamin E. They also provide oil to allow the absorption of the other oil soluble vitamins from other sources. Improved technologies and nutritional education to increase the production and consumption of oil-type groundnuts can contribute significantly to alleviating any deficiencies that may exist, particularly of vitamin E.

If the new technology requires additional inputs ADMARC would have to adjust to provide them. Also ADMARC would have to increase its capacity to handle the increased volume of groundnuts. Currently, only Lever Brothers (Malawi) Ltd. is producing oil, and it may have to increase its capacity also. Attention should be paid to the price structure to ensure that oil nuts are profitable without resulting in a surplus.

With Increased Exports. The export possibilities for groundnut oil may be good in neighboring countries and even possibly in Asia. If such markets are identified, it is important that studies be done to examine Malawi's ability to compete on price and quality considering the c.i.f. price obtained, transportation costs, processing costs in Malawi, etc. (i.e., the value added at each stage of the movement from the Malawian farmer to the foreign consumer), and the profitability of the crop under the new technology compared with the profitability of other crops. Care should be taken not to assume that the relative profitability will be the same in all parts of the country. Some areas will have a comparative advantage in groundnuts while other areas will have an advantage in another crop. ADMARC may have to provide additional inputs and increase its capacity to handle the product. The processing industry, Lever Brothers (Malawi) Ltd., in this case, will need to increase capacity and perhaps product characteristics and packaging. Also transportation must be adequate both within the country and if necessary, to seaports.

Improvement in Both Eating and Oil Nuts

The consequences of increased yields in both eating and oilnuts would be much the same as stated above with the added complication that oil and eating nuts may compete with each other more than if only one was improved. This is particularly true if exports are increased substantially for both.

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Appendix I

Potential Sources of Information

Technical Director
Lever Brothers (Malawi) Ltd.
P.O.Box 5151
Limbe
Ph: 651-000

Chief Executive
Sales Services Ltd.
P.O. Box 500
Blantyre
Ph: 631-355

Chief Agricultural Research Officer
Dept.of Agricultural Research
P.O.Box 30136
Lilongwe 3
Ph: 731-300

Deputy CARO
(Attn: Groundnut Agronomy Section)
Chitedze Agricultural Research Station
P.O. Box 158
Lilongwe 1
Ph: 767-222

National Seed Company of Malawi Ltd.
P.O.Box 30050
Lilongwe 3
Ph:765-114, 765-209

Program Manager
Blantyre Agricultural
Development Division
P.O. Box 30227
Chichiri
Blantyre 3
Ph: 632-622

Program Manager
Kasungu Agricultural
Development Division
P.O. Box 92
Lilongwe
Ph:720-344

Program Manager
Mzuzu Agricultural
Development Division
P.O. Box 131
Mzuzu
Ph:332-066

Program Manager
Lilongwe Agricultural
Development Division
P.O. Box 259
Lilongwe
Ph.720-066

Program Manager
Liwonde Agricultural
Development Division
P/Bag 3
Liwonde
Ph:532-410

Program Manager
Ngabu Agricultural
Development Division
Private Bag
Ngabu. Ph: 11/13/37

Program Manager
Karonga Agricultural
Development Division
P.O. Box 43
Karonga
Ph:Karonga 53/54

Program Manager
Salima Agricultural
Development Division
P/Bag 1
Salima
Ph: 262-371, 261-361

Principal Economist
Planning Division
Ministry of Agriculture
P.O. Box 30134
Lilongwe 3
Ph: 731-300

Assistant General Manager
Primary Marketing, and
Assistant General Manager, Sales
Agricultural Development
and Marketing Corporation
P.O. Box 5052
Limbe
Ph:651-244

Liwonde Groundnut
Factory (ADMARC)
P/Bag 5
Liwonde
Ph:532-202

General Farming Co. Ltd.
P/Bag
Kasungu
Ph:200-566

Malawi Export Promotion Council
Delamere House, 4th Floor
P.O. Box 1299
Blantyre
Ph:634-499

Press (Farming) Ltd.
P.O. Box 245
Lilongwe
Ph:721-311, 721-918

Peoples Trading Center Ltd.
Johnstone Road, Ginnery Corner
P.O. Box 30402, Chichiri
Blantyre 3
Ph:631-900

Chief Executive
KANDODO
Victoria Avenue
Box 549
Blantyre
Ph:633-866

Produce Export Company
P.O. Box 5767
Limbe
Ph:651-388

The Extension and Training System in Malawi

J.A. Mhango*

Summary

This paper describes the organization of agricultural extension and training in Malawi. Basic policies are stated, planning of the extension approach is outlined, and training described. Linkages with the Department of Agricultural Research are given considerable emphasis, and training and research liaison meetings are important components of the system.

Résumé

***Le système de vulgarisation et de formation au Malawi :** Cette communication décrit l'organisation actuelle de la vulgarisation et de la formation agricoles au Malawi. Les politiques essentielles sont citées et l'on donne un bref aperçu de la planification de l'approche de la vulgarisation; le processus de formation est décrit. Les liens avec la Direction de la Recherche agricole sont d'une grande importance. Les réunions de liaison de la formation et de la recherche sont des composants importants du système.*

Since the inception of the National Rural Development Program (NRDP) in the late 1970s, Malawi has been trying to improve and develop its extension and training concepts and strategies in order to meet the challenges of the 1980s. Before NRDP, the then Ministry of Agriculture and Natural Resources (now split into Ministry of Agriculture and Ministry of Forestry and Natural Resources) administered, apart from other services, the Extension Services on a regional basis. However, within the regions four major agricultural projects were established, operating as autonomous units outside the regional structure. At that time the extension services to the farmer were largely based on the individual approach in both areas under the regional agricultural officer and the major agricultural projects.

Under the NRDP however, the Extension Services have been reorganized into Extension Planning Areas (EPA), Rural Development Projects (RDP), and Agricultural Development Divisions (ADD). This has necessitated a change in extension policy from individual to group or mass approach. All this is designed to spread rural development throughout the country within a reasonable period of time.

Organization

In order to understand our extension system a knowledge of our present organizational structure is vital. Instead of having a regional structure consisting of only three regions, the Extension Services have now been reorganized into eight ADDs, each headed by a program manager who is supported by an assistant and a number of subject matter specialists (SMS) in various fields, e.g., extension, training, crops, animal husbandry, evaluation, forestry, credit and marketing, land husbandry, and women's programs. Previously the program managers reported to the head of the Department of Agricultural Development responsible for the Extension Services, but they now report to the principal secretary through the controller of Agricultural Services. However, technically the principal secretary is still being supported by several heads of departments and their specialist officers under him based at Ministry headquarters.

Below the ADDs are RDPs manned by project officers. Initially there were 40 RDPs planned for a phased development period of 15-20 years. The plans have since been revised by combining or phasing in certain areas so that we now have 28

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International Crops Research Institute for the Semi-Arid Tropics. 1984. Regional Groundnut Workshop for Southern Africa, 26-29 March 1984, Lilongwe, Malawi. Patancheru, A.P. 502324, India: ICRISAT.

RDPs to implement, This will necessitate a quicker development of the whole country than was originally planned. Each RDP area is supposed to have approximately 25000 to 30000 farm families (approximately 125000 to 150000 people) to be covered.

There are about 180 EPAs and each has an average of 5000 farm families (approximately 25000 people) headed by a development officer (DO). It is here where the key to planning, development, and implementation of all extension programs lies. That is why at both RDP and EPA levels there are replicas of ADD level SMSs, only their professional qualifications and grades tend to be lower as you go down the ladder.

Each DO is supposed to control up to 10 field assistants in his area under what is considered to be an ideal situation, so there is a 1:500 recommended staff/farm family ratio per field assistant section. However, the real situation on the ground is different in that on the average there are more farm families to each field assistant than the recommended ratio. This and other factors have had a great bearing on the present trend of our extension approaches in Malawi.

Details of the organizational structure are given in Figures 1 and 2.

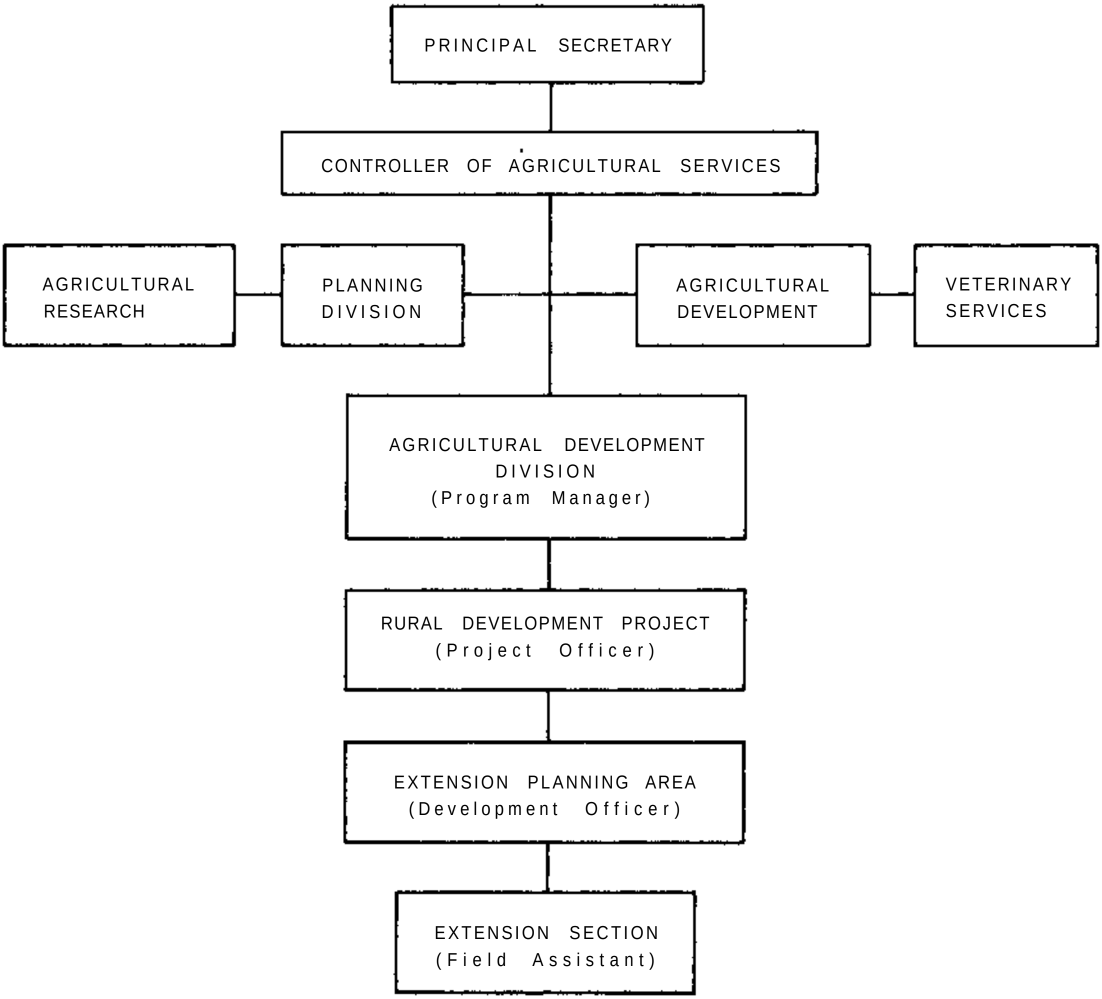

Figure 1. Ministry of Agriculture—-Professional departments.

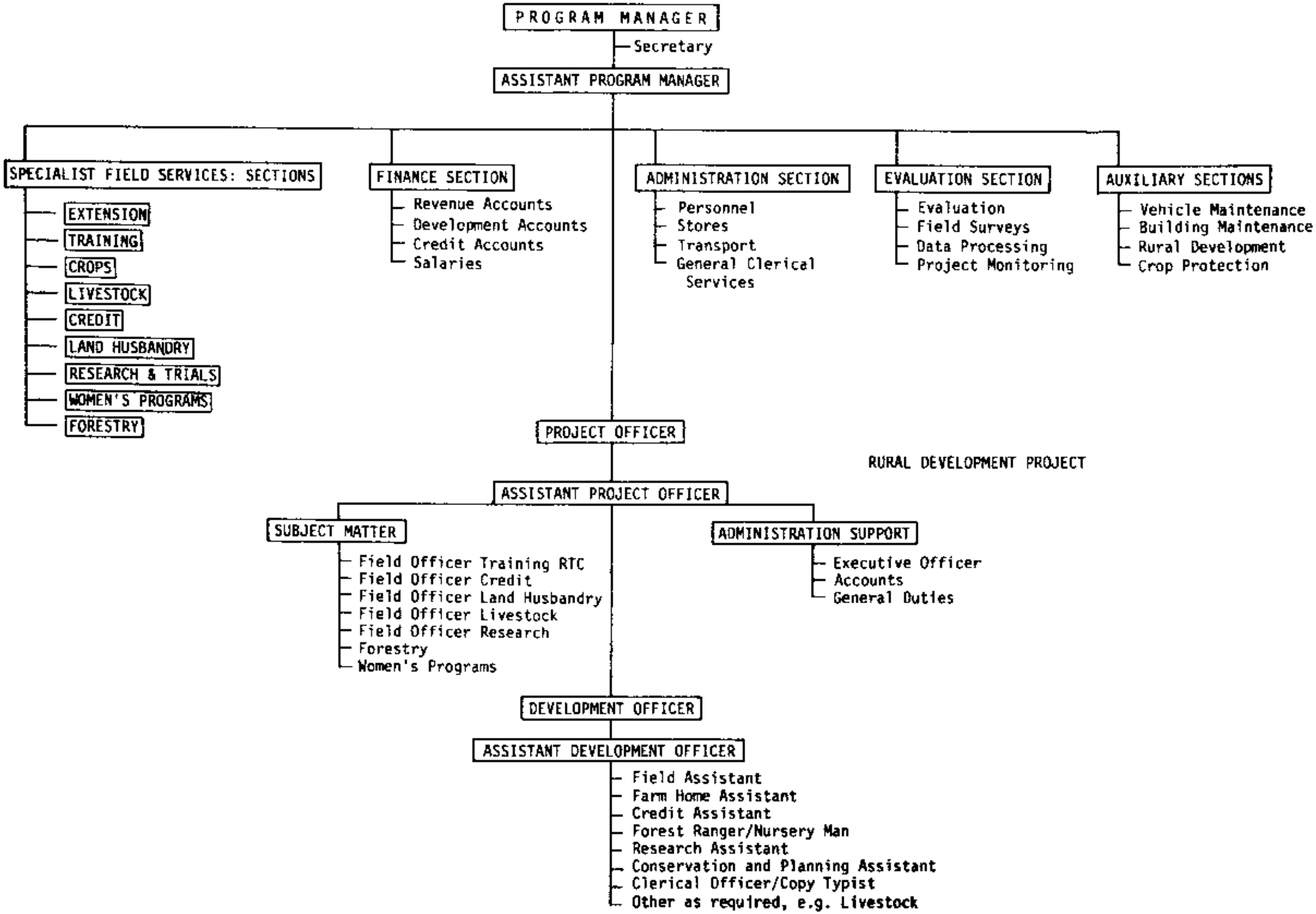

Figure 2. The Agricultural Development Division organization.

Extension and Training Policy

The policy of Extension and Training in Malawi is geared towards meeting the needs and aspirations of the smallholder farmers who are the main producers of basic food crops in the country. In order to meet this requirement we have tried to plan and develop a reasonably satisfactory and workable delivery system aimed at the generation and continuous transfer of agricultural knowledge to the majority of smallholders. Embodied in the policy are the following salient features which were developed in early 1981:

- Extension contacts to be based on a group approach, i.e., each field assistant to divide farm families in his section into reasonable sized groups/subsections or blocks and to arrange to meet them at least once a fortnight at a specified place, date, and time.
- The technical messages to be, as far as possible, delivered through demonstration, client participation, and practice, preferably on farmers' gardens or club/group gardens.
- The DO to conduct training of his extension workers by demonstrations during his regular scheduled meetings (fortnightly or monthly) to ensure that they are sufficiently proficient to teach farmers through demonstrations.
- Extension staff to ensure that all farmers in different groups in their sections are invited to attend the demonstrations at the predetermined times and places. Farmers or club members to be involved as demonstrators in teaching the skills to the groups.
- Apart from scheduled supervisory programs, DOs to carry out surprise checks on extension workers based on their monthly/fortnightly work programs to ensure that the agreed approach and methods are being followed.
- Farmers to participate in extension and training program planning and implementation.
- Residential and Day Training Centres to act as back-up services to extension programs by planning and running courses based on the overall annual workplan of each EPA.
- Staff to transfer technology to the farmers correctly and in a timely manner, based on the calendar of farm activities.

Extension Program Planning

Annual work plans (WPs) are drawn up by the DO and his extension and subject matter staff with the involvement of local leaders representing the farming population. The DO holds a series of meetings to which he invites the SMSs from the Project headquarters if he feels that their input is necessary. This exercise takes the following steps:

1. Collecting and updating basic data by each extension worker and SMS before the meetings are convened. The majority of the data is gathered continuously as each member of staff goes about his/her work. Other data are gathered annually during the lax period before the Annual Program formulation meetings. Evaluation sections of each agricultural division also make available for discussion working papers which they produce from their annual surveys.
2. Review of progress according to the previous Annual Work Plan which involves an analysis and discussion on the achievements compared with the targets that had been set for each activity subject by subject. Successes, failures, and problems and their possible causes are noted.
3. Formulation of the program considering:
   a. the lessons learned during the review, and
   b. the National Policy directives, current and new technical recommendations, observations or comments brought up on each activity during the year as a result of special surveys conducted by the Evaluation Section of the ADD in the area, etc.
4. Setting new targets and drawing up an Annual Work Calendar for each activity according to the proposed Work Program. This deliberation includes suggestions for the equipment, tools, and inputs which will have to be included in the project officer's internal budget.

Once the work plan has been agreed at EPA level, it becomes the draft instrument and is subject to further discussion and ratification at a meeting convened by the project officer. At this meeting, the project officer, his SMSs, ADD-based SMSs and the DOs examine the proposals and consider the items suggested for inclusion in the Internal Budget in the context of the funds likely to be available to the project. After the necessary modifications and amendments have been made, the Work Plan is then approved for fairing and adopting at the EPA level. Thereafter the project officer compiles a Project Work Plan as discussed and agreed for submission to the program manager.

At ADD level, the program manager, together with project officers and ADD-based specialists, examine each Project Work Plan, paying particular attention to each demand on the annual financial allocation. Budgets (one for each Project) are prepared in detail for each EPA and each Project by component of project activity in line with the Work Program.

Every year, program managers are informed by the Treasury through the Secretary for Agriculture (Planning Division) of the (revised) ceilings of the funds within which they should budget for each fully funded Project on Development Account for the following fiscal year. In the case of Projects which are still operating on Revenue Account, they are advised of the percentage within which they should budget for their programs. This information is provided before the preparation of Work Plans and Internal Budgets starts in July/August to enable this exercise to be carried out with a clear picture of the availability of funds.

The program manager submits the agreed Work Plans and Internal Budgets to the Ministry of Agriculture for ratification, a matter of procedure to ensure that the documents are agreeable to Government.

Figure 3 summarizes the stages involved in preparing an Annual Work Plan and Budget.

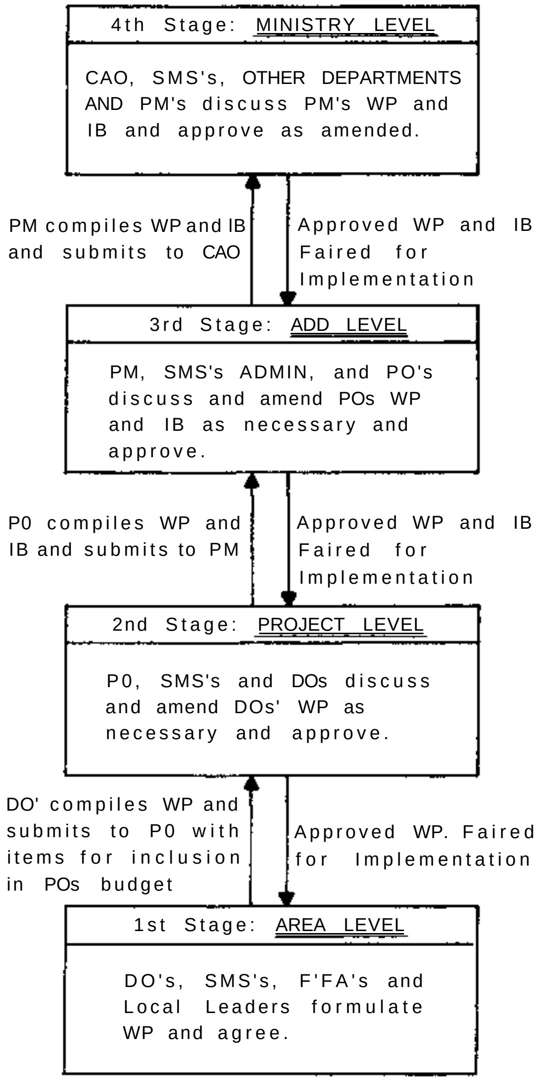

Figure 3. Stages in the Annual Work Plan and internal budget preparation.

Extension Approach

The individual, group, and mass methods of extension have been employed in Malawi since the early 1960s. While the individual method is known to be the most effective, it is slow in terms of coverage of the farming population. It is also expensive in terms of supervision and can be segregating in a situation where Government policy stresses that every farmer must have access to new farming technologies. It does not involve much of the influential traditional leadership and can thus cause an extension program to move without the essential support.

In all three regions the importance of the group method was recognized as providing a faster and much wider method of spreading messages. Extension staff were fully supported by Management in their efforts to disseminate information, skills, and newly available technologies by demonstrations and field days. The results were more significant than in the case of individual visits. By the early 1970s extension staff were encouraging farmers to form groups to improve management of their crops and livestock enterprises. Such organizations as farmers' clubs, which are now the basis for issuing seasonal credit in most Divisions, plowing groups using work-oxen, strip cropping groups which practice communal crop rotations and good management, water control groups in rice areas, etc. developed in many places.

Thus the individual method became second to the group method in areas where extension workers were organizing farmers successfully. Follow-up visits to individual farmers were made after group demonstrations, meetings, or field days had been conducted. The Extension Aids Branch has continued to provide the needed support through mass media such as radio, farmers' magazines, films, and puppet shows. The programs are planned in conjunction with the extension staff of ADDs so that messages are transmitted or broadcast according to the needs of each Division.

In 1981 an official policy guide was produced by the chief agricultural officer, which directed that the group method should be given more emphasis by all Divisions. The guide further elaborated on the systematic manner in which the whole chain of transfer of messages to the farmer should be carried out. This systematic approach calls for:

- Sub-divisions of the field assistant's section into smaller units or blocks with a demonstration facility in each unit. For example, the field assistant must ensure that he arranges for technical skill demonstrations with farmers participating and practicing to satisfy himself that the messages have been delivered effectively.
- All farmers in each block, including any voluntarily formed groups such as farmers' clubs, to be invited through the leadership of the block to attend the demonstrations on a predetermined date and time during the month. The dates and time to be agreed with the farmers' representatives (village headmen and/or committee leaders).
- The Field Assistant to visit each block at least once a fortnight to train farmers at the agreed demonstration site.
- The DO to practically review the technical messages with the field assistant once every month to ensure that everyone is prepared to teach his farmers with necessary skill. This emphasizes that training sessions must be conducted by the DO.
- The SMSs to continually review technical material in their subject matter fields and ensure that messages are made available to the DO before the day he conducts the training of the field assistants. The SMS is also required to assist as far as possible with the training.

This approach to extension provides order in the work of the field assistant to ensure that everything being normal, he will be committed to training farmers at the fixed place and time, or he will be at a training session at the EPA center according to his work plan. Participation of local leaders in the organization and in soliciting the attendance of the people at the demonstration ensures better results.

Supervision and support of the field assistants is straightforward. Objective training programs can be drawn up with the aim of ensuring that technical information and skills are being transferred correctly from SMSs through the DO and the field assistants to the farmers.

Farmer Training Centers

Extension programs are supported by two types of training institutions, the Day Training Center (DTC) and the Residential Training Center (RTC). Courses for farmers are run at these centers. At DTCs, one-day courses are held at which skills are taught for immediate use by the farmers on their return home. The strategy is that each EPA should have at least one DTC. At the moment some EPAs do not have any, particularly those in nonfunded rural development projects (RDPs). DOs are in charge of these centers. The capacity of each DTC ranges from 20-30 participants per course.

RTCs hold 1 -2 week courses at which both theory and practice are taught. Each Center has a principal and two to three staff members. Subjects taught include general agriculture, home economics, food and nutrition, health education, local leadership, etc. Of late, emphasis has been on using RTC facilities for specialized courses such as dairy technology, and tobacco and cotton production. The capacity of the RTCs ranges from 20-100 beds per center. Since the reorganization of the Extension Services under the NRDP, not all RDPs have RTCs. Therefore the strategy is that each project area should have at least one RTC. Finally, training programs for both DTCs and RTCs are held either half-yearly or yearly, and reviewed quarterly or half-yearly as the case may be. Local leadership is involved in program planning.

Extension Aids Branch

The Extension Aids Branch plays an important role in supporting field services. It produces and carries out mass media programs in conjunction with SMSs at Headquarters and in the Divisions. Radio farm forums, films, puppet shows, farmers' magazines, posters, and other visual aids are especially aimed at the farming population. Extension circulars, books, and other materials are produced for staff at all levels in the Department as well as outside.

Seven Sections comprising Publications, Editorial, Maintenance of Equipment and Vans, Photographic, Cinematographic, Radio, and Evaluation and Action Research (EARU) have been functioning for many years. Of significant importance is the operation of Mobile Cinema Campaigns in all ADDs every year, using well-equipped yellow vans to back up extension programs. The campaign schedules are made with the help of the ADDs.

Linkage between DAR and DOA

Although it is widely stated that the linkage between the Departments of Agricultural Research and Agriculture has been very weak, there are several ways in which the two have been cooperating in order to facilitate the flow of relevant technical information between them. This has been made possible because all along the two departments have either been under the same department, or separated but under the same Ministry, a situation which still prevails today. Therefore, being so close and interdependent they have been devising various ways and means of promoting effective communication with each other in order to serve the farmer properly.

The following forms of communication are currently in use to foster linkages:

Research Project Meetings

These are held annually at which research project coordinators discuss their findings and proposals for the following season with staff members of the DOA, DAR, University, and ADMARC (Agricultural Development and Marketing Corporation) in order to determine their suitability to the smallholder farmer.

Research-Extension Meetings

These are joint meetings held quarterly to discuss problems of mutual interest and decide how best they can be solved. ADMARC is also invited.

Annual Extension Seminars

ADDs hold annual staff seminars at which DAR staff members are invited to present papers on agreed specific subjects, followed by discussions.

Commodity Committee Meetings

There are a number of National Commodity Committees which facilitate the interaction of DAR and DOA: these are Rice and Cotton Development Committees, Variety Release Committee, Seed Technology Working Party, Tobacco Working Party, Oil Seed Working Party, Pesticides Working Party, etc. The meetings take place when the chairman is available and keen to hold them.

Training

DAR staff are from time to time involved in extension staff In-Service Training Programs as lecturers. For example, courses on army worm control and potato production are normally run by DAR staff.

Field Days

These are held seasonally at Research Stations for field staff, and sometimes farmers, in order to enable them to see potentially useful technology.

Other Means

Other means of communication include annual reports, research bulletins, handbooks, extension circulars, Guide to Agricultural Production in Malawi, etc., in which new recommendations and/or technologies may be found.

The various ways and means of communication outlined above have fostered research/extension linkage over a number of years, but it has been realized that they do not go far enough. A good example is the idea of formulating technical extension messages. Although DAR provides technical materials and support to DOA staff, it does not have full involvement in the formulation of technical extension messages. This vital exercise has largely been left to DOA SMSs whose effectiveness depends on the flow of new technology from DAR and their level of training in their subject matter fields. Therefore, in order to further improve the linkage between the two Departments, plans are underway to introduce Adaptive Research Teams (ARTs) in each of the eight ADDs whose role will be to conduct on-farm trials designed to solve farmers' problems.

Conclusion

The Extension System in Malawi has developed over a number of years. It has now reached a stage when it should effectively address itself to the problems of the smallholder farmers through the formulation and implementation of suitable extension programs that will boost agricultural production in the country. To achieve this objective there is great need for the DAR and DOA to foster their linkage further so as to be able to jointly address themselves to the problems of the farmers.

Methodology of Surveys and Field Experiments to Assess Crop Losses Due to Insect Pests of Groundnut

P.W. Amin and D. McDonald*

Summary

Surveys and field experiments to determine yield loss from insect pests are rarely simple, and unless properly planned, can be wasteful and misleading. Major difficulties in conducting surveys are accessibility to fields, availability of transport, and communication. There are also the problems of large variations in soil climate, cultivation practices, and pest distribution and abundance from place to place. Surveys are expensive and proper planning is required to make them cost effective.

The accuracy of estimates of "avoidable loss" from simple "paired" plots or from multiple treatment experiments can be improved by proper planning. Methods of estimating crop loss by surveys and field experiments are described.

Resume

***Méthodologie des enquêtes et des essais au champ pour évaluer les pertes de récolte dues aux insectes ravageurs de l'arachide :** Des enquêtes et essais au champ destinés à évaluer les pertes de récolte occasionnées par les insectes nuisibles sont, pour la plupart, peu simples. A moins qu'ils soient bien planifiés, ils peuvent se révéler trompeurs et peu économes. L'accessibilité aux champs, la disponibilité des moyens de transport et la communication peuvent poser de grands problèmes pour la bonne conduite des enquêtes. Il existe également d'autres sources de problèmes, telles que des variations importantes, d'une région à une autre, dans le pédoclimat, les pratiques culturales et la répartition et l'abondance des insectes nuisibles. Les enquêtes coûtent chères, et une bonne planification est nécessaire pour qu'elles soient rentables.*

Une planification appropriée pourrait améliorer la précision des évaluations des "pertes évitables" à partir des essais à parcelles "appariées" ou des expériences à traitement multiple. La communication décrit les méthodes d'évaluation des pertes de récolte à travers des enquêtes et des essais aux champs.

Groundnut pest research can be grouped into two phases: (1) an exploratory or problem identify phase, and (2) an "action" or problem solving phase. The impact of problem solving largely depends upon how correctly the problems have been identified and assessed. All too often estimates of crop losses are exaggerated by researchers. For example, at the 1983 All India Seminar on Crop Losses Due to Insect Pests held at Hyderabad, India, loss estimates for different crops in India ranged from very little to 100%. In the same seminar the yield losses for groundnut were estimated at U.S. $ 800 million (Vyas 1983) and U.S. $ 160 million (Amin 1983) based on the same set of trials conducted under the All India Coordinated Research Project on Oilseeds (AICORPO). It is difficult for planners and policy makers to decide upon the resources that should go into problem solving on the basis of such varied "guess-estimates".

It is necessary to conduct surveys to ascertain pest abundance and distribution and to estimate the amount of crop loss caused by each species so that key pests may be identified and research prior-

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ities allocated.

The assessment of yield loss is, however, often difficult and complex. A number of problems have to be recognized and overcome in order to obtain meaningful results. These are examined in the following discussion based largely on our experience during the last few years with groundnut pests at ICRISAT.

Surveys

Before undertaking surveys we collected all available background information on groundnut insect pests. A comprehensive list of insects injurious to groundnut was prepared, based on literature records, of 42 insect species attacking groundnut in India, and our own collections which showed more than 70 pest species. We next acquainted ourselves with the injury symptoms of common pest species. This was essential because the damage caused by one species can sometimes be confused with that caused by others (Thimmaiah and Panchbhavi 1973). For each species we took color photographs of typical injury symptoms and prepared detailed descriptions.

The first survey to estimate crop loss was carried out during the 1982/83 postrainy season (Dec-Apr) when groundnuts are grown under irrigation. This season follows the rainy or monsoon season (Jun-Oct).

Survey Purpose

The purpose of the survey was to estimate losses due to pests and thrips-transmitted bud necrosis disease (BND).

Selecting Sample Points

The survey was conducted in 11 major groundnut growing districts of Andhra Pradesh state in India. Agriculture officers in the selected districts were informed of the purpose of the survey and given likely dates of visits well in advance.

Church (1971) described the four common methods of survey sampling: (1) simple random sampling, (2) stratified sampling, (3) cluster sampling, and (4) systematic sampling. A combination of the stratified and systematic sampling methods was chosen. Simple random sampling could not be used because the total number of fields (sample points) in a given district were not known. Cluster sampling was inappropriate because the groundnut growing districts were easily accessible and could be surveyed in a short period. Stratified sampling was used by forming strata based on climate, the cultivar (growth habit), sowing and harvest dates, fertilizer application, plant stand density, and pesticide use. Differences between fields and areas in pest infestation and BND incidence could be explained well in terms of these strata. For example, in Guntur district, BND incidence ranged from 40-60% in crops with plant densities of 8-10/m^2 while in fields with plant densities of 30-35/m^2 it was 10-20%. Plant density was therefore an important parameter in explaining interactions of this kind. Once the strata were formed we decided upon the frequency of sampling points. A groundnut field was a sampling point in which sampling units were taken. Sample fields were selected at approximately 25 km intervals along motorable roads, and 6-9 fields were sampled per district.

Survey time

As it was impossible to sample the crop at different stages of growth over large areas, the best times to assess pest damage had to be selected. Preliminary observations at ICRISAT Center indicated that peak infestations of insect pests and BND occurred in September in the rainy season and in April in the postrainy season (Table 1). As the survey was planned for the postrainy season it was carried out during the last week of March and the first week of April.

Sample Unit Selection

Selection of sampling units for pests was based on their spatial distribution in the field. Most fields were of 0.5 ha, but for larger fields more sampling units were demarcated. Pest distribution and the method of selecting sampling units are given in Table 2.

Measuring Pest Damage Severity

The damage caused by the various insect pest species is fully described later. Damage assessments in the field were made using the criteria given in Table 3.

Sampling Time

The feeding activities of insects vary considerably, some are nocturnal feeders and others are diurnal. The optimum time of sampling for the majority of insect pest species was the morning (Table 4).

Table 1. Months of peak infestation of various pests and bud necrosis disease (BND) in the rainy and postrainy season.

Pest/disease	Peak infestation	
	Rainy season	Postrainy season
Termites causing		
plant mortality	September	--
scarification	November	--
White grub	September	--
Wireworms	September	--
Ants	September	--
Thrips *S. dorsal is*	September	March
F. schultzei	September	February
C. indicus	Drought periods	April
Jassids	September	--
Aphids	July-August	April
Tobacco caterpillar	--	April
Hairy caterpillar	August	--
Bollworm	August	March
Leafmmer	September	April
BND	September	April

Table 2. Spatial distribution of insect pests and bud necrosis disease (BND) in a field and the selection of sample units.

Pest/BND	Distribution	Method of selection of sample units
Termite, white grubs, ants, wireworms, aphids, mites	Aggregated	x = 2 m^2 (1 m^2 for aphids and mites)
Thrips, jassids, Leafminer, BND	Random	x = 1 m row (1 m for BND)
Hairy caterpillars	More infestation near bunds, elevated soil	x = 2 m row
Tobacco caterpillar	Near borders	x = 2 m row

Collecting Insects

Small insects, other than thrips, were collected with a sweep net, and a small paint brush was used to transfer them to 70% alcohol in glass vials. Thrips were preserved in 60% alcohol. Small homeopathic vials, 3 cm long and 1 cm in diameter, made excellent collecting vessels. Larvae were killed in KAAD mixture (kerosene, 1 part; 95% ethyl alcohol, 10 parts; glacial acetic acid, 2 parts; and dioxane, 1 part). The collecting container was wider than the larvae so that specimens could be oriented in a horizontal position. Large larvae, e.g., *Spodoptera litura,* were punctured at several places to improve penetration of the preserving fluid.

Apparatus Required

Tools commonly used included clip board, ice pail to keep samples fresh, towel, tape measure, grip bags and plastic pots, homeopathic vials, ethyl alcohol, hand tally counter, hand lens, sweep net, an aspirator, killing bottle, camera, data sheets, farmers' history sheets, pencils, eraser, scissors, gum boots, rain coat, and hat.

Estimates of Crop Losses

Estimates of crop losses are required to determine the relative importance of particular pests, and thus

Table 3. Criteria used for the measurement of the severity of pest damage and bud necrosis disease (BND).

Pest	Distribution	Measurements	Sampling unit
Termites	Aggregated	Percentage of plants killed	2 m^2
		Percentage of pods scarified	
White grubs	Aggregated	Percentage of plants killed	2 m^2
Wireworms/ants	Aggregated	Percentage of pods bored	
Thrips	Random	Percentage of leaflets damaged	1 m row
Jassid	Random	Percentage of yellowed foliage	1 m row
Aphids	Aggregated	Size cf aphid colonies:	1 m^2
		Small =< 25 aphids/plant Medium = 26-50 aphids Large = > 51 aphids	
Tobacco caterpillar	Random	No. of larvae Percentage of defoliation	2 m row
Hairy caterpillars	Random	No. of larvae Percentage of dried foliage	2 m row
Leafminer	Random	Percentage of dried foliage	1 m row
		No. of larvae	
BND	Random	Percentage of plants infected	1 m^2

decide upon the level of resources that should be devoted to research and pest management inputs. Obtaining crop loss estimates is never simple, particularly for pests that attack foliage. Even with those that kill plants in the early stages of crop growth, the loss of a few plants may have little effect on yield, provided the initial plant density is adequate. For foliage-feeding insects, chemical control often significantly reduces damage but may not significantly increase yields. The groundnut plant can often effectively compensate for the tissue removed by insects, particularly of young foliage (Wall and Berberet 1979), or when the crop is damaged while still young (Bass and Arant 1973). Generally, the groundnut crop can withstand considerable leaf damage without significant yield loss, but direct damage to pods and seeds is likely to result in substantial yield loss.

The most convenient way to measure the avoidable loss is by conducting paired plot trials. Avoidable loss may be defined as the yield difference between pairs of representative plots of the crop, one of which has been protected from pest attack, usually with an insecticide, and the other left unprotected. General guidelines for conducting crop loss experiments have been given by Le Clerg (1971).

At ICRISAT we have conducted experiments to measure yield differences in protected and unprotected plots from (1) the pest complex, and (2) specific insect pests. Some of the problems encountered and means of overcoming them are discussed.

Table 4. Optimum time for sampling for different insects and bud necrosis disease, and notes on their habits.

Pest/BND	Optimum time of sampling	Notes on habits of pests
Termites	Morning	Termites forage on the soil surface in the morning
White grubs	Morning	Grubs are near the soil surface in the morning but move deeper in the soil in the afternoon
Wireworms	Not known	--
Ants	Not known	--
Thrips/Jassids	Morning	They inhabit young leaves and are less active in the morning than in the afternoon
Aphids	Any time	Aphids feed on leaves, shoots, flowers, ana pegs
Tobacco caterpillar	Early morning/evening	Caterpillars are nocturnal feeders. They take shelter on soil and in debris near the plants during the day
Bollworm	Morning	They feed on flowers
Hairy caterpillar	Morning	Feeds on foliage
Leafminer	Any time	Feeds on foliage
BND	Morning	Symptoms of ringspots are clearer in the morning.

Planning and Conducting Experiments

Experiment Duration

Results based on one season's experiments can be misleading because of large season-to-season variations in pest populations. For example, a trial conducted to estimate yield loss from thrips at ICRISAT in the 1981 /82 season did not show substantial losses, but similar trials in the 1979/80, 1980/81, and 1982/83 seasons showed consistent yield losses, primarily from high thrips populations. Therefore, crop loss estimates should be based on at least 3 years' trials.

Number of Locations

It is difficult to determine the minimum number of locations for conducting trials on avoidable loss, even within the same climatic zone, because of the variation in pest abundance and distribution within a zone. As a general guideline, locations where host damage occurs frequently and locations where pest problems are less common should be selected. It would not be feasible to set up experiments to cover an entire country, but a minimum of 3-5 representative locations should be selected in each zone.

Site Selection

The most appropriate sites for conducting experiments are farmers' fields. However, because the experimenter has little control over farmers' cultivation practices such as sowing dates, seeding rates, and pesticide application, experiments are usually conducted on research farms where crop management and pest infestation are usually different from those in farmers' fields. The best compromise is to select sites on research farms that most closely resemble farmers' fields, and to ensure that the recommended cultivation practices for the area are followed. At ICRISAT we conduct our trials on low fertility alfisols.

Pest distribution, particularly of airborne insects such as thrips, is greatly affected by barriers that influence air movement. All trials were consequently located at least 100 m away from buildings, hedges, tall crops, bunds, etc.

Plot Size

The mobility of insects influences the choice of optimum plot size. For example, where *Heliothis* sp is a key pest, large plots may be necessary because this insect is very mobile, and considerable interplot distribution effects can result if small plots are used. Joyce and Roberts (1959) showed that plots of 3 ha separated by 150 m may be necessary to overcome interplot effects for *H. armigera* In cotton. However, most trials are conducted on plots of less than 0.03 ha and some researchers use plots of 25 m^2 or less. Clearly these are too small. At ICRISAT we use plots of 100-500 m^2, depending upon the objectives of a trial. Yield trials are usually conducted on "precision fields" with uniform soil fertility.

Guard Rows

Insect behavior in the crop may be influenced by the presence of bare soil and by edge effects. It is, therefore, not desirable to leave gaps between plots (Lewis 1973). At ICRISAT we sow 1 m wide guard rows of the same cultivar on all sides of each plot to reduce the "interplot" effects and to reduce the effects of pesticide drift (Jenkyn et al. 1979). The presence of guard rows considerably reduces the coefficient of variation (Jenkyn et al. 1979) and has helped to reduce the effect of soil application of pesticides between plots (Verma and Pant 1979).

Replications

A minimum of four replications is necessary (Le Clerg 1971). However, for pests such as termites or white grubs whose distribution in a field is nonrandom and often highly aggregated, more replications are often necessary.

Plant Stand

In any yield trial, plant density should be similar in ail treatments. A high plant density tends to dilute the infestation of such pests as thrips, jassids, and leafminers, but invites more infestation from pests such as the tobacco caterpillar. The incidence of BND is also greatly affected by plant density. At ICRISAT two methods are followed to ensure optimum plant stands in experimental plots: (1) more than one seed is sown per planting hole, or (2) high seeding rates are used, and then the crop is thinned to obtain the optimum plant population. Planting partially germinated seeds can also be useful, particularly for filling gaps, as seed viability is assured. Often groundnut seed may look healthy but may have lost viability, particularly when pods were dried at high temperatures. Therefore, germination tests prior to sowing are necessary. Other factors that reduce the plant stand are soilborne fungal pathogens and Insects. Fungi such as *Fusarium* spp., *Rhizoctonia* spp. and *Aspergillus* spp. can cause heavy seedling mortality. Seed treatment with thiram at 3.0 g/kg of seeds is necessary to control fungal pathogens. Ants, termites, or millipedes may be controlled with soil treatment of chlordane or heptachlor.

Pest Control

In yield loss assessment trials it is essential to obtain good control of the target pests in treated plots to avoid underestimating yield losses. In several trials conducted under the All India Coordinated Research Project on Oilseeds from 1977-82, insect numbers were 30-80% less in protected than in nonprotected plots.

Sometimes it may be desirable to consider the effect of only one group of insects. To avoid interference from other pests, selective insecticides or application methods may have to be employed. For example, when the effect of only foliar pests is being investigated, all plots should be protected from soil pests.

Disease Control

Many fungal diseases such as leaf spots and rust not only interfere with observations on insect injury, but also affect yields. At ICRISAT all entomological trial plots are protected from fungal diseases. Sulphur-based fungicides have an adverse effect on insects, and are therefore not used. Chlorothalonil, which does not have insecticidal properties, gives good control of both rust and leaf spot diseases, and is therefore routinely used. Alternatively a mixture of Dithane M-45 and Benlate may be used.

Harvesting

Prior to harvest, the plants in a border of at least 0.3 m on all sides of the plot are discarded to avoid border effects. When the effects of pests such as termites are under investigation, special care is taken to harvest all the pods in each plot since termites can damage pegs resulting in pods being left in the ground at lifting. Considerable variation in pod yield can result from the duration of drying. Once harvested, pods rapidly lose moisture. At ICRISAT we record the weights of pods after drying them in the shade for 4-5 days.

Field Layouts

The layout of an experiment depends upon its objective. For experiments to determine (1) total yield loss from a pest or pest complex, and (2) yield loss from individual pest species at different growth stages, different layouts were employed.

Total Yield Loss Assessment

Paired plots, in which one plot is protected from all pests with pesticides and the other not protected are commonly used. Usually 5-6 replications are arranged as described by Le Clerg (1971) (Fig. 1).

Paired plots are compared by a 't' test using the formula:

$$t = \frac{Xp - Xnp}{Sd}$$

where Xp = mean yield of treated plots
Xnp = mean yield of nontreated plots
Sd = standard error of the difference between the two mean yields.

Yield Loss from Individual Pest Species

Multiple treatment trials were conducted succeeding determination of total yield loss from a pest complex. These included treatments in which:

- appropriate (selective) insecticides were chosen to effectively minimize the damage caused by a specific pest, e.g., dimethoate to control thrips and leafminer, or carbaryl to control tobacco caterpillar;
- insecticide treatments were applied so that one or more growth stages remained unprotected while the others were protected (Fig. 3); and
- fully protected and nonprotected plots were included for comparison. Pests and their damage were monitored in all plots and the results analyzed statistically.

At ICRISAT we used the design shown in Figure 2 and the schedule of protection shown in Figure 3. Using this method yield differences between plots treated at successively later stages of development will reflect yield loss caused by the pest during the respective successive growth stages. It is difficult to apportion the losses caused by two pests such as leafminer and tobacco caterpillar that occur together unless selective insecticides are available to control one pest without affecting the other. Two cultivars having different susceptibilities to the two pests but a similar yield potential could also be used.

Measurement of Pest Damage Severity

Success in relating crop loss to the severity of insect damage depends upon accurate damage assessment. Methods of measuring pest damage should be simple and reliable. For example, thrips damage can be assessed rapidly by counting the

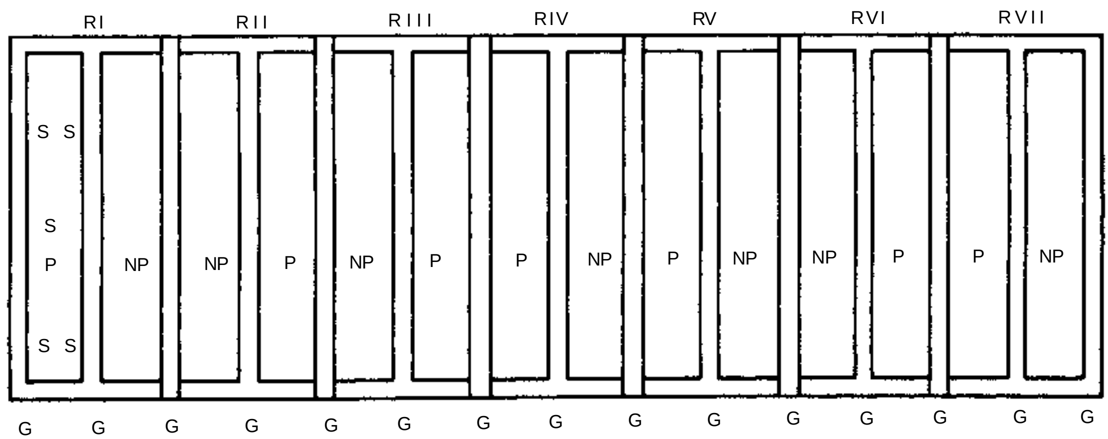

Figure 1. Layout of randomized compiete block strip trial in paired plot treatment experiment (P = protected, NP = non-protected, G = guard rows, RI to RVII = replication blocks, S = sampling place).

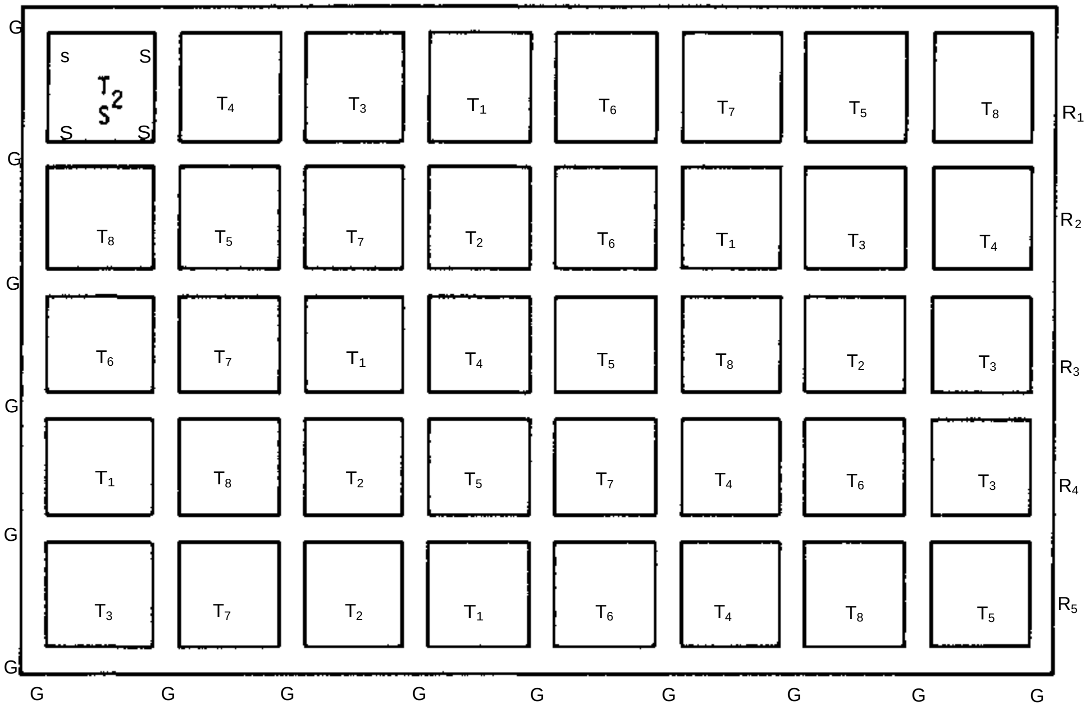

Figure 2. Layout of randomized block trial for partitioning of yield loss among different pests (T_1 to T_8 = treatments, R_1 to R_5 = replication blocks, G = guard rows, S = sampling place).

number of thrips-damaged leaflets. This is a simple and reliable method. Similar simple methods can be used for other pests.

Specific Pests

Termites

Termites cause three types of damage to groundnuts: (1) they can kill branches or entire plants by tunneling into roots and/or stems, (2) they can penetrate the pods by boring and feed on the kernels, and (3) they can scarify the pods. *Odontotomies obesus* Rambur causes the first two types of damage in India while termites of other species of *Odontotomies* in India and *Microtermes* species in Africa cause pod scarification. The following observations give a measure of termite damage: (1) percentage of plants killed, (2) percentage of pods bored, (3) percentage of pods scarified, and (4) injury rating of scarified pods on a 1 -9 scale where 1 = no scarification and 9 = total scarification of the pod surface.

The distribution of termites in a field is unlikely to be either uniform or random, therefore, the field should be sampled at several locations. As pods mature they are increasingly attacked by termites causing scarification. Therefore, pods lifted some time after maturity have more damage from scarification than pods lifted earlier.

White grubs (*Holotrichia* spp.)

White grub larvae feed on the roots of groundnut and kill the plant. The number of seedlings per plot killed by white grub attack is an adequate measure of damage. In wet weather seedlings damaged by white grubs may not wilt but do so with the onset of dry weather, giving a false impression of the time of attack.

The selection of experimental plots for white grub control experiments is difficult because of the extremely patchy distribution of this insect in the field. High infestation usually occurs near host plants of the adult beetles. It is, therefore, necessary to use a large number of replications. Small plots at many locations are preferable to large plots

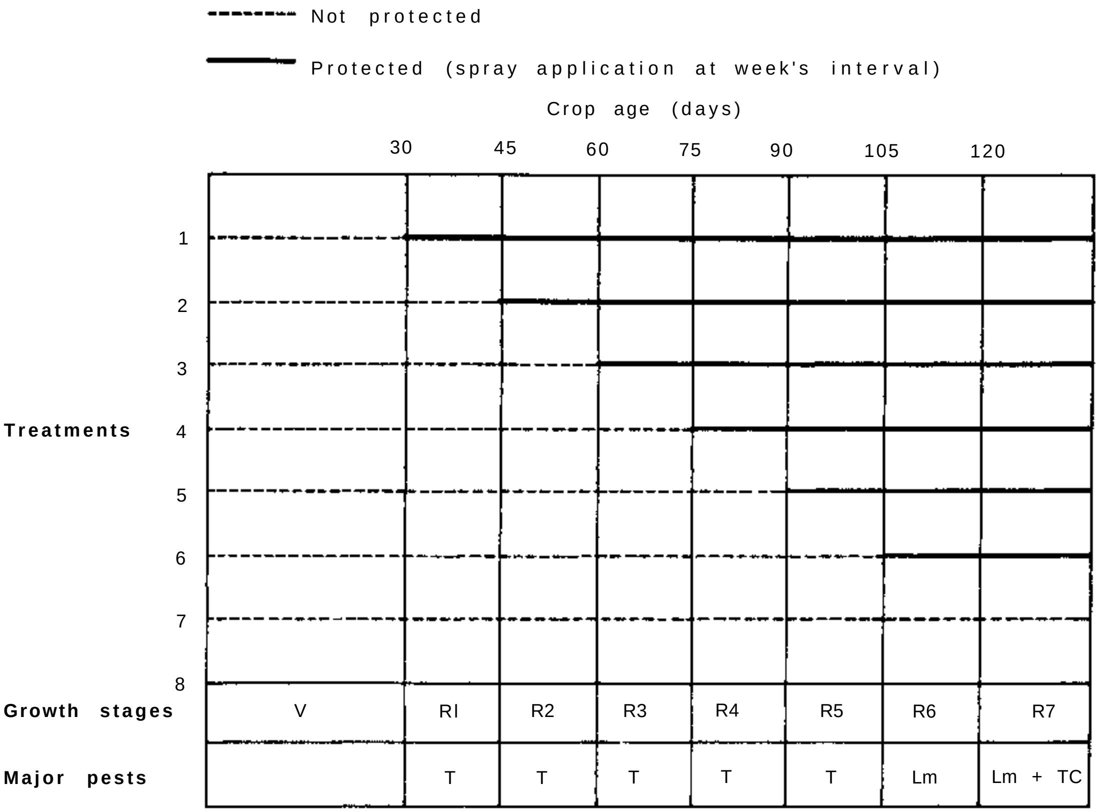

Figure 3. Partitioning of yield loss among different pests of groundnut in postrainy season at ICRISAT. Growth stages (Boote, 1982): V = vegetative, R1 = bloom, R2 = pegging, R3 = podding, R4 = full pod, R5 = seed formation, R6 = full seed, R7 = maturity. Major pests: T = thrips, Lm = leafminer, TC = tobacco caterpillar.

at a few locations in a field.

White grubs are pests mainly in sandy or loamy soils where substantial seedling mortality also results from fungal diseases such as *Aspergillus* crown rot. Seed treatment with thiram is essential. It is also necessary to keep a record of fungus-killed plants. Because of the extremely uneven distribution of white grubs, the whole plot should be treated as a sampling unit, a practice also necessary for termites, wireworms, and other soil insects.

Thrips

Three species of thrips commonly infest groundnuts in India. *Scirtothrips dorsalis* adults and nymphs feed on young leaves, with injury symptoms of brownish green patches on the upper leaf surface and dark brown necrotic patches on the lower leaf surface. Injury symptoms of *Frankliniella schultzei* are white scars on the upper surface of young foliage, with leaf deformation under heavy infestation. Feeding by *Caliothrips indicus* results in spots or 'stippling' on the upper surface of the older leaves, and when infested by several thrips the excessive feeding results in foliage drying. At ICRISAT we record (1) the number of leaflets showing thrips injury, and (2) the severity of damage to individual leaflets recorded on a 1-9 scale, where 1 = no damage and 9 = severe damage.

Thrips are usually randomly distributed in the field. Five sampling units, each 1 m of a row, arranged diagonally in a plot, have been routinely used at ICRISAT for recording the severity of thrips damage.

Jassids

Feeding by the jassid, *Empoasca kerri,* causes foliage to yellow beginning at the tip of a leaflet and later spreading to the other portions. Most jassids inhabit the younger foliage. At ICRISAT we record (1) the percentage of yellowed foliage, and (2) the number of jassid nymphs on three terminal leaves. The observations are recorded from five 1 m row units arranged diagonally across a plot.

Aphids

Aphis craccivora is a sporadic pest of groundnut, with heavy infestations occurring in drought years. Aphids first live on young leaves, but later move to flowers and pegs where they remain hidden under the plant canopy. The canopy should therefore be opened to count aphids. The distribution of aphids in a field is aggregated, so the size of sampling unit needs to be increased. We record (1) the number of plants infested with aphids, and (2) the size of each individual aphid colony (small, 1-25 aphids; medium, 26-100; and large>100).

Leafminer

The larvae of *Aproaerema modicella* initially mine the leaves, but after 5-6 days they emerge from the mines, draw the leaflets together, and feed inside the webbed leaves where they later pupate. The mined area becomes dry, and when a leaflet has several mines the whole leaflet dries up. The leafminer is randomly distributed in the field and five 1 m row units arranged diagonally form the sampling unit. At ICRISAT we routinely record percentage of dried foliage as a measure of leafminer damage severity.

Tobacco Caterpillar, (*Spodoptera litura),* and Hairy Caterpillars, (*Amsacta spp.)*

Caterpillars of both species feed on the foliage and growing tips, and can completely defoliate the crop under severe infestations. At ICRISAT we record the percentage of foliage consumed. In addition we record the number of larvae/2 m rows arranged diagonally at five places in a plot.

Conclusion

The groundnut yields, as those of any other crop, are influenced by the cultivar, soil type and fertility, plant density, time of sowing, and weather conditions, as well as the interaction of pests and diseases. It is therefore difficult to obtain absolute values for the losses caused by any one of these factors, but useful results can be obtained from properly designed and well conducted field experiments.

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Field Visits

Meeting Organization and Participants

General Discussion and Recommendations

Recommendations

Field Visits

Chitedze Agricultural Research Station

On the afternoon of Tuesday, 27 March participants visited Chitedze Agricultural Research Station near Lilongwe. This is the main agricultural research station in Malawi and also provides accommodation for the ICRISAT Regional Groundnut Program for Southern Africa.

Mrs. Patricia Ngwira explained the purpose and progress of the field experiments of the Malawi National Program. Mr. J.H. Luhanga demonstrated the work of the Seed Technology Unit. After looking over the seed technology, breeding, agronomy, and pathology trials, participants visited the farm machinery workshop where they were shown different kinds of equipment being developed for use with groundnuts. Particular interest was shown in a small groundnut sheller being developed from plans provided by the Tropical Development and Research Institute, London.

Delegates then visited the ICRISAT field trials where Dr. S.N. Nigam showed the introduced germplasm and breeding lines, and the material being developed from them. Dr. K.R. Bock showed the distribution of rosette virus disease on the farm and detailed how the initial aphid infestations were marked and the development of the disease monitored. The usefulness of such studies on a regional basis was emphasized.

Farmers' Fields and Chitala Research Station

On Wednesday, 28 March the entire day was devoted to visits organized by the Malawi Ministry of Agriculture.

The first visit was to farmers' fields in the Lilongwe Agricultural Development Division. After a brief explanation of the work and organization of the Development Division, delegates were shown several farms and had groundnut production methods explained by Ministry staff and farmers themselves. In this area the cultivar Chalimbana had been sown in a timely manner with resultant high plant populations. Farmers had used Daconil for control of leaf spots and this had proved effective. There was excellent vegetative growth and good suppression of weeds. Some attack by *Hilda patruelis* was noted.

The party then traveled towards the lake shore region. Some farms were visited en route. Where groundnuts had been sown late, the management was not as good as in the Lilongwe area, and weed growth was a problem. After arriving in the Salima Agricultural Development Division, participants visited several farms, some with excellent and well managed groundnut crops and others where the standards were not as high, thus providing a representative range of groundnut production levels for discussion. The predominant cultivar in the Salima Division is Mani Pintar, an oil type. *Hilda patruelis* attack was noted, and early and late leaf spots were causing damage. Rust disease was just starting to appear. Weeds were generally a problem.

Lunch was provided by the Ministry of Agriculture at the Chitala Training Institute, followed by a visit to the groundnut trials at Chitala Experiment Station Farm. Leaf spot disease levels were very low, perhaps due to groundnuts on the farm being grown in a very long rotation. The diseases were certainly present at much higher levels on farmers' fields in the same area. After visiting a number of farmers' fields participants were taken to the Grand Beach Hotel on the lake shore for refreshments, and then returned to Lilongwe.

General Discussion and Recommendations

Report of General Discussion

The final session of the Workshop was devoted to discussion of the various problems limiting groundnut production in the Southern Africa region with the goal of improving research effectiveness through regional cooperation.

Topics covered included agronomy and farming systems, pests and germplasm exchange, regional germplasm evaluation trials, training research staff, and information exchange including coordinating meetings and workshops.

Agronomy and Farming Systems

It was agreed that a labor shortage at periods of peak demand was an important bottleneck that prevented small-scale farmers from adopting improved farming practices. The suggestion was made that research on use of animal power should be expanded, especially on the design and development of animal drawn equipment, and that new ideas, designs, etc, should be freely circulated within the region. Cultural practices found effective in one country should be examined for possible use in other countries.

Weed problems were considered to be important in most countries. While it was generally accepted that good land preparation, timely sowing, and early weeding were effective in reducing the weed problem, availability of labor and competition for attention from other crops often prevented farmers from giving optimum treatment to their groundnut crop and weed problems before they became serious. Herbicides were found effective in specific situations, but their widespread use by small-scale farmers was considered far in the future for most countries. It was agreed that much more research was needed on the problem of weed control. Although this would have to be carried out principally by national programs there could be useful input from farming systems programs of International Institutes, UNESCO, and other bodies.

Economic research into prices, markets, and production of groundnuts on both country and regional bases is needed. More information is required on the relative profitability of groundnuts compared with other crops of the region. Groundnuts have to be studied as a component of different farming systems and in relation to their end uses. Little is known of the value of groundnut hay in some areas. Mention was made of Zimbabwe being given responsibility for developing a food security program, but it was considered unlikely that any uniform quota or pricing system could be imposed generally over SADCC countries.

Participants agreed on the need to consider all aspects of existing farming systems before trying to introduce improved technology. They also agreed on the need to examine possible impacts of increased production on marketing and storage infrastructures, and the economics of groundnut production, processing, and marketing at national and regional levels. At present the ICRISAT Regional Groundnut Program has only limited resources and its work is concentrated on introduction and evaluation of germplasm and breeders' lines, and on breeding for resistance to important yield reducers. However, some help can be given to national programs in coordinating research on farming systems. Help may also be available from ICRISAT Center.

Pests and Diseases

There was lengthy discussion on the importance of various pests and diseases in the different countries of the region. Most attention has been given to diseases and those of particular importance were the early and late leaf spots, rust, phoma leaf blight, pod rots, and rosette virus disease. Insect pests considered included termites, aphids, jassids, and *Hilda patruelis.* Special mention was made of the flowering plant parasite alectra. While the present and possible future importance of various pests and diseases was recognized, there was very little data available on actual yield losses caused by them. The need to undertake pest and disease surveys within the region was clearly recognized. The shortage of trained staff in crop protection was also recognized and participants agreed on the need to train staff at all levels to provide improved identification, survey, and crop protection services. It was suggested that experienced crop protection scientists in the region could cooperate in training staff within the region and that ICRISAT might be able to assist. The possibility of developing training kits with color slides to assist with disease and pest identification was discussed. The particular difficulties involved in identification of virus diseases were noted. The need for standard methods for scoring specific diseases was emphasized.

The need for research and training to concentrate on national program priorities was stressed but the value of cooperative programs was also recognized. Several participants supported the organization within the region by the ICRISAT Regional Program of uniform pest and disease nurseries.

There was general agreement that work on leaf spots, rust, and rosette disease should have the highest priority in the region.

Germplasm Exchange and Regional Trials

Participants agreed on the very considerable benefits from increased exchange of germplasm lines, breeders' lines, and segregating material within the region. However, plant quarantine regulations would have to be considered to move seed materials between countries and into the region. Fortunately, diseases and pests are much the same in the different countries of Southern Africa thus simplifying matters and reducing the chance to introduce new pests and diseases into the region. The increased flow of germplasm into the region and particularly into Malawi might require strengthening of Plant Quarantine services to cope with this extra work. The need to exclude seed-borne viruses was recognized.

The need to collect, evaluate, and maintain local germplasm was stressed. It was suggested that ICRISAT and IBPGR might assist in this.

There was lengthy discussion on the organization of regional germplasm evaluation trials and it was agreed they would be useful. The desirability of having seed for regional trials multiplied at one location was accepted. All countries were interested in the development of short- and medium-duration cultivars and in the incorporation of resistance to the important pests and diseases of the region. High priority was also indicated for development of cultivars with tolerance to drought and to the pops condition.

It was noted that ICRISAT was already involved in germplasm collection in the region and that research aimed at developing cultivars with resistance to foliar diseases, drought, pops, and rosette disease was being conducted at ICRISAT Center and in the ICRISAT Regional Groundnut Program in Lilongwe.

Training

The various kinds of training offered by ICRISAT Center in India were described and their usefulness discussed in relation to the needs of the national programs of the countries of Southern Africa. Participants were mainly concerned with the possibilities of organizing training for scientific and technical staff within the region. They considered that this would be more effective in the short- and medium-terms than training overseas.

It was agreed that there was a need for very specific short courses to train appropriate staff for regional trials, pest and disease surveys, etc. The possibility of universities in the region cooperating in short term training was discussed and this was supported by the participants from the universities. It was suggested that the ICRISAT Regional Program and ICRISAT Center staff might participate in such courses. It was agreed that these suggestions would be communicated to the ICRISAT Training Program.

It was suggested that each country should give careful consideration to the type of training required, the numbers of trainees envisioned at each level, and whether the training should be specifically on groundnuts, on farming systems, or other areas involving groundnut production.

Exchange of Information

It was agreed that a regional workshop on groundnuts should be held at regular intervals, perhaps once in every two years, and that the workshop should be held in a different country each time. Participants considered that the workshop should be of general scope rather than concentrating on a single problem or discipline. In addition to providing an information exchange the workshops would also provide opportunities for planning and evaluating regional trials.

A proposal that the ICRISAT Regional Program should produce a Regional Groundnut Newsletter was strongly supported by participants. Items suggested for inclusion were research reports, information on new books and important research publications, notice of and reports on conferences, and bibliographies relating to groundnuts. Information from "Peanut Research" could be included. It was noted that IDRC could provide help with computer searches of literature as this service is available to the ICRISAT Regional Program and to other IDRC-assisted projects.

Recommendations

1. The Meeting expressed appreciation of the work of the ICRISAT Regional Groundnut Program since its inception, and recommended that it continue to assist with groundnut improvement in relation to the priorities of the Region by operating through and cooperating with National Programs.

   It was noted that strengthening of the National Programs themselves would enable most effective use of and maximum benefits to accrue from the Regional Program.

2. The Meeting endorsed the Regional Program's existing research priorities being directed towards the Cercospora leafspots, rust, and rosette diseases. The Meeting emphasized the importance of Hilda, termites, and other widespread pests such as jassids and thrips in the Region and recognized the need for an understanding of their ecology.

3. The Meeting recommended that the Regional Program continues to acquire new germplasm and to develop breeding populations; to disseminate these and assist with their evaluation, and to respond to specific requests for assistance with hybridizations.

4. The Meeting recommended that the Regional Program fosters, where appropriate, cooperative research among countries of the Region, particularly on such aspects as the epidemiology of rosette disease and the evaluation of material in regional trials and of germplasm.

   The Regional Program was therefore asked to devise an effective strategy to enable the National Programs, each within its own particular limits, to be involved in cooperative research and to feed back results effectively and rapidly.

5. Noting that the National Programs were not strong in all areas, the Meeting recognized the need for consultancy services to be provided by the Regional Program. The Regional Program should therefore make every effort to respond to requests for visits, both for training and for advice on specific technical procedures.

6. The Meeting noted the urgent need for strengthening National Programs by appropriate and relevant training of personnel at various levels. It recommended that the Regional Program develop training programs within the Region, drawing jointly on the expertise of ICRISAT and of local institutes, to ensure high relevance and to minimize costs.

7. The Meeting noted the fact that while much ecological, economic and social variation existed within the Region, much was often common across countries and that this should be exploited through the facility of the Regional Program, by means of a newsletter and of regular Meetings.

   The Meeting therefore warmly welcomed the suggestion that the Regional Program develop a newsletter on groundnut improvement, and recommended that this be used to facilitate the exchange of information on research results, national programs, specific technology, training, and workshops, both within and outside the Region.

   The Meeting further recommended that an effort be made to make the information available in both English and Portuguese and therefore requested the Regional Program to explore the feasibility of publishing all or part in Portuguese.

8. The Meeting recommended that:
   - A regional multidisciplinary workshop be organized by the Regional Program at least once in every two years in different countries of the Region, and that these should be held at a time when maximum benefit would be derived from field visits during the course of the Meeting.
   - Such workshops be supplemented by monitoring tours or visits made by restricted groups drawn from the National Programs which would form on specialized areas and
   - ICRISAT center staff make specialist visits to meet particular needs on request of National Programs when these arise, those visits to be coordinated after the regional level.

9. While emphasizing the great benefits of easy germplasm flow, the Meeting noted the stringent need for vigilance and appropriate quarantine procedures.

   It requested that representation be made to SACCAR to convene a Meeting to develop appropriate regional practices.

   The Meeting appreciated further that there was a need to assist host countries of regional programs to upgrade and improve existing quarantine facilities in order to handle effectively the increased volume of material.

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