Proceedings of the

Fourth Regional Groundnut Workshop for Southern Africa

International Crops Research Institute for the Semi-Arid Tropics

Abstract

Citation: ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

Twenty-three out of 32 national program scientists actively engaged in groundnut improvement in the Southern African Development Coordination Conference (SADCC) region participated in the Regional Workshop; Angola and Zimbabwe were the only countries of the region not represented in person. However, a paper by a groundnut scientist in Zimbabwe was accepted as presented in his absence. Also participating were groundnut scientists from Kenya, Mauritius, Uganda, ICRISAT Center (India), ICRISAT Saheiian Center (Niger), SADCC/ICRISAT Groundnut Project (Malawi), and ICRISAT's Eastern Africa Regional Cereals and Legumes program (Kenya). Papers reviewed groundnut research on breeding, entomology, agronomy, leaf spot diseases, and cropping systems. The recommendations of the Workshop's plenary session provide valuable guidelines for regional project activities.

Résumé

Référence : ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Comptes rendus du Quatrième colloque régional sur l'arachide pour l'Afrique australe, 19-23 mars 1990, Arusha, Tanzanie. Patancheru, A.P. 502 324, Inde : ICRISAT.

Ce Colloque régional a réuni vingt-trois des 32 chercheurs de programmes nationaux travaillant activement en matière d'amélioration de l'arachide dans la région de la Conférence de coordination du développement en Afrique australe (SADCC). L'Angola et le Zimbabwe étaient les seuls pays de la région ne pas être représentés en personne. Toutefois, une communication par un chercheur de l'arachide au Zimbabwe a été acceptée comme présentée en son absence. Ont également participés à ce Colloque, des chercheurs du Kenya, de l'île Maurice, de l'Ouganda, du Centre ICRISAT (Inde), du Centre sahélien de l'ICRISAT (Niger), du Projet arachide SADCC/ICRISAT (Malawi), et du Réseau régional pour l'Afrique orientale sur les céréales et les légumineuses de l'ICRISAT (Kenya). Les communications ont fait le point des travaux de recherche sur l'arachide portant sur la sélection, l'entomologie, l'agronomie, les cercosporioses, et les systèmes de culture. Les recommandations de la session plénière du Colloque offrent des lignes directrices précieuses pour les activités du projet régional.

Sumário

Citação: ICRISAT (Instituto Internacional de Investigação de Culturas para os Trópicos Semi-Áridos). 1990. Anais da Quarta Conferência Regional de Amendoim para a África Austral, 19-23 de Março de 1990, Arusha, Tanzania. Patancheru, A.P. 502324, India: ICRISAT.

Vinte e três dos 32 cientistas, dos programas nacionais activamente engajados no melhoramento do amendoim na região da Conferência Coordenadora do Desenvolvimento da África Austral (SADCC), participaram na Conferência Regional; Angola e Zimbabwe foram os únicos países da região que não estiveram representados em pessoa. Contudo, um artigo dum cientista do amendoim do Zimbabwe foi aceite e apresentado na sua ausência. Participaram também cientistas do amendoim vindos do Quénia, Maurícias, Uganda, ICRISAT-Centro (India), ICRISAT-Centro Saheliano (Niger), Projecto do Amendoim do SADCC/ICRISAT (Maláwi) e da Rede Regional para Cereais e Leguminosas para a África Oriental do ICRISAT (Quénia). Os artigos versaram sobre a investigação em melhoramento, entomologia, agronomia, doenças de manchas foliares e sistemas de cultivo do amendoim. As recomendações da sessão plenária da Conferência providenciam importantes directrizes para as actividades do projecto regional.

Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa

19-23 Mar 1990
Arusha, Tanzania

ICRISAT

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

1990

Citation: ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

Scientific Editors

G.L. Hildebrand
G. Schmidt
Laxman Singh
P. Subrahmanyam
J.A. Wightman

Publication Editor

J.J. Abraham

Portuguese translation

M.J. Freire

ISBN 92-9066487-9

Contents

Opening Session Chairman's Remarks

F.M. Shao[1]

Our Guest of Honor, Mr Ludovick Rimisho, Deputy Principal Secretary in Ministry of Agriculture and Livestock Development, Team Leader of the SADCC/ICRISAT Groundnut Project Dr Schmidt, the Representative of SACCAR Dr D.M. Wanchinga, participants of the Fourth Regional Groundnut Workshop, ladies and gentlemen:

On behalf of the Commissioner for Research and Training in the Ministry of Agriculture and Livestock Development (MALD), I would like to welcome you to the Fourth Regional Groundnut Workshop for Southern Africa.

We in the Department of Research and Training of the MALD, Tanzania, were very pleased to host the Fourth Regional Groundnut Workshop in Arusha, Tanzania.

We accordingly appointed a local organizing committee to work with the regional scientists to organize the workshop.

We are happy to see that the workshop has materialized and the family of SADCC-groundnut scientists together with other invited national, international, and regional scientists are meeting here this week.

We believe that through regional and international cooperation and collaboration we can strengthen our national programs. It is in that spirit that we participate in the various SADCC regional programs, notably the SADCC/ICRISAT Sorghum and Millets Improvement Program, the SADCC/CIAT Phaseolus Bean Improvement Program, the Grain Legume Improvement Program, in particular the SADCC/ICRISAT Groundnut Project and the SADCC Regional Gene Bank.

Through these programs we expect to see some impact in our national programs in the areas of manpower development and training, and varietal improvement through exchange of germplasm.

Our national groundnut research program is probably not as elaborate as we have in some of the other SADCC countries, e.g., Zambia, Malawi, and Zimbabwe. It is a subprogram of the National Oilseeds Research Program including sunflower and sesame. We need to develop its full complement of research scientists, and we hope that through our collaborative efforts with the regional program we shall be able to do so.

Our guest of honor, before I invite you to officially open the workshop, we shall first receive messages from the Director General of ICRISAT, through the Team Leader of the SADCC/ICRISAT Groundnut Project Dr Schmidt, and from SACCAR by Dr D.M. Wanchinga who is its Manpower and Training Officer. These I believe will be of interest to all of us.

1. Assistant Commissioner, Research and Training, Ministry of Agriculture and Livestock Development, Government of Tanzania.

Welcome from ICRISAT

L.D. Swindale[1]

Participants of the Groundnut Workshop, ladies and gentlemen:

It is with great pleasure that I welcome you to the Fourth Regional Groundnut Workshop for Southern Africa. ICRISAT is most appreciative of the support it has received from the SADCC countries, and we hope to be able to respond with continued and increased input into the improvement of groundnut production in this region.

The active collaboration that has developed between the groundnut researchers of the SADCC countries over the past few years is very gratifying.

Today this workshop takes place in Tanzania, and on behalf of ICRISAT, I thank the Government of Tanzania and the officials who have made this possible. Two previous workshops were held in Malawi and one in Zimbabwe. Holding such meetings in different countries of the region broadens our knowledge and demonstrates the type of regional networking we all desire.

Your advice and assistance are critical in making the SADCC/ ICRISAT Groundnut Project serve you better. We hope the deliberations and the recommendations of this Fourth Regional Workshop will lead to further cooperation and success in helping the groundnut farmers of the SADCC region.

Thank you.

---

1. Director General, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). (The address was read by Dr G. Schmidt, Team Leader and Principal Groundnut Agronomist, SADCC/ICRISAT Groundnut Project, on behalf of Dr Swindale.)

SACCAR Representative's Address

D.M. Wanchinga[1]

The Honorable Guest of Honor Mr Ludovick Rimisho, the Deputy Principal Secretary, the Chief Agricultural Research Officer Dr Frank Shao, the Team Leader of SADCC/ICRISAT Groundnut Project Dr Gerhard Schmidt, and fellow participants:

It is indeed a great privilege for me to say a few words, on behalf of the SADCC-member states, and in particular, on behalf of the Southern African Centre for Cooperation in Agricultural Research and Training (SACCAR). SACCAR, as the Honorable Guest of Honor and fellow participants are aware, is the designated management entity for SADCC regional agricultural research and training programs. These programs are part of the broader SADCC program of action aimed at enhancing food security in the region.

The Honorable Guest of Honor, exactly 2 years ago, at the Third Regional Groundnut Workshop for Southern Africa, held 13-18 Mar 1988 in Lilongwe, Malawi, I was asked to say a few words at the start of the Workshop. To those of you who were there, I apologize if I sound like the kind of guy who can't say anything new. However, the fact that I am mentioning them underscores the significance of these elements. Cooperative agricultural research in SADCC countries started off on the directive of Heads of State and Government when SADCC was formally launched on 1 Apr 1980 in Lusaka, Zambia. Agricultural research and training were among the priority sectors identified by SADCC-member States when they established a program of action in the food, agriculture, and natural resources section.

SACCAR was formed in 1984 as a management entity of collaborative regional agricultural research and training programs. This function is being carried out on behalf of the Government of Botswana, which was mandated by other SADCC-member States (at the formation of SADCC) to coordinate agricultural research and training in the region.

To date there are 16 regional programs which are planned or on-going.

Sir, the Regional Grain Improvement Program is one such program. As a regional program, its conceptual framework is based on a SADCC Grain Legume Improvement Program Feasibility Study conducted in 1984.

The SADCC Regional Grain Legume Improvement Program is conceived as a 15-year program and has three projects under it as recommended by the feasibility study, i.e.,

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

ICRISAT, which had already been running a regional groundnut improvement network with the financial backing of International Development Research Centre (IDRC), has kindly agreed to continue its activities under the auspices of SADCC. This phase of the Regional Groundnut Program (the SADCC phase) is now being funded by the Federal Republic of Germany through the Deutsche Gesellschaft fur Technische Zussamenarbeit (GTZ) wing. In the mean time, we are very grateful to ICRISAT for having been able to sustain this program from its core funds. We are also very grateful to the Government of Malawi which hosts the Project.

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

With the independence of Namibia, this country will formally be inducted as the 10th member of SADCC next month. We are hoping that this Project, like all others under the SADCC program of action, will extend its activities to the new member in our SADCC family of countries. We hope that our cooperating partners will see the need to increase their financial support and goodwill in view of this increased responsibility.

Let me repeat once more that SACCAR is committed to the support of its regional programs, such as this one by soliciting donor support, by direct support to individual scientists through its travel and small research grant programs, by facilitating scientific information exchange through workshops, maintenance of databases on regional agricultural resources, such as those on display here. This support is based on the value these programs have in the development of germplasm required by our farmers and in the development of the human resource base to man our agricultural research systems.

However, sir, we at SACCAR still have a short wish list:

- We are anxious that the situations in Angola and Mozambique should improve quickly so that these countries can benefit fully from the SADCC program of action.
- We are anxious that all regional projects should have functional steering and technical advisory panels to legitimize and systematize the involvement of member States in the management of regional programs.
- We also require that all projects should sign all the formal memoranda of understanding to facilitate the movement of equipment, funds, posting of staff, and in establishing a legal basis for the project activities.
- We are hoping to issue identity cards to project staff to facilitate their movement, particularly to ease the current problems on the requirement of visas.

On behalf of SADCC, and SACCAR in particular, I would like to especially welcome Dr Gerhard Schmidt to the SADCC family and also our colleagues from outside the region who have come to share their experiences with us.

Finally, sir, I would also like to thank the Government of Tanzania for allowing this Workshop to take place here under a very congenial scientific environment. Thanks are also due to the management of Mt. Meru Hotel for providing us with the conference facilities.

In the course of our scientific exchanges, I am hoping that new recommendations will be made to enhance the impact of this Regional Project. As we do so, I hope that we shall also take a critical look at the Project's progress since we last met 2 years ago and also review the progress made on the recommendations made at the Third Regional Groundnut Workshop for Southern Africa.

I look forward to a successful workshop. Thank you.

Opening Address[1]

L. Rimisho[2]

Mr Chairman, distinguished guests, ladies and gentlemen:

I am greatly honored to be with you this morning on this important occasion of the Fourth Regional Groundnut Workshop for Southern Africa.

Indeed, it is a great honor for Tanzania to host this Workshop. First of all, on behalf of the Government and the people of the United Republic of Tanzania, I would like to take this opportunity to welcome you all to Tanzania, particularly to Arusha.

It is unfortunate that the venue of this groundnut workshop is away from the major groundnut-growing areas of the country and you will not be able to see for yourselves the environment under which our farmers grow this crop. Nevertheless, there are many other attractions in this part of the country, such as the best game parks known in the world (e.g., Serengeti, Manyara, Ngorongoro) and the highest mountain in Africa, Mt. Kilimanjaro, perpetually snow-capped. I hope that you will take advantage of being here to see some of these attractions.

Secondly, Mr Chairman, I would like to express our sincere thanks to the sponsors and organizers of this workshop, SADCC/ICRISAT Groundnut Project, Malawi. The initiative and efforts of the Project have made this workshop a success.

I understand that the SADCC/ICRISAT Groundnut Project, in collaboration with national programs, is in the process of developing a regional research program aimed at benefiting all the groundnut-growing areas of southern and eastern Africa.

In this endeavor, the Project has organized three regional workshops similar to this one within the past 7 years. The objective of these workshops is to provide an opportunity for SADCC groundnut research scientists to share effectively and at regular intervals their research experience, to review progress made during the intervening years, and to interact further by jointly discussing problems, possible solutions, and prospects for improvement within the region through cooperative ventures for mutual benefit.

I am told that this workshop brings together participants from Lesotho, Swaziland, Botswana, Zimbabwe, Zambia, Malawi, Mozambique, Tanzania, and representatives from Mauritius, Kenya, and Uganda as well as scientists from other parts of the world. I am proud to note that the spirit of regional cooperation embodied by the SADCC-member states is not mere rhetoric, but is here translated into practical scientific research for the benefit of the region.

Mr Chairman, I wish to assure you that my Government recognizes the role played by the SADCC/ICRISAT Groundnut Project in promoting groundnut research in the region, and fully supports the cooperation between national programs fostered by the Project.

However, Mr Chairman, allow me to mention the obvious, that the main actor involved in all this organization and research efforts is the farmer. A groundnut farmer is, to be specific, a large-scale commercial farmer or a small-scale, resource-poor farmer. Therefore, the profitable interactions between the Project and the national programs and between the national programs themselves will take place only if we know the needs of our farmers. That is, the resources available to the farmer and their limitations, the complexity of the problems which limit increased yields and efficiency in the utilization of resources. Careful consideration of all these factors should form the basis of properly laid out research strategies, for agricultural research takes time and is expensive.

For historical reasons, it is appropriate that the Fourth Regional Groundnut Workshop for Southern Africa is held in Tanzania. The first concerted efforts to promote large-scale groundnut cultivation in what is now the SADCC region, started here in Tanzania (then Tanganyika) during the late 1940s when the colonial government

1. Delivered on behalf of the Minister of Agriculture and Livestock Development S. Wassira.
2. Deputy Principal Secretary, Ministry of Agriculture and Livestock Development, Tanzania.

embarked upon a large-scale groundnut scheme in southeast and central Tanzania. The original plan was to grow 3.2 million acres (1.3 million ha) of groundnut estimated to produce 800 000 t of nuts annually. Sadly, because of the lack of knowledge of the local environment and inadequate research, the scheme failed after an estimated expenditure of over 36,000,000 pounds sterling in less than 10 years.

It is significant to note that the calamity of the Groundnut Scheme did not deter the small resource-poor farmer to continue growing groundnuts. Today, central and southeastern Tanzania are still the major groundnut areas of the country.

Mr Chairman, I have no doubt that the distinguished scientists gathered here today have more knowledge than myself on the problems limiting production of groundnuts in our region. I believe that problems such as diseases (e.g., leaf spots, rust, and rosette virus) and drought are common throughout the region. There are also other problems that are unique to each country.

In Tanzania, 100% of groundnuts are produced by the small-scale, resource-poor farmers. Intercropping is predominant without the use of mineral fertilizers and pesticides. Seeds of improved varieties are not available. The crops are devastated by disease and insect pests. Under such situations, the yields are low. Most of the improved production packages provided in the past were based on pure stand culture, which may be in conflict with other interests of the farmer.

Mr Chairman, here is a challenge to the scientists. What is required is to understand the philosophy behind the farmers' production systems and to improve on those systems, without interfering too much with the basic philosophy. In short, the small-scale farmers require specific production packages to suit their needs under their environment. These packages include varieties adapted to the specific farming systems including intercropping, and also adapted to very low-input situations. These varieties should be resistant to insect pests and diseases. This should not be construed to mean that the scientist is forced to research on mediocre production systems, but far from it; the research scientist must strive to develop production packages that will increase small-scale farmers' yields per unit area of land. But, these packages must be in concert with the resources available to the farmers and their level of management. This, then, will be appropriate technological innovation for the small-scale farmer. High-yielding varieties requiring high inputs are also required to encourage medium- and large-scale farmers to join the groundnut subsector.

However, Mr Chairman, the development of suitable production packages should not be an end in itself. Scientists and Extension Officers must work closely together to ensure that the farmers adopt the recommended packages. The concept of the systems approach may be of great advantage.

Mr Chairman, in conclusion, I have no doubt that you and the other scientists present here today will agree with me that the small-scale farmer is the target beneficiary of research findings today in the SADCC region as well as in other developing countries. This is because the small-scale farmer is the main producer of food crops and export crops. For these reasons, I believe that your deliberations this week will focus on the needs of our small-scale farmers and the opportunities available to improve their lot.

With these remarks Mr Chairman, it is my great pleasure to declare your workshop officially open.

Thank you for your attention.

Regional Program

Effect of Timing of Single Applications of Fungicide on Groundnut Yield

G.L. Hildebrand[1] and K.R. Bock[2]

Abstract

Recent research in Zambia has shown that a strategically timed single application of fungicide to control early leaf spot (Cercospora arachidicola) *in groundnut (*Arachis hypogaea *L.) has resulted in significant yield responses.*

The current recommendation for early leaf spot control in some countries is to make six fungicide applications, a practice recently shown to be uneconomic in Malawi.

Investigations at Chitedze Research Station, Lilongwe, Malawi, into the effect on groundnut yield of timing of single applications of fungicide have provided promising results. A single application of chlorothalonil made 50-70 days after sowing resulted in significant yield responses in Malimba groundnut in the 1987/88 and 1988/89 cropping seasons. A single application made 63 days after sowing resulted in a significant yield response in the Virginia cultivar ICGV-SM 83708 (ICGMS 42), in the 1988/89 cropping season.

Further research on timing of fungicide applications in relation to progress of the epidemic is warranted.

Sumário

Efeito do Tempo de Aplicações Únicas de Fungicidas no Rendimento do Amendoim. *Investigação recente na Zambia mostrou que, para o controlo da mancha temporã (*Cercospora archidicola*) no amendoim (*Arachis hypogaea *L.), uma aplicação única de fungicida, feita numa data estratégicamente definida, resultou em significativas respostas do rendimento.*

A actual recomendação para o controlo da mancha temporã em alguns países, é fazer seis aplicações de fungicida. Recentemente, esta prática mostrou não ser económica no Maláwi.

Investigações na Estação de Investigação de Chitedze, Lilongwé, Maláwi, sobre o efeito do tempo de aplicações únicas de fungicidas forneceram resultados promissores. Uma aplicação única de chlorthalonil, feita 50-70 dias depois da sementeira, resultou em significativas respostas do rendimento do amendoim Malimba, durante as estações de cultivo de 1987/88 e 1988/89. Uma aplicação única, feita 63 dias depois da sementeira, resultou numa significativa resposta do rendimento do cultivar , do tipo virginia, ICGV-SM 83708 (ICGMS 42), durante a estação de cultivo de 1988/89.

Futura investigação sobre aplicações atempadas de fungicida em relação ao progresso da epidemia é garantida.

1. Principal Groundnut Breeder, SADCC/ICRISAT Groundnut Project, Chitedze Agricultural Research Station, P.O. Box 1096, Lilongwe, Malawi.
2. Team Leader and Principal Groundnut Pathologist at the above address. Present address: P.O. Box 641, Ukunda, Kenya.

ICRISAT Conference Paper no. CP 621.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

Introduction

Early leaf spot (*Cercospora arachidicola* Hori) is the most important groundnut *(Arachis hypogaea* L.) disease in the Southern African Development Coordination Conference (SADCC) region. Epidemics are consistently severe and, at Chitedze Research Station in Malawi, yields are reduced by 40-80%.

Fungicidal control of early leaf spot is very effective and yields can be increased dramatically by the use of chemicals. However, most groundnut growers in the SADCC region are smallholder farmers who have limited financial and other resources. The current recommendation in some countries of six fungicide applications is very costly and has recently been shown to be uneconomic in Malawi (Mwenda and Cusack 1989).

Researchers in Zambia have shown that a single fungicide application to Virginia cultivars at about 75 days after sowing (DAS) has resulted in economic control of leaf spot (Kannaiyan et al. 1989).

The fungicide used in these studies was thiophanate methyl + maneb (Labilite®), a locally formulated fungicide, but more recently a mixture of mancozeb and benomyl has been shown to be equally effective and more economical (J. Kannaiyan, Legumes Pathologist, Msekera Regional Research Station, P.O. Box 510089, Chipata, Zambia, personal communication).

We have investigated responses of two groundnut cultivars to a factorial combination of up to five applications of chlorothalonil at varying dates.

Materials and Methods

The susceptible Spanish cultivar Malimba was sown in a trial at Chitedze Research Station in 1987/88 to assess the effect of a single application of chlorothalonil on the severity of early leaf spot and on yield. The design used was a 2^5 factorial in incomplete blocks with two replications. The fungicide was applied at 36, 50, 64, 78, or 92 DAS.

In 1988/89 the Malimba factorial trial was sown at two dates to assess the effect of single applications on crops at different stages of growth during the disease epidemic.

The fungicide was applied at 36, 50, 64, 78, or 92

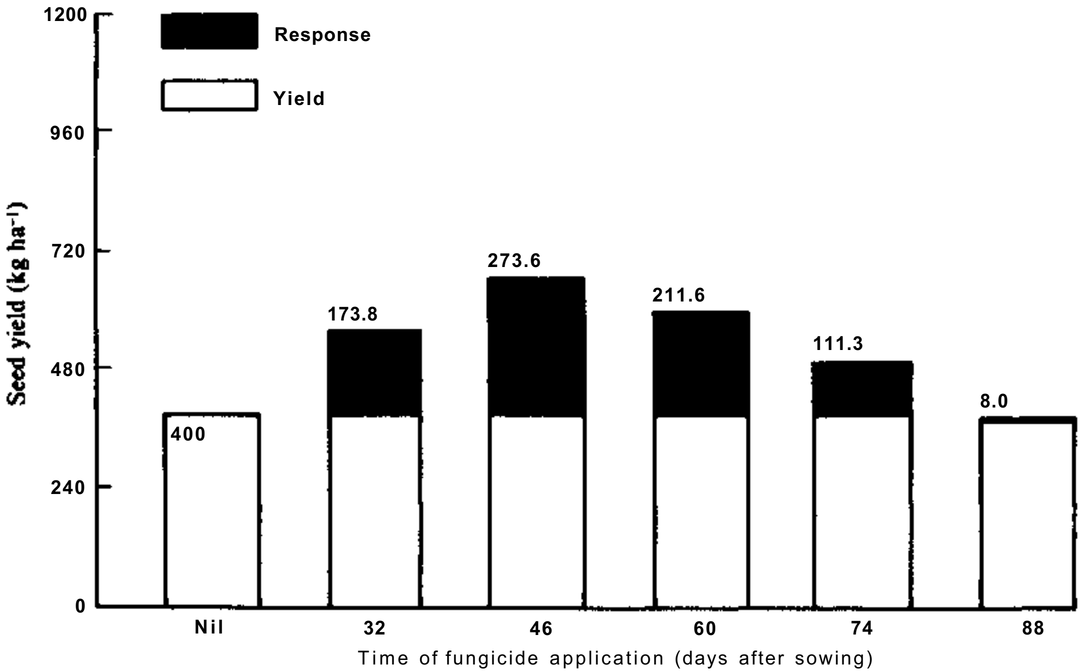


Figure 1. Effect of timing of single applications of fungicide on seed yield of groundnut cv Malimba, at Chitedze Agricultural Research Station, Malawi, 1987/88.

DAS in the early-sown Malimba, and at 34, 48, 62, 76, or 90 DAS on the late-sown Malimba.

In a different experiment, we assessed the effects of single applications of chlorothalonil on the early leaf spot tolerant Virginia selection, ICGV-SM 83708 (ICGMS 42). Fungicide was applied at 36, 49, 63, 77, or 93 DAS.

Assessments of early leaf spot severity were made on all trials at regular intervals throughout the season. After harvest, measurements were made on yield, shelling percentage, and seed size.

Results

There were highly significant yield responses in 1987/88 to single applications of fungicide made at 32, 46, 60, or 74 DAS. The largest response was 273 kg ha^{-1} and resulted from an application at 46 DAS (Fig. 1).

In 1988/89, there were highly significant yield responses to single applications of fungicide made at 36, 64, 78, or 92 DAS on Malimba sown with the first rains. The largest response (122 kg ha^{-1}) was from a spray at 64 DAS (Fig. 2). Sprays at 64, 78, or 92 DAS resulted in significant increases in seed size but shelling percentage was not affected.

On late-sown Malimba, single applications at 48, 62, or 76 DAS resulted in significant yield responses (Fig. 3). The largest response (74 kg ha*[1]) was from a spray at 62 DAS.

Applications at 62, 76, or 92 DAS increased shelling percentage significantly and sprays at 62 or 76 DAS resulted in significant increases in seed size.

Yield of the late-sown Malimba was considerably lower than that of the early-sown trial (Figs. 2 and 3). This could be attributed to the effect of later sowing and to high leaf spot inoculum levels prevailing at earlier stages of crop development.

On ICGV-SM 83708 (ICGMS 42), only the application made at 63 DAS resulted in a significant yield increase (153 kg ha^{-1}) (Fig. 4). The spray at 92 DAS resulted in a significant decrease in shelling percentage but seed size was not affected by fungicide application.

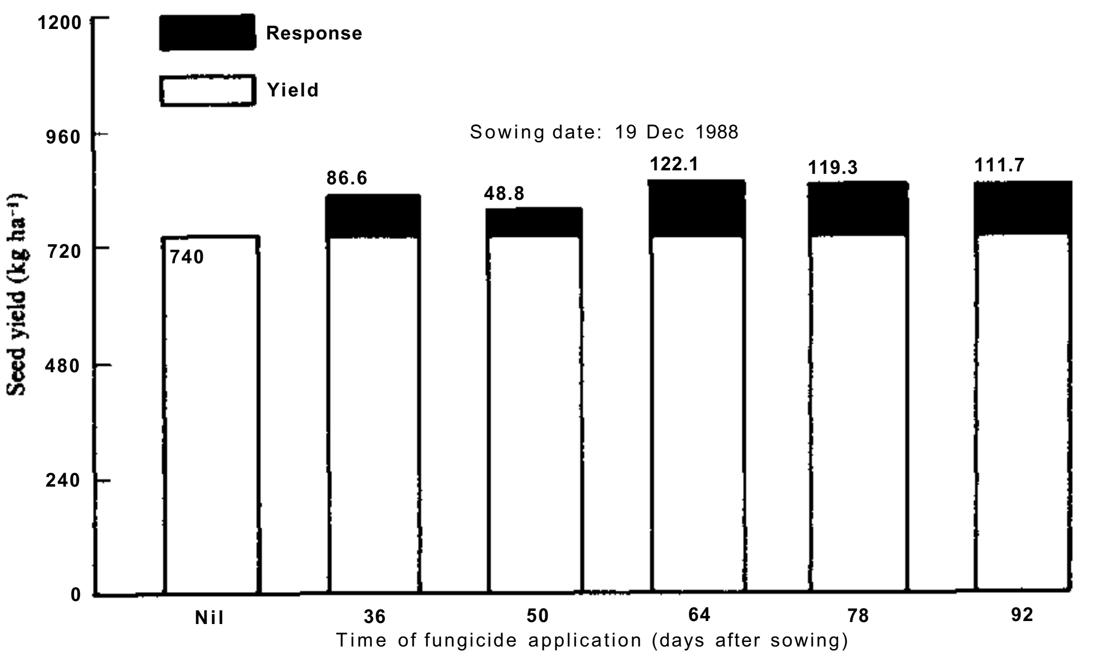


Figure 2. Effect of timing of single applications of fungicide on seed yield of groundnut cv Malimba, at Chitedze Agricultural Research Station, Malawi, 1988/89.

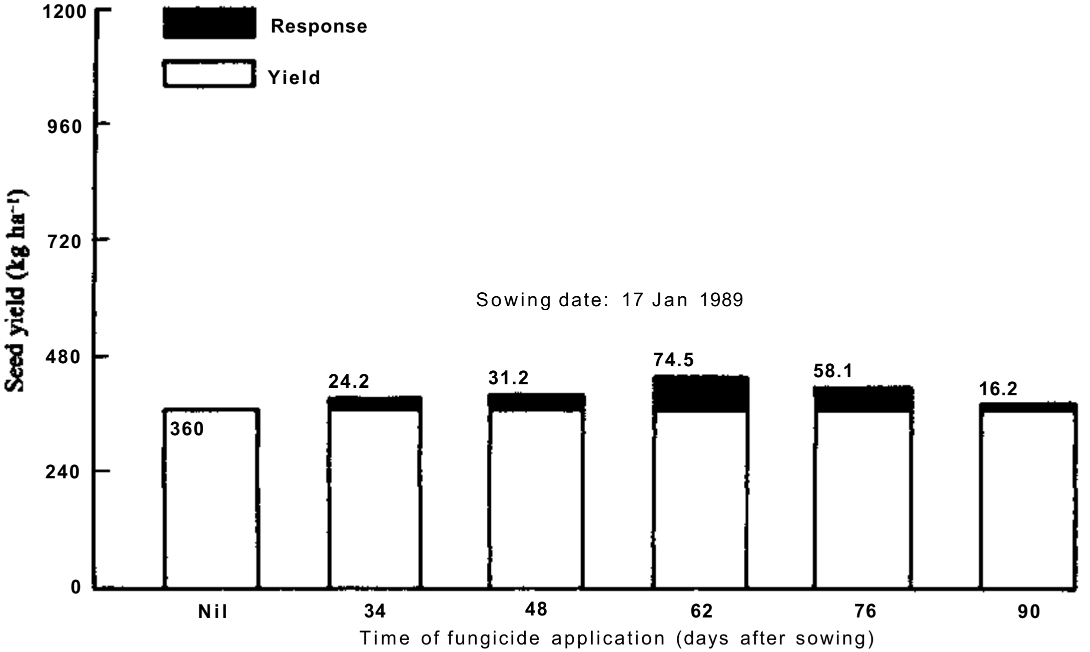


Figure 3. Effect of timing of single applications of fungicide on seed yield of groundnut cv Malimba, at Chitedze Agricultural Research Station, Malawi, 1988/89.

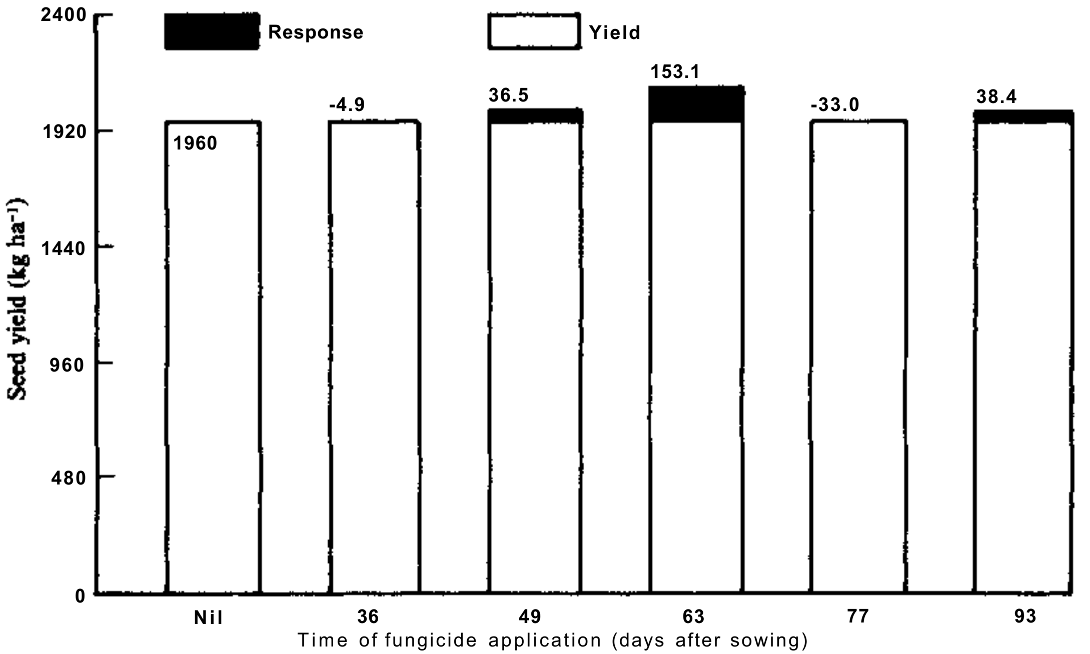


Figure 4. Effect of timing of single applications of fungicide on seed yield of groundnut ICGV-SM 83708 (ICGMS 42), at Chitedze Agricultural Research Station, Malawi, 1987/88.

Discussion

These results support the Zambian findings and indicate considerable promise for yield improvement at considerably lower cost than the current recommendation of six applications.

Although the limited data presented here suggests that fungicide applied to Malimba at 50-70 DAS is most beneficial, regardless of season or sowing date, we have not fully investigated the differences in the epidemic progress among seasons, host genotypes, and sowing dates. Further research is warranted on timing of fungicide application in relation to progress of the epidemic.

References

Kannaiyan, J., Sandhu, R.S., Haciwa, H.C., and Reddy, M.S. 1989. Management of leaf spots of groundnut in Zambia. Pages 35-41 *in* Proceedings of the Third Regional Groundnut Workshop for Southern Africa, 13-18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Mwenda, A.R.E., and Cusack, T.J. 1989. An economic evaluation of smallholder farmers' use of the fungicide chlorothalonil (Daconil® 2787 W-75) on groundnuts in Lilongwe Agricultural Development Division, Malawi. Pages 65-73 *in* Proceedings of the Third Regional Groundnut Workshop for Southern Africa, 13-18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Discussion

Subrahmanyam: Did you work out the cost-benefit ratio?

Hildebrand: The results are only preliminary. The cost-benefit ratio was not worked out.

Subrahmanyam: Did you consider the possibility of using other cost-effective fungicides?

Hildebrand: We will consider this for inclusion in future trials.

Rao: Do you have data on the relative disease pressures at different sowing times?

Hildebrand: We have collected the data but have not analyzed it so far. Hopefully the new pathologist would be able to do it.

Rao: Do you feel that an optimal disease pressure is a prerequisite for a positive response of the crop to fungicidal spraying?

Hildebrand: We hope that together with Dr Butler, Principal Microclimatologist, we will be able to explore the relationship of yield (and therefore, disease pressure) and response.

Subrahmanyam: The research on optimizing the fungicide use in early leaf spot management is fascinating and should be continued. Some of the differences in yield response between seasons were probably dependent on the time of onset of the disease and the rate of disease progress.

Hildebrand: Yes, we have sufficient data. It needs to be evaluated.

Mayeux: Apparently your best results from chlorothalonil have been obtained during the drier season of 1988/89. This means that chlorothalonil, being a contact fungicide, was not washed away by rainfall and was able to protect plants for a longer period. Therefore, early treatment at 46 DAS was better—but the peak of the attack should be at about 60 DAS.

Recent Results with Early-maturing Groundnut Genotypes

G.L. Hildebrand[1]

Abstract

*Greater emphasis has recently been placed on the need for groundnut (*Arachis hypogaea *L.) genotypes that are able to give high yields in short growing seasons. In some areas of the Southern African Development Coordination Conference (SADCC) region the rainy seasons are short, while in some other areas of the region slow growth rates caused by low temperatures require early-maturing groundnut genotypes.*

Recent evaluation of a group of early-maturing groundnut breeding lines at Chitedze Research Station, Lilongwe, Malawi, has shown that there are genotypes available that have the ability to produce encouraging yields in short seasons and when sown late.

Use of the concept of thermal time to estimate growing season length for genotypes at Chitedze has shown a considerable degree of consistency across seasons. There was, however, a lack of consistency in thermal season length among different locations.

Sumário

Resultados Recentes com Genótipos de Amendoim de Maturação Precoce. *Maior enfase tem sido posta recentemente na necessidade de genótipos de amendoim (*Arachis hypogaea *L.) capazes de produzir altos rendimentos em estações de crescimento curtas. Nalgumas áreas da região da Conferência Coordenadora do Desenvolvimento da África Austral (SADCC) a estação das chuvas é curta, enquanto que nalgumas outras áreas da região, baixas taxas de crescimento causadas por baixas temperaturas requerem genótipos de amendoim de maturação precoce.*

A recente avaliação de um grupo de linhas de melhoramento de amendoim de maturação precoce, na Estação de Investigação de Chitedze, Lilongwé, Maláwi, mostrou que existem genótipos disponíveis com a habilidade de produzir rendimentos encorajadores em estações curtas e quando semeados tarde.

O uso do conceito de tempo termal para estimar a duração da estação de crescimento, em Chitedze, mostrou um considerável grau de consistência em relação às estações. Houve, contudo, uma falta de consistência na duração da estação termal em relação aos diferentes locais.

Introduction

The SADCC/ICRISAT Groundnut Project recognizes two major constraints to groundnut (*Arachis hypogaea* L.) production in the Southern African Development Coordination Conference (SADCC) region. These are diseases, of which early leaf spot (*Cercospora arachidicola* Hori) is the most serious, and

1. Principal Groundnut Breeder, SADCC/ICRISAT Groundnut Project. Chitedze Agricultural Research Station, P.O. Box 1096, Lilongwe, Malawi.

ICRISAT Conference Paper no. CP 622.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

the lack of suitable genotypes adapted to the many and varied agroecological requirements of the region. One such requirement is that of genotypes adapted to short rainy seasons or areas that frequently experience drought spells during the growing period.

The areas most affected by short seasons are Botswana, southern Mozambique, and southern Tanzania, where the rainy seasons are short. Lesotho experiences a similar constraint in that the season length of groundnut is extended by low temperatures which reduce growth rate and delay maturity.

The incorporation of fresh seed dormancy into early-maturing genotypes would be of great benefit because of poor and unpredictable rainfall distribution in Botswana, with rains often falling at end of the season when groundnuts are mature.

It has not been possible for the SADCC/ICRISAT Groundnut Project to place much emphasis on screening and breeding for drought resistance, but it has attempted to evaluate germplasm for early maturity and to make this material available to national programs. Promising lines have also been used as parents in the breeding program.

We have evaluated entries in the Third International Early Groundnut Varietal Trial distributed by ICRISAT Center and the results of trials conducted at the Chitedze Research Station are reported in this paper. We also report our attempts to use temperature parameters as an index for season length, and to establish a base-line for season length that can be used to select, at Chitedze, early-maturing germplasm likely to be adapted to other areas.

Materials and Methods

The International Early Groundnut Variety Trial (IEGVT) was first conducted at the Chitedze Research Station in the 1987/88 cropping season. On the basis of the results, it was decided to repeat the trial in the 1988/89 cropping season but at two sowings, normal and late, and to harvest each trial on two dates, early and normal.

A mean season length for the Spanish cultivar Malimba was established for Chitedze from data recorded on groundnut varietal trials conducted from 1982/83 to 1987/88 cropping seasons (Table 1). Mean season length was estimated by time (days) and thermal time °C day (Ong 1986). A mean value of 1350°C day was used as a standard for Spanish genotypes and entries in the first sowing were harvested at 1200°C days (early) and 1350°C days (normal) to determine performance under short-season conditions and to identify those entries that did not require extended season length to realize their full potential.

The second sowing was made to determine the effect of delayed sowing on these entries and to identify any entries that were relatively insensitive to delayed sowing.

Temperature data for the past few seasons have been assembled for selected locations in the SADCC region to estimate respective thermal season lengths. These locations were selected to cover a wide range of latitudes and altitudes and represented some of the areas identified above.

Table 1. Season length for groundnut cv Malimba at Chitedze, Malawi, 1982/83 to 1987/88.

Season	Sowing date	Time to maturity (days)	Time to maturity (°C day)
1982/83[1]	29 Nov 82	129	1603
1983/84	13 Dec 83	120	1425
1984/85	16 Nov 84	116	1364
1985/86	20 Nov 85	113	1301
1986/87	8 Dec 86	109	1337
1987/88	7 Dec 87	108	1359
Mean		116	1398

1. Trial was dry sown; first significant rain fell on 9 Dec 1982.

Results

The first (normal) sowing of the IEGVT in the 1988/89 cropping season was harvested on two dates: the first, when the crop had accumulated about 1200°C days [at 107 days after sowing (DAS)], and the second at about 1350°C days (117 DAS).

All the 23 test entries outyielded the local control Natal Common, in the early-harvested plots (plant stand of Natal Common was only 76% of normal). The highest-yielding entry was ICGV 86061 (Table 2). Natal Common recorded only 59.2% shelling, whereas 16 test entries recorded more than 65% shelling, and ICGV 86061 more than 70% shelling.

All entries again outyielded Natal Common on plots harvested after 1350°C days. The highest-yielding entries were ICGV 86061 and ICGV 86105 with yields of 859 kg ha^{-1}, whereas the yield of Natal

Table 2. Mean seed yields of entries in Third International Early Groundnut Variety Trial, Chitedze, Malawi, 1988/89.

Identity	Mean seed yield (kg ha^{-1})		
	Season A[1]	Season B[1]	Season C[1]
ICGV 86038	489	586	566
ICGV 86042	595	762	461
ICGV 86045	522	809	577
ICGV 86053	650	706	558
ICGV 86055	674	786	616
ICGV 86056	535	695	483
ICGV 86060	560	773	581
ICGV 86061	704	871	687
ICGV 86063	411	555	456
ICGV 86066	578	678	510
ICGV 86014	466	732	553
ICGV 86015	424	526	429
ICGV 86081	526	659	537
ICGV 86086	529	698	555
ICGV 86016	572	522	429
ICGV 86017	430	579	509
ICGV 86091	545	777	493
ICGV 86092	372	581	515
ICGV 86094	531	673	451
ICGV 86103	500	639	465
ICGV 86105	637	859	652
ICGV 86112	595	639	406
ICGV 86117	415	538	447
Controls			
Chico	488	422	445
Natal Common	212	395	338
SE	±48.5	±52.4	±33.3
Trial mean (25 entries)	518	659	509
CV (%)	16.9	13.8	11.3

1. Season A = Normal sowing (7 Dec 1988), early harvest (1200 °C day, 107 days after sowing).
B = Normal sowing (7 Dec 1988), normal harvest (1350 °C day, 117 days after sowing).
C = Late sowing (6 Jan 1989), early harvest (1200 °C day, 110 days after sowing).

Common was 395 kg ha^{-1}. Shelling percentages were more than 68% in all entries, the highest (74.1%) recorded by ICGV 86061.

Only one harvest (early) was taken from the late-sown trial as all entries approaching maturity had severe defoliation by early leaf spot. Some entries were harvested after 97 days when only 1094°C days had accumulated. In spite of an improved plant stand in Natal Common, it was outyielded by all other entries. The highest-yielding lines were ICGV 86061 and ICGV 86105. Both recorded seed yields more than 650 kg ha^{-1}. Shelling percentage was 70% for ICGV 86061 and 72% for ICGV 86105. These entries have shown remarkable yield stability at Chitedze.

Comparison of season lengths for selected locations (Table 3) indicates a lack of agreement of data for Sebele (Botswana) and Umbeluzi (Mozambique) with that of Chitedze (Malawi) and Maseru (Lesotho), although in terms of days, Sebele, Umbeluzi, and Chitedze compare reasonably well. High thermal unit values at Sebele could be attributed to high daily maxima, although the reason for reduced growth rate is reported to be low daily minima. At Umbeluzi, high thermal unit values are because of the high daily minima recorded. However, season length does not appear to be reduced accordingly.

Discussion and Conclusions

These results indicate the availability of groundnut genotypes that could be well adapted to areas of short rainfall duration and also to areas or cropping systems where sowing of groundnut is delayed until after cash crops have been sown. Two genotypes in this trial series show particular merit.

Use of the concept of thermal time to establish an index for selection for early maturity seems possible, but lack of agreement in values among locations deserves further investigation. The need to consider different base temperature values in the calculation of thermal unit values is suggested.

Evaluation of early-maturing germplasm from the ICRISAT Center Breeding Unit will continue. We have selected promising early-maturing lines to include as parents in crosses and we have also recently included dormant Spanish germplasm lines in crosses.

There will be a greater need in the future to screen and evaluate for earliness of growing numbers of germplasm lines and breeding populations. We look forward to delegating some of this responsibility to national programs, which are better located geographically than our Project, to undertake this work.

Table 3. Season length for spanish groundnut genotypes at four selected SADCC locations, 1986-89.

Location	Genotype	Season	Sowing date	Time to harvest (days)	Time to harvest (°C day)
Sebele,	Sellie	1986/87	10 Nov 86	113	1914
Botswana[1]		1987/88	30 Nov 87	128	1973
		1988/89	11 Nov 88	124	1736
Maseru,	All	1987/88	4 Dec 87	193	1437
Lesotho[2]	entries	1988/89	18 Dec 88	195	1287
Umbeluzi	Bebiano	1987/88	2 Dec 87	131	2292
Mozambique	Branco	1988/89(1)	30 Aug 88	141	1932
		1988/89 (2)	31 Oct 88	105	1577
		1988/89 (3)	31 Dec 88	110	1725
Chitedze,	Malimba	1986/87	8 Dec 86	109	1337
Malawi		1987/88	7 Dec 87	108	1359
		1988/89	7 Dec 88	121	1403

1. Severe rainfall deficits occurred at critical stages of growth in 1986/87 and 1987/88 seasons.
2. Thermal unit values estimated from mean monthly temperatures.

Reference

Ong, C.K. 1986. Agroclimatological factors affecting phenology of groundnut. Pages 115-125 *in* Agrometeorology of groundnut. Proceedings of an International Symposium, 21-26 Aug 1985, ICRISAT Sahelian Center, Niamey, Niger. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Discussion

Freire: The use of thermal units for the evaluation is a good approach to assess groundnut duration. To make the method of evaluation uniform, the time to get a certain percentage of mature seeds could be used instead of the harvest date. In this way, various SADCC countries could use the same methodology.

Hildebrand: This is what we are doing. In the 1989/90 cropping season, we have a lifting date trial, where we harvested two varieties on eight dates to plot trends of yield and seed size to establish optimal season length.

Busolo-Bulafu: It is true that many countries in Africa experience dry spells of varying lengths during the growing season, thus affecting the yields of the groundnut crop. As a result, many breeding programs have started to breed for resistance to drought per se, or for earliness, so that the varieties can grow within the rainfall pattern. What would you consider to be the lowest acceptable yield expected in these early-maturing varieties?

Hildebrand: That is a difficult question. We have not considered the lowest acceptable yield, but I agree with you that there must be a limit. This would depend on the partitioning of assimilates and on the type of groundnut the farmer wants to grow.

Mayeux: Which parents are you using for your dormancy breeding program?

Hildebrand: 73-30 and ICG 944 are being used.

Mayeux: Do you intend to submit your selected lines to physiological tests?

Hildebrand: We would welcome additional evaluation of our material.

Mayeux: It will be a pleasure to test your new early-maturing material.

Syamasonta: What are the possibilities of separation of dormancy from early-maturity period?

Hildebrand: True Spanish varieties do have dormancy of up to 42 days which is being used in the hybridization program at Chitedze.

Chigwe: Can some of the variation in time to harvest between Maseru and the other three sites (Table 3) be attributed to the use of all entries at Maseru compared to a single genotype at the other sites?

Hildebrand: No, all the entries used were harvested on the same day in both seasons. The differences are therefore true variations in days to harvest among the sites.

Special Reports

A Review of Pops' Research in Zambia

M.B. Syamasonta[1]

Abstract

*Between 1958 and 1978, several experiments were conducted to study the occurrence of 'pops' in groundnut (*Arachis hypogaea *L.) in Zambia. The results have revealed that 'pops' occurs when groundnuts are grown on acidic soils (pH below 4.5). Calcium deficiency in the soil was singled out as the main cause of 'pops'. High potassium : calcium ratios in the soil were found to raise aluminium toxicity and lower the pH value of the soil. Liming significantly raised the soil pH, lowered 'pops' percentages, and increased seed yields of groundnuts. Varietal differences in susceptibility to 'pops' were observed. A hybridization program followed by screening for 'pops' tolerance is suggested.*

Sumário

Uma Revisão da Investigação sobre "pops" na Zambia. *Entre 1958 e 1978, muitos experimentos foram conduzidos para estudar a ocorrência de "pops" (vagens chochas) no amendoim (*Arachis hypogaea *L.) na Zambia. Os resultados revelaram que as "pops" ocorrem quando o amendoim é cultivado em solos ácidos (pH menor que 4,5). A deficiência de cálcio foi identificada como a principal causa das "pops". Observou-se que uma alta razão potássio : cálcio no solo aumenta a toxicidade do alumínio e baixa o pH do solo. Calagens aumentaram significativamente o pH do solo, baixaram a percentagem de "pops" e aumentaram os rendimentos de amendoim em grão. Diferenças varietais quanto à susceptibilidade às "pops" foram observadas. Um programa de hibridação seguido por avaliação da tolerância às "pops" é sugerido.*

Introduction

Groundnut (*Arachis hypogaea* L.) is well adapted to the medium-rainfall areas of Central Africa. It is an important food legume which grows well on most soil types but is susceptible to foliar diseases such as early leaf spot (*Cercospora arachidicola* Hori) and rosette virus. The popularity of groundnut in this region is well demonstrated by the rapid disappearance of Bambara groundnuts, for many years a dominant crop in Central Africa.

In spite of a high-yielding capacity and good adaptability, groundnut seed yields are reduced because of the occurrence of pops (empty pods), caused by calcium (Ca) deficiency in the soil, according to Herbert's report of 1970 (Sarmezey 1978, pp. 3-5). The most striking is that 'pops' becomes apparent only at shelling after an apparently normal growth, nodulation, and pod setting.

The occurrence of 'pops' in groundnuts was first observed in 1885 by Jones (Sarmezey 1978, pp. 3-5) who reported that unless the soil contains a good percentage of lime in some form in an available state, no land will produce a paying crop of pods, although it may yield large luxuriant vines.

Experiments with liming (calcareous and dolomi-

1. Groundnut Breeder and Coordinator, Msekera Regional Research Station, P.O. Box 510089, Chipata, Zambia.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

tic) materials and later with gypsum ($CaSO_4.2H_2O$) were initiated by Duggar and Funchess in 1911 in USA. Killinger and others carried out the first experiments from 1923 to 1928 with gypsum, while Brady and others in 1945 reported varietal differences in the response of groundnuts to the application of lime and gypsum (Sarmezey 1978, pp. 3-5). The results of these experiments helped to identify the cause of 'pops' occurrence and varietal variation in groundnuts.

Pops' Research in Zambia

The problem of 'pops' in the high-rainfall areas of Zambia, where the heavily leached soils have a pH of less than 4.5, is far more serious than in the southern USA (Sarmezey 1978). The phenomenon is not only confined to Zambia but also occurs in neighboring countries of Zimbabwe and Malawi, although with less frequency and severity. Sellschop in 1960 reported the occurrence of 'pops' in the Rusape area of Zimbabwe in Virginia types of groundnuts (Sarmezey 1978, pp. 3-5). In Malawi, the occurrence of 'pops' is restricted to the northern region, which has similar soil conditions to those of the Northern and Northwestern Provinces of Zambia (Laurence 1973).

'Pops' are not a seasonal phenomenon, but always occur in specific areas. Calcium levels below 1.0 milliequivalent Ca (100 g of soil)$^{-1}$ are conducive to the formation of 'pops.' According to Henrickson (1967), potassium, magnesium, and boron do not seem to be important.

Between 1958 and 1964, a series of experiments was conducted in Zambia, by different agricultural scientists, to determine the cause of 'pops' in groundnuts. The results of these experiments showed highly significant seed yield increases and low percentages of 'pops' where lime was applied. This suggested that calcium deficiency was the cause of high 'pops' percentages and low seed yields in groundnuts (Hoehman 1982). More experiments were conducted between 1965 and 1970 primarily to confirm the results of the previous workers and to determine the role of other elements in the occurrence of 'pops'. Contrary to Henrickson (1967), Herbert (1970) concluded that calcium was the most important nutrient for groundnuts, although potassium may also be important because of its role in potassium:calcium ratios in certain soils (Table 1).

He further observed that pops occurred when 'here is less than 1.0 milliequivalent Ca (100 g of soil)$^{-1}$. When Ca falls below this critical level, the ratio of soil potassium to soil calcium increases to above 0.2 and 'pops' occur with increasing severity. Further, when the soil pH drops below 4.5, exchangeable aluminium increases markedly. As a result, any addition of calcium in the form of gypsum is less

Table I. Effect of added nutrition on seed yield of groundnuts at three locations, Zambia, 1970[1].

	Seed yield (t ha^{-1})					
	Misamfu		Mansa		Copperbelt	
Nutrient	Without nutrient	With nutrient	Without nutrient	With nutrient	Without nutrient	With nutrient
Lime	0.886	1.063	1.142	1.416	0.357	0.410
Gypsum	0.842	1.107	1.157	1.401	0.381	0.386
Sulfur	0.905	1.044	1.208	1.350	0.386	0.381
Nitrogen	0.896	1.053	1.258	1.300	0.376	0.390
Phosphorus	0.888	1.061	1.043	1.515	0.343	0.424
Potassium	0.911	1.038	1.315	1.315	1.243	0.410
SE	±0.0196		±0.0518		±0.0212	
Mean	0.975		1.285		0.457	
CV (%)	11.4		22.9		31.4	

1. Source: Herbert (1970).

effective in raising the pH of the soil or lowering the levels of aluminium as compared with the same quantity of calcium added as lime. This may be because gypsum is fast reacting and may bind the aluminium oxides completely, leaving no free calcium as soil nutrient. Gypsum was, therefore, found to have negative effects upon haulm growth and was only recommended for crops grown on soil of already suitable reaction (Herbert 1970). However, this type of soil condition is not found in areas where 'pops' occur. Burkhart and Collins (1941) suggested that excessive potassium intake by the growing groundnut fruits in a low-calcium medium retards the transportation of calcium from the plant into the young embryos to such an extent that these may fail to develop. Unfilled inferior fruits or 'pops' are the consequence. Calcium nonavailability to the young seed is reported by Beringer and Taha (1976). A much lower calcium content of the seed compared to that of the shell indicates that calcium does not move passively along a concentration gradient, and that the seed coat may have a regulating function for the calcium supply of the seed. Beringer and Taha carried out an experiment with nutrient solutions using labelled ^{45}Ca and compared cultivars Makulu Red and Natal Common. Translocation of calcium from the shells to the seeds was greater in Natal Common than in Makulu Red. Herbert (1970) also reported a varietal difference in susceptibility to 'pops' in groundnuts. He noted that cv Makulu Red, a medium- to large-seeded Virginia bunch type was more susceptible to 'pops' than Natal Common, the small-seeded Spanish type.

Sarmezey (1978, pp. 3-5) came to the same conclusion. He reported a negative correlation of 'pops' percentage with seed yield, whereas the correlation of 'pops' percentage with the number of pods $plant^{-1}$ was either positive or nonsignificant, but never negative. These relationships confirm previous observations that seed yield is reduced when 'pops' increase, whereas the number of pods $plant^{-1}$ increase or remains unchanged (Table 2).

'Pops' may also be caused by unfavorable conditions, such as drought at pod filling. According to Herbert (1970), the root hairs of the pods are unable to absorb nutrients from the surrounding soil during dry conditions and 'pops' will occur regardless of the calcium status of the soil.

In general, positive responses to lime application have been recorded on soils with a pH below 4.5. Economic assessment of the use of lime and/or gypsum has not been made. Preliminary results of the long-term lime trials indicate a necessity of lime application to acid soil, unless acid-tolerant groundnut cultivars are readily available. However, lime is not easily available and is costly in regions of the country where it is most needed. Most Zambian subsistence

Table 2. Relationship of 'pops' incidence with yield components of groundnut at selected locations, Zambia, 1973-77[1].

Location	Year	Relationship with seed yield (r)	Relationship with number of pods per plant (r)	'Pops' incidence (%) Trial mean	'Pops' incidence (%) Makulu Red
Mufulira	1973	-0.76**	0.21*	27.2	56.5
	1974	-0.212	0.06[2]	29.3	50.2
	1975	-0.64**	-	50.8	82.4
	1976	0.28[2]	0.13[2]	11.2	35.6
	1977	-0.84**	0.63**	29.7	75.5
Luapula	1974	0.31*	0.71**	30.9	56.0
	1975	-0.34*	-	47.6	87.0
	1976	-0.33*	0.35*	50.5	81.2
	1977	-0.58**	0.46*	31.0	67.5
Misamfu	1977	-0.92**	-	24.8	79.3
Mwinilunga	1977	-0.67**	0.082	46.7	79.7

1. Source: Sarmezey (1978, p. 29).
2. NS = Not significant.

farmers expect dramatic yield responses to applied nutrients that do not necessarily apply to calcium applications. Since groundnuts are grown mainly by subsistence farmers whose emphasis is on the production of staple food (maize) rather than cash crops, liming appears an unnecessary expenditure.

Conclusions

In view of the difficulties involved in liming groundnut fields, the best way of overcoming the 'pops' problem seems to be the development of acid-tolerant groundnut cultivars. Screening of new groundnut lines for acid tolerance has identified useful genotypes. A deliberate hybridization program should be initiated to create progenies from which acid tolerance may be effected. It should therefore be possible to make progress using cultivars such as Natal Common, Makulu Brown, and Copperbelt Runner as parents. Breeding will undoubtedly need considerable time, and financial and human resources, but it could be a more effective and cheaper solution than liming.

References

Beringer, H., and Tana, M.A. 1976. ^{45}Calcium absorption by two cultivars of groundnut *(Arachis hypogaea).* Experimental Agriculture 12:1-7.

Beringer, H., and Tekete, A. 1979. Influence of mineral nutrition on seed development of two groundnut cultivars. Communications in Soil Science and Plant Analysis 10(1-2):49l-501.

Burkhart, L., and Collins, E.R. 1941. Mineral nutrients in peanut plant growth. Soil Science Society Proceedings (1941) 6:272-280.

Herbert, R.F. 1970. Summary of work done on the problem of 'pops' in groundnuts. Report. Mount Makulu, Zambia: Department of Agriculture, Research Branch. (Limited distribution.)

Henrickson, K.M. 1967. Survey of proper 'pops' incidence in Northern Province. RB. 7, Chilanga, Zambia: Research Branch, Mount Makulu Central Research Station. (Limited distribution.)

Hoehman, E.M. 1982. A brief review of work done on 'pops' in groundnut in Zambia. Report. Mount Makulu, Zambia: Department of Agriculture, Research Branch. (Limited distribution.)

Laurence, R.C.N. 1973. Improvement of groundnut pod-filling by lime and gypsum, application to some soils in Northern Malawi. Experimental Agriculture 9:353-360.

Sarmezey, A.A.V. 1978. Groundnut (*Arachis hypogaea* L.) variety selection and experiments with respect to pops. MN. 1929 Series. Research Memorandum no. 22 (1971-77). Copperbelt Regional Research Station, P.O. Box 668, Mufulira, Zambia. Mufulira, Zambia: Research Branch, Department of Agriculture, Ministry of Lands and Agriculture. (Limited distribution.)

Discussion

Wanchinga: What is the involvement of the International Institute of Tropical Agriculture (IITA) in solving the acidic soil problem in Zambia?

Syamasonta: I am not aware of the extent of IITA's involvement at a national level.

Wanchinga: Is there a relationship between acidity and calcium deficiency?

Syamasonta: Yes.

Wanchinga: Are there any crops affected by acidity in Zambia?

Syamasonta: Yes. Maize.

Shongwe: In Table 1, I would like to make a correction on the solubility of gypsum. This material is soluble in the soil solution and thus calcium becomes available to plants. Therefore, the decreased yields at the Copperbelt site cannot be attributed to calcium deficiency. Therefore, it is possible that the decreases in groundnut yields at this site are because of possible aluminium toxicity and/or phosphorus deficiency. The addition of gypsum results in the replacement of $A1^{+++}$ from the exchange complex by Ca^{++}, thus increasing the concentration of $A1^{+++}$ in the soil solution. $A1^{+++}$ may affect groundnut growth directly through its toxic effect and indirectly through the fixation of phosphorus.

Syamasonta: Being a plant breeder, I would accept the correction and comments by the soil scientist in good faith. I would like to add also that the Ca:K ratio seems to have some effect on groundnut yields notwithstanding the possible interactions between pH, aluminium and phosphorus.

Mkhabela: Is the SE in Table 1 the SE of the mean or the mean differences?

Syamasonta: It is the standard error of the mean differences.

Ker: Have local sources of phosphate rock been tested on the acid soils in Zambia, and have the economics of phosphate rock and lime been examined?

Syamasonta: Little testing of phosphate rock or analysis of the economics of application of phosphate rock or lime has been carried out.

Ndunguru: Results from work carried out elsewhere indicate that rock phosphates in their natural forms take longer before one gets any response. But when partially acidulated, as is done by the International Fertilizer Development Center (IFDC), then yields obtained are the same as with SSP. Perhaps the Zambian group could link up with IFDC and the Sokoine University studies, supported by International Development Research Centre (IDRC), to jointly look further into this problem.

Musanya: Local people in acid-prone areas grow groundnuts only after they have cut down some tree branches and burned them (Chitemene system). The process seems to overcome the effects of soil acidity. Did the early researchers find out how this process overcomes the effects of soil acidity on groundnuts?

Syamasonta: Yes, the farmers do not burn the branches but their order of crops is millet and cassava; then groundnuts may follow in the second season. McPhilips did some work on the topic but no concrete results were obtained.

Chigwe: There is some useful information presented in this paper especially on the nutritional aspects underlining 'pops' in groundnuts.

Doto: In your conclusions, you advocate hybridization as one possible alternative to deal with the 'pops' problem. Do you have information related to the genetic control for the 'pop' character.

Syamasonta: No.

Rweyemamu: You mentioned that more than 90% of the groundnut crop in Zambia is grown by peasants. You further noted that these peasants regard maize as a major or main crop. Thus, to advise these peasants to apply lime to the groundnut crop (which is regarded as a minor crop) is not acceptable by many peasants in Zambia. Have you tried to advise the farmers to intercrop the maize crops with groundnut so that application of lime to the maize fields could also help reduce 'pops' formation in groundnuts?

Syamasonta: Intercropping trials have been conducted to assess the benefits in groundnut production. However, this cannot be encouraged under large or commercial groundnut production. Also, one should remember that whenever an innovation is taken to the farmers, a scientist should not try to change everything the peasants have been practising.

Regional Screening for Late Leaf Spot and Rust Resistance of Groundnut in Swaziland

Y.P. Rao[1]

Abstract

Swaziland has been charged with the task of screening groundnut (Arachis hypogaea *L.) germplasm for resistance to late leaf spot* (Phaeoisariopsis personata) *and rust* (Puccinia arachidis) *for the Southern African Development Coordination Conference (SADCC) region. The germplasm was sown in January 1990. According to preliminary assessments, the two diseases did not appear in the germplasm screening plot though some germplasm was affected by bacterial wilt* (Pseudomonas solanacearum).

Sumário

Avaliação Regional para a Resistência à Ferrugem e à Mancha Tardia do Amendoim na Swazilândia. *A Swazilândia foi responsabilizada pela tarefa de avaliação de germoplasma de amendoim* (Arachis hypogaea *L.) para a resistência à mancha tardia* (Phaeoisariopsis personata) *e à ferrugem* (Puccinia arachidis) *na região da SADCC (Conferência Coordenadora do Desenvolvimento da África Austral). O germoplasma foi semeado em Janeiro de 1990. De acordo com observações preliminares, nenhuma das doenças apareceu no talhão de avaliação de germoplasma, embora algum germoplasma tenha sido afectado pela murchidão bacteriana* (Pseudomonas solanacearum).

Introduction

Two diseases of groundnut *(Arachis hypogaea L.)*—late leaf spot *[Phaeoisariopsis personata* (Berk. & Curt.) v. Arx] and rust *(Puccinia arachidis* Speg.)—have become endemic and occur annually in epiphytotic proportions in Swaziland. Participants of the Second Southern African Development Coordination Conference (SADCC) Groundnut Breeders' and Agronomists' Meeting held in 1989 at Lilongwe, Malawi, therefore recommended that Swaziland be charged by the SADCC/ICRISAT Groundnut Project with the task of screening germplasm for resistance to these diseases, for the benefit of the SADCC region.

Accordingly, about 75 late leaf spot and rust resistant germplasm lines were received from ICRISAT Center (India) and the SADCC/ICRISAT Groundnut Project (Malawi). Since the germplasm arrived late, it was not possible to sow it at the normal sowing time (October/November). However, the sowing was delayed to mid-January 1990.

Experimental Methods

The test lines were sown in double rows, each 4-m long, at an interrow spacing of 45 cm and an intrarow spacing of 10 cm. A spreader row of Natal Common,

1. Professor, Crop Production Department, Faculty of Agriculture, University of Swaziland, P.O. Luyengo, Swaziland.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

one of the most susceptible cultivars to late leaf spot and rust diseases, was sown after each test line. Compound N:P:K fertilizer 2:3:2(22) was applied at 300 kg ha^{-1} at sowing. The plot was weeded twice. The ICRISAT 1-9 scale was used for scoring each germplasm line against rust and late leaf spot at different stages of crop development.

Progress

Both diseases had already affected the early-sown Regional Yield Trials, especially the Spanish trial, in severe proportions. The diseases had not appeared in the germplasm screening plot. However, bacterial wilt *(Pseudomonas solanacearum* E.F. Smith) was noticed in the plot at about 4 weeks after seedling emergence. Several lines were found severely attacked by the disease, resulting in a heavy loss of plant stand.

The screening nursery is otherwise progressing well and results will be reported in due course.

Breeding

Groundnut Research in Swaziland: 1988/89 Cropping Season

Y.P. Rao[1] and M.S. Mkhabela[2]

Abstract

*Groundnut (*Arachis hypogaea *L.) yield trials, involving 25 Spanish and Virginia entries each, were conducted during the 1988/89 cropping season. Significant differences (P<0.05) were observed among entries in seed yield, shelling percentage, 100-seed mass, and disease reaction. Seed yields ranged from 316 kg ha^{-1} to 896 kg ha^{-1} for the Spanish type, and from 482 kg ha^{-1} to 1158 kg ha^{-1} for the Virginia type. Some entries, especially the large-podded ones, were found to have poor pod filling and shrivelled seed. As expected, late leaf spot* (Phaeoisariopsis personata) *and rust* (Puccinia arachidis) *were the most prevalent diseases. Spanish entries differed with regard to late leaf spot incidence while Virginia entries differed with regard to rust. By their yield performance and reaction to diseases, four Spanish entries ICGV-SMs 85001, 85053, 86014, and 86053, and four Virginia entries ICGM 336 and ICGV-SMs 85751, 85764, and 86761 were identified as the most promising lines. These entries have been selected for evaluation in the National Groundnut Yield Trial, 1989/90.*

Sumário

Investigação do Amendoim na Swazilândia: Estação Agrícola de 1988/89. *Ensaios para o rendimento do amendoim (*Arachis hypogaea *L.), envolvendo 25 variedades - spanish e virginia -cada um, foram conduzidos durante a estação de 1988/89. Foram observadas diferenças significativas (P<0,05) entre variedades, no tocante ao rendimento de grão, percentagem de descasque, massa de 100 sementes e reacção a doenças. Os rendimentos de grão variaram de 316 a 896 kg ha^{-1}, para o tipo "spanish", e de 482 a 1158 kg ha^{-1}, para o tipo virginia. Algumas entradas, especialmente aquelas com vagens grandes, mostraram ter pobre enchimento da vagem e semente enrugada. Como era esperado, a mancha tardia (*Phaeoisariopsis personata*) e a ferrugem (*Puccinia arachidis*) foram as doenças de maior incidência. As entradas "spanish" diferiram no respeitante à incidência de mancha tardia, enquanto que as entradas virginia diferiram no respeitante à ferrugem. Pelo comportamento do seu rendimento e pela reação às doenças, quatro entradas "spanish" (ICGV-SM's 85001, 85053, 86014 e 86053) e quatro entradas virginia (ICGM 336 e ICGV-SM's 85751, 85764 e 86761) foram identificadas como as linhas mais prometedoras. Estas entradas foram seleccionadas para avaliação no Ensaio Nacional de Rendimento de Amendoim, 1989/90.*

1. Professor, Crop Production Department, Faculty of Agriculture, University of Swaziland, P.O. Luyengo, Swaziland.
2. Lecturer at the above address.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

Introduction

Groundnut *(Arachis hypogaea* L.) production in Swaziland is limited to small-scale farmers in the Swazi National Land (SNL) areas. Groundnuts are seldom grown as a sole crop but rather in association with other crops, principally maize.

Groundnut production occupies only 2% of the cultivable land in Swaziland. The national average yield for the crop is disappointingly low. A diagnostic survey of the Cropping System Project revealed that lack of improved varieties, poor quality seed, low soil pH, disease and pest incidence, and lack of marketing opportunities are important constraints to groundnut production in Swaziland.

Until recently, very little attention was paid to groundnut research. Through the assistance of the SADCC/ICRISAT Groundnut Project in Malawi, improved groundnut germplasm has been introduced and tested locally for yield and tolerance of pests and diseases. The germplasm is screened at the University farm at Luyengo Campus and at Malkerns Research Station. Groundnut genotypes found to possess good yield and tolerance of pest and diseases are selected and included in the National Groundnut Yield Trials. These multilocational trials are conducted in areas representing the four agroecological regions of the country. Thirty-one SADCC/ICRISAT groundnut genotypes have been entered into the National Yield Trials, and the SADCC/ICRISAT Regional Yield Trials continue to be a major source of germplasm for the national program.

We report here the results of two regional groundnut yield trials conducted during the 1988/89 cropping season at Luyengo Campus.

Materials and Methods

The trials were conducted during the 1988/89 cropping season (Nov-Apr) on the Crop Production Research farm (altitude 900 m above sea level, annual rainfall 980 mm) at Luyengo Campus of the University of Swaziland. The mean temperatures are 26°C maximum and 15°C minimum, and soils are of ferrisolic type. These soils are characterized by high iron and aluminium oxide contents. They contain about 2% organic matter. The pH (KCl) of the soil was 4.9.

One trial consisting of 25 entries of Spanish, and another of 25 Virginia type groundnuts were sown between 14 and 18 Nov 1988. The design used was a 5 x 5 lattice with four replications. Each plot consisted of four rows 6-m long and spaced 60 cm apart. Seeds were spaced 10 cm apart for the trial of Spanish types and 15 cm for that of Virginia types. A basal application of phosphate (30 kg ha^{-1}) was applied at sowing. Management practices included at least three hand weedings. No chemicals were applied for control of diseases and insect pests. The harvested area consisted of the two center rows of each plot, and seed yield, shelling percentage, 100-seed mass, late leaf spot, and rust incidence (using the ICRISAT 1-9 scale) were measured.

Results and Discussion

Significant differences ($P<0.05$) among entries were recorded in both trials for seed yield, shelling percentage, 100-seed mass, late leaf spot, and rust incidence (Tables 1 and 2). Fifteen Spanish and 14 Virginia entries outyielded their respective controls. As in previous seasons, late leaf spot and rust have been the dominant diseases. Average late leaf spot score in the Spanish trial was 7, and for rust the average score was 1, while in the Virginia trial the score for late leaf spot was 5 and for rust 7. It appears that the Spanish type groundnuts have a higher degree of tolerance of rust than of late leaf spot. Only four entries were satisfactory for both high-yield potential and disease tolerance in each trial. The Spanish cultivars ICGV-SMs 85001, 85053, 86014, and 86053 showed most promise for disease tolerance, while ICGM 336 and ICGV-SMs 85751, 85764, and 86761 showed most promise among the Virginia varieties. These have been selected for further evaluation in the National Groundnut Yield Trial in 1989/90.

In addition to severe disease incidence and dry spells experienced during the season, a further potential production problem is the frequently observed poor pod filling and shriveling of seeds. This may be due to nutritional imbalance.

Future Research

The search will continue for superior genotypes possessing high-yield potential and tolerance of late leaf spot and rust. Since drought appears to be increasingly frequent in certain areas, more emphasis is intended to be placed on screening and selection for drought tolerance. More detailed studies are needed on agronomic practices, including time of sowing,

Table 1. Performance of 25 Spanish type groundnut entries in the SADCC Regional Yield Trial, Luyengo Campus, Swaziland, 1988/89[1].

Entry	Seed yield (kg ha^{-1})	Shelling (%)	100-seed mass(g)	LLS score[2]	Rust score[2]
ICGV-SM 85001	896	65.0	47.5	7.0	1.0
ICGV-SM 83011	830	72.4	49.5	8.1	1.0
ICGV-SM 85038	820	67.4	58.0	9.0	1.0
ICGV-SM 85045	750	71.1	44.5	8.8	1.0
ICGV-SM 83005	732	70.6	50.3	8.8	1.0
ICGV-SM 86053	708	66.5	47.8	7.2	1.0
ICGV-SM 86014	699	66.8	50.8	7.2	1.0
ICGV-SM 86080	687	69.8	44.3	8.7	1.0
ICGV-SM 83031	652	69.2	41.9	8.7	1.0
ICGV-SM 85053	654	63.4	58.5	7.5	1.0
ICGV-SM 87009	627	74.5	43.3	8.0	1.0
ICGV-SM 86077	578	66.8	41.5	8.7	1.0
ICGV-SM 87003	513	74.0	38.3	9.0	1.0
ICGV-SM 86070	510	75.4	36.5	8.7	1.0
Natal Common	509	75.3	34.0	9.0	1.0
ICGM 721	502	77.4	33.0	8.7	1.0
ICGV-SM 86043	486	77.0	38.3	9.0	1.0
ICGM 473	482	75.3	32.0	9.0	1.0
ICGV-SM 850.11	476	76.0	35.0	8.9	1.0
ICGM 522	449	73.0	34.3	9.0	1.0
ICGV-SM 86039	448	69.8	42.8	9.0	1.0
ICGV-SM 86079	386	71.5	37.3	9.0	1.0
ICGV-SM 86062	316	74.5	34.0	8.9	1.0
Controls					
Malimba	400	71.4	35.8	8.8	1.0
Sellie	465	76.3	33.8	8.5	1.0
SE	±77.5	±2.2	±1.7	±0.17	-
Trial mean	583	71.6	42.0	8.5	1.0
CV(%)	26.6	6.3	8.5	3.9	-

1. Time to maturity was 132 days for all entries.
2. Field disease scored on a 1-9 scale, where 1 = No disease, and 9 = 50-100% foliage destroyed.

spacing, fertilizer application rates, and mixed cropping. Poor pod filling especially in large-podded genotypes also warrants detailed investigation. Rapid evaluation of promising genotypes in national yield and on-farm trials for suitability for release, is an important objective of the groundnut improvement program.

Acknowledgment

We are sincerely grateful to E. Dlamini for his assistance with field operations. Thanks go to the Head of the Crop Production Department for allowing us to use Department facilities, and special thanks to E. Zikalala for typing the manuscript.

Discussion

Sibuga: At Morogoro (Tanzania), we have observed what appears to be bacterial wilt. However, we also have a problem with ants and termites, and in most cases, we associated the wilting to these insects rather than bacterial wilt. Do you have any suggestions or short-term measures to contain this disease? What

Table 2. Performance of 25 Virginia type groundnut entries in the SADCC Regional Yield Trial, Luyengo Campus, Swaziland, 1988/89.

Entry	Seed yield (t ha^{-1})	Shelling (%)	100-seed mass (g)	Time to maturity (days)	Late leaf spot score[1]	Rust score[1]
ICGV-SM 83708	1.158	73.3	63.0	150	5.5	7.7
ICGV-SM 86708	1.122	73.1	79.8	150	7.9	6.8
ICGV-SM 86720	1.065	77.5	55.0	149	8.7	6.1
ICGV-SM 86725	0.994	75.3	59.8	150	8.2	7.0
ICGV-SM 85764	0.991	72.9	66.3	149	6.7	9.0
ICGV-SM 86704	0.997	76.6	59.8	150	9.0	7.4
ICGV-SM 86719	0.946	71.3	56.3	150	6.9	7.6
ICGM 336	0.889	72.1	46.5	151	5.5	7.4
ICGV-SM 85718	0.880	75.1	65.5	155	7.8	7.3
ICGV-SM 86734	0.850	70.9	48.5	167	5.8	7.9
ICGV-SM 87707	0.822	72.3	53.8	125	6.6	6.1
ICGV-SM 86760	0.812	67.0	45.0	169	5.5	7.7
ICGV-SM 86715	0.790	69.3	59.0	189	5.1	1.7
ICGV-SM 86737	0.774	68.1	50.0	150	5.2	7.5
ICGV-SM 85726	0.719	67.4	44.5	173	8.0	1.7
ICGM 749	0.717	65.4	45.5	150	5.9	7.3
ICGV-SM 86761	0.663	67.1	48.5	150	5.0	7.4
ICGV-SM 85752	0.577	60.1	43.8	167	7.6	2.4
ICGV-SM 86722	0.557	58.1	38.5	172	7.4	2.6
ICGV-SM 85751	0.549	57.5	51.0	172	4.2	6.8
ICGV-SM 86703	0.532	60.9	50.3	157	6.9	7.7
ICGV-SM 85727	0.510	69.0	46.3	168	7.3	1.7
ICGV-SM 85753	0.482	59.3	40.0	172	7.6	2.3
Controls						
Egret	0.611	68.9	54.0	148	5.7	7.7
Mani Pintar	0.736	67.6	52.8	149	5.5	7.5
SE	±0.0645	±1.82	±2.85	±2.8	±0.33	±0.5
Trial mean	0.789	68.7	52.9	159	6.5	6.1
CV(%)	16.4	5.3	10.9	3.5	10.2	17.0

1. Field disease scored on a 1-9 scale, where 1 = No disease, and 9 = 50-100% foliage destroyed.

should be the strategy, on a regional basis, towards solving this problem? I would like to draw the attention of entomologists on the issue of ants that are proving to be a serious problem, at least in our station at Sokoine University of Agriculture, Morogoro, Tanzania.

Rao: Screening for resistance to the disease can be of help. If material is made available, the first step would be to screen for tolerance of bacterial wilt in different locations of the region.

Busolo-Bulafu: Although Dr. Rao has said that he is not aware of any report on bacterial wilt from the other countries, we actually have been working on the disease since 1973. Resistance does exist and even some crosses were made. This work is now being handled by a colleague.

Rao: We would appreciate if your colleague from Uganda could arrange to make some of that material available to us. This would also enhance regional cooperation on the disease.

Subrahmanyam: There are sources of resistance to bacterial wilt available and development of high-yielding breeding lines with resistance to bacterial wilt is underway in many countries in Asia (e.g., the People's Republic of China, Indonesia, etc.)

Ismael: You mentioned that you have extensive canopy development in Swaziland. I have observed in Mauritius that when you have this extensive canopy development it is often associated with fewer number of pods. Have you observed this?

Rao: Yes.

Evaluation of Advanced Groundnut Genotypes at Morogoro, Tanzania

S.O.W.M. Reuben[1] and T.S.K. Mrema[2]

Abstract

*Fifteen advanced breeding lines and varieties of groundnut (*Arachis hypogaea *L.) were evaluated in a yield trial during the 1989 cropping season at the Sokoine University of Agriculture, Morogoro, Tanzania. Seed yield ranged from 1.23 t ha^{-1} (for the line 1/24) to 0.88 t ha^{-1} (for the line 1/4). Control cv Nyota (Spancross) yielded 0.95 tha^{-1} and control cv Natal Common yielded 0.94 tha^{-1}. Genotypes 2/91, 1/24, 1/69, 2/114, Baka, and AH 139 outyielded the two controls.*

Nodule dry mass plant^{1}, root dry mass plant^{-1}, nodules plant^{-1}, pod mass m^{-2}, shelling percentage, and 100-seed mass correlated with most of the yield differences between genotypes. Nodule dry mass plant^{-1}, nodules plant^{-1}, root dry mass plant^{1}, and seed yield were all positively correlated.

Sumário

Avaliação de Genótipos Avançados de Amendoim em Morogoro, Tanzania. *Quinze linhas de melhoramento avançadas e variedades de amendoim (*Arachis hypogaea *L.) foram avaliadas num ensaio avançado de rendimentos avançado, durante a estação de cultivo de 1989, na Universidade de Agricultura de Sokoine, Morogoro, Tanzania. O rendimento de grão variou de 1,23 t ha^{-1} (da linha 1/24) a 0,88 t ha^{-1} (da linha 1/4). O cv. de controlo Nyota (Spancross) teve um rendimento de 0.95 t ha^{-1} e o cv. de controlo Natal Comum teve um rendimento de 0,94 t ha^{-1}. Os genótipos 2/91, 1/24, 1/69, 2/114, Baka e AH 139 tiveram um rendimento maior que os dois controlos.*

A massa de nódulos secos planta^{-1}, a massa de raízes secas planta^{-1}, o número de nódulos planta^{-1}, a massa de vagens m^{-2}, a percentagem de descasque e a massa de 100 sementes estão correlacionadas com a maior parte das diferenças de rendimento entre os genótipos. A massa de nódulos secos planta^{-1}, o número de nódulos planta^{-1}, a massa de raízes secas planta^{-1} e o rendimento de grão são caracteres associados positivamente.

Introduction

The main objectives of groundnut *(Arachis hypogaea* L.) research at the Sokoine University of Agriculture (SUA), Morogoro, are to develop improved genotypes for yield, resistance to diseases and insect pests, and nodulation (Reuben et al. 1985; Doto and Reuben 1986; Sibuga et al. 1989).

Little work had been done on groundnut improvement before the project was initiated in December

1. Lecturer in Plant Breeding, Department of Crop Science and Production, Sokoine University of Agriculture, P.O. Box 300S, Morogoro, Tanzania.
2. B.Sc. (Agriculture) Crop Science Option student, 1989 batch, at the above address.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

Table 1. Performance of 15 groundnut genotypes at Sokoine University of Agriculture, Morogoro, Tanzania, 1989.

Genotype	Nodules plant^{-1}	Nodules dry mass plant^{-1} (g)	Root dry mass plant^{-1} (g)	Time to 95% maturity (days)	Plants m^{-2}	Begs plant[1]	Pods plant^{-1}	Pod mass m^{-2} (g)	Shelling (%)	100-seed mass (g)	Seed yield (t ha^{-1})
2/91	107.15 a-d[1]	0.36 a-e	1.18 a-g	91.50 cd	15.40 cd	35.85 g-i	24.86 b	156.94 cd	60.65 ab	33.47 a-d	1.193 a-c
1/24	106.60 a-d	0.44 a	1.21 a-f	89.75 f-i	15.50 cd	40.15 a-i	20.97 b	171.20 a	55.60 cd	33.63 ab	1.231 a
1/80	100.60 b-d	0.20 h	0.74 1	91.00 c-e	16.25 a-d	38.50 b-k	23.70 b	143.74 f-i	54.80 cd	31.92 b-i	0.960 g-k
1/4	101.45 a-d	0.25 f-h	0.78 j-1	91.00 c-e	15.10 cd	35.70 g-1	20.87 b	136.59 i	53.60 d	31.15 b-j	0.879 k
1/69	109.00 a-c	0.38 a-d	1.07 a-h	93.25 ab	18.40 a	32.40 1	22.37 b	169.25 ab	57.63 b-d	33.61 a-c	1.204 ab
2/114	112.25 a	0.38 a-d	1.29 a	90.00 e-h	15.45 cd	44.55 a	29.11 a	153.78 de	57.02 b-d	33.08 a-f	1.082 d-f
Spathoma	102.30 a-d	0.28 e-h	1.06 a-i	92.00 bc	18.00 ab	42.12 a-e	22.30 b	136.37 i	58.21 bc	29.41 h-j	0.982 gh
Tamnut 74	101.10 a-d	0.26 f-h	0.88 h-1	91.00 c-e	17.25 a-c	40.35 a-h	22.15 b	137.39 i	57.33 b-d	28.48 j	0.972 g-j
Baka	109.85 ab	0.36 a-e	1.27 a-c	90.50 d-g	14.62 d	42.05 a-f	20.87 b	164.76 a-d	56.10 cd	33.35 a-e	1.114 b-e
Jonca	99.65 b-d	0.30 c-g	0.97 g-k	91.00 c-e	15.00 cd	43.67 ab	22.0 b	136.73 i	57.20 b-d	32.06 b-h	0.961 g-k
AH 139	105.65 a-d	0.26 f-h	1.04 c-j	93.75 a	16.23 a-d	39.20 a-j	25.18 ab	147.94 d-h	62.37 a	30.47 c-j	1.158 a-d
Bebiano Encarnado	107.15 a-d	0.43 ab	1.28 ab	88.75 i	15.27 cd	42.80 a-d	19.65 b	146.38 e-i	54.73 cd	28.63 j	0.975 g-i
PI 315608	105.80 a-d	0.39 a-c	1.23 a-d	89.75 f-i	15.55 cd	38.50 b-k	23.73 b	151.96 d-f	55.73 cd	35.20 a	1.036 f-g
Controls											
Nyota (Spancross)	97.60 d	0.23 f-h	0.87 h-1	90.75 d-f	16.50 a-d	40.65 a-g	20.75 b	141.60 g-i	55.10 cd	32.77 a-g	0.951 g-k
Natal Common	103.27 a-d	0.32 c-f	1.22 a-e	89.00 hi	16.20 a-c	43.10 a-c	23.65 b	147.96 d-g	53.10 cd	30.04 f-j	0.945 h-k
SE	± 3.33	±0.03	±0.07	±0.37	±0.72	±1.60	±1.65	± 3.10	±1.33	±0.94	±2.63
Mean	104.63	0.32	1.07	90.87	16.05	39.97	22.81	149.51	56.66	31.82	1.045
CV(%)	6.4	21.0	13.4	1.3	8.9	8.0	14.4	4.2	4.7	5.9	5.0

1. Values followed by the same letter within the same column do not differ significantly ($P < 0.05$), according to Duncan's Multiple Range Test.

Table 2. Phenotypic correlation coefficients between variables studied in 15 groundnut genotypes, Morogoro, Tanzania, 1989.

Variable	Nodules plant^{-1}	Nodule dry mass plant^{-1}	Root dry mass plant^{-1}	Time to 95% maturity (days)	Plant m^{-2} at harvest	Pegs plant^{-1}	Pods plant^{-1}	Pod mass m^{-2}	Shell-ing (%)	100-seed mass	Seed yield
Nodules plant^{-1}	-										
Nodule dry mass plant^{-1}	0.76	-									
Root dry mass plant^{-1}	0.79	0.87	-								
Time to 95% maturity (days)	-0.05	-0.40	-0.40	-							
Plant m^{-2} at harvest	-0.18	-0.26	-0.28	0.53	-						
Pegs plant^{-1}	-0.04	0.07	0.34	-0.55	-0.33	-					
Pods plant^{-1}	0.41	0.00	0.22	0.17	0.01	0.10	-				
Pod mass m^{-2}	0.75	0.18	0.59	0.00	-0.07	-0.29	0.08	-			
Shelling (%)	0.25	-0.03	0.12	0.72	0.23	-0.18	0.44	0.11	-		
100-seed mass	0.35	0.34	0.24	0.02	-0.27	-0.33	0.23	0.62	0.01	-	
Seed yield	0.70	0.57	0.52	0.34	0.03	-0.31	0.24	0.87	0.57	0.52	-

1980. A germplasm collection was made from the major groundnut-growing areas in Tanzania and introductions from elsewhere were also made to broaden the genetic base. The value of local groundnut germplasm in the search for improved types was realized at the onset of the project. Local varieties, introductions, and breeding lines derived from crosses have been evaluated since 1982. Segregating populations are grown twice each year to hasten generation advance and selections are made using the pedigree method.

Promising genotypes, consistently superior to the controls over several locations and seasons, were reevaluated at Morogoro during the 1989 main rainy season. The objective was to identify entries for on-farm and national yield trials before recommendation for release.

Materials and Methods

Fifteen entries were included in a yield trial grown under rainfed conditions during the 1989 (March-July) cropping season at SUA (575 m above sea level, 6° 5' 20" S and 37° 39' 20" E). The design used was a randomized complete block design with four replications. Plots consisted of four rows spaced 50 cm apart and 5 m long. Seed was spaced 10 cm apart in the row.

The trial was sown on 31 Mar 1989. Phosphorus (50 kg P_2O_5 ha^{-1}), in the form of triple super phosphate (TSP), was applied before sowing and the crop was topdressed with sulfate of ammonia (20 kg N ha^{-1}) 15 days after sowing. Data analyses (ANOVA and correlation) were carried out using the procedures suggested by Snedecor and Cochran (1980).

Results and Discussion

Seed yields ranged from 1.23 t ha^{-1} for line 1/24 to 0.88 t ha^{-1} for line 1/4 (Table 1). Lines 2/91, 1/24, 1/69, 2/114, Baka, and AH 139 outyielded the two controls Nyota (Spancross) and Natal Common. Line 1/4 gave the lowest yield though not significantly lower than the controls.

Nodule and root dry matter, nodule number, pod mass, shelling percentage, and 100-seed mass were positively correlated with yields and there were significant varietal effects on these variables (Tables 1 and 2). Varietal differences applied also to time to 95% maturity, plant stand, pegs plant^{-1}, and pods plant^{-1} but no relation between these characteristics and yields could be established. These results support those of Reddi et al. (1986), Doto and Reuben (1987), and Sibuga et al. (1989), Who also observed positive correlations between 100-seed mass and yield and between shelling percentage and yield.

It was interesting to note that nodules plant^{-1}, nodule dry mass, and root dry mass were also significantly and positively associated with yield. Consideration should be given to the use of such variables as selection indices in our groundnut improvement program.

Conclusion

Lines 2/91, 1/24, 1/69, 2/114, Baka, and AH 139 could be further tested in on-farm and national trials before being recommended for release.

References

Doto, A.L., and Reuben, S.O.W.M. 1987. Search for improved groundnut varieties in Tanzania: genetic versus environmental challenges. Pages 81-86 *in* Proceedings of the Second Regional Groundnut Workshop for Southern Africa, 10-14 Feb 1986, Harare, Zimbabwe. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Reddi, M.V., Subramanyam, D., Ramachandra Reddy, J., Krishna Murty, B., Reddy, N.S., and Dhana Raj, A. 1986. Character association in Virginia bunch and runner types of groundnut *{Arachis hypogaea* L.). Indian Journal of Genetics and Plant Breeding 46(2):360-365.

Reuben, S.O.W.M., Keswani, C.L., and Doto, A.L. 1985. Groundnut research at Morogoro. Pages 59-64 *in* ICRISAT Regional Groundnut News, 2 Nov 1985. Vol. 2. Lilongwe, Malawi: SADCC/ICRISAT Groundnut Project. (Limited distribution.)

Sibuga, K.P., Reuben, S.O.W.M., and Doto, A.L. 1989. A progress report on the performance of advanced groundnut breeding lines in various agroecological zones of Tanzania. Pages 99-103 *in* Proceedings of the Third Regional Groundnut Workshop for Southern Africa, 13-18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Snedecor, G.W., and Cochran, W.G. 1980. Statistical methods. 7th edn. Ames, Iowa, USA: Iowa State University Press. 507 pp.

Discussion

Shongwe: Please comment on the apparent assumption you made that the groundnut breeding lines you evaluated have similar nutritional requirements and thus the comparisons made among them.

Reuben: I did not definitely say that the lines have similar nutritional requirements, only that it is a general recommendation. It is important that in the future, we identify those few elite lines and establish specific recommendations for specific genotypes. This practice is, however, rare."

On-farm Verification of Three New Groundnut Varieties in Zambia

K. Kanenga[1]

Abstract

Yields of three new groundnut (Arachis hypogaea *L.) varieties—MGS 2, MGS 3, and MGS 4 (1CGV-SM 83708 or ICGMS 42)—were evaluated in on-farm trials in the Eastern Province, Zambia, during the 1987/88 and 1988/89 cropping seasons. In the first season, MGS 2 gave higher yields than the control cv Chalimbana in all locations and MGS 4 (ICGV-SM 83708) gave yields on par when compared with the control Makulu Red. In the second season, MGS 3 was found superior in yield to MGS 2. In this season, MGS 4 (ICGV-SM 83708) gave higher yields when compared to Makulu Red. Partial budgeting and marginal analysis showed that the adoption of variety MGS 2 was economically beneficial compared with cv Chalimbana.*

Sumário

Verificação de Três Novas Variedades de Amendoim em Pleno Campo na Zambia. *Os rendimentos de três novas variedades de amendoim (*Arachis hypogaea *L.) - MGS 2, MGS 3 e MGS 4 (ICGV-SM 83708 ou ICGMS 42) - foram avaliados em ensaios de campo na Província Oriental, Zambia, durante as estações de cultivo de 1987/88 e 1988/89. Na primeira estação, MGS 2 produziu maiores rendimentos que o cv Chalimbana em todos os locais e MGS 4 (ICGV-SM 83708) teve rendimentos semelhantes que o controlo, Makulu Red. Na segunda estação, MGS 3 mostrou-se superior, em rendimento, a MGS 2. Nesta estação, MGS 4 (ICGV-SM 83708) produziu maiores rendimentos que Makulu Red. O orçamento parcial e a análise marginal mostraram que a adopção da variedade MGS 2 foi económicamente preferêncial se comparada ao cv. Chalimbana.*

Introduction

Lancon et al. (1989) have documented the importance of on-farm research in the verification of the value of any new variety or technology. Evaluations, taking into account the farmers' growing seasons, attitudes, constraints, and related socioeconomic factors, supported by agronomic interpretation along with economic analysis, help in formulating technology recommendations appropriate to small-scale farmers (CIMMYT 1988).

In Zambia, groundnut (*Arachis hypogaea* L.) is largely grown by small-scale farmers. The groundnut improvement program has identified in research station trials promising new varieties of good yield potential. In this paper, the results of on-farm testing and verification of three of these varieties are discussed.

1. Food Legume Agronomist, Msekera Regional Research Station, P.O. Box 510089, Chipata, Zambia.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

Materials and Methods

In the 1987/88 cropping season, 15 representative small-scale farmers were chosen in five districts of the Eastern Province. In the following season, 12 farmers were selected in four districts. In each district, three experimental sites were chosen. In the first season, four groundnut varieties were compared. These were two new varieties MGS 2 and MGS 4 (ICGV-SM 83708 or ICGMS 42) and the two previously released varieties, Chalimbana and Makulu Red. In the second season, Chalimbana was replaced by MGS 3.

The design used was complete randomized-block design with two replications. Sowing was done between mid-November and early December on ridges at 75 cm x 10 cm spacing. No fertilizer was applied as groundnut usually follows a fertilized maize crop in the recommendation domain (group of farmers).

Each plot consisted of five rows, 10 m long. The gross plot area amounted to 37.5 m^2. All cultural operations were carried out by field workers from the research station. Border effects were eliminated by excluding from yield determinations two border rows $plot^{-1}$ as well as two plants on either side of each row. Data collected included numbers of plants at harvest and of pods $plant^{1}$, pod and seed yields, and 100-seed mass. However, only seed yields are presented in this paper. Individual site and combined analysis across locations were conducted. Partial budgeting and marginal analysis were used to determine the economics of adoption of the variety MGS 2 in comparison with Chalimbana.

Table 1. Performance of groundnut entries in on-farm variety verification trials at five locations in the Eastern Province, Zambia, 1987/88 and 1988/89.

	Location and seed yield (kg ha^{-1})					
Variety	Chipata south	Chipata north	Katete	Chadiza	Lundazi	Mean (kg ha^{-1})
1987/88						
MGS 2	567	752	637	667	604	646
Control						
Chalimbana	507	467	405	475	354	441
Increase over control (%)	12	61	57	40	71	48
MGS 4						
(ICGV-SM 83708)	976	993	688	746	668	807
Control						
Makulu Red	993	1020	691	728	688	824
Increase over control (%)	-2	-3	0	2	-3	-1
SE						±50
CV (%)						27
1988/89						
MGS 3	1055	899	626	522	-	776
Control						
MGS 2	965	538	509	426	-	609
Increase over control (%)	9.3	67	23	23	-	31
MGS 4						
(ICGV-SM 83708)	947	757	592	439	-	684
Control						
Makulu Red	580	712	598	377	-	567
Increase over control (%)	63	6	-1	16	-	21
SE						±75
CV (%)						30

Results

In the 1987/88 cropping season, seed yield of MGS 2 (Table 1) was higher than that of the control cv Chalimbana across all locations. MGS 4 (ICGV-SM 83708) and Makulu Red had comparable yields. In the 1988/89 cropping season MGS 3 gave superior yields than MGS 2. On the other hand, MGS 4 (ICGV-SM 83708) was superior to Makulu Red at Chipata South only. A combined analysis across locations did not show any significant interaction between genotypes and experimental sites.

Partial budgeting (Table 2) indicated that for each Zambian Kwacha (ZK, U.S.$1=15 ZK) invested in the adoption of the new variety MGS 2 over Chalimbana, a farmer would have gained 5.5 ZK. The net benefit would thus have amounted to 4.50 ZK.

Discussion and Conclusions

According to the results, variety MGS 2 is superior to cv Chalimbana and should be recommended to farmers.

On the other hand, the erratic performance of MGS 4 across five locations may indicate that this variety is suitable for certain locations only. The information gained from this experiment will assist in further improvements in the planning and conduct of such verification trials.

References

CIMMYT (Centra Internacional de Mejoramiento de Maiz y Trigo). 1988. From agronomic data to farmer recommendations: An economics training manual. Completely revised edition. 06600 Mexico, D.F.: CIMMYT. 84 pp.

Lancon, J., Chanselme, J.L., and Klassou, C. 1989. Representativeness of varietal trials carried out under controlled, semi-real and real conditions in the North Cameroon Cotton Zone. Coton et Fibres Tropicales 44:118-125.

Discussion

Chigwe: Would you really evaluate marginal return without considering variable costs apart from cost of seed?

Kanenga: No, other costs need to be considered, but in my study I was only considering the comparative advantage of growing the new variety and the old one.

Table 2. Partial budget: net benefits and marginal rate of return by the adoption of a new technology for two groundnut varieties, Zambia[1].

Yield cost, benefits	Chalimbana		MGS 2
Average yield (kg ha^{-1})	441		646
Adjusted yield (kg ha^{-1}) (10% less)	397		581
Gross field benefits[2] (ZK ha^{-1})	3970		5810
Cost of seed[3] (ZK ha^{-1})	2100		1575
Net benefit (ZK ha^{-1})	1870		4235
Marginal analysis (ZK)	2365	(difference between the two net benefits)	
	525	(difference in variable costs)	
Marginal rate of return	$\frac{2365 \times 100\%}{525}$ = 450%		

1. As suggested by CIMMYT (1988).
2. Income at farm price of 10 ZK kg^{-1}.
3. Seed costs at 21 ZK kg^{-1} for Chalimbana (100 kg ha^{-1}) and MGS 2 (75 kg ha^{-1})

Groundnut Breeding Program in Malawi

H.K. Mande[1]

Abstract

The importance of groundnut (Arachis hypogaea *L.) to Malawi, the research achievements of the Malawi national breeding program, and the progress made in breeding confectionery groundnut lines by the national program during the 1988/89 cropping season are outlined. The problems associated with developing confectionery varieties and the future strategies of national research programs are also discussed.*

Sumário

O Programa de Melhoramento de Amendoim do Maláwi. *Neste artigo é delineada a importância do amendoim (*Arachis hypogaea *L.) para o Maláwi, os avanços conseguidos na investigação do programa nacional de melhoramento do Maláwi e o progresso feito no melhoramento de linhas de amendoim para confeitaria, pelo programa nacional, durante a estação de cultivo de 1988/89. Os problemas associados com o desenvolvimento de variedades de confeitaria e o futuro crescimento dos programas nacionais de investigação são tambem discutidos.*

Introduction

Groundnut *(Arachis hypogaea* L.) is an important crop as it is a major source of fat and protein. Groundnuts arc also a source of edible vegetable oil, and groundnut haulms are utilized as livestock feed.

In the smallholder sector, groundnut is the second most important crop after maize, and provides a supplementary source of income for most smallholders. Groundnuts improve soil fertility and increase yield of other following crops, such as maize. Groundnut also contributes significantly to export earnings in Malawi, and ranks fourth after tobacco, tea, and sugar.

The main objective of the groundnut improvement program in Malawi is to increase the yield and quality of groundnut. The development of stable high-yielding varieties for both confectionery and oil-extraction purposes is a priority objective. This objective is achieved through a multidisciplinary team comprising a breeder, a pathologist, and an agronomist.

Past achievements by the national breeding program include development of rosette resistant and confectionery varieties. RG 1, a rosette-resistant cultivar, was selected from a cross between Makulu Red (female parent) and 48-14 (source of rosette resistance).

Chitembana, a large-seeded, alternately branched runner, originated from a cross between RJ 15 and Chalimbana, a large-seeded variety on which Malawi's confectionery market is based. One defect of Chalimbana is that its seeds are not symmetrical, be-

1. Groundnut Breeder, Chitedze Agricultural Research Station, P.O. Box 158, Lilongwe, Malawi.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa. 19-23 Mar 1990, Arusha. Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

cause the pods are relatively unconstricted, resulting in flat faces at one end. Therefore, Chitembana was developed to improve on this defect of Chalimbana.

Breeding for Confectionery Quality

Confectionery varieties from various breeding programs were evaluated for confectionery purposes in trials in 1987/88 and 1988/89 cropping seasons.

Thirty-four entries were compared with Chalimbana and Chitembana in a 6 x 6 balanced lattice design. Results of the 1988/89 trial are presented in Table 1.

The overall performance of these lines was encouraging (Table 1). In particular, ICGMS 42, B80/1, D58/1, B910/1/2, D27/3, and B80/3/2 had high yields and good shelling percentages.

Problems Associated with Development of Confectionery Varieties

Many problems have been encountered in the development of confectionery varieties. One of these is market fluctuations. Malawi's groundnut export market has been based on the Chalimbana and Chitembana groundnut varieties. However, because of inconsistent supply from Malawi, there has been a significant swing to the American runner varieties with seed count per ounce (1 g = 0.03527 ounces) of 40-50 seed ounce^{-1}. Most processors in Europe are now geared to process these small-seeded American runner varieties and there is a reduced demand for large-seeded Chalimbana and Chitembana groundnuts.

Another problem is that of oil stability in some varieties. The oleic/linoieic acid ratio is an indicator of oil stability (shelf life) in groundnuts. The minimum ratio requirement sought by KP Foods Limited, Chesterton Road, Eastwood Trading Estate, Rotherham, UK (the major buyer of Malawi confectionery groundnuts), is 1.6:1. Most of the Malawi confectionery varieties, such as Malimba and JL 24, possess an O/L ratio below the minimum ratio required by the trade but in some varieties, such as Chalimbana and Chitembana, the O/L ratio is acceptable.

Table 1. Performance of 36 confectionery type groundnut genotypes, Chiledze, Malawi, 1988/89.

Entry	Pod yield (t ha^{-1})	Seed yield (t ha^{-1})	Shelling (%)
ICGM 42	1.913	1.447	76
E267/3	1.858	1.261	68
B80/1	1.825	1.297	71
B910/1/2	1.788	1.221	68
B80/3/2	1.781	1.208	68
C851/7	1.745	1.154	66
E685/1/2	1.738	1.195	69
C 100/3/2	1.717	1.127	65
C100/3/1/1	1.698	1.073	63
B434/1	1.686	1.147	68
D58/1	1.635	1.161	71
D27/3	1.592	1.141	72
B201/3	1.542	1.077	70
E267/11	1.526	0.992	65
B487/3/2	1.524	1.039	68
E685/3/1	1.520	1.024	67
E685/1	1.488	1.053	71
D636/3	1.486	1.017	68
B80/2	1.459	1.007	69
D196/1/1/2	1.446	0.991	69
B80/3	1.428	0.981	69
D 196/3/1	1.423	0.987	69
E685/2	1.395	0.947	68
C763	1.378	0.865	63
C2/2/2	1.355	0.940	69
C100/3/1/2	1.323	0.871	69
D341/1	1.317	0.907	69
C763/1/1	1.311	0.764	58
E267/2	1.294	0.880	68
D261/2	1.285	0.876	68
D657/2/2	1.203	0.769	64
B201/1	1.123	0.708	63
D636/2	1.062	0.703	66
B624/1	0.870	0.570	66
Controls			
Chalimbana	0.947	0.626	66
Chitembana	0.941	0.622	66
SE	±0.0874	±0.0587	±1.6
Trial mean (36 entries)	1.462	0.990	66
CV (%)	12.0	11.9	4.8

Aflatoxin contamination is another problem associated with confectionery variety development work. This problem is well appreciated worldwide but control measures are lagging behind.

High levels of aflatoxin in groundnut have high health implications for both humans and livestock. Dietary intake of aflatoxin through groundnuts has been implicated in the development of liver cancer in various parts of Africa and childhood cirrhosis in India.

Future Research

Since the objective of the groundnut improvement program in Malawi is to improve the quantity and quality of groundnut we intend to pursue three research programs, which have been submitted to the Rockefeller Foundation for funding support. These are as follows:

Diversification of Malawi's export confectionery nuts research program

The significant swings in market trends suggest that the research program should diversify to the American runner type varieties with smaller seed. This diversification will ensure that Malawi maintains its production of the large-seeded groundnut varieties while increasing its production of small-seeded runners and other varieties.

In addition to enhancing the production of American runner varieties, the program will work towards enhancing research and development of in-shell nuts and red-skin nuts, which are also in great demand in the confectionery export nut market. The red-skin varieties favored are ACG 1 from the Malawi National Groundnut Improvement Program and ICGV-SM 83708 (ICGMS 42) from the SADCC/ICRISAT Groundnut Project.

Research program on aflatoxin contamination of groundnut

In Malawi, monitoring of aflatoxin contamination is done for export groundnut at the groundnut factory in Liwonde run by the Agricultural Development and Marketing Corporation (ADMARC) and only those consignments that pass the minimum acceptable standard are exported. It is widely known that large quantities of groundnuts are consumed in various forms within the country but there are no efforts to minimize the health implications arising from consumption of aflatoxin-contaminated groundnuts.

Factors that predispose groundnut to aflatoxin contamination in the field and after harvest are well known and it is the aim of this research to identify cultural practices that can ensure the prevention of aflatoxin contamination of groundnut. In addition, genotypes have been identified at ICRISAT Center (India), with stable resistance to aflatoxin contamination. Therefore, this program will also aim at transferring this resistance into new groundnut cultivars.

Program to improve the oleic/linoleic acid ratio in the JL 24 groundnut variety

The final quality of edible groundnut is assessed principally by the quality of the processed seed and by the chemical composition of the oil, protein, and carbohydrate fractions of the seed.

The oleic/linoleic (O/L) acid ratio is an indicator of oil stability (shelf life) in groundnuts. The minimum O/L acid ratio requirements sought by KP Foods Limited, UK, which is the major buyer of Malawi confectionery nuts is 1.6:1.

JL 24 is an Indian cultivar introduced in Malawi in 1982 by the SADCC/ICRISAT Groundnut Project. It is a high-yielding, early-maturing variety suitable for the Lower Shire Valley of Malawi. In several replicated experiments conducted in the Lower Shire Valley during five seasons (1983/84 through 1988/89), cv JL 24 averaged 47% higher yield than cv Malimba, the recommended variety for the area. Like Malimba, JL 24 has an O/L ratio below the minimum ratio required by the trade.

This program will aim to incorporate improved shelf life in JL 24 while maintaining its high yield potential.

Acknowledgment

I would like to extend my sincere thanks to Dr P.K. Sibale for his valuable contributions and advice on this paper.

Discussion

Ismael: You said that you will be breeding for higher O/L ratio. How heritable is the O/L ratio?

Hildebrand: We do not have sufficient data available but it is fairly heritable.

Syamasonta: The yields of Chalimbana and Chitembana don't seem to differ significantly. Are you interested only in seed uniformity in Chitembana?

Mande: At this particular site and season, the varieties seem to be the same, but overall results have shown that Chitembana yields better than Chalimbana and has added advantage of seed uniformity.

Chigwe: From your work, have you found any close relationship between seed size, shelling percentage, and yield among the genotypes tested?

Mande: The closest relationship is between shelling percentage and seed yield. The higher the shelling percentage, the higher the yield of seed. Seed yield, however, depends on the number of pods $plant^{-1}$, pod filling, and may also be affected by seed size, if pod filling is poor.

Ndunguru: In West Africa there has been a decline in exports of even small-seeded cultivars. In your diversification strategy, would it not have been useful in diversifying uses of the varieties produced rather than completely rely on an external market that exporters cannot control?

Mande: This diversification has been taken in an orderly step-by-step fashion. It will ensure that Malawi maintains its production in the large-seeded groundnut varieties, while at the same time increasing its production in small-seeded runners and other varieties. Therefore, in a way, we are satisfying the external market while at the same time we are satisfying the local uses of the varieties produced.

A Path Coefficient Analysis of Phenotypie Correlations of Yield Components in Advanced Groundnut Breeding Lines in Tanzania

S.O.W.M. Reuben[1] and T.S.K. Mrema[2]

Abstract

*A path coefficient analysis revealed that time to 95% maturity, pod mass m^{-2}, and nodule dry mass had large direct effects on groundnut (*Arachis hypogaea *L.) seed yield directly, in that order. However, shelling percentage and JOO-seed mass had large negative direct effects on yield. These results show the importance of compensatory effects and the overall relationships between the variables measured and yield.*

The indirect effect of shelling percentage on yield through time to maturity modified the negative independent effect of shelling percentage on yield to a significant positive relationship, while the indirect effects of 100-seed mass on yield through pod mass m^2 and nodule dry mass $plant^1$ compensated for the negative direct effect of 100-seed mass resulting in a significant positive relationship. On the other hand, the large direct effect of time to maturity on yield was modified to a nonsignificant relationship by the indirect effects through shelling percentage and nodule dry mass $plant^{-1}$.

It is suggested that provision for adequate moisture during nodule development could improve the relationship between time to maturity and seed yield.

Sumário

Uma Análise de Coeficientes "Path" das Correlações Fenotípicas dos Componentes do Rendimento em Linhas de Melhoramento de Amendoim Avançadas na Tanzania. *Uma análise de coeficientes "path" revelou que o tempo para 95% de maturação, massa de vagens m^{-2} e massa dos nódulos secos influenciaram o rendimento de grão do amendoim (*Arachis hypogaea *L.) directamente, nessa ordem. Contudo, a percentagem de descasque e a massa de 100 sementes tiveram altos efeitos independentes negativos sobre o rendimento. Os resultados mostram a importância dos efeitos compensatórios e das relações globais das variáveis com o rendimento.*

O efeito indirecto da percentagem de descasque no rendimento, atravéz do tempo para a maturação, compensou o efeito independente negativo da percentagem de descasque sobre o rendimento para uma relação positiva significativa, enquanto que os efeitos indirectos da massa de 100 sementes sobre o rendimento, atravéz da massa de vagens^{-2} e da massa de nódulos secos planta^{-1}, compensaram o efeito directo negativo da massa de 100 sementes para uma relação positiva significativa. Por outro lado, o alto efeito directo do tempo para a maturação no rendi-

1. Lecturer in Plant Breeding, Department of Crop Science and Production, Sokoine University of Agriculture, P.O. Box 3005, Morogoro, Tanzania.
2. B.Sc. (Agriculture) Crop Science Option student, 1989 batch, at the above address.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

mento foi compensado para uma relacao nao significativa, pelos efeitos indirectos atraviz da percentagem de descasque e da massa de nddulos secos planta^{-1}.

Foi sugerido que a provisdo duma humidade adequada durante o desenvolvimento dos nddulos, pode melhorar a relacao entre o tempo para a maturacao e o rendimento de graos.

Introduction

The task of developing higher-yielding groundnut *(Arachis hypogaea* L.) genotypes by the judicious combination of lines selected for their independent yield component superiorities is made considerably less rewarding by the almost universal occurrence of yield component compensation (Adams 1967). Yield is the result of combined effect of several quantitative characters. In a system of variable interrelations, the indirect associations and hence compensation effects become more complex and important. It is important to investigate the cause of these compensatory mechanisms to formulate breeding strategies to eliminate adverse relationships. The independent (direct) contributions of the components upon yield can then be used to greater benefit. It is, therefore, desirable to have numerical estimates of the independent contribution of each component to yield and to understand how the components interact in compensatory patterns during development.

Although the study of the associations between pairs of different characters and yield provides a basis for further breeding plans, the correlation study docs not reveal the direct and indirect contributions of individual characters to yield. Thus, to have a clearer picture of the yield components for an effective selection program, it is desirable to consider the relative importance of the various characters through direct and indirect effects contributing to the observed correlation. Path coefficient analysis (Wright 1921) has been found useful in establishing direct and indirect causes of associations and allows a detailed examination of the specific forces acting to produce a given correlation and a measure of the relative importance of each causal factor. It also provides information about the dependence of yield on correlated characters and helps in the formulation of selection indices.

Materials and Methods

The data were collected from an advanced yield trial conducted at Sokoine University of Agriculture, Morogoro, Tanzania, during the 1989 cropping season (Reuben and Mrema 1990).

Statistical analyses were based on plot means of the variables shown in Table 1. The importance of each causal factor was determined by path analysis of phenotypic correlations, each involving nine variable models for seed yield, according to Wright (1921) and as revised by Dewey and Lu (1959). The matrix procedure of the statistical analysis system (Barr et al. 1976) was used to solve the simultaneous equations (Appendix 1) involved in the calculation of path coefficients. A generalized path diagram for the seed yield model is given in Figure 1. The dependent variable is designated as trait number 9. Traits 1 through 8 for each model are identified in Figure 1.

In the path diagram, the r_{ij}'s are the correlation coefficients between ith and jth trait and the P_{i9}'s are the direct effects of the ith trait on trait number 9 as shown. The indirect effect of one variable upon another was measured by the appropriate r_{ij} P_{i9} component. The X variable represents all residual factors affecting trait number 9 which are not accounted for by the variables used in the model.

Results and Discussion

Results (Fig. 1 and Table 1) indicate that nodule dry mass plant^{-1}, time to 95% maturity (days), and pod mass m^{-2} had large positive direct effects on seed yield. On the other hand, shelling percentage and 100-seed mass had large negative independent influences on yield.

Pod mass m^{-2} was highly and significantly ($P <$ 0.01) correlated ($r = 0.87$) with seed yield. This was due predominantly to its high positive direct effect (1.22) on seed yield.

The moderate but positive and significant ($P <$ 0.05) correlation ($r = 0.57$) between nodule dry mass plant^{-1} and yield was due mainly to its large positive direct influence (1.075) on yield. However, this effect was reduced to a moderate correlation by the negative indirect effects of time to 95% maturity (-0.636) and 100-seed mass (-0.228). The former was because of

Table 1. Path coefficients of phenotypic correlations of the components of yield on seed yield of selected groundnut lines at Morogoro, Tanzania, 1989.

Variable[1]	Nodule dry mass plant^{-1}	Time to 95% maturity (days)	Plant density (plant m^{-2})	Pegs plant^{-1}	Pods plant^{-1}	Pod mass m^{-2} (g)	Shelling (%)	100-seed mass (g)	Total correlation
	Indirect effect via								
Nodule dry mass	*1.075*[2]	-0.636	0.095	0.025	0.000	0.220	0.019	-0.228	0.57
Time to 95% maturity (days)	-0.430	*1.590*	-0.194	-0.196	0.047	0.000	-0.464	-0.013	0.34
Plants m^{-2}	-0.280	0.843	*-0.366*	-0.117	0.003	-0.085	-0.148	0.181	0.03
Pegs plant^{-1}	0.075	-0.875	0.121	*0.356*	0.028	-0.354	0.115	0.222	-0.31
Pods plant^{-1}	0.000	0.270	-0.004	0.036	*0.278*	0.097	-0.283	-0.154	0.24
Pod mass m^{-2}	0.193	0.000	0.025	-0.103	0.022	*1.220*	-0.070	-0.416	0.87
Shelling (%)	-0.032	1.145	-0.084	-0.064	0.122	0.134	*-0.644*	-0.007	0.57
100-seed mass	0.365	0.032	0.098	-0.117	0.064	0.756	-0.006	*-0.672*	0.52

1. Residual effect = 0.01.
2. Italicized (diagonal) figures are the direct effects; other diagonal figures are the indirect effects.

the negative association (-0.40) between nodule dry mass and time to 95% maturity (days) and a large direct effect (1.590) of time to 95% maturity on yield.

Time to 95% maturity (days) was not significantly related (r = 0.34) with yield. However, its direct contribution to yield (1.590) was large and positive. This relationship was influenced by the cumulative negative indirect effects on yield of time to 90% maturity through nodule dry mass plant^{-1} (-0.430) and through shelling percentage (-0.464). The relationship between maturity and yield was influenced by the negative relationship (-0.40) between nodule dry mass plant^{-1} and time to 95% maturity, and the positive direct effect (1.075) of nodule dry mass plant"^{1} on yield. Similarly, the negative indirect effect through shelling percentage was attributed to the highly significant *(P* < 0.01) positive relationship (r = 0.72) between days to 95% maturity and shelling percentage and a relatively high negative direct contribution (-0.644) of shelling percentage on yield.

Shelling percentage was moderately but significantly *(P* < 0.05) correlated (r = 0.57) with yield. This was because of its large indirect effect (1.145) on yield through time to 95% maturity and relatively large negative direct effect (-0.644) of shelling percentage on yield. The large indirect effect was attributed to the highly positive direct effect (1.590) of time to 95% maturity on yield while the correlation (r = 0.72) between shelling percentage and time to 95% maturity was positive and highly significant *(P* < 0.01).

The relationship (r = 0.52) between 100-seed mass and yield was positive and moderately significant *(P* < 0.05). However, its direct effect (-0.672) on yield was relatively large and negative. The combined positive indirect contributions to yield through pod mass nr^{2} (-0.756) and through nodule dry mass plant^{-1} (0.365) greatly compensated the negative direct effect resulting in the moderately positive correlation between 100-seed mass and yield. The large positive indirect effect through pod mass m^{-2} was attributed to the large and positive direct contribution (1.220) of pod mass on yield while a significant *(P* < 0.05) positive correlation (r = 0.62) existed between 100-seed mass and pod mass m^{-2}.

Summary and Conclusions

Path analysis suggests the importance of time to 95% maturity, pod mass m^{-2}, and nodule dry mass, in that order, in influencing seed yield directly.

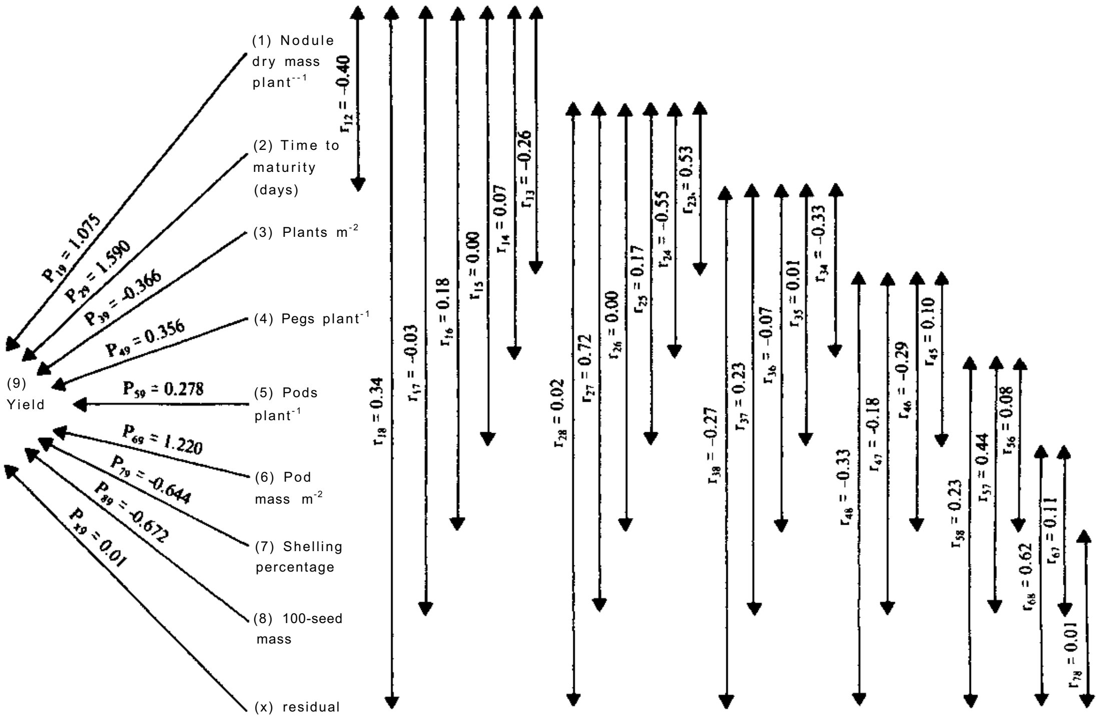


Figure 1. A path diagram and coefficients of factors, P_{IJ}, influencing seed yield in the groundnut lines. Double arrows indicate the mutual association between variables, r_{ij} and x (residual).

The importance of compensation mechanisms in the final relationship of the components with yield was revealed. Certain compensatory effects through indirect effects improved the relationships between some variables and seed yield. For instance:

A. The indirect effect of shelling percentage on yield through time to 95% maturity compensated for the negative independent effect of shelling percentage on yield to a significant positive relationship.

B. The indirect effects of 100-seed mass on yield through pod weight m^{-2} and nodule dry mass plant^{-2} compensated for the negative direct effect of 100-seed mass to a significant positive relationship.

On the other hand, some of the compensating mechanisms jeopardized the relationships between the components and yield. For example, although the independent effect of time to 95% maturity on yield was relatively large, the negative indirect effects through shelling percentage and nodule dry mass plant^{1} reduced this effect to a nonsignificant relationship. The negative indirect effect of nodule dry mass plant^{1} could be offset by improving the relationship between nodule dry mass and time to 95% maturity to a positive value. This could be achieved by providing adequate soil moisture during nodule development as this was certainly adversely affected by the low (378.5 mm) and poorly distributed rainfall during the cropping season.

References

Adams, M.W. 1967. Basis of yield component compensation in crop plants with special reference to the field bean, *Phaseohis vulgaris* (L.). Crop Science 7:505-510.

Barr, A.J., Goodnight, J.H., Sall, J.P., and Helwig, J.T. 1976. A user's guide to SAS. 76, Raleigh, NC, USA: SAS Institute Incorporated.

Dewey, D.R., and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. Agronomy Journal 51:515-518.

Reuben, S.O.W.M., and Mrema, T.S.K. 1990. Evaluation of advanced breeding lines at Morogoro, Tanzania. (See in this volume.)

Wright, S. 1921. Correlation and causation. Journal of Agricultural Research 20:557-587.

Appendix 1. Simultaneous equations which express the basic relationship between correlation and path coefficients in the groundnut lines as suggested by Dewey and Lu (1959).

1. $r_{19} = P_{19} + r_{12} P_{29} + r_{13} P_{39} + r_{14} P_{49} + r_{15} P_{59} + r_{16} P_{69} + r_{17} P_{79} + r_{18} P_{89}$
2. $r_{29} = P_{29} + r_{12} P_{19} + r_{23} P_{39} + r_{24} P_{49} + r_{25} P_{59} + r_{26} P_{69} + r_{27} P_{79} + r_{28} P_{89}$
3. $r_{39} = P_{39} + r_{13} P_{19} + r_{23} P_{29} + r_{34} P_{49} + r_{35} P_{59} + r_{36} P_{69} + r_{37} P_{79} + r_{38} P_{89}$
4. $r_{49} = P_{49} + r_{14} P_{19} + r_{24} P_{29} + r_{34} P_{39} + r_{45} P_{59} + r_{46} P_{69} + r_{47} P_{79} + r_{48} P_{89}$
5. $r_{59} = P_{59} + r_{15} P_{19} + r_{25} P_{29} + r_{35} P_{39} + r_{45} P_{49} + r_{56} P_{69} + r_{57} P_{79} + r_{58} P_{89}$
6. $r_{69} = P_{69} + r_{16} P_{19} + r_{26} P_{29} + r_{36} P_{39} + r_{46} P_{49} + r_{56} P_{69} + r_{67} P_{79} + r_{68} P_{89}$
7. $r_{79} = P_{79} + r_{17} P_{19} + r_{27} P_{29} + r_{37} P_{39} + r_{47} P_{49} + r_{57} P_{59} + r_{67} P_{69} + r_{78} P_{89}$
8. $r_{89} = P_{89} + r_{18} P_{19} + r_{28} P_{29} + r_{38} P_{39} + r_{48} P_{49} + r_{58} P_{59} + r_{68} P_{69} + r_{78} P_{79}$

$$
\begin{aligned}
1 = {} & P^2_{x9} + P^2_{19} + P^2_{29} + P^2_{39} + P^2_{49} + P_{259} + P^2_{69} + P^2_{79} + P^2_{89} + 2P_{19}r_{12}P_{29} + \\
& + 2P_{19}r_{13}P_{39} + 2P_{19}r_{14}P_{49} + 2P_{19}r_{15}P_{59} + 2P_{19}r_{16}P_{69} + 2P_{19}r_{17}P_{79} + 2P_{19}r_{18}P_{89} + \\
& + 2P_{29}r_{23}P_{39} + 2P_{29}r_{24}P_{49} + 2P_{29}r_{25}P_{59} + 2P_{29}r_{26}P_{69} + 2P_{29}r_{27}P_{79} + 2P_{29}r_{28}P_{89} + \\
& + 2P_{39}r_{34}P_{49} + 2P_{39}r_{37}P_{59} + 2P_{39}r_{36}P_{69} + 2P_{39}r_{37}P_{79} + 2P_{39}r_{38}P_{89} + 2P_{49}r_{45}P_{59} + \\
& + 2P_{49}r_{46}P_{69} + 2P_{49}r_{47}P_{79} + 2P_{49}r_{48}P_{89} + 2P_{59}r_{56}P_{69} + 2P_{59}r_{57}P_{79} + 2P_{59}r_{58}P_{89} + \\
& + 2P_{69}r_{67}P_{79} + 2P_{69}r_{68}P_{89} + 2P_{79}r_{78}P_{89}.
\end{aligned}
$$

Discussion

Subrahmanyam: What is the range of genotypes employed in your path coefficient analysis? Does this range cover all botanical types? Does it cover a wide spectrum of maturity groups? Is it not important to include a wide diversity of genotypes in a study like this?

Reuben: Yes, I agree. We need to include a wide range of genotypes in a study like this.

Sibuga: Somewhere in your conclusions you suggest that to offset the negative indirect effect of nodule dry mass $plant^{-1}$, one would have to ensure adequate soil moisture during the period of nodule development. How can you ensure the supply of adequate moisture when you are depending on rainfall, the intensity and distribution of which are not easy to predict?

Reuben: I agree entirely that our economic and climatic conditions will not easily allow availability of moisture during that critical period of development. But, at least, we have identified a problem through path analysis. How we can solve it, is another matter. Could we apply deliberate irrigation using the most economical way, i.e., just what the plant needs at that time? Another way is to sow earlier so that the critical stage of growth (i.e, nodule development) could coincide with the period of high rainfall. But this needs to be done only after making sowing-date experiments at that location.

Schmidt: I was impressed by the indication of a direct effect of root nodule mass (difficult to assess) on grain yield (easy to measure). Do you not think this is more an indirect effect: improvement of N-availability leading to increased vegetative growth and leaf area thereby influencing grain yields?

Reuben: Root nodule mass had a direct effect on grain yield but may have had other effects as well. We could include only eight variables but we would have liked to include more.

Mayeux: Your work must have required much time to compute the data, but because we know groundnut must be harvested at the right time, do you think it will be also interesting to know the relationship between yield and other components such as evapotranspiration, root system development, leaf area, and other vegetative developments, etc.? Can this be considered to help scientists select varieties for specific environmental conditions?

Reuben: Yes, I agree. In future we are going to include all vegetative components.

Doto: In the past, path analysis has been avoided because of the complex statistical operations involved. Do you now have a computer program that makes the operation simple? If so, what is the name of that program?

Reuben: Without a computer facility, we could not have easily undertaken this type of analysis. The methodology employed was that of Barr et al. (1976). A well-tailored program was not available.

Ismael: You mentioned the use of path analysis to help breeders in their selection. You did not analyse the correlation of canopy development with yield. Do you intend to include this in future analysis?

Reuben: In future we will try to include other factors affecting yield.

Performance of Recently Released Commercial Groundnut Cultivars in Tanzania

F.F. Mwenda[1] and M.G. Mpiri[2]

Abstract

Groundnuts (Arachis hypogaea *L.) are grown in most parts of Tanzania by small-scale farmers. Local groundnut cultivars, together with the cultivars Red Mwitunde and Natal Common, have been released to farmers from the late 1940s up to the present phase of groundnut improvement in the country. Recently two varieties were released to farmers: Nyota (Spancross), a short-season, Spanish type; and Johari (Robut 33-1), a medium-maturity, Virginia type. A combined analysis over five locations, representing the major groundnut-growing agroecological zones and a range of different management regimes, indicates that Nyota is still superior in yield while both Nyota and Johari are relatively more stable than most other varieties tested. However, they are very susceptible to major diseases, especially leaf spots.*

Sumário

Comportamento de Cultivares Comerciais de Amendoim Recentemente Libertados na Tanzania. *O amendoim (*Arachis hypogaea *L.) é cultivado na maior parte da Tanzania por agricultores de pequena escala. Cultivares de amendoim locais, em conjunto com os cultivares Red Mwintunde e Natal Comum, foram libertados para os agricultores, desde o fim dos anos 1940 até à presente fase do melhoramento do amendoim no país. Recentemente, duas variedades foram libertadas para os agricultores: Nyota (Spancross), do tipo "spanish", de curta duração, e Johari (Robut 33-1), do tipo virginia, de maturação média. Uma análise combinada sobre cinco locais, representando as principais zonas agroecológicas para a produção de amendoim, e uma gama de diferentes regimes de maneio, indicou que Nyota é superior no rendimento, enquanto que ambas, Nyota e Johari, são relativamente mais estáveis que a maioria das variedades testadas. Contudo, elas são muito susceptíveis às principais doenças, especialmente manchas das folhas.*

Introduction

Groundnut *(Arachis hypogea* L.) is one of the major grain legume crops in Tanzania. It is grown by small-scale farmers in most parts of the country where it is an important component crop in traditional mixed cropping systems. In most parts of the country, local cultivars belonging to all three botanical groups are commonly grown (Mwenda 1987). Two additional cultivars released in the late 1940s are also grown by farmers in some parts of the country. Red Mwitunde, a long-season type of the Virginia group, is widely

1. Senior Breeder, Research and Training Institute, Naliendele, P.O. Box 509, Mtwara, Tanzania.
2. Breeder at the above address.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa. 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

grown in southeastern Tanzania while Natal Common, a short-season type of the Spanish group, is grown mainly in the central and western Tanzania. Breeding work, which started in 1978, has resulted in the identification and recommendation to farmers of two new varieties: Nyota (Spancross) released in 1983, and Johari (Robut 33-1) released in 1985.

Nyota is a short-season Spanish variety (90-100 days) and Johari is a medium-duration variety (100-120 days). This paper reports the performance of these two cultivars in trials conducted at various locations and in many seasons since their release.

Yield Performance

In advanced varietal trials, 12 elite varieties including the 2 recommended varieties were tested at more than 20 locations in the major groundnut-growing areas of the country. Local cultivars specific to each location were used as local controls, while the recommended varieties were used as high-yielding controls. In the 1988/89 cropping season, a combined analysis was conducted on five of the test locations. These locations had been carefully selected to represent different agroecological zones and management regimes. For example, Tumbi, in the west, represents a zone of inadequate and poorly distributed rain, characteristic of central and western Tanzania. It is far away from the breeding center and supervision is therefore difficult. Suluti, in southern Tanzania, represents a zone receiving long periods of adequate and well-distributed rains. Naliendele, in the southeast, is fairly representative of the light sandy soils of the coastal belt. It is the center of groundnut-breeding activities and has the advantage of good supervision and management. Nachingwea and Mtopwa, also in the southeast, are substations of this Institute and share the advantages of Naliendele. These three locations are characterized by long periods of rain alternating with frequent dry spells.

These data were also subjected to a simplified pattern analysis technique (Singh and Chaudhary 1977, pp. 253-280) to evaluate the stability of the two recommended cultivars. Results of these analyses are presented in Table 1 and Figure 1. The local control entries have been omitted from the analyses as these were not common to all locations.

Table 1. Mean seed yields of 11 selected groundnut genotypes at five locations in Tanzania, 1988/89.

	Location and mean seed yield (t ha^{-1})					
Entry	NAL[1]	NAC[1]	MTO[1]	SUL[1]	TUM[1]	Mean
ICGV-SM 83021 (ICGMS 21)	1.69K1)[2]	1.250(1)	1.338(1)	0.866(7)	0.592(10)	1.157
69.62.2.5	1.400(3)	1.172(5)	1.204(3)	0.965(2)	0.860(2)	1.120
Red Mwitunde	1.418(2)	1.088(6)	0.927(9)	1.049(1)	0.568(11)	1.010
1529	1.120(7)	1.243(2)	0.938(8)	0.881(6)	0.630(9)	0.962
ICGV-SM 83712 (ICGMS 46)	1.230(5)	1.006(7)	1.059(7)	0.664(11)	0.688(5)	0.929
2-5 x Johari (Robut 33-1)	1.153(6)	0.863(9)	1.234(2)	0.699(10)	0.648(8)	0.919
Bebiano Encarnado	0.768(9)	0.930(8)	0.915(10)	0.845(8)	0.672(6)	0.826
Njombe 3	0.498(10)	0.726(11)	1.173(4)	0.943(3)	0.776(4)	0.824
ICGV-SM 83702 (ICGMS 36)	0.456(11)	0.754(10)	1.120(5)	0.892(5)	0.832(3)	0.811
Controls						
Nyota (Spancross)	1.277(4)	1.225(3)	1.098(6)	0.896(4)	0.880(1)	1.075
Johari (Robut 33-1)	0.819(8)	1.176(4)	0.764(11)	0.748(9)	0.672(6)	0.836
SE 1. Varieties			±24.43			
2. Locations			±16.47			
3. Varieties x locations			±54.63			
Location mean	1.067	1.039	1.070	0.857	0.710	
CV(%)			5.1			

1. NAL = Naliendele; MTO = Mtopwa; TUM = Tumbi; NAC = Nachingwea; SUL = Suluti.
2. Numbers in parentheses are rankings.

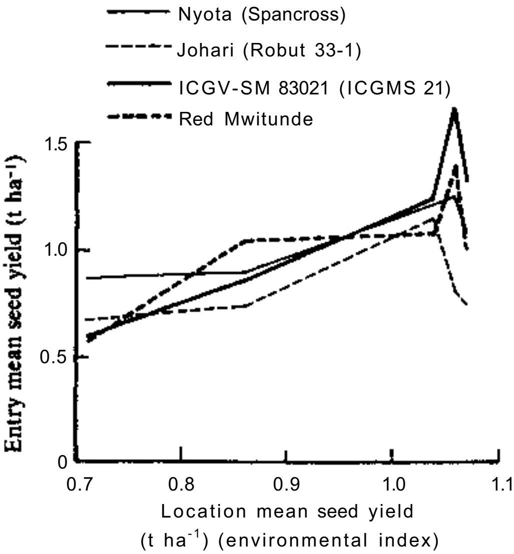


Figure 1. Genotype x environment interaction of four selected groundnut genotypes at five locations, Tanzania, 1988/89.

The yields of Nyota (Spancross) were comparable to the highest-yielding variety ICGV-SM 83021 (ICGMS 21). Significant yield differences between these varieties existed only at Naliendele. ICGV-SM 83021 is a very recent introduction and was included in the advanced yield trials for the first time this season following its good performance in previous preliminary yield tests. ICGV-SM 83021 is currently the most serious competitor to Nyota, still considered the highest-yielding variety 8 years after its release. The variety 69.62.2.5, which did not differ appreciably from Nyota at several sites, is a selection from Natal Common and one of the oldest varieties in our program. However, its performance is inconsistent and, therefore, does not pose any threat to Nyota.

Johari (Robut 33-1) was significantly less productive than most other varieties under test. At several sites, the yield of Johari was lower than those of ICGV-SM 83712 (ICGMS 46) and Red Mwitunde, all three of which belong to the same botanical group.

Stability and Other Parameters

For a crop grown in such a wide range of agroclimatic environments, stability becomes one of the most desirable properties of a genotype released for wide cultivation. Further it is a strong indicator of adaptability of a genotype. Resistance to the major stresses—both biotic ones, such as diseases, and abiotic ones, such as droughts—are other desirable attributes.

There were highly significant genotype x environment interactions. However, Nyota and Johari interacted less strongly with environment than most of the other varieties, e.g., ICGV-SM 83021 (ICGMS 21) and Red Mwitunde (Fig. 1).

Diseases, particularly early leaf spot, late leaf spot, and rust, are among the major constraints to groundnut production in Tanzania. Reactions of selected genotypes to late leaf spot [*Phaeoisariopsis personata* (Berk. & Curt.) v. Arx] severity (Table 2) indicate that the two commercial varieties are very susceptible to this disease, Nyota being the more susceptible.

Table 2. Severity of late leaf spot on selected groundnut genotypes, Naliendele, Tanzania, 1988.

Entry	Mean late leaf spot score[1]
Red Mwitunde	5.0
ICGV-SM 83702 (ICGMS 36)	5.3
Johari (Robut 33-1)	6.7
2-5 x Johari (Robut 33-1)	6.7
Nyota (Spancrcss)	8.0

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

References

Mwenda, F.F. 1987. Genetic and ecological diversity of local groundnuts in Tanzania. Pages 87-89 *in* Proceedings of the Second Regional Groundnut Workshop for Southern Africa, 10-14 Feb 1986, Harare, Zimbabwe. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Singh, R.K., and Chaudhary, B.D. 1977. Biometrical methods in quantitative genetic analysis. New Delhi, India: Kalyani Publishers.

Discussion

Sibuga: In a paper presented at this workshop, Johari (Robut 33-1) was rated as susceptible to rust, late leaf spot, and early leaf spot. What were the qualities considered in releasing this variety?

Mwenda: Despite the susceptibility to rust, late leaf spot, and early leaf spot, it was giving higher yields than the local varieties. Therefore, it was released purely because of its yield potential.

Subrahmanyam: Both Spancross and Johari (Robut 33-1) are susceptible to late leaf spot and rust.

Groundnut Improvement Program in Uganda

C M . Busolo-Bulafu[1]

Abstract

Groundnut (Arachis hypogaea *L.) is the second most widely grown grain legume in Uganda, the first being common bean* (Phaseolus vulgaris *L.). Groundnut is very well established in the country and is well accepted for cultivation and consumption. Recent research efforts to improve groundnut yield and quality in Uganda are discussed. Performance of breeding lines grown during the first rainy season in 1989 is reported.*

Sumário

O Programa de Melhoramento de Amendoim do Uganda. *O amendoim (*Arachis hypogaea *L.) é a segunda leguminosa de grão mais largamente cultivada no Uganda, sendo a primeira o feijão comum (*Phaseolus vulgaris *L.). O amendoim está bem estabelecido no país e é bem aceite para cultivo e consumo. Neste artigo são discutidos os recentes esforços da investigação para melhorar o rendimento e a qualidade do amendoim no Uganda. O comportamento das linhas de melhoramento, cultivadas durante a primeira estação chuvosa de 1989, é relatado.*

Introduction

Groundnut *(Arachis hypogaea* L.) has been grown in Uganda since 1862. It is now grown widely in the country and mostly consumed locally. The use of groundnut as a food and cash crop has increased substantially because of an increased awareness of protein shortages in Uganda. Groundnut is rich in proteins (25-35%) and fats (44-56%). Total production in the country is estimated at 140 000 t grown on 175 000 ha. It was in 1962-63 that the first hybridization work was conducted on the crop in Uganda. The aim was to incorporate resistance to rosette virus disease in the potentially high-yielding cultivars by utilizing resistant but poor yielders, and susceptible but high-yielding ones. Until then, groundnut research was confined mainly to agronomic studies, and selection and testing of promising varieties in the collection at Serere Research Station. This report highlights the various aspects of the groundnut research being undertaken in Uganda to improve the crop.

Uses of Groundnut in Uganda

Groundnut is a multipurpose crop. The seeds are consumed as roasted nuts. Groundnut flour is used in many of the dishes. Groundnut oil makes an excellent cooking medium. Groundnut cake, the by-product of oil extraction, is a rich livestock feed because of its high protein content. However, care must be taken to use clean, properly cured seed to avoid contamination

1. Groundnut Breeder, Namulonge Research Station, P.O. Box 7084, Kampala, Uganda.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

by aflatoxin, a metabolite of the fungus *Aspergillus fiavus.*

Groundnut is a good rotation crop as it improves soil fertility by fixing nitrogen through its symbiotic association with *Rhizohium.*

Problems of Groundnut Production in Uganda

In Uganda almost all the groundnut is grown by small-scale farmers of limited means. The average dried pod yield of 0.8 t ha^{-1} compares unfavorably with 3 t ha^{-1} (ICRISAT 1987) obtained in countries with developed agriculture. However, yields of over 2.5 t ha^{-1} have been achieved in experimental plots in some parts of the country, indicating a good potential to improve farmers' yields. Constraints to groundnut production in Uganda include disease and pest incidence. The main diseases are rosette virus disease and early leaf spot *(Cercospora arachidicola* Hori) but others which deserve mention are bacterial wilt disease (*Pseudomonas solanacearum*), rust, and stem rot caused by *Sclerotium rolfsii.* The insect pests include aphids which are vectors of the rosette virus, thrips, and white grubs (Scarabaeidae). Termites also cause damage in some areas. Other constraints include unreliable rainfall in some areas, with recurring drought, lack of high-yielding cultivars, poor agronomic practices, and little or no use of fertilizers. Storage diseases and pests are also a serious problem. These include *Aspergillus flavus,* moths, flour beetles *(Tribolium* spp), grain beetles *(Oryzaephilus* spp), etc., and occur especially when the pods are not properly dried or are stored in damp places.

Current Status of Groundnut Improvement in Uganda

To attain improved yields and good quality, selection and breeding efforts were initially directed at developing genotypes with resistance to the major diseases and pests (rosette virus disease, early leaf spot, bacterial wilt), early maturity, resistance to drought and to field sprouting, good storage quality, and high protein or oil content. In future, full use will be made of the germpiasm developed by ICRISAT on a collaborative basis. New varieties can be developed fairly rapidly (2-3 years) from the ICRISAT germpiasm, but they have to be carefully screened and tested for adaptability in the different agroecological zones.

Groundnut Research Projects

Breeding for resistance to rosette virus disease

The objective of this project is to develop cultivars resistant to rosette with acceptable agronomic and commercial qualities.

Rosette is one of the major diseases of groundnut in Uganda. It is a virus disease transmitted by aphids *(Aphis craccivora).* Heavy infestation may result in complete crop failure. Effective chemical control of the vector is possible, but it is too costly for the peasant farmer. The use of resistant varieties would be a much cheaper alternative.

We have evaluated seven lines derived from three crosses, together with the source of resistance, and one commercial variety, i.e., Roxo, in different agroecological zones. Four of these lines, i.e., Y6, X3, AT 5 (138/2/3/3), and AT 5 (139/6/4/1) gave significantly higher yields than the resistant parent in a preliminary yield trial (Table 1). It is hoped to release at least one of these in the near future.

Table 1. Yields of breeding groundnut lines and control varieties for first rains, Namulonge Research Station, Uganda, 1989.

Breeding line/ genotype	Yield (in shell) of dry pods (t ha^{-1})
Y6	1.687 a[1]
X3	1.562 ab
ATI 261/5/2/8	1.243 bc
AT4 107/2/4/3	1.1133c
ATS 138/2/3/3	1.543 ab
AT5 139/6/4/1	1.1882 a
AT4 74/3/5/3	1.1177c
295 (Resistant parent)	1.1072 c
Control	
Roxo	1.597 ab
CV(%)	23.5

1. Column means followed by the same letter(s) do not differ significantly at the 5% level of probability (*P* <0.05), according to Duncan's Multiple Range Test.

Mutation breeding

The objective of this project is to utilize induced mutation as a method of breeding groundnut to improve grain yield, quality, disease resistance, earliness, and adaptability.

Until 1976, the only method to create genetic variation in Uganda was controlled cross pollination. For this technique to give the best results, emasculation has to be conducted at night (about 2100) and pollination in the morning (between 0500 and 0700). This is inconvenient and time-consuming. The technique also does not produce many F_1 seed in groundnut.

Induced mutations have been used as an alternative, complementary, or unique solution in crop improvement (MacKey 1981), in addition to conventional methods. The advantages of induced mutations are that mutants can often be produced at high frequency, in a short time, and in selected genetic background (MacKey 1981). Several mutant groundnut varieties have been produced in various countries, especially in India and the USA (Gregory 1966).

In 1976, we initiated a mutation breeding program to broaden the genetic base in groundnut and to achieve some of the following breeding objectives:

- To improve resistance to
  - a. rosette virus disease transmitted by aphids, and
  - b. early leaf spot and late leaf spot [*Phaeoisariopsis personata* (Berk. & Curt.) v. Arx.].
- To shorten the maturity period of high-yielding varieties so that they can adapt better to the rainfall pattern of the main growing areas.
- To improve seed uniformity, size, and quality mainly of Red Beauty variety.
- To reduce plant height (in variety Roxo) by shortening the internodes so that more flowers are produced near the ground.

In this program, preliminary yield data have shown considerable increase in yield of one mutant (13/17/31/2/21) as compared with the control variety Roxo (Table 2). There are indications that mutation breeding can be a potentially valuable tool when yield is considered. It is hoped that one of these mutant lines will be released to the farmers after other parameters have been considered.

Breeding short- and medium-duration varieties resistant to leaf spots

Early and late leaf spots are the most important foliar fungal diseases of groundnut in Uganda. The loss

Table 2. Yields of mutant groundnut lines and control varieties at three locations for the first rains, Namulonge Research Station, Uganda, 1989.

Mutant line/ genotype	Yield of dry pods (t ha^{-1})			Mean yield
	Namulonge	Iki Iki	Kisindi[1]	(t ha^{-1})
32/25/11/6/1	1.15 a[2]	1.08 b[2]	2.52 ab[2]	1.58
32/25/11/1/32	1.26 a	1.38 a	2.40 bc	1.68
32/25/44/9/18	1.13a	1.06 b	1.74 e	1.31
32/25/11/6/19	1.32 a	1.03 b	2.44 bc	1.59
32/25/44/9	1.24 a	1.07 b	1.98 d	1.43
32/25/8/2	1.13a	1.03 b	2.57 a	1.58
13/17/31/2/21	1.12a	1.23 a	2.72 a	1.69
13/17/31/21/25	1.12 a	1.16b	2.03 d	1.44
Controls				
B1 (parent)	1.16a	1.03 b	1.75 e	1.31
Roxo	1.17a	1.64 a	2.35 c	1,72
CV (%)	10.5	19.9	18.5	

1. The trial at Kisindi Farm was given on ridges.
2. Column means followed by the same letter(s) do not differ significantly at the 5% level of probability ($P < 0.05$), according to Duncan's Multiple Range Test.

varies in magnitude and can be up to 80% in very severe infections, depending on the stage at which the crop is attacked. Considering the high cost of chemical control of the diseases, the most practical alternative is to develop and use resistant varieties.

Several sources of resistance are available, e.g., Kanyoma, Makulu Red, Mani Pintar, 292, RMP 12, and 295 but most of them are late maturing (4-5 months). Such varieties are only suitable for areas with unimodal rainfall patterns. Most of the groundnut-growing areas have bimodal rainfall patterns of about 90-110 days duration. Our aim is, therefore} to breed short-duration varieties that are adapted to the short rainfall season.

We are evaluating and selecting within half diallel crosses involving 10 parents. The materials are now at the F_6 generation and preliminary yield trials of promising lines will begin during the second rainy season in 1990.

Breeding for resistance to bacterial wilt disease

Bacterial wilt of groundnut has been observed in some areas of central and northwestern Uganda. Losses because of this disease can be severe if the soil is heavily infested. The disease is soilborne and, therefore, difficult to control chemically. The most effective means of control is the use of resistant varieties.

We have started screening germplasm accessions including those reported to be resistant. These include Kanyoma, ICG 5313, ICG 7393, ICG 6417, and ICG 7968. Congo Red, Red Beauty, and Roxo are being used as controls. Hybridization work might be considered if resistant genotypes cannot be directly used as cultivars.

Germplasm collection, maintenance, and utilization

The objectives are to build a gene bank through collection and conservation of local and exotic varieties as well as landraces.

Our collection at Serere Research Station had about 650 accessions in 1986. But because of insecurity in the area, some were lost and we now have about 350 accessions. We are planning to request more from ICRISAT. The accessions are maintained by active regeneration, because of lack of cold storage.

Maintenance breeding

The objective of maintenance breeding is to maintain and evaluate cultivars released by the Uganda Seed Project (USP) for stability.

In conjunction with the USP, we are currently maintaining Red Beauty and Roxo varieties. The work is being carried out on the Seed Farm of USP at Kisindi in Masindi district.

References

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1987. Annual report 1986. Patancheru, A.P. 502 324, India: ICRISAT.

Gregory, W.C. 1966. Mutation breeding. Pages 189-218 *in* Plant Breeding; a symposium held at Iowa State University (Frey, Kenneth J., ed.). Ames, Iowa, USA: Iowa State University Press.

MacKey, J. 1981. Value of induced mutation research for improving genetic knowledge. Pages 3-22 *in* Induced mutations—a tool in plant research: Proceedings of a Symposium, 9-13 Mar 1981. Vienna, Austria: International Atomic Energy Agency.

Discussion

Ismael: From your presentation, I gather that you have a very extensive research program. Do you have sufficient resources to carry out successfully all these programs?

Busolo-Bulafu: Each project is limited and we deal with few lines.

Ismael: Don't you think it would be better to select a few projects and allocate some resources to each so that you can achieve your aim much more efficiently and quickly?

Busolo-Bulafu: We have certain priorities and in practice we terminate the project when a new one is begun.

Haciwa: What progress has been achieved in mutation breeding as regards the objectives listed in the paper?

Busolo-Bulafu: Different varieties have shown desirable qualities in some aspects but no mutant has combined all the qualities that were sought for in the objectives.

Hildebrand: What is the background of your rosette resistant parent (295)?

Busolo-Bulafu: It is from Senegal.

Hildebrand: Is it *hypogaea* or *fastigiata?*

Busolo-Bulafu: I think it is Virginia.

Musanya: Yields at Kisindi appear to be much higher than those from the other two sites and according to the footnote, the varieties were sown on ridges. Is it common to grow groundnuts on the flat and not on ridges?

Busolo-Bulafu: In Uganda, groundnut is grown on the flat. At Kisindi, it was grown on ridges by the management; it is not a common practice.

Achievements of the Zambia Groundnut Improvement Program

M.B. Syamasonta[1]

Abstract

The results of the groundnut (Arachis hypogaea *L.) improvement program of Zambia during the 1987/88 and 1988/89 cropping seasons are discussed. One long-duration cultivar M13, which had consistently yielded better than the control cv Chalimbana, was released in 1988 as MGS 2. Two other long-duration varieties ICGV-SM 83708 (ICGMS 42) and 4a/8/2, which have yielded better than control cv Makulu Red, have been prereleased. Three short-duration Spanish varieties, ICGV-SM 83002 (ICGMS 2), ICGV-SM 83005 (ICGMS 5), and ICGV-SM 83011 (ICGMS 11) have shown promise and been found suitable for low-rainfall areas.*

Sumário

Resultados Conseguidos pelo Programa de Melhoramento de Amendoim da Zambia. *São discutidos os resultados do programa de melhoramento de amendoim (*Arachis hypogaea *L.) da Zambia, durante as estações agrícolas de 1987/88 e 1988/89. Um cultivar de longa duração, M 13, que teve um rendimento consistentemente melhor que o do controlo, cv. Chalimbana, foi libertado em 1982 como MSG 2. Duas outras variedades de longa duração, ICGV-SM 83708 (ICGMS 42) e 4a/8/2, que tiveram rendimentos melhores que o controlo, cv. Makulu Red, foram pré-libertadas. Três variedades "spanish" de ciclo curto, ICGV-SM 83002 (ICGMS 2), ICGV-SM 83005 (ICGMS 5) e ICGV-SM 83011 (ICGMS 11) mostraram-se promissoras e adequadas para áreas de baixa precipitação.*

Introduction

Prior to 1979, the groundnut (*Arachis hypogaea* L.) research program involved mostly varietal testing and agronomic studies. These studies resulted in the release of cv Makulu Red in 1964. Research conducted thereafter was intensified to cover an enlarged germplasm collection, the evaluation of long-duration genotypes, development of a hybridization program to cater to local needs, and the bulking of breeder and prebasic seed under rigid control. Extension activities were directed at dissemination of technology for groundnut production to extension personnel, seed services, and groundnut growers.

Evaluation of Long-duration Varieties

Two advanced groundnut varietal trials, consisting of 10 promising lines and local cultivars as control were conducted at four locations representing different agroecological zones during the 1987/88 and 1988/89

1. Groundnut Breeder and Coordinator, Msekera Regional Research Station, P.O. Box 510089, Chipata, Zambia.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

Table 1. Performance of selected oil type Virginia entries in advanced groundnut variety trials at four locations, Zambia, 1987/88 and 1988/89.

	Seed yield (t ha^{-1})										Percentage over control	
	Msekera[1]		Masumba		Chisamba		Kabwe		Entry Mean			
Entry	1987/88	1988/89	1987/88	1988/89	1987/88	1988/89	1987/88	1988/89	1987/88	1988/89	1987/88	1988/89
Flamingo	1.09	0.47	0.33	0.94	2.47	0.32	1.67	1.89	1.20	0.91	100	98
Gambia Bunch D	1.24	0.61	0.51	1.05	2.62	0.28	1.67	1.60	1.36	0.91	113	98
ICGV-SM 83702												
(ICGMS 36)	0.95	0.58	0.39	0.92	2.81	0.27	1.59	1.59	1.25	0.84	104	90
MGS 3	1.35	-[2]	0.46	-	2.55	-	1.71	-	1.31	-	109	-
MGS 4	1.34	0.96	0.75	1.47	2.91	0.20	1.67	1.85	1.46	1.12	122	120
MGS 5	1.26	0.73	0.45	0.99	2.46	0.27	1.90	1.24	1.18	0.81	98	87
MGS 6	1.09	0.60	0.41	0.94	2.66	0.20	1.29	1.50	1.18	0.92	98	99
P12/5/1	0.99	0.95	0.36	1.02	2.22	0.21	1.18	1.61	1.20	0.95	100	102
SAC 58	1.19	-	0.27	-	2.27	-	1.61	-	1.15	-	96	-
Control												
Makuiu Red	1.14	0.53	0.46	1.06	2.48	0.27	1.42	1.78	1.20	0.93		
SE	±0.039	±0.011	±0.033	±0.076	±0.137	±0.036	±0.147	±0.166				
Trial mean (14 entries)	1.16	0.65	0.44	1.10	2.56	0.28	1.55	1.69				
CV (%)	7	23	17	14	12	25	21	20				

1. Regional Research Station.
2. Not included in 1988/89.

cropping seasons. One trial compared oil-type entries with cv Makulu Red, and the other compared confectionery-type entries with cv Chalimbana. The design was a randomized block with four replications, and plots consisted of four rows, 6 m long, spaced 0.75 m apart. Seed was sown on ridges at a spacing of 10 cm.

Significant differences were observed in yields of oil-type entries at all the locations in both the seasons (Table 1). Four entries, i.e., ICGV-SM 83702 (ICGMS 36), MGS 3, Gambia Bunch D, and MGS 4 (ICGV-SM 83708 or ICGMS 42), significantly outyielded the conrol Makulu Red in the 1987/88 season. In the 1988/89 season only MGS 4 (ICGV-SM 83708) significantly outyielded Makulu Red.

Both Flamingo and MGS 4 recorded higher shelling percentage (77%) compared to Makulu Red (72%). Four other entries recorded significantly higher 100-seed mass than that of Makulu Red (53 g). These four entries are MGS 3 (66 g), MGS 4 (62 g), Flamingo (59 g), and P12/5/1 (59 g). All entries matured 2-12 days later than Makulu Red (134 days).

In the 1988/89 season, shelling percentages were nonsignificantly different at Msekera and Masumba, but at Chisamba and Kabwe significant differences were observed among the test entries. Entry 6/6/5 recorded the highest shelling percentage (70%) and was significantly superior to Makulu Red (58%). Entries also differed significantly in 100-seed mass at all the locations. The mean 100-seed mass was highest at Kabwe, with 8/8/1 and HYQ(CG)S/10 (83 g) recording significantly larger seed masses than Makulu Red (73 g).

High overall leaf spot severity was observed at Msekera, possibly because of the high rainfall received in February and March 1989. With the exception of Gambia Bunch D and MGS 5 (rating 6) the remaining entries recorded a rating between 7 and 9 on a 1-9 scale (1-2 = no disease, 3-6 = medium, and 7-9 = severe).

Among the confectionery-type entries, significant differences in seed yield were recorded in 1987/88 (Table 2). All the entries recorded higher mean seed yields than the control Chalimbana. MGS 2 yielded the highest, and had superior shelling percentage (68%) compared to Chalimbana (64%). Mean leaf spot severity ranged from 5.6 at Kabwe to 9 at Msekera.

In the 1988/89 season, seed yields were low but differed significantly among entries (Table 2). However, all entries except Ch. 88/74 performed better than Chalimbana by margins of 7% to 34%. Entries 16/10/16, 16/10/11, and MGS 2 were among the best yielders. Significant differences in shelling percentage were recorded only at Masumba. Entries 16/10/16 (69%) and MGS 2 (68%) showed a higher shelling percentage than the control Chalimbana (64%). Leaf spot severity, 100-seed mass, and defoliation percentage were significantly different among entries at Msekera and Masumba. The highest 100-seed mass of 83 g was recorded at Masumba by MGS 7 while Chalimbana recorded 77 g.

SADCC Regional Groundnut Yield Trials

Virginia

Twenty-five entries were sown in a 5 x 5 lattice design at Msekera and Chisamba in the 1988/89 season. The trial at Chisamba was destroyed by heavy rains.

Eight entries outyielded the control variety Makulu Red (Table 3) by margins of 8% to 57% (ICGV-SM 86751). ICGV-SMs 86725 and 86720 had greater shelling percentages than Makulu Red, while only one entry, ICGV-SM 87707, recorded significantly (*P* < 0.05) higher 100-seed mass.

Moderate mean leaf spot severity (rating 6.9) was observed in the trial. Entry ICGV-SM 86751 recorded the lowest leaf spot severity (rating 4.8) compared with Makulu Red (rating 7.0) and MGS 2 (rating 6.5). Sucking pest damage rating ranged from 1.9 to 5.1. Entry ICGV-SM 86703 showed tolerance to sucking pests.

Spanish

Twenty-five entries were sown in a 5 x 5 lattice design at Masumba and Mochipapa.

On an average, across the two locations, nine entries significantly outyielded the control variety Comet (0.68 t ha^{-1}). Three entries, ICGV-SMs 85038, 87003, and 83005, gave impressive seed yields. Shelling percentage ranged from 57% to 77% and is considered extremely good for Spanish types. Mean leaf spot ratings, 100-seed mass, and defoliating and sucking pest ratings were significantly different at both locations. At Masumba, leaf spot severity rating ranged from 4.4 to 8.3, while at Mochipapa it ranged from 2.1 to 5.0.

At Masumba, ICGV-SMs 85001 (rating 3.3) and 83005 (rating 3.9), showed good tolerance of sucking

Table 2. Performance of selected confectionery-type Virginia entries in advanced groundnut variety trials at four locations, Zambia, 1987/88 and 1988/89.

	Seed yield (t ha^{-1})										
	Msekera[1]		Masumba		Chisamba		Kabwe[2]	Entry mean		Percentage over control	
Entry	1987/88	1988/89	1987/88	1988/89	1987/88	1988/89	1987/88	1987/88	1988/89	1987/88	1988/89
8/8/19	1.01	0.45	0.54	0.74	2.65	1.11	1.55	1.26	0.76	138	107
16/10/11	1.11	0.38	0.44	1.06	2.67	1.17	1.49	1.22	0.87	134	123
16/10/16	1.02	0.47	0.42	1.25	2.58	1.14	1.33	1.19	0.95	131	134
Ch. 147/80	0.64	.2	0.27	-	2.34	-	1.33	1.15	-	126	-
MGS 7	0.71	0.33	0.42	0.85	2.56	1.01	1.21	1.12	0.73	123	103
Ch.83/74	0.70	0.34	0.32	0.57	2.15	1.09	1.15	0.95	0.67	104	94
Ch.83/286	0.64	-	0.36	-	2.57	-	1.30	1.21	-	133	-
E879/6/4	0.77	-	0.28	-	2.51	-	1.12	1.17	-	128	-
MGS 2	1.30	0.63	0.59	1.19	2.98	0.93	1.39	1.32	0.92	145	130
Control											
Chalimbana	0.56	0.32	0.29	0.75	2.14	1.06	1.11	0.91	0.71	100	100
SE[3]	±0.030	±0.007	±0.039	±0.053	±0.150	±0.073	±0.063				
Mean	0.85	0.50	0.39	0.99	2.51	1.03	1.30				
CV (%)	7.8	21.8	22.3	21.8	13.3	18.5	13.7				

1. Regional Research Station.
2. Not included in 1988/89.
3. Statistic for 16 entries.

Table 3. Performance of 25 Virginia entries in SADCC Regional Groundnut Variety Trial, Msekera, Zambia, 1988/89.

Entry	Plant density (%)	Seed yield (t ha^{-1})	Shelling (%)	Time to maturity (days)	ELS score[1] (1-9)	100-seed mass(g)
ICGV 336		0.58	70.8	130	7.8	43
ICGV 749	75	0.89	69.0	146	6.5	47
ICGV-SM 83708	82	0.57	60.5	130	7.3	46
ICGV-SM 85718	63	0.56	68.8	127	7.0	43
ICGV-SM 85726	87	0.46	62.3	129	7.3	33
ICGV-SM 85727	75	0.62	67.1	146	6.8	40
ICGV-SM 86751	69	1.05	58.4	146	4.8	41
ICGV-SM 85752	75	0.80	54.5	146	5.5	35
ICGV-SM 86753	70	0.91	56.9	146	6.3	33
ICGV-SM 85764	72	0.47	65.2	127	6.8	46
ICGV-SM 86715	64	0.73	67.3	146	6.5	50
ICGV-SM 86719	68	0.53	63.9	134	7.0	43
ICGV-SM 86720	81	0.53	72.1	127	7.8	44
ICGV-SM 86722	75	0.99	56.9	146	6.0	34
ICGV-SM 86725	81	0.65	71.9	127	9.0	45
ICGV-SM 86703	69	0.54	63.5	134	7.5	43
ICGV-SM 86704	65	0.34	70.6	126	9.0	34
ICGV-SM 86708	55	0.36	69.1	127	8.8	51
ICGV-SM 86734	65	0.90	71.8	146	6.8	47
ICGV-SM 86737	75	0.66	64.4	146	6.8	47
ICGV-SM 86760	63	0.73	70.3	146	6.5	49
ICGV-SM 86761	57	0.64	62.9	146	6.8	48
ICGV-SM 87707	56	0.65	65.3	146	6.0	51
Controls						
MGS 2	73	0.48	67.6	134	6.5	45
Makulu Red	71	0.67	70.0	146	7.0	47
SE	±6.6	±0.089	±3.1	±0.06	±0.21	±1.5
Trial mean	70	0.65	65.6	138	7.0	43
CV (%)	19	27	10	-	7	7

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

pest damage. At Mochipapa, sucking pest damage ranged from 3.8 to 6.8. Pod damage and pod scarification by soil pests were of no economic importance in this trial.

Achievements

A Virginia runner, M 13, developed at the Punjab Agricultural University, India, was released as MGS 2 in 1988. MGS 2 was found to be superior (25%) to Chalimbana in seed yield, tolerant to early leaf spot or *Cercospora arachidicola* (5%), and superior in shelling percentage (5%) but is 17 g inferior to Chalimbana in 100-seed mass. Mean seed yield of MGS 2 in 5 years of on-station testing was 2.5 t ha^{-1}.

In the same year ICGV-SM 83708 (ICGMS 42), from the SADCC/ICRISAT Groundnut Project, Malawi, was accepted for prerelease as MGS 4. Genotype 4a/8/2 from Zimbabwe was accepted for prerelease as MGS 3 in 1989. These varieties have superior seed characteristics and yield than Makulu Red.

Discussion

Chinganga: How many accessions of groundnuts do you have in your germplasm collection? Do you have a collection of wild relatives of groundnuts?

Syamasonta: The Zambian Groundnut Improvement Programme has got more than 1000 accessions of groundnuts. Unfortunately, it does not include wild relatives of groundnuts. However, when a need for these arises, they will be collected for use in the crossing programs. Also, the SADCC/ICRISAT Groundnut Project has got a good collection of wild relatives of groundnuts and when the Zambian program needs these they could make a request to the SADCC/ICRISAT Groundnut Project.

Wanchinga: It is important for national programs to indicate clearly in their presentations what contributions the regional program is making to the development of the necessary germplasm at the national level. This quantification is of interest to SACCAR as well as the donors who support the program.

General Discussion on Breeding

Syamasonta: Is there any program in the region which is trying to use groundnut plant residues as livestock feed?

Ndunguru: In West Africa this is very important but in the SADCC region it seems no program is using it, but it is worthy of investigation.

Production Constraints and Stress Resistance

Drought Effects on Growth and *Aspergillus* Infestation of Groundnut Cultivars in West Africa[1]

D.C. Greenberg[2], J.H. Williams[3], F. Waliyar[4], and BJ. Ndunguru[5]

Abstract

Groundnut (Arachis hypogaea *L.) genotypes from SADCC / ICRISAT Groundnut Project (Malawi), ICRISAT Center (India), and West Africa were evaluated for growth rates, partitioning to reproductive components, and susceptibility to* Aspergillus *spp in five stress environments. Poor partitioning observed in genotypes from the SADCC region may be indicative of greater susceptibility to stress during the reproductive stage than lines with proven drought resistance. Most SADCC lines were also found to be more susceptible to seed infection by* Aspergillus flavus *and* A. niger *than the established West African cultivars.*

Sumário

Efeito da Seca no Crescimento e na Infecção com *Aspergillus* de Cultivares de Amendoim na África Ocidental. *Genótipos de amendoim (*Arachis hypogaea *L.) do Projecto de Amendoim da SADCC/ICRISAT (Maláwi), ICRISAT-Centro (India) e da África Ocidental, foram avaliados em cinco ambientes de stress no respeitante às suas taxas de crescimento, partição para os componentes reprodutivos e pela susceptibilidade ao* Aspergillus *sp. A pobre partição dos genótipos provenientes da região da SADCC, pode ser indicador duma maior susceptibilidade ao stress, durante o estádio reprodutivo, em relação a linhas de comprovada resistência à seca. Foi ainda determinado que a maioria das linhas da SADCC são mais susceptíveis à infecção da semente com* Aspergillus flavus *e* A. niger, *do que os cultivares da África Ocidental já estabelecidos.*

Introduction

Drought is a common problem facing dryland farmers of the semi-arid tropics. Droughts are complex situations and crops may experience various combinations of drought stress, heat stress, and nutrient stress and may become more susceptible to damage by diseases or pests. Drought is commonly associated with low atmospheric humidity, which can in its own right reduce the proportion of flowers that

1. Paper was presented by Dr B.J. Ndunguru.
2. Principal Groundnut Breeder, ICRISAT Sahelian Center, B.P. 12404, Niamey, Niger (via Paris).
3. Principal Physiologist at the above address.
4. Principal Groundnut Pathologist at the above address.
5. Principal Groundnut Agronomist and Team Leader at the above address.

ICRISAT Conference Paper no. CP 469.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

form pods in groundnuts *(Arachis hypogaea* L.) (Lee et al. 1972). The development of genotypes that are more productive under drought-stress conditions is an important objective of the ICRISAT groundnut improvement programs.

Research on the effects of drought may be facilitated by the use of many useful statistical and process-based models to analyze yields achieved by crops. Firstly, breeders commonly use the stability analysis methods proposed by Finlay and Wilkinson (1963) and modified by Eberhart and Russell (1966) to assist in selection of genotypes with stability of yield over a range of environments. These methods have gained widespread acceptance and are used in this paper without detailed discussion of the methodology.

Secondly, for indeterminate crops, Duncan et al. (1978) proposed that yield differences could be analyzed against the model:

$$Y = C \times d \times p$$

where Y is the yield, C is the mean crop growth rate, d is the duration of reproductive growth, and p is the mean fraction of crop growth partitioned towards the reproductive sink. This approach has the advantage of separating the determination of yield into distinct independent processes and allowing an understanding of the various attributes of genotypes. To date, there have been many analyses of the yields of various crops exploiting the Duncan et al. 1978 model. These analyses have been restricted to few treatments because of the perceived need to undertake growth analysis to determine the C and p components of the model and have not been applicable for the selection of genotypes. However, J.H. Williams and V.M. Ramraj (ICRISAT Center, India, personal communication, 1989) have shown that final vegetative and reproductive yield data combined with limited phenological observations (times from sowing to flowering and harvest) can provide good estimates of the C and p determinants of yield without the need for destructive growth analysis. This approach, when applied to a large numbers of chickpea *(Cicer arietinum* L.) lines, has been effective in determining the scope for genetic improvement (J.H. Williams and N.R Saxena, ICRISAT Center, India, personal communication, 1989).

The most commonly perceived effect of droughts is loss of yield. But, in the case of groundnuts, drought over the period that the crop is approaching maturity (end-season drought) results in increased infection of the pods by *Aspergillus* spp with attendant deterioration in quality (Zambettakis et al. 1981; Mchan et al. 1988).

The SADCC/ICRISAT Groundnut Project in Malawi has not so far been able to screen groundnut material for drought responses in a systematic way, but this has been done for some SADCC lines provided to the West African Groundnut Improvement Program and which have performed well in western Africa. This paper compares the drought responses of these lines to those of the western Africa released cultivars, for the stability of their C, p, and yields in five quantified water-supply environments. It also reports on the relative susceptibility of these lines to *Aspergillus* spp in a situation where a terminal drought stress was imposed at about 50% pod-fill.

Materials and Methods

The results presented in this paper come from two trials grown at the ICRISAT Sahelian Center, Niamey, Niger, in 1989. These trials used 36 groundnut lines of which 4 were from the SADCC/ICRISAT Groundnut Project, 5 from the Niger national program, 2 from national programs in India, and 25 from ICRISAT Center. The first trial was sown on 2 February in the dry season. This trial was a split-plot design with three irrigation treatments replicated three times as the main plots. The quantity of irrigation given was calculated by estimating the potential evapotranspiration (PET) according to the Penman (1948) equation, and multiplying this figure by five. In the three irrigation treatments, the calculated quantity was applied once every 5, 10, or 15 days, giving these treatments 100%, 50%, and 33% of the PET. All treatments were given sufficient irrigation to establish the crop and the different treatments were imposed 3 weeks after sowing. Each main plot was surrounded by 1.5 m of border on all sides and contained two replicates of subplots of 36 groundnut lines arranged in a 6 x 6 simple lattice design. The subplots comprised three rows, each 1.5 m long, with 0.5 m between rows. For each groundnut genotype, all the three irrigation treatments were harvested when the control treatment was mature to avoid the stress treatments receiving more water than expected by remaining in the field longer.

The second trial was sown on 31 Jul 1989, about a month after the rains had set in, and used 35 of the same 36 groundnut lines as the first trial. This trial was divided in two halves with one half being irrigated through to maturity after the rains ceased (5 Oct

1989) and the other half being subjected to end-season drought. Each half of the trial contained the 36 groundnut genotypes, arranged as a 6 x 6 lattice with four replicates with five-row plots 3-m long with rows 0.5 m apart (7.5 m^2 plot area). The trial was harvested between 25 October and 11 November.

Both trials were regularly observed to determine the date at which 50% of the plants in each plot had commenced flowering. At harvest, the dry mass of haulms, pods, and seeds were measured. The times between sowing, flowering, and maturity were converted to thermal time (°C day) using daily temperature data (recorded at the ICRISAT Sahelian Center meteorological station) in the equation below (Mohamed et al. 1988), which assumes a base temperature for development of 10°C.

$$TT\ (°C\ day) = [(Max + Min)/2] - 10$$

The thermal times for the crops to mature in the two experiments were very similar for most genotypes (the largest difference for any genotype was 15%) but the means of the two experiments differed by only 9%, with the second trial maturing earlier.

Crop growth rate (C) and pod growth rate (PGR) were calculated as the linear rate of increase in t ha^{-1} (°C $day)^{-1}$ over the relevant crop growth periods for each genotype. To determine C, the growth period was measured from sowing to harvest, and to determine the PGR the growth was measured from 50% flowering to harvest. The partition coefficient (p) was calculated as PGR/C, according to the method of Duncan et al. (1978).

For the second experiment, the seeds were examined for infection by *Aspergillus* spp. This was done by plating on filter paper 75 surface-sterilized seeds of each genotype in two replicates of the trial. High humidity was maintained by adding distilled water to the plates to keep the filter paper moist. After 6 days of incubation, the number of seeds colonized by *A. flavus* and *A. niger* were recorded.

Results

The yields and estimated values of C and p for the genotypes in each of the environments showed that in all the five water-supply environments there was considerable diversity, and the environments highlighted different attributes of the genotypes. Because of the differences that existed in time-to-maturity between genotypes, we have grouped the genotypes as early maturing and medium/late maturing for comparison.

Yields

Yields of pod, seed, and haulm in all these environments are shown in Table 1. Significant differences in yield were found between genotypes. Pod yields were the highest in the rainy season control treatment, whereas haulm yields were the highest in the the dry-season control treatment.

Crop growth rate

Growth rates varied threefold between the best and the poorest environment, and among genotypes, but the variation among genotypes within the environments was generally smaller. However, the performances of individual genotypes across environments were usually consistent (as indicated by the high r^2 values in the Finlay and Wilkinson stability analysis) (Table 2).

Early lines. The C of ICGV-SM 83033 (ICGMS 33) was above average (Fig. 1) in all the five environments, while that of ICGV-SM 85045 (ICGMS 68) was below average in all environments, particularly so in the control environment of Experiment 1. The western African released (and drought tolerant) cv 55-437 was average for C in the best environment but tended to be better than average in the treatments that resulted in low C. However, 796, another western African released line, was below average for growth rate. ICGV 86047, which was bred in India, was consistently better than average across each environment.

Medium and late lines. ICGV-SM 83708 (ICGMS 42) and the western Africa cv 28-206 had similar C across the environments (Fig. 2), which was almost double the average of the control treatment but only slightly better than the average of the driest treatment. The other lines, i.e., ICGV-SM 83005 (ICGMS 5), ICGV-SM 85038 (ICGMS 63), and ICGV 87123 were very close to average across the environments, but it should be noted that there was considerable instability reflected in the lower r^2 of their regressions on the mean yields under different environments (Table 2).

Partitioning

In the second experiment, partitioning coefficients were, generally speaking, high (around 0.90) for both

Table 1. Performance of selected genotypes in drought simulation trials, ICRISAT Sahelian Center, Sadore, Niger, 1989[1].

Genotype	Irrigation treatment [2]										Mean days to harvest
	1	2	3	4	5	1	2	3	4	5	
	Haulm yield (t ha^{-1})					Pod yield (t ha^{-1})					
ICGV 86047	3.11	1.99	1.56	0.92	0.80	1.41	0.58	0.35	1.22	1.07	100
796	2.18	1.36	1.24	0.84	0.57	1.72	0.61	0.38	1.15	0.84	101
55-437	2.00	1.77	1.50	0.73	0.60	1.44	0.61	0.26	0.99	0.86	101
ICGV-SM 83033 (ICGMS 33)	4.19	2.94	1.91	1.26	0.95	0.78	0.33	0.18	1.30	0.99	103
ICGV-SM 85045 (ICGMS 68)	3.13	2.52	1.98	1.10	0.81	1.46	0.51	0.32	1.25	0.88	103
ICGV 87123	2.61	2.16	1.93	1.18	0.69	1.80	0.58	0.29	1.34	0.82	108
ICGV-SM 83005 (ICGMS 5)	3.69	2.72	2.16	1.29	0.64	1.21	0.49	0.13	0.86	0.57	108
ICGV-SM 85038 (ICGMS 63)	3.95	2.85	2.66	0.47	0.55	1.19	0.26	0.09	0.67	0.47	110
28-206	6.20	4.06	3.12	1.22	1.24	1.23	0.39	0.16	1.15	0.66	118
ICGV-SM 83708 (ICGMS 42)	5.57	3.60	2.90	0.78	1.08	1.42	0.34	0.17	0.87	0.88	119
SE	±0.26	±0.26	±0.26	±0.12	±0.11	±0.10	±0.10	±0.10	±0.11	±0.10	± 0.4
Mean (35 cvs)	3.58	2.42	1.79	1.06	0.85	1.24	0.52	0.23	1.10	0.84	108
CV(%)	18	18	18	21	26	28	28	28	19	23	1

1. 6 x 6 lattice with 4-6 replicates, plot size 2.25 m^2 (prerainy season) and 7.5 m^2 (rainy season).
2. Treatment 1 = Irrigated every 5 days; prerainy season.
   Treatment 2 = Irrigated every 10 days; prerainy season.
   Treatment 3 = Irrigated every 15 days; prerainy season.
   Treatment 4 = Irrigated through to maturity; rainy season.
   Treatment 5 = No irrigation at the end of the season; rainy season.
3. Numbers in parentheses are Aresin transformed values.

Continued.

Table 1. Performance of selected genotypes in drought simulation trials, ICRISAT Sahelian Center, Sadore, Niger, 1989[1]. *Continued.*

	Irrigation treatment[2]								
	1	2	3	4	5	4	5	4	5
Genotype	Seed yield (t ha^{-1})					*A.flavus* infestation (%)		*A. niger* infestation (%)	
ICGV 86047	0.62	0.21	0.10	0.78	0.78	8(16)[3]	4(12)	33(35)	26(31)
796	0.58	0.26	0.16	0.72	0.62	4(12)	1(5)	28(30)	10(18)
55-437	0.77	0.26	0.08	0.69	0.58	2(8)	1(5)	41(40)	10(18)
ICGV-SM 83033 (1CGMS 33)	0.19	0.09	0.04	0.84	0.54	21(27)	2(6)	37(36)	23(28)
ICGV-SM 85045 (ICGMS 68)	0.50	0.15	0.08	0.84	0.57	41(40)	9(17)	66(56)	31(33)
ICGV 87123	0.86	0.21	0.13	0.85	0.53	11(20)	3(9)	65(54)	17(25)
ICGV-SM 83005 (ICGMS 5)	0.30	0.10	0.02	0.54	0.37	19(26)	3(7)	63(53)	25(30)
ICGV-SM 85038 (ICGMS 63)	0.45	0.01	0.00	0.41	0.27	5(12)	32(34)	92(74)	48(44)
28-206	0.32	0.09	0.00	0.73	0.43	12(20)	3(10)	45(42)	34(35)
ICGV-SM 83708 (ICGMS 42)	0.53	0.08	0.03	0.55	0.54	57(49)	83(69)	83(66)	81 (67)
SE	±0.05	±0.05	±0.05	±0.08	±0.07	(±5)	(±5)	±11(±7)	±11 (±7)
Mean (35 cvs)	0.40	0.15	0.06	0.66	0.51	14(19)	9(14)	51(46)	46(33)
CV(%)	40	40	40	24	28	(40)	(40)	(36)	(36)

1. 6 x 6 lattice with 4-6 replicates, plot size 2.25 m^2 (prerainy season) and 7.5 m^2 (rainy season).
2. Treatment 1 = Irrigated every 5 days; prerainy season.
   Treatment 2 = Irrigated every 10 days; prerainy season.
   Treatment 3 = Irrigated every 15 days; prerainy season.
   Treatment 4 = Irrigated through to maturity; rainy season.
   Treatment 5 = No irrigation at the end of the season; rainy season.
3. Numbers in parentheses are Arcsin transformed values.

Table 2. Regression parameters for the relationship of genotype crop growth rate (C) and partition on mean crop growth rate and partitioning, ICRISAT Sahelian Center, Sadore, Niger, 1989.

	C regression parameters			Partition regression parameters			
Genotype	a	b1	r^2	a	b1	b2	r^2
ICGV-SM 85045 (ICGMS 68)	0.165	0.798	99	0.035	1.018		97
55-437	0.246	0.921	98	-0.462	3.831	-2.375	99
ICGV 86047	0.095	1.011	94	0.171	0.950		99
796	0.011	0.913	94	0.038	0.263	-1.329	99
ICGV-SM 83033 (ICGMS33)	0.237	0.954	94	0.237	0.599	1.499	99
ICGV-SM 83005 (ICGMS 5)	-0.115	1.055	89	-0.103	1.059		98
ICGV-SM 83708 (ICGMS 42)	-0.395	1.418	80	-0.225	1.248		99
ICGV-SM 85038 (ICGMS 63)	-0.314	1.119	66	-0.256	1.269		97
ICGV 87123	0.095	1.011	94	0.087	1.021		98
28-206	-0.353	1.490	88	-0.242	1.208		96

the water treatments; however, in the first experiment, the mean partitioning showed that there was a steady decline as the treatments became less favorable (Figs. 3 and 4). Partitioning of genotypes across these treatments demonstrated considerable variation, and the responses differed from those observed for C in that some very strongly curvilinear patterns were observed, while the C were usually linearly related to the treatment means. The partition coefficients above 1.0 (Fig. 3) indicate that either the assimilate already formed in the leaves is being translocated to the pods, or that the leaves are being shed before maturity.

Early genotypes. The partitioning response of ICGV-SM 85045 (ICGMS 68) was average and that of ICGV-SM 83033 (ICGMS 33) well below average (Fig. 3), except in the rainy-season experiments when the variability among genotypes was much smaller. In contrast to this, the Sahelian lines (55-437 and 796) were substantially better than average over all the three environments of Experiment 1. ICGV 86047 from ICRISAT Center was consistently better than average over all the environments.

Medium and late genotypes. In all the environments, the ICGMS selections were below average in their partitioning (Fig. 4). The same applies to the western African line 28-206. However, ICGV 87123 from ICRISAT Center was found to be consistently above average across all the environments.

Infection by *Aspergillus flavus* and *Aspergillus niger*

Seed colonization was high in all the genotypes in both irrigated and end-season draughted treatments (Table 1). ICGV-SM 83708 (ICGMS 42) was the most infected by *A.flavus* (49% in the irrigated treatment and 69% in the other treatment). The least infected line was the western African cv 55-437, which is known for its resistance to *A.flavus* (Zambettakis et al. 1981). All the lines tested were susceptible to *A. niger* but the lines from SADCC were infected approximately twice as severely as the western African lines were.

Discussion

Before we consider the C and p of varieties, we should consider the factors that influence these parameters in the test environments created by different irrigation treatments. Where water is in short supply, crop growth rate is the outcome of (a) the crops' ability to take up water and (b) the ratio of water used to carbon assimilated (Passioura 1977). The differences between genotypes and environments reflect the ability of genotypes to initiate enough fruit to utilize the carbon assimilates available. Duncan et al. (1978) showed that groundnut yields in Florida, USA, were associated with changes in p. In our experiments, we

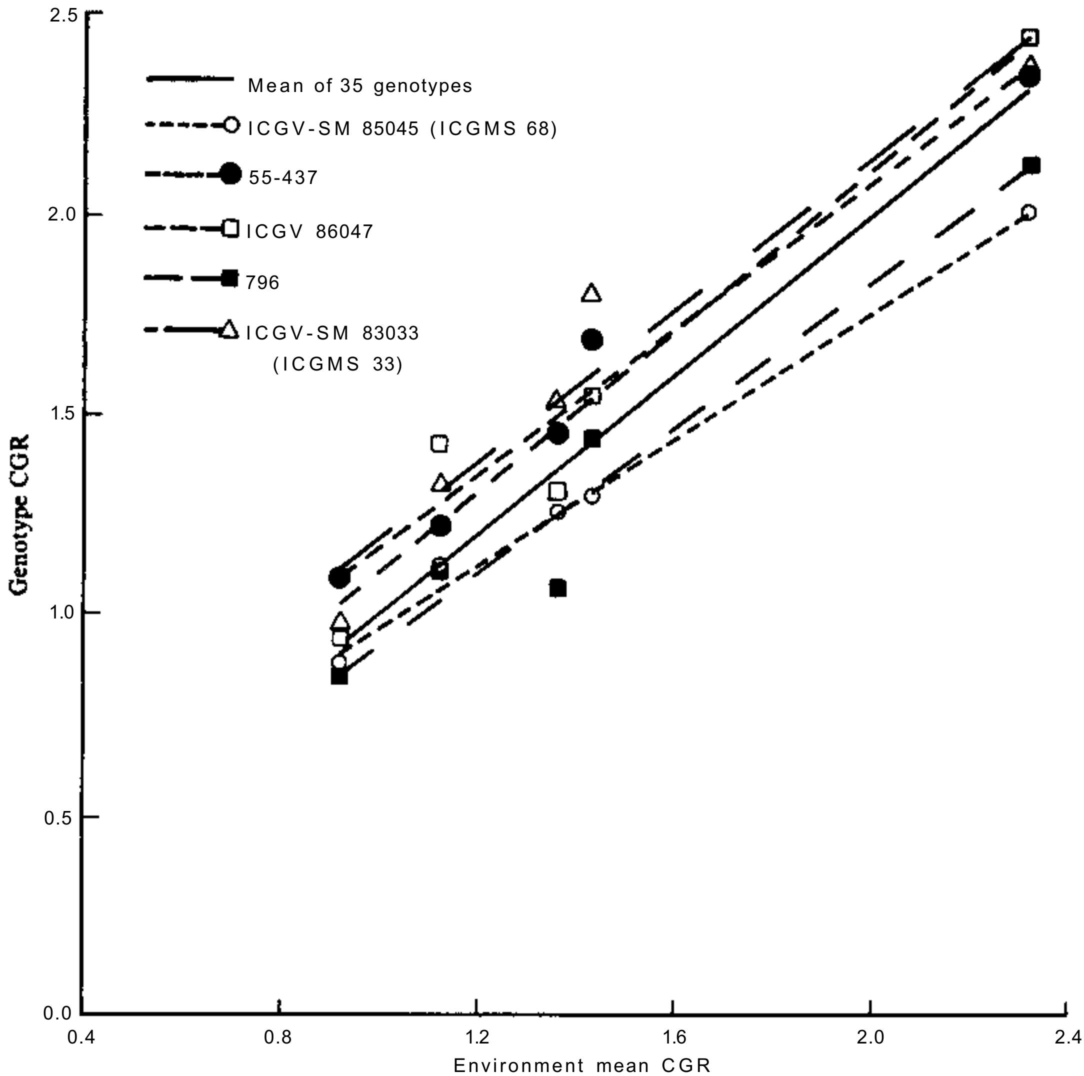


Figure 1. Crop growth rate (CGR) of selected groundnut genotypes over five drought environments, ICRISAT Sahelian Center, Sadore, Niger, 1989.

exposed the crops to high temperature, low humidity, and inadequate water supply, either throughout the crops' life or only towards the end. Even in the fully irrigated summer crop, the plants were subjected to low humidity and high temperatures. Despite the high crop-growth rates in this environment, the failure in producing enough pods to utilize the available water resulted in lower yields than in the rainy season when the C was lower but p was higher. Temperatures above 33°C have been shown to reduce flower development (Fortanier 1957; de Beer 1963). The tolerance of reproductive processes to high temperatures is certainly a desirable attribute in drought-prone areas, considering the association of drought with higher plant and atmospheric temperatures. The high partitioning observed in both the end-season drought and the control of Experiment 2 is to be expected because of the priority that established pods have for assimilates in the event of assimilate shortage (Williams et al. 1976). In the rainy season control treatment, the

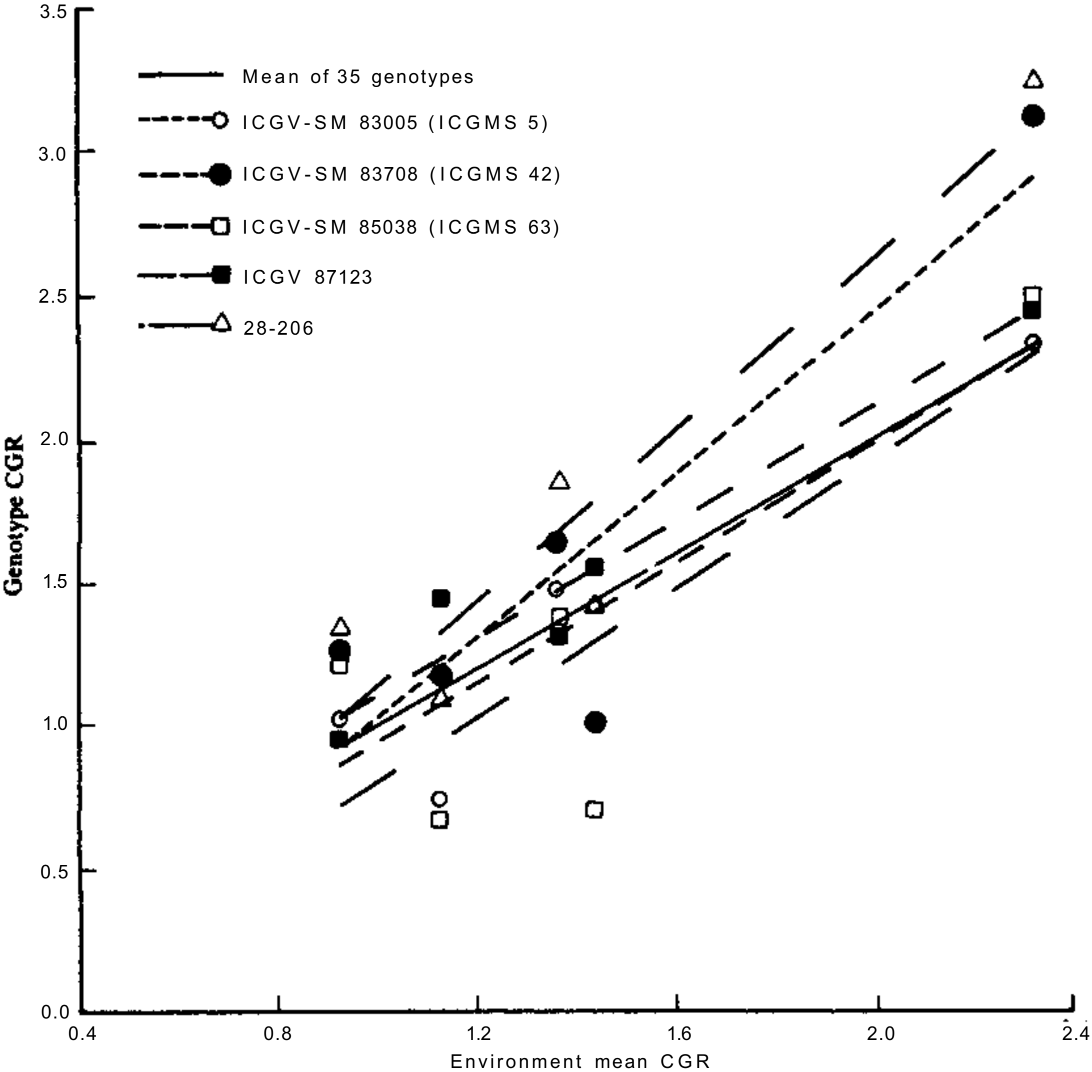


Figure 2. Crop growth rate (CGR) of selected groundnut genotypes over five drought environments, ICRISAT Sahelian Center, Sadore, Niger, 1989.

high partitioning of the genotypes discussed is consistent with their ability to yield well in nonstressed environments (Duncan et al. 1978).

The varieties compared in this paper provide some interesting insights into the processes that lead to high yields and adaptation to the areas where they originate. Generally, all those genotypes with known drought tolerance (55-437, ICGV 87123, and 796) had C that was close to or slightly above the average in all the environments. Also, they were substantially better in partitioning in Experiment 1, where temperature and drought stress occurred during the reproductive initiation stage. In contrast, cv 28-206, which was released for the more humid zones of western Africa, was lower than average in partitioning and had above-average growth rate. This, we believe, is because the longer vegetative phase and the lower partitioning allowed more root growth, which led to

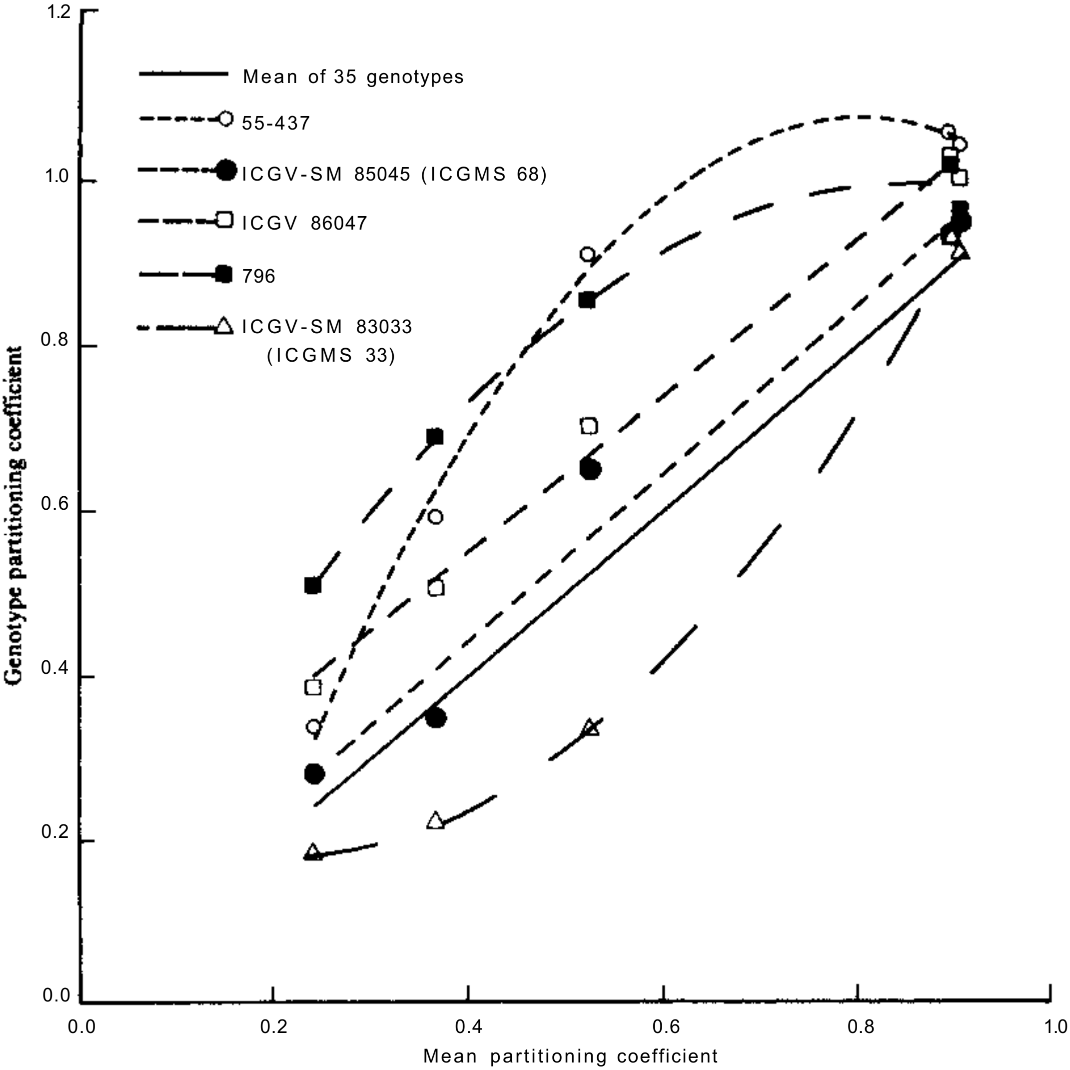


Figure 3. Partitioning of selected groundnut genotypes over five drought environments, ICRISAT Sahelian Center, Sadore, Niger, 1989.

increased water uptake, resulting in the higher growth rate.

The generally poor partitioning of the SADCC/ ICRISAT Groundnut Project (Malawi) lines in the early droughts must be a cause for concern since it indicates that this material is much more vulnerable to these stresses. One could argue that since the SADCC/ICRISAT Groundnut Project lines are proving to be successful in the region, the stresses encountered in western Africa are not common in southern Africa. However, droughts are a serious problem in many areas in the SADCC region. Since, from the evidence of western Africa genotypes, it is possible to have these stress-resistant attributes in lines with good partitioning in nonstressed conditions, we feel that a deliberate effort to introduce stability for partitioning under stress conditions into the breeding and evaluation program would be beneficial. The method that we have employed here is relatively simple and does not require sophisticated equipment.

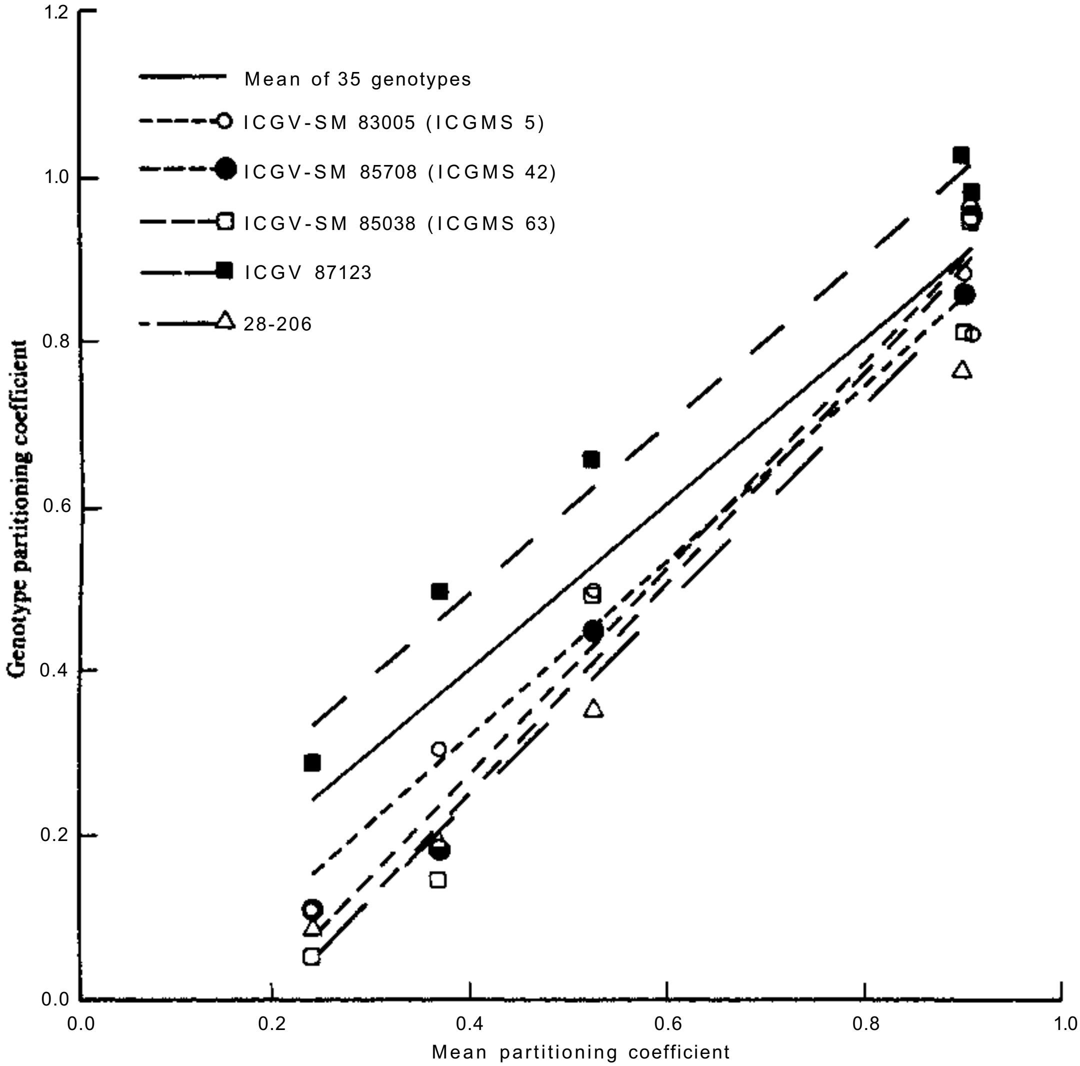


Figure 4. Partitioning of selected groundnut genotypes over five drought environments, ICRISAT Sahelian Center, Sadore, Niger, 1989.

We feel that analyses, such as we have undertaken, could be a valuable addition to the SADCC/ICRISAT Groundnut Project (Malawi) crop improvement process.

The observed levels of resistance to *A. flavus* show that within the ICGMS lines there is considerable variability in this resistance. Clearly, with increased emphasis on screening, resistant materials could be developed within the SADCC/ICRISAT Groundnut Project. However, while the levels of resistance demonstrated by the western African lines are generally higher than those in the SADCC/ICRISAT Groundnut Project lines, it is possible that these lines are more resistant to the local strains of fungi. Therefore, these results should be confirmed in the region before further action is taken. The same consideration would seem to apply to *A. niger,* which affects seed quality of groundnut, reduces germination, and causes crown rot or seedling disease.

References

de Beer, J.F. 1963. The influences of temperature on *Arachis hypogaea* with special reference to its pollen viability. Ph.D. thesis, State Agricultural University, Wageningen, the Netherlands.

Duncan, W.G., McCloud, D.E., McGraw, R., and Boote, K.J. 1978. The physiology of peanut yield improvement Crop Science 18:1015-1020.

Eberhart, S.A., and Russell, W.A. 1966. Stability parameters for comparing varieties. Crop Science 6:36-40.

Flnlay, K.W., and Wilkinson, G.N. 1963. The analysis of adaptation in a plant-breeding programme. Australian Journal of Agricultural Research 14:742-754.

Fortanier, E.J. 1957. De beinvloeding van der bloej by *Arachis hypogaea* L. Ph.D. thesis, State Agricultural University, Wageningen, the Netherlands.

Lee, T.A., Ketring, D.L., and Powell, R.D. 1972. Flowering and growth responses of peanut plants at two levels of relative humidity. Plant Physiology 48:190.

Mehan, V.K., Nageswara Rao, R.C., McDonald, D., and Williams, J.H. 1988. Management of drought stress to improve field screening of peanuts for resistance to *Aspergillus flavus.* Phytopathology 78:659-663.

Mohamed, H.A., Clark, J.A., and Ong, C.K. 1988. Genotype differences in the temperature responses of tropical crops. Journal of Experimental Botany 39:1121-1128.

Passioura, J.B. 1977. Grain yield, harvest index and water use of wheat. Journal of Australian Institute of Agricultural Science 43:117-120.

Penman, H.L. 1948. Natural evaporation from open water, bare soil, and grasses. Royal Society of London Proceedings (Series A) 193:120-145.

Williams, J.H., Wilson, J.H.H., and Bate, G.C. 1976. The influence of defoliation and pod removal on growth and dry matter distribution in groundnuts *(Arachis hypogaea* L. cv. Makulu Red). Rhodesian Journal of Agricultural Research 14:111-117.

Zambettakis, G., Waliyar, F., Bocklee-Morvan, A., and de Pins, O. 1981. Results of four years of research on resistance of groundnut varieties to *Aspergillus flavus.* Oleagineaux 36:377-385.

Discussion

Freire: Do you think that drought screening during the dry/cool season can be used with a good degree of reliability?

Ndunguru: We attempted to screen for drought at ICRISAT Sahelian Center during the cold season without much success. Hence, all our screening for drought is carried out either during the hot season or during the rainy season by sowing date.

Hildebrand: Why did cold-season screening for drought resistance in Niger fail?

Ndunguru: Temperatures were decreasing and these low temperatures may have resulted in evapotranspiration rates that were too low to allow imposition of sufficiently severe drought treatments.

Schmidt: I am impressed by the varietal differences in drought tolerance. The question is, whether there is a complication by differences in vegetative growth or leaf area leading to differences in moisture consumption. This may result in differences between varieties with regard to optimal spacing. Would the differences in drought resistance still exist with each variety sown at its optimal spacing?

Ndunguru: The experiments have been conducted during one season only and the question of optimal spacing has not yet been included.

Mande: How did you determine the quantity of water to be applied in the irrigated treatments and when did you start irrigating?

Ndunguru: The quantity of irrigation given was calculated by estimating the potential evapotranspiration (PET) according to the Penman equation and multiplying this figure by 5. In all the treatments, irrigation started 3 weeks after emergence.

Pathology

Resistance to Rust and Late Leaf Spot of Groundnut at ICRISAT Center: Problems and Progress

P. Subrahmanyam[1], D. McDonald[2], L.J. Reddy[3], S.N. Nigam[4], J.P. Moss[5], A.K. Singh[6], and V. Ramanatha Rao[6]

Abstract

Rust (Puccinia arachidis *Speg.) and late leaf spot* (Phaeoisariopsis personata) *are the most important fungal diseases of groundnut* (Arachis hypogaea *L.) worldwide. Simple and effective screening methods for resistance to these diseases have been developed at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Center, India. Over 12000 germplasm lines from all over the world have been successfully screened for these two diseases from 1977 to 1990 and several sources of resistance to these diseases have been identified. Components of resistance to the two diseases were investigated and the stability of resistance to the diseases established through multi-locational trials. Most of the germplasm lines resistant to these diseases are not agronomically acceptable. Hence, a large-scale hybridization program was initiated and several high-yielding, agronomically superior lines with resistance to the two diseases were bred. Several accessions of wild* Arachis *species were found to be immune or highly resistant to the two diseases. Cytogenetic research incorporating these resistances into cultivated groundnut has been very successful in developing high-yielding, disease-resistant lines. The progress made on these aspects at ICRISAT Center is briefly discussed and future research needs are presented.*

Sumário

Resistência do Amendoim à Ferrugem e Mancha Tardia das Folhas no ICRISAT-Centro: Problemas e Progresso. *A ferrugem (*Puccinia arachidis *Speg) e a mancha tardia das folhas (*Phaeoisariopsis personata*) são as mais importantes doenças do amendoim (*Arachis hypogaea *L.), causadas por fungos, em todo o mundo. Métodos simples e efectivos de avaliação da resistência a estas doenças, foram desenvolvidos no Instituto Internacional de Investigação de Culturas para os Trópicos Semi-Áridos (ICRISAT) Centro, India. Mais de 12000 linhas de germoplasma, vindas de*

1. Senior Plant Pathologist (Legumes Program), ICRISAT Center, Patancheru, A.P. 502324, India.
2. Principal Plant Pathologist and Program Director (Legumes Program) at the above address.
3. Groundnut Breeder (Legumes Program) at the above address.
4. Principal Groundnut Breeder (Legumes Program) at the above address.
5. Principal Cell Biologist (Legumes Program) at the above address.
6. Botanist (Genetic Resources Unit) at the above address. Present address of Dr Rao: Genetic Diversity Officer, IBPGR, 142, via delle Sette Chiese, Rome 00145, Italy.

ICRISAT Conference Paper no. CP 623.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

todo o mundo, foram avaliadas com sucesso para estas ducts doengas, desde 1977 a 1990. Vdrias fontes de resistencia a estas doencas foram identificadas. Atraviz de ensaios multi-locais, os componentes da resistencia a estas duas doengas foram investigados e a estabilidade da resistincia a estas doengas estabelecida. A maior parte das linhas de germoplasma resistentes a estas doengas nao sao agrondmicamente aceitdveis. Assim, urn programa de hibridacao de larga escala foi iniciado e vdrias linhas de alto rendimento, agrondmicamente superiores, resistentes a estas duas doengas foram cruzadas. Determinou-se que vdrias aquisigoes de especies selvagens de Arachis *sao imunes ou altamente resistentes a estas duas doengas. Investigagao citogenetica, incorporando estas resistincias no amendoim cultivado, tern sido hem sucedida no desenvolvimento de linhas de alto-rendimento, resistentes a doengas. O progresso feito nestes aspectos, no ICRISAT-Centro, e brevemente discutido e as necessidades de investigagdo futura sao apresentadas.*

Introduction

Rust *(Puccinia arachidis* Speg.) and late leaf spot *[Phaeoisariopsis personata* (Berk. & Curt.) v. Arx] are the most serious fungal diseases of groundnut *(Arachis hypogaea* L.) on a worldwide scale (Subrahmanyam et al,. 1985b; McDonald et al. 1985). Both diseases are commonly present wherever groundnut is grown, but their incidence and severity vary among localities and seasons. Yield losses are generally substantial when the crop is attacked by both rust and late leaf spot. At ICRISAT Center, India, both diseases normally occur together causing severe damage to foliage and occasioning yield losses as high as 70% (Subrahmanyam et al. 1984). Although rust and late leaf spot can be controlled effectively by certain fungicides (Smith and Littrell 1980), it is not economically feasible for the vast majority of small-scale farmers in the semi-arid tropics (SAT). Hence, developing high-yielding, disease-resistant cultivars and making them available to farmers is one of the best means of reducing the yield losses from these diseases (Gibbons 1980). Recognition of this has stimulated research in many countries to exploit host-plant resistance to rust and late leaf spot.

In this paper, the progress made on breeding for resistance to rust and late leaf spot diseases by a multidisciplinary research team at ICRISAT Center is briefly reviewed, and future research strategies are discussed.

Screening Methods

Effective screening methods have been developed for use in areas where natural disease pressure is high or where such pressure can be artificially created. Genotypes to be screened are sown in replicated plots with infector rows of highly susceptible cultivars on either side. To enhance disease development, plants in infector rows are inoculated with spore suspensions. This is most successful if done in the evening, following irrigation. Additional late leaf spot inoculum is provided by scattering leaf debris collected from the previous season's diseased crops along the infector rows. Potted spreader plants heavily infested with rust or late leaf spot are also placed systematically throughout the field to provide further sources of inoculum. When necessary, to obtain one disease without the other, infector rows are sprayed with carbendazim to control leaf spot or with tridemorph to control rust. Depending on the climatic conditions, fields may be irrigated using overhead sprinklers until harvest. Some 10 days before harvest each genotype is scored for the development of rust and late leaf spot using a 9-point scale (Subrahmanyam et al. 1982a, 1982b).

Screening of germplasm for resistance to rust and late leaf spot can also be done on a limited scale in the greenhouse using potted plants, or in the laboratory using detached leaves, by measuring one or more components of disease resistance such as incubation period, infection frequency, lesion diameter, percentage leaf area damage, defoliation, and sporulation (Subrahmanyam et al. 1982b, 1983a, and 1983b). A greenhouse or laboratory screening method could be useful in areas where rust and late leaf spot epidemics do not occur regularly or where other foliar diseases interfere with field screening. However, these techniques are of limited use in identifying moderate levels of resistance.

Sources of Resistance

At ICRISAT Center, a world collection of over 12 000 germplasm lines has been screened in the field against rust and late leaf spot during the period 1977-89, and 124 rust-resistant, 54 late leaf spot resistant, and 29 rust and late leaf spot resistant germplasm lines were identified (Table 1). These include 14 rust-resistant germplasm lines jointly released by the United States Department of Agriculture and ICRISAT (Subrahmanyam and McDonald 1983). It is interesting that most of the rust and/or late leaf spot resistant genotypes have originated in Peru (Subrahmanyam et al. 1989), which is believed to be one of the secondary gene centers of cultivated groundnut (var. *hypogaea* and *var. fastigiata)* (Gregory et al. 1980).At ICRISAT

Table 1. Sources of resistance to both rust and late leaf spot in groundnut available at ICRISAT Center (in 1989).

					Disease score[2]	
ICG No.[1]	Identity	*Arachis* type/variety	Seed color	Origin	Rust	Late leaf spot
1703	NC Ac 17127	*fastigiata*	Variegated	Peru	4.7	5.0
1707	NC Ac 17132	*fastigiata*	Purple	Peru	4.0	4.0
1710	NC Ac 17135	*fastigiata*	Dark purple	Peru	4.0	4.0
2716	EC 76446 (292)	*fastigiata*	Dark purple	Uganda	3.3	4.7
3527	USA 63	*fastigiata*	Purple	USA	4.7	4.7
4747	PI 259747	*fastigiata*	Purple	Peru	3.7	4.0
4995	NC Ac 17506	*fastigiata*	Purple	Peru	4.3	4.3
6022	NC Ac 927	*fastigiata*	Purple	Sudan	4.0	4.0
6330	PI 270806	*hypogaea*	Tan	Zimbabwe	2.1	3.3
6340	PI 350680	*fastigiata*	Dark purple	Honduras	3.0	4.0
7013	NC Ac 17133-RF	*fastigiata*	Dark purple	India	3.3	4.0
7881	PI 215696	*fastigiata*	Dark purple	Peru	4.3	3.7
7884	PI 341879	*fastigiata*	Purple	Israel	3.0	3.7
7885	PI 381622	*fastigiata*	Purple	Honduras	3.0	4.3
7886	PI 390593	*fastigiata*	Tan	Peru	4.7	3.3
7894	PI 393641	*fastigiata*	Variegated	Peru	4.0	4.7
7897	PI 405132	*fastigiata*	Purple	Peru	2.7	4.0
10010	PI 476143	*fastigiata*	Variegated	Peru	4.0	5.0
10023	PI 476152	*fastigiata*	Tan	Peru	4.3	4.7
10028	PI 476163	*fastigiata*	Purple	Peru	4.7	5.0
10029	PI 476164	*fastigiata*	Tan	Peru	4.3	5.0
10035	PI 476172	*fastigiata*	Purple	Peru	4.0	3.7
10889	PI 476016	*fastigiata*	Red	Peru	3.3	4.3
10915	PI 476148	*fastigiata*	Variegated	Peru	2.3	5.0
10936	PI 476168	*fastigiata*	Dark purple	Peru	4.3	4.0
10940	PI 476173	*fastigiata*	Variegated	Peru	2.3	5.0
10941	PI 476174	*fastigiata*	Light purple	Peru	4.7	4.7
11182	PI 476015	*fastigiata*	Tan	Peru	2.7	5.0
11485		*fastigiata*	Light purple	Peru	5.0	3.7
Susceptible control cultivars						
221	TMV 2	*vulgaris*	Tan	India	8.3	8.0
799	Robut 33-1	*hypogaea*	Tan	India	7.7	7.3

1. ICRISAT groundnut accession number.
2. Scored on a modified 9-point disease scale, where 1 = 0%, 2 = 1 to 5%,3 = 6 to 10%, 4 = 11 to 20%, 5 = 21 to 30%, 6 = 31 to 40%, 7 = 41 to 60%, 8 = 61 to 80%, and 9 = 81 to 100% foliage destroyed; ICRISAT Center, rainy season 1989.

Center, several accessions of wild *Arachis* spp were also systematically evaluated for their reactions to rust and late leaf spot in the field and in the laboratory. Many of the species were found to be immune/ highly resistant to rust and/or late leaf spot (Subrahmanyam et al. 1983c and 1985a).

Components of Resistance

Urediniospores germinate and germ tubes enter through stomata irrespective of whether a genotype is immune, resistant, or susceptible to rust. Rust resistance is not correlated with either the frequency or the size of stomata. Differences in resistance are associated with differences in rate and extent of mycelial development within the substomatal cavity and within leaf tissues. In immune *Arachis* spp the fungus dies shortly after entering the cavity. The rust resistance available at present in the cultivated groundnut is of the "slow-rusting" type, i.e., resistant genotypes have decreased infection frequency, increased incubation periods, and reduced pustule size, spore production, and spore germinability (Subrahmanyam et al. 1983a and 1983b). The extent of rust damage to foliage is dependent on the physiological age of the plant. Young plants are most susceptible to rust attack and the susceptibility declines with age (Subrahmanyam et al. 1982a).

Late leaf spot resistance is also not correlated with either the frequency or the size of stomata. Resistance to the late leaf spot pathogen also operates through prolonging incubation and latent periods, and reducing infection frequency, lesion size, sporulation, and defoliation (Subrahmanyam et al. 1982b).

The effects of these components of resistance to rust and late leaf spot are cumulative over the course of a disease epidemic. In general, on resistant genotypes, the disease appears late, builds up only slowly, and does little apparent damage to the foliage, as evidenced by the lower rates of disease development (r) and area under the disease progress curve (AUDPC).

Stability of Resistance

Stability of host resistance over space and time is an important breeding objective. Some of the rust and/or late leaf spot resistant genotypes identified at ICRISAT Center are being tested in different locations of the SAT in the International Groundnut Foliar Diseases Nursery. The results obtained indicate that rust and late leaf spot resistances of most genotypes are stable over a wide range of geographic locations but the genotype NC Ac 17090 is highly resistant to rust at ICRISAT, only moderately resistant in the People's Republic of China, and susceptible in Taiwan. In contrast, the genotype PI 298115 is only moderately resistant at ICRISAT, and highly resistant in the People's Republic of China and Taiwan. Although this indicates the possibility of variation in the pathogen, there is no authenticated report of the occurrence of pathotypes.

Utilization of Resistance

Most rust and late leaf spot resistant germplasm lines have undesirable pod and seed characters such as dark testa and heavily reticulated pods. At ICRISAT Center, more than 1000 single, two-way, and three-way crosses were made between lines with good agronomic characters and lines resistant to rust and/or late leaf spot. Large F_2 populations, and subsequent generations, were grown in the field during the rainy season and screened for resistance using the infector row method. Several high-yielding agronomically superior lines with high levels of resistance to rust and moderate levels of resistance to late leaf spot were bred by pedigree and mass pedigree methods (Reddy et al. 1984). Backcrossing was also used in a few instances to improve pod, seed, and plant characters. Several of these resistant lines outyielded released susceptible cultivars when tested in multilocational trials (Table 2), and some are in advanced stages of testing in several countries. For example, the high-yielding varieties ICG (FDRS) 4 and ICG (FDRS) 10 resistant to rust and moderately resistant to late leaf spot will soon be released for cultivation in the peninsular zone of India.

Early generation breeding materials have been freely distributed to scientists in national and international programs to enable them to carry out further selection *in situ* under local agroclimatic conditions. This has resulted in a successful development and release of some rust and late leaf spot resistant groundnut varieties such as Girnar 1, DOR 18-10, and ALR 1 in India.

Cytogenetic research incorporating resistances from wild *Arachis* spp into the cultivated groundnut has also resulted in many resistant lines. The wild *Arachis* spp resistant to rust and/or late leaf spot are diploid, and groundnut cultivars are tetraploid. Tetraploid segregating populations were produced by incorporating genes from wild *Arachis* spp and by screening for resistance. By backcrossing with the cultivated groundnut, and by screening for resistance, several high-yielding lines with resistance to rust and/or late leaf spot were developed (Moss 1985; Singh et al. 1987).

Table 2. Performance of some best groundnut entries in the International Foliar Diseases Resistance Groundnut Varietal Trials conducted in seven countries, 1985-89.

Country	Variety	Pod yield ($t\ ha^{-1}$)
Bangladesh	ICGV 87183	3.62
	Control Dacca 1	1.58
SE		±0.26
CV (%)		24
Myanmar	ICGV 87179	1.73
	Control Japan Kalay	0.14
SE		±0.12
CV (%)		23
India	ICGV 86687	2.30
	Control ICGS 11	0.88
SE		±0.16
CV (%)		20
The Philippines	ICGV 87184	3.06
	Control BPI PN-9	1.45
SE		±0.40
CV (%)		32
Sudan	ICGV 87152	4.84
	Control Kiriz	4.39
SE		±0.37
CV (%)		18
Swaziland	ICGV 87157	2.37
	Control Natal Common	1.63
SE		±0.22
CV (%)		21
Thailand	ICGV 87358	3.92
	Control Tainan 9	2.16
SE		±0.31
CV (%)		20

The level of resistance to late leaf spot in wild species, and in derivatives of crosses between cultivated and wild species, was higher than in *A. hypogaea.* Crosses with A. *cardenasii* have produced many superior derivatives. Line 259-2 was rated 2 on a 1-9 scale for late leaf spot, and withstood a severe infection when most other resistant material were heavily damaged. It also showed some tolerance of early leaf spot *(Cercospora arachidicola* Hori) in a preliminary trial at Pantnagar in northern India.

In addition to resistance to foliar diseases, the derivatives had good pod yields. Many lines yielded over 3 $t\ ha^{-1}$, compared with 1.7 $t\ ha^{-1}$ for Robut 33-1. Yields of over 8 $t\ ha^{-1}$ of dried haulm have also been produced. Forty-four consignments of derivatives have been sent to 21 countries for screening and for use in crossing programs. ICRISAT breeders have used 53 derivatives in 249 cross combinations in groundnut improvement.

In addition to resistance to late leaf spot and to rust, some species in sections *Rhizomatosae* and *Erectoides* are resistant to early leaf spot. Intersectional hybrids between these species and species of section *Arachis* have been established using embryo-rescue techniques. These interspecific hybrids will be particularly useful for early leaf spot resistance breeding programs because of lack of adequate levels of resistance to this disease in the cultivated groundnut.

Genetics of Resistance

Genetic studies of rust resistance were carried out at ICRISAT Center. The F_2 plants segregated in the ratio of 15:1, suggesting that resistance to groundnut rust is governed by duplicate recessive genes. However, quantitative genetic analysis of parents, F_1, F_2, BC_1, and BC_2 generations of rust-resistant x susceptible crosses of the cultivated groundnut using generation mean analysis (Jinks and Jones 1958) indicated that rust resistance is predominantly controlled by additive, additive x additive, and additive x dominance gene effects. Duplicate epistasis was observed both for rust disease scores and for leaf area damage (Reddy et al. 1987). Further studies are required to show conclusively if rust resistance is governed by two or three major genes or by many genes. Wild *Arachis* spp may have mechanisms of rust and/or late leaf spot resistance that differ from those in the cultivated groundnut. In some diploid wild *Arachis* spp, rust resistance appears to be partially dominant (Singh et al. 1984), unlike in the cultivated groundnut (Nigam et al. 1980), indicating that different genes may be involved. Combination of these resistances may result in more stable resistance in the cultivated groundnut.

Resistance to late leaf spot is recessive and quantitatively inherited, and is determined by alleles at five loci.

Future Research Needs

Although many sources of resistance to rust and late leaf spot have been identified from the available germplasm collections, these represent only a narrow genetic base. There is a need to collect more germplasm from the primary and secondary gene centers and to identify genotypes with disease resistance and good agronomic traits for utilization in breeding programs. Utilization of tetraploid or near-tetraploids derived from interspecific crosses should be intensified to accumulate more genetic diversity. The levels of resistance to late leaf spot and the quality of pod and seed characters need to be improved. Existing field screening techniques should be modified to suit various geographic locations. Further research on host genotype, pathogen, and environment interactions is required to determine the stability of resistance to rust and late leaf spot. Identification of pathotypes and their geographical distribution is also necessary for a successful breeding program.

References

Gibbons, R.W. 1980. Groundnut improvement research technology for the semi-arid tropics. Pages 27-37 *in* Proceedings of the International Symposium on Development and Transfer of Technology for Rainfed Agriculture and the SAT Farmer, 28 Aug to 1 Sep 1979, ICRISAT Center, India. Patancheru, Andhra Pradesh 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Gregory, W.C., Krapovikas, A., and Gregory, M P. 1980. Structure, variation, evolution, and classification *of Arachis.* Pages 469-481 *in* Advances in legume science: proceedings of the International Legume Conference, 31 Jul to 4 Aug 1978, Kew, London, UK. (Summerfield, J., and Bunting, A.H., eds.). Kew, Surrey, UK: Royal Botanic Gardens.

Jinks, J.L., and Jones, R.M. 1958. Estimation of components of heterosis. Genetics 43:223-234.

McDonald, D., Subrahmanyam, P., Gibbons, R.W., and Smith, D.H. 1985. Early and late leaf spots of groundnut. Information Bulletin no. 21. Patancheru, Andhra Pradesh 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 24 pp. 56 ref. ISBN 92-9066-090-2.

Moss, J.P. 1985. Breeding strategies for utilization of wild species of *Arachis* in groundnut improvement. Pages 93-99 *in* Proceedings of an International Workshop on Cytogenetics of *Arachis,* 31 Oct to 2 Nov 1983, ICRISAT Center, India. Patancheru, Andhra Pradesh 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Nigam, S.N., Dwivedi, S.L., and Gibbons, R.W. 1980. Groundnut breeding at ICRISAT. Pages 62-68 *in* Proceedings of the International Workshop on Groundnuts, 13-17 Oct 1980 ICRISAT Center, India. Patancheru, Andhra Pradesh 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Reddy, L.J., Nigam, S.N., Dwivedi, S.L., and Gibbons, R.W. 1987. Breeding groundnut cultivars resistant to rust *(Puccinia arachidis* Speg.). Pages 17-25 *in* Groundnut rust disease: proceedings of a Discussion Group Meeting, 24-28 Sep 1984, ICRISAT Center, India. Patancheru, Andhra Pradesh 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Reddy, L.J., Nigam, S.N., Subrahmanyam, P., Dwivedi, S.L., Gibbons, R.W., and McDonald, D. 1984. Development of foliar diseases resistant groundnut lines at ICRISAT. Proceedings of the American Peanut Research and Education Society 16:38 (Abstract.).

Singh, A.K., Moss, J.P., and Rao, B.G. 1987. Incorporation of rust resistance from wild *Arachis* species into the cultivated groundnut. Pages 41-48 *in* Groundnut rust disease: proceedings of a Discussion Group Meeting, 24-28 Sep 1984, ICRISAT Center, India. Patancheru, Andhra Pradesh 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Singh, A.K., Subrahmanyam, P., and Moss, J.P. 1984. The dominant nature of resistance to *Puccinia arachidis* in certain wild *Arachis* species. Oleagineux 39(11):535-538.

Smith, D.H., and Littrell, R.H. 1980. Management of peanut foliar diseases with fungicides. Plant Disease 64:356-361.

Subrahmanyam, P., Gibbons, R.W., Nigam, S.N., and Rao, V.R. 1982a. Screening methods and further sources of resistance to peanut rust. Peanut Science 7:10-12.

Subrahmanyam, P., and McDonald, D. 1983. Rust disease of groundnut. Information Bulletin no. 13. Patancheru, Andhra Pradesh 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 20 pp. 38 ref. ISBN 92-9066-058-9.

Subrahmanyam, P., McDonald, D., Gibbons, R.W., Niga.m, S.N., and Nevill, D.J. 1982b. Resistance to rust and late leafspot diseases in some genotypes of *Arachis hypogaea.* Peanut Science 9:6-10.

Subrahmanyam, P., McDonald, D., Gibbons, R.W., and Subba Rao, P.V. 1983a. Components of resistance to *Puccinia arachidis* in peanuts. Phytopathology 73(2):253-256.

Subrahmanyam, P., McDonald, D., and Subba Rao, P.V. 1983b. Influence of host genotype on uredospore production and germinability in *Puccinia arachidis.* Phytopathology 73(5):726-729.

Subrahmanyam, P., Moss, J.P., McDonald, D., Subba Rao, P.V., and Rao, V.R. 1985a. Resistance to leaf spot caused by *Cercosporidium personation* in wild *Arachis* species. Plant Disease 69(11):951-954.

Subrahmanyam, P., Moss, J.P., and Rao, V.R. 1983c. Resistance to peanut rust in wild *Arachis* species. Plant Disease 67(2):209-212.

Subrahmanyam, P., Ramanatha Rao, V., McDonald, D., Moss, J.P., and Gibbons, R.W. 1989. Origins of resistances to rust and late leaf spot in peanut (*Arachis hypogaea,* Fabaceae). Economic Botany 43:444-455.

Subrahmanyam, P., Reddy, L.J., Gibbons, R.W., and McDonald, D. 1985b. Peanut rust : a major threat to peanut production in the semi-arid tropics. Plant Disease 69:813-819.

Subrahmanyam, P., Williams, J.H., McDonald, D., and Gibbons, R.W. 1984. The influence of foliar diseases and their control by selective fungicides on a range of groundnut *(Arachis hypogaea* L.) genotypes. Annals of Applied Biology 104:467-476.

Discussion

Chigwe: Most of the accessions identified as resistant to rust or late leaf spot are of the *fastigiata;* very few or none from *hypogaea, vulgaris,* and *hirsuta.* How extensive has the germplasm collection been in order to identify genotypes from the other varieties/types which are resistant to the diseases? Does ICRISAT have a record of the botanical types of all its collections?

Subrahmanyam: Most (90%) of the rust and/or late leaf spot resistant genotypes available from ICRISAT Center are from South America. We have the records of the botanical types for all germplasm lines but I can't say what the percentages are right now.

Doto: In your slide presentation, differences between susceptible, resistant, and immune genotypes to rust have been attributed to differences in mycelial development. What is the factor responsible for such differences in development (mycelial) in the three different genotypes?

Subrahmanyam: Suberization in immune genotypes takes place immediately when mycelia get in contact with host cells. Five phenolic compounds have also been identified as factors responsible for resistance.

Ndunguru: Do you see any potential for the FDRS lines to be released as pasture material since they produce high yields of haulms?

Subrahmanyam: Some interspecific hybrid derivatives developed at ICRISAT Center may have good potential as pasture material.

Prevalence of Groundnut Diseases and Extent of Yield Losses Due to Leaf Spot Diseases in Zambia

H.C. Haciwa[1] and J. Kannaiyan[1]

Abstract

During 1987/88 and 1988/89 cropping seasons, roving surveys were conducted to determine prevalence and importance of groundnut (Arachis hypogaea *L.) diseases in the major groundnut-growing areas of Zambia. Surveys of 13 districts in five provinces revealed that early leaf spot* (Cercospora arachidicola), *late leaf spot* (Phaeoisariopsis personata), *rust* (Puccinia arachidis), *groundnut rosette, and groundnut streak necrosis were important diseases. Of these, both early leaf spot and late leaf spot were the most damaging to groundnut crops than other diseases. Avoidable seed yield losses because of these two diseases (mostly because of early leaf spot) in five seasons (1984-89) ranged from 32% to 68%. However, the extent of such losses was found to vary among cultivars and seasons.*

Sumário

Preponderância das Doenças do Amendoim e Dimensão das Perdas Devido à Mancha Tardia na Zambia. *Durante a estação de cultivo de 1987/88 e 1988/89, foram realizados levantamentos móveis para determinar a preponderância e importância das doenças do amendoim (*Arachis hypogaea *L.) nas principais áreas de produção de amendoim na Zambia. Levantamentos em 13 distritos, em cinco províncias, revelaram que a mancha temporã (*Cercospora arachidicola*), a mancha tardia (*Phaeoisariopsis personata*), a ferrugem (*Puccinia arachidis*), a roseta e a necrose listrada são doenças importantes. Destas, a mancha temporã e a mancha tardia são as que mais danos causam na cultura do amendoim, em comparação com as outras doenças. Em cinco estações (1984-89), as perdas evitáveis de sementes, causadas por estas duas doenças (principalmente devido à mancha temporã), variaram de 32% a 68%. Contudo, a dimensão das perdas variou com os cultivares e as estações.*

Introduction

Diseases are a major constraint to groundnut *(Arachis hypogaea* L.) production in Zambia. Angus (1962-66) reported several diseases including early leaf spot *(Cercospora arachidicola* Hori.) and late leaf spot *[Phaeoisariopsis personata* (Berk. & Curt.) v. Arx.] on the crop. Later, Raemakers and Preston (1977) reported the outbreak of rust *(Puccinia arachidis* Speg.) in the 1974/75 cropping season in all ground-

1. Legume Pathologist, Food Legumes Research Team, Msekera Regional Research Station, P.O. Box 510089, Chipata, Zambia.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

nut-growing areas of the country. Occurrence of web blotch *(Didymella arachidicola* (Chock) Taber, Pettit & Philley), leaf scorch *[Leptosphaerulina crassiasca* (Sechet) Jackson & Bell], leaf blight (*Phomopsis* sp), mottle (peanut mottle virus), streak necrosis (sunflower yellow blotch virus), and mild mottle (cowpea mild mottle virus) diseases were recorded on the crop in recent years. Of these, early leaf spot (ELS) and late leaf spot (LLS) are the most important diseases (Kannaiyan et al. 1989). However, information was lacking on the relative prevalence of various diseases in different groundnut-growing areas of the country and on the extent of seed yield losses caused by leaf spots. This paper summarizes results of a recent survey on these aspects in Zambia.

Methods

Disease surveys

Roving surveys were conducted in each season between late March and early April when the crop was in active pod-filling stage. In 1988, 31 farmers' fields were inspected in seven districts of the Eastern Province (the main groundnut-growing area of Zambia), i.e., Chadiza, Chipata North, Chipata South, Katete, Lundazi, Mambwe, and Petauke. The 1989 survey was conducted in 27 farmers' fields spread over three districts of Northern Province (Kasama, Luwingu, Mbala), and one district each from Luapula (Mansa), Southern (Choma), and Western (Kaoma) Provinces. Observations were recorded in groundnut fields located at 20-30 km intervals. The data for each field were recorded using a proforma. Severity of fungal or viral diseases was scored visually on a 1-9 scale (1 = No disease, and 9 = 50-100% foliage damaged). The mean score for each district was calculated and classified as low when the mean severity score was 1-3, moderate when 4-5, and severe when 6-9.

Avoidable yield losses because of leaf spots

To estimate avoidable seed losses by leaf spots (mostly by ELS), comparisons were made between protected' and 'nonprotected' treatments in replicated field plots. These trials contained one or three cultivars; Chalimbana (the most popular), MGS 2 (a recently released high-yielding cultivar), and MGS 3 (a prerelease high-yielding cultivar) at Msekera Regional Research Station in the Eastern Province during five cropping seasons from 1984/85 to 1988/89. In all trials, the 'protected' treatment received three sprays of benomyl (1 kg a.i. ha^{-1}), thiophanatemethyl 20% + maneb 50% (1 kg a.i. ha^{1}), or benomyl (250 g a.i. ha^{-1}) + mancozeb (1.2 kg a.i. ha'^{1}) about 50, 70, and 90 days after sowing. The 'nonprotected' treatment received only water sprays. The extent of loss was estimated from the difference in seed yield between 'nonprotected* and 'protected* treatments.

Results and Discussion

Disease surveys

Data on the prevalence of important groundnut diseases in various districts are summarized in Table 1. The results show that both ELS and LLS were observed in all the fields examined in the 1987/88 and 1988/89 cropping seasons. Combined infection in most fields resulted in severe premature defoliation leading ultimately to substantial seed yield losses as observed in the research station trials (Kannaiyan et al. 1989).

The 1988 survey of the Eastern Province showed ELS scores ranging from 3 to 8 and a moderate severity (4-5) across the seven districts. LLS was moderate in three and severe in the remaining four districts (Chadiza, Katete, Mambwe, and Petauke). The relatively greater severity of LLS compared to ELS observed in farmers' fields in the Eastern Province was in contrast to observations on trials at Msekera Regional Research Station (located in Chipata South district). The agronomic practices at the research station, especially early sowing, may favor the early build-up of ELS to compete more strongly than LLS which usually appears in the later stages of the crop development.

In 1989, ELS severity ranged from 3 to 8 and the district mean severities varied from moderate to severe. LLS scores ranged from 2 to 8 and the district mean severities were low to moderate. The higher ELS severity recorded in the high-rainfall region (Luapula and Northern Provinces) agreed with severity recorded on research station trials. The low rainfall and warm conditions in the Southern and Western Provinces appeared to inhibit ELS and LLS severity, even though the short-season (Spanish type) cultivars that are grown in that region are generally susceptible to both leaf spots.

Table 1. Relative severity of some groundnut diseases in five provinces of Zambia, 1987-89.

		Mean disease severity[1] and range[2]						
Province/ district	Number of fields observed	Early leaf spot	Late leaf spot	Rust	Web blotch	Rosette virus	Groundnut streak necrosis	Peanut mottle virus
Eastern								
Chadiza	5	M(3-6)	S(4-7)	L(1-3)	Nil	L(1-3)	Nil	Nil
Chipata N	2	M(4-6)	M(3-5)	Nil	Nil	L(l-3)	M(4)	Nil
Chipata S	9	M(3-8)	M(2-8)	Nil	Nil	L(l-5)	L(1-3)	Nil
Katete	2	M(4)	S(7)	Nil	Nil	L(1-2)	L(l-2)	Nil
Lundazi	7	M(3-7)	M(2-8)	L(l-3)	Nil	L(1-3)	L(2-4)	L(1-2)
Mambwe	4	M(3-5)	S(3-8)	Nil	Nil	L(1-3)	L(1-2)	Nil
Petauke	2	M(3-5)	S(8)	Nil	Nil	L(1-3)	M(3-6)	Nil
Luapula								
Mansa	6	S(5-7)	M(3-6)	L(2-6)	L(1-5)	L(1-2)	Nil	L(1-3)
Northern								
Kasama	1	M(4)	M(4)	M(5)	M(4)	Nil	Nil	L(3)
Luwingu	2	S(4-7)	M(3-6)	Nil	M(4-6)	Nil	Nil	M(4)
Mbala	2	S(4-8)	L(2)	Nil	L(1-3)	L(1-2)	Nil	M(1-6)
Southern								
Choma	8	M(3-5)	M(2-8)	Nil	Nil	L(l-3)	Nil	Nil
Western								
Kaoma	8	M(3-5)	L(2-3)	L(l-3)	Nil	Nil	Nil	Nil

1. Scored on a 1-9 scale, where 1 = No disease, and 9 = 50-100% of foliage destroyed.
2. S = Severe (6-9), M = Moderate (4-5), L = Low (1-3).

Groundnut rust was only observed in 5 of the 13 districts surveyed and was rated low in Chadiza, Lundazi (Eastern Province), Mansa (Luapula Province), and Kaoma (Western Province) districts. Moderate rust was observed in the Kasama district of Northern Province. Low severity and sporadic occurrence of rust confirms the observations of Cole (1987) that many groundnut-growing regions of southern Africa are not optimal for widespread rust epidemics. However, Kannaiyan et al. (1987) reported severe levels of rust disease in the 1983/84 cropping season in research trials and in farmers' fields in the Eastern Province.

Fusarium wilt (*Fusarium oxysporum* Schlecht emend Synd. & Hans.) and leaf scorch were observed at low levels in most districts of Eastern Province only. On the other hand, low to moderate severity of web blotch was recorded only in the high-rainfall region (Luapula and Northern Provinces).

Among the viral diseases, groundnut rosette virus (GRV) was recorded in all districts surveyed except in Kasama and Luwingu (Northern Province), and Kaoma (Western Province). However, its severity was low. There was a serious incidence of GRV in the 1982/83 cropping season at Msekera Regional Research Station (Sandhu et al. 1985). Other viral diseases recorded during these surveys were groundnut streak necrosis, peanut mottle, and mild mottle. All these three virus diseases have only recently been observed in Zambia. Peanut mottle virus disease was present in the Eastern, Luapula, and Northern Provinces, whereas groundnut streak necrosis disease (GSND) and mild mottle virus disease were restricted to the Eastern Province. GSND severity was moderate in two districts (Chipata North and Petauke) and low in four districts (Chipata South, Katete, Lundazi, and Mambwe).

These surveys showed that ELS, LLS, rust, GRV, and GSND were the most important diseases in these areas. Of these, ELS and LLS were the most widespread and caused severe damage to the crop. This confirms our earlier assessment of the overall importance of leaf spot diseases in the country. Rust, GRV, and groundnut streak necrosis are potentially important diseases. Rust and rosette diseases are known to cause occasional epidemics under favorable conditions in Zambia. Other diseases were of minor importance.

As a result of these surveys, the groundnut improvement program has given additional priority to research on the leaf spot diseases. Investigations are presently aimed at developing leaf spot tolerant high-yielding cultivars and also to develop integrated methods of leaf spot control including the use of tolerant cultivars, cost-effective application of fungicide, and beneficial cultural practices.

Avoidable yield loss because of leaf spots

The avoidable seed yield loss because of leaf spots across *five* seasons and three cultivars varied from 32% to 68% (458-1302 kg ha^{-1}) at Msekera Regional Research Station (Table 2). Across seasons, the extent of loss because of leaf spots tended to be higher (54%) in the popular and relatively more leaf spots susceptible cultivar, i.e., Chalimbana than in the improved high-yielding and less leaf spots susceptible cultivars, MGS 2 and MGS 3 (41%).

The overall avoidable seed yield loss was lower in 1986/87 (36%) and 1988/89 (32%) than the other three seasons (51-58%). This could have been because of the relatively less favorable environmental conditions (especially rainfall) for leaf spot development. These results confirm the observations of McDonald et al. (1985) that leaf spots cause yield losses up to 50%.

These results show clearly that considerable variability does occur in extent of avoidable yield losses among seasons and cultivars. Similar trials need to be conducted to ascertain the relative economic importance of leaf spots in other agroecological regions of Zambia.

References

Angus, A. 1962-66. Annotated list of plant pests, disease and fungi in Zambia. 7 parts, Chilanga, Zambia: Mount Makulu Research Station.

Cole, Desiree L. 1987. Rust disease of groundnut in southern Africa: Present situation and possible interactions with other groundnut foliar diseases. Pages 109-114 *in* Groundnut rust disease: proceedings of a Discussion Group Meeting, 24-28 Sep 1984, ICR1SAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Kannaiyan, J., Sandhu, R.S., and Haciwa, H.C. 1987. Recent developments in groundnut pathology research in Zambia. Pages 51-56 *in* Proceedings of the Second Regional Groundnut Workshop for Southern Africa, 10-14 Feb 1986, Harare, Zimbabwe. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Table 2. Estimates of avoidable yield losses caused by leaf spots in three groundnut cultivars, Msekera Regional Research Station, Eastern Province, Zambia, 1984-89.

		Seed yield (t ha^{-1})			
Season	Cultivar	Protected treatment	Nonprotected treatment	Avoidable loss	Avoidable loss in seed yield (%)
1984/85	Chalimbana	1.791	0.811	0.980	55
1985/86	Chalimbana	2.574	1.272	1.302	51
1986/87	Chalimbana	1.289	0.780	0.509	40
	MGS 2	1.681	1.135	0.546	33
	MGS 3	1.491	0.970	0.521	35
1987/88	Chalimbana	0.870	0.278	0.592	68
	MGS 2	0.981	0.407	0.574	59
	MGS 3	1.129	0.593	0.536	48
1988/89	MGS 2	1.438	0.980	0.458	32

Kannaiyan, J., Sandhu, R.S., Haciwa, H.C., and Reddy, M.S. 1989. Management of leaf spots of groundnut in Zambia. Pages 35-41 *in* Proceedings of the Third Regional Groundnut Workshop for Southern Africa, 13-18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

McDonald, D., Subrahmanyam, P., Gibbons, R.W., and Smith, D.H. 1985. Early and late leaf spots of groundnut. Information Bulletin no. 21. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 24 pp.

Raemakers, R., and Preston, G. 1977. Groundnut rust occurrence and foliar disease control in Zambia. PANS 23:166-170.

Sandhu, R.S., Kelly, G., and Kannaiyan, J. 1985. Groundnut production and research: problems and priorities in Zambia. Pages 107-113 *in* Proceedings of the Regional Groundnut Workshop for Southern Africa, 26-29 Mar 1984, Lilongwe, Malawi. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Discussion

Subrahmanyam: I must congratulate the Zambian group for the excellent information they have been generating on crop losses and determining the relative importance of various diseases in Zambia. Similar information is also available from some other countries in the region (e.g., Malawi, Zimbabwe, and Swaziland). I wish we generate such information from other SADCC countries in the immediate future. Such data arc required to prepare disease distribution maps on a regional basis and fix the regional priorities.

Hildebrand: How important would you rate GSND in Eastern Province of Zambia?

Haciwa: It is seen occasionally in the Eastern Province but not considered important.

Hildebrand: Is it important anywhere else in Zambia?

Haciwa: It is not known to be important anywhere else in Zambia.

Laxman Singh: What are the reasons for the progressive decline in performance of cv Chalimbana?

Haciwa: Perhaps the rainfall pattern is the reason.

Weather Requirements for Infection by Late Leaf Spot in Groundnut[1]

D.R. Butler[2]

Abstract

*The literature on effect of weather on infection of groundnut (*Arachis hypogaea *L.) by late leaf spot* (Phaeoisariopsis personata) *is examined. In addition, results from experiments at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Center are used as a basis to propose a simple model to describe the effects of temperature and leaf wetness on infection.*

Sumário

Necessidades Climáticas para a Infecção com Mancha Tardia no Amendoim. *O efeito do clima na infecção do amendoim (*Arachis hypogaea *L.) pela mancha tardia (*Phaeoisariopsis personata*), descrito na literatura, é examinado. Adicionalmente, resultados de experimentos feitos no Instituto Internacional de Investigação de Culturas para os Trópicos Semi-Áridos (ICRISAT) Centro são usados como base para propôr um modelo simples, para descrever os efeitos da temperatura e da humidade das folhas na infecção.*

Introduction

In 1933 Woodroof published a detailed description, distinguishing two pathogens of groundnut *(Arachis hypogaea* L.) that cause early leaf spot (*Cercospora arachidicola* Hori) and late leaf spot [*(Phaeoisariopsis personata* (Berk. & Curt.) v. Arx)]. She noted differences in the seasonal patterns between the two diseases in Georgia, USA, and concluded tentatively "that C. *arachidicola* occurs rather consistently year after year, even when the weather is quite dry." She also stated that "the conditions conducive to the development of *P. personata* are not well enough understood to attempt to explain why it appears only in certain years. Possibly wetter seasons are more favorable to its development than drier seasons."

More than 50 years later there was little improvement in our ability to distinguish between the weather requirements of these two pathogens. Hemingway (1955) observed large differences in the rates of disease increase in eastern Africa, which he attributed to greater spore production of *P. personata. A* similar situation was observed in southern India where the numbers of airborne spores of the two species were compared (Sreeramulu 1970). Effects of temperature and humidity on conidial germination of *C. arachidicola* were reported by Oso in 1972, but equiva-

1. Presented by Dr P. Subrahmanyam on behalf of the author.
2. Principal Microclimatologist, Resource Management Program, ICRISAT Center, Patancheru, A.P. 502324, India.

ICRISAT Conference Paper no. CP 576.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

lent information on *P. personata* was not available until recently (Sommartya and Beute 1986). Shew et al. (1988) pointed out that long periods of leaf wetness are necessary for late leaf spot lesions to develop on inoculated plants, and demonstrated that infection occurs with intermittent wetness.

The situation at ICRISAT Center, India, is different from that described by Woodroof (1933) for Georgia and it is probable that this is partly caused by differences in climate. At ICRISAT Center, both early and late leaf spot normally infect groundnut in the rainy season, but late leaf spot is usually the dominant disease. Infrequently (less than 1 year in 5), early leaf spot is the more serious disease (P. Subrahmanyam, ICRISAT Center, personal communication). It is still not clear why this happens and, as part of a program to improve our understanding of how weather affects these diseases, we examine in this paper evidence pertaining to infection by *P. personata.*

Weather Variables Affecting Infection

Current knowledge

Jensen and Boyle (1965), Sommartya and Beute (1986), and Shew et al. (1988) made significant contributions to our understanding of how weather affects late leaf spot infection. Findings from these three papers are summarized in this paper with some further analysis of their data.

In 1965, Jensen and Boyle published the results of 2 years' field observations and proposed a scheme for disease prediction (Jensen and Boyle 1966). Advice to growers for fungicide applications in the USA is still based on this scheme, although no distinction was made between early and late leaf spot. The scheme could be used for either disease and since it is so widely used and therefore requires examination in detail.

Jensen and Boyle (1966) recognized the importance of leaf wetness to infection and used a thermohygrograph placed in a screen on the ground between the rows of groundnut in their field experiments. In interpreting their results they made three important assumptions:

1. Adequate inoculum is always present.
2. Free water is necessary for spore germination, and the speed of germination depends on temperature.
3. Periods of relative humidity (RH) greater than 95% indicate periods of leaf wetness (this includes wetness from rain).

On days when RH > 95% occurred in more than one continuous period, they selected the longest continuous period.

Their prediction scheme (Fig. la) uses periods of wetness and temperature to compute an infection index from 0 to 3, which indicates the extent to which environmental conditions are favorable for spore germination and penetration. This index can be thought of as a measure of the number of lesions (unit area)$^{-1}$ that will subsequently develop. When the infection index is plotted against wetness periods (Fig. lb) it becomes clear that Jensen and Boyle thought that the period required for maximum infection decreased with increasing temperature between 18°C and 27°C. This implies that the rate of infection increases with temperature, but suggests that, with adequate wetness periods, the final level of infection would not be affected by temperature between 20°C and 27°C.

They observed that favorable conditions must persist for 2-3 days to detect the increase in disease easily; 1 favorable day had little effect on the disease. Although they could not distinguish between the effects of high levels of humidity and rain from their field results, they believed that RH was the best indicator of leaf wetness either from rain or dew.

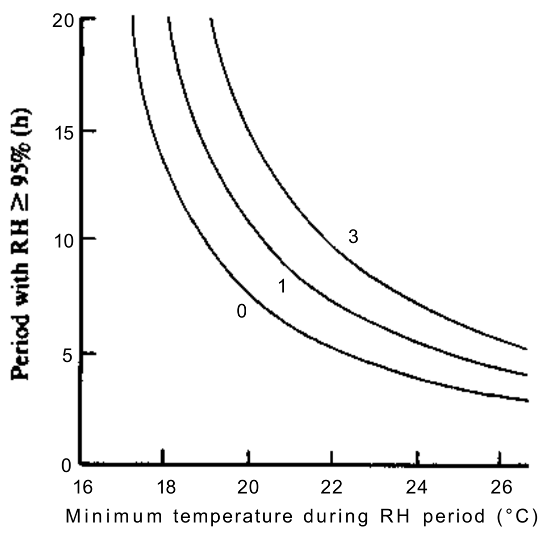


Figure 1a. Graph to predict leaf spot infection in groundnut. The infection indices (0 to 3) are shown between the curves. [Redrawn from Jensen and Boyle (1966).]

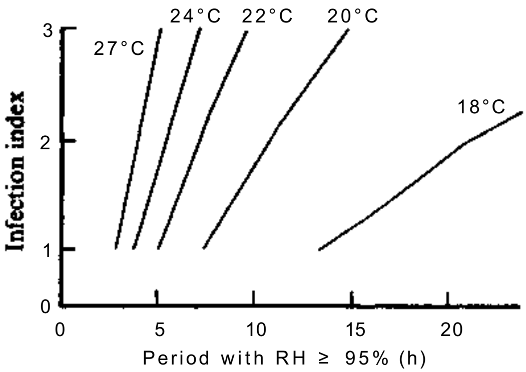


Figure Ib. The implied requirements of leaf wetness (RH≥95%) and temperature for leaf spot infection in Figure Ia.

Sommartya and Beute (1986) studied the germination of different isolates of *P. personata* in vitro and found that the percentage germination of conidia after 48 h decreased with increasing temperatures between 16°C and 32°C (Fig. 2). The steepest reduction was at temperatures greater than 28*C. They also commented on the effect of temperature on the germination rate. In contrast to Jensen and Boyle (1966), Sommartya and Beute (1986) stated that the germination rate was maximum at 20°C, and at this temperature, more than 50% of the conidia had germinated after 12 h. They give no details of germination rates at other temperatures.

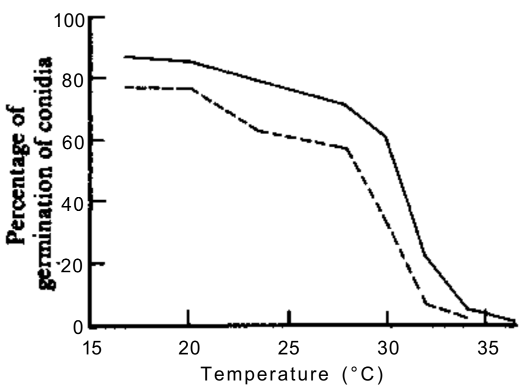


Figure 2. The effect of temperature on the percentage of conidial germination after 48 h in vitro. The two sets of data are for different isolates of *P. personata*. [Redrawn from Sommartya and Beute (1986).]

Shew et al. (1988) examined the effect of periods of leaf wetness on infection at different temperatures. They did this by transferring plants between high and low humidity chambers, so that the period of surface moisture on leaves varied between 3 and 24 h day^{-1}. The humidity treatments were continued for 6 days at temperatures between 20°C and 32°C. For the majority of groundnut genotypes, the maximum number of lesions were obtained at 20°C, but differences between 20°C and 24°C were not large. I have fitted logistic (Gompertz) curves to their data, which relate lesion numbers to wetness periods. For this, the data for 20°C and 24°C were combined and a separate curve was fitted to the data for 28°C. There were no statistical differences between parameters that define the delay and slope of the curves (Fig. 3); they are distinguished only by their asymptotes.

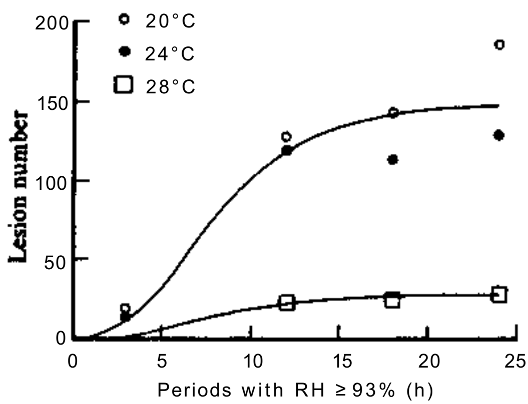


Figure 3. The effect of leaf wetness duration (RH ≥93%) on lesion number at different temperatures. Wetness periods were repeated for 6 days. The Gompertz curves, fitted to the data from Shew et al. (1988), have the same parameters for slope and delay (only the asymptotes are different).

Implications

Several interesting points arise from the work cited above. The relation between percent spore germination and temperature (Sommartya and Beute 1986) is important, since germination is a prerequisite to infection.

It is necessary to reconcile the differences between the conclusions from the field experiments of Jensen and Boyle, and the findings of Shew et al. (1988) and Sommartya and Beute (1986). Jensen and Boyle concluded that the infection rate increased with temperature up to 27°C; therefore, much longer periods of leaf wetness would be required at lower temperatures to achieve a given infection level. However, Sommartya and Beute (1986) found that the germination rate was maximum at 20°C and that the percentage germination decreased with increasing temperature above 20°C. The latter result agrees with the finding of Shew et al. (1988) that the number of lesions decreases with increasing temperature between 20°C and 28°C for all the periods of leaf wetness. Although Jensen and Boyle interpreted their results in terms of infection, they were assessing disease development in the field, which is the result of the whole disease cycle. It is possible that disease progress at low temperatures was limited by inoculum since, for early leaf spot, sporulation is reduced markedly at temperatures below 20°C (Alderman et al. 1987).

Further progress

We carried out a series of experiments at ICRISAT Center in which potted plants were inoculated with conidia of *P. personata.* After inoculation, plants were kept in a greenhouse where the leaves remained dry. At night, selected plants were placed in a dew-chamber for different numbers of nights (each night providing about 16 h of leaf wetness). The air temperature in the dew-chamber was controlled to +0.5 °C and experiments were carried at various temperatures between 13°C and 28°C. The number of lesions that appeared on inoculated leaves was recorded daily until there was no further increase.

With only 1 night of leaf wetness, lesions never developed and with 2 nights, there were usually none or very few lesions. After an initial delay, the number of lesions increased linearly with the number of nights in the dew-chamber until a plateau was reached. Both the initial delay and the time taken to reach the plateau varied with temperature. Infection was most rapid at 23°C when the plateau was reached after 5 nights (Fig. 4a). In contrast, at 13°C infection began after 4 nights and continued to increase in severity even after 11 nights (Fig. 4b).

Our results confirm the finding of Shew et al. (1988) that infection occurs with intermittent periods of surface moisture. It appears that the dominant variable affecting infection at a particular temperature is the total number of hours of leaf wetness. When our results at 23°C and those of Shew et al. (1988) at 20°C and 24°C are shown with that time scale, the agreement is remarkable (Fig. 5).

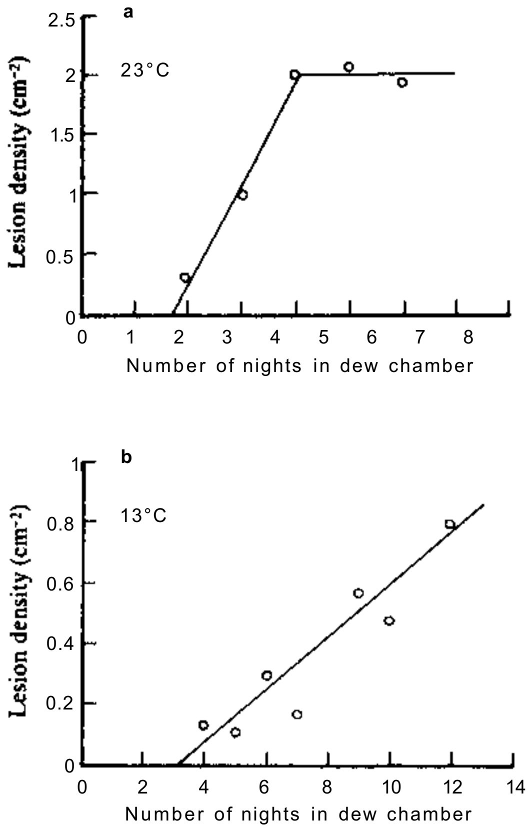


Figure 4. Lesion numbers on inoculated groundnut plants in relation to numbers of nights in a dew-chamber (each night providing 16 h of leaf wetness). Dew-chamber temperatures: (a) 23°C; (b)13°C.

Compared with these results, the findings of Sommartya and Beute (1986) are surprising in that such long periods of leaf wetness are necessary for infection when more than 50% of conidia germinate in 12 h. Initial observations of conidia on leaf surfaces indicate that germ-tube growth is slow and leaf penetration is rare within the first 32 h of wetness.

We now have sufficient evidence to propose a simple model to describe late leaf spot infection in terms

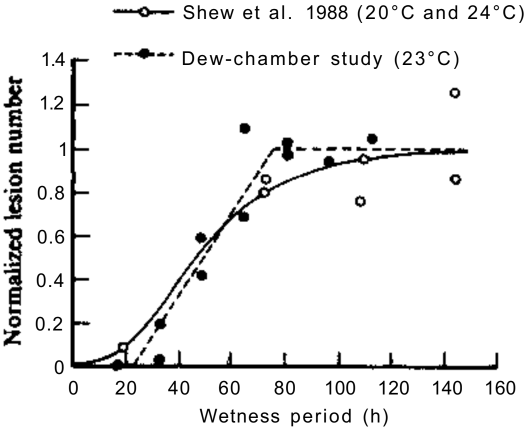


Figure 5. Lesion numbers in relation to the total number of hours of leaf wetness on inoculated groundnut plants.

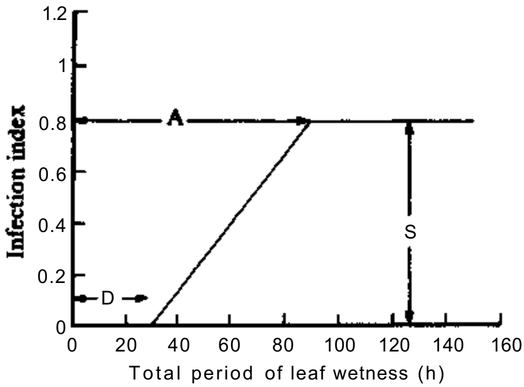


Figure 6. Temperature sensitive parameters for a model of late leaf spot infection. D is the initial delay; A is the period beyond which there is no further increase in disease; S is the maximum disease severity.

of leaf wetness periods and temperature. Temperature affects the process in two ways: (a) it determines the percentage germination of conidia and (b) it determines the rate of infection (this includes germination, germ-tube growth, and leaf penetration). It seems reasonable to assume that infection does not proceed if the leaves are dry, but that the process starts again where it left off, when leaves are re-wetted. With this assumption, the total period of leaf wetness after spore deposition and the mean temperature during that period are required to calculate the amount of infection. If the rate of infection is rapid, the time required to reach maximum infection would be short, and a shorter period of accumulated leaf wetness would be required but if the rate of infection is slow, a longer period of accumulated leaf wetness would be required. The maximum level of infection with non-limiting wetness periods, will vary with temperature since it depends to a large extent on the proportion of spores that germinate.

The model has three parameters (Fig. 6): an initial delay (D) when no infection occurs, the period (A) beyond which there is no further increase in disease, and a severity (S) which determines the maximum level of infection in relation to temperature. S accounts for the effect of temperature on percentage germination of conidia. If the parameters D and A are expressed as rates (1/D and 1/A) it is likely that the temperature response will be linear, as has been found in an analogous situation of seeds germination (Garcia-Huidobro et al. 1982). Current experiments at ICRISAT Center aim to obtain relationships between temperature and the parameters D, A, and S.

To use the model, it is necessary to have a measure of leaf wetness as well as temperature. This could be either measured directly with an electronic sensor or estimated from humidity and rainfall records. We are exploring methods to obtain estimates of leaf wetness from weather records. We believe that such an approach will be a valuable aid to disease prediction, which is an important component of efficient disease control. It will also help interpret results of screening trials where weather conditions may not be ideal for infection.

References

Alderman, S.C., Matyac, C.A., Bailey, J.E., and Beute, M.K. 1987. Aeromycology of *Cercospora arachidicola* on peanut. Transactions of the British Mycological Society 89:97-103.

Garcia-Huidobro, J., Monteith, J.L., and Squire, G.R. 1982. Time, temperature and germination of pearl millet (*Pennisetum typhoides* S. & H.). I. Constant temperature. Journal of Experimental Botany 33:288-296.

Hemingway, J.S. 1955. The prevalence of two species of *Cercospora* on groundnuts. Transactions of the British Mycological Society 38:243-246.

Jensen, R.E., and Boyle, L.W. 1965. The effect of temperature, relative humidity and precipitation on peanut leafspot. Plant Disease Reporter 49:975-978.

Jensen, R.E., and Boyle, L.W. 1966. A technique for forecasting leafspot on peanuts. Plant Disease Reporter 50:810-814.

Oso, B.A. 1972. Conidial germination in *Cercospora arachidicola* Hori. Transactions of the British Mycological Society 59:169-172.

Shew, B.B., Beute, M.K., and Wynne, J.C. 1988. Effects of temperature and relative humidity on expression of resistance to *Cercosporidiwn personatum* in peanut. Phytopathology 78:493-398.

Sommartya, T., and Beute, M.K. 1986. Temperature effects on germination and comparative morphology of conidia for Thai and USA isolates of *Cercosporidiwn personatum.* Peanut Science 13:67-70.

Sreeramulu, J. 1970. Conidial dispersal in two species of *Cercospora* causing likka leaf spots on groundnut (*Arachis hypogaea* L.). Indian Journal of Agricultural Sciences 40:173-178.

Woodroof, N.C. 1933. Two leafspots of peanut (*Arachis hypogaea* L.). Phytopathology 23:627-640.

Discussion

Doto: What is the practical utility of information depicted by the last figure you presented?

Subrahmanyam: It is useful in disease prediction and providing advice on effective disease control.

Ismael: How much does the growth stage affect the requirement of temperature and relative humidity for disease development?

Subrahmanyam: We don't have adequate information.

Ismael: Is the plant more susceptible at a particular growth stage when the required temperature and relative humidity is present?

Subrahmanyam: Plants are susceptible at all stages of development.

Resistance to Botrytis Gray Mold in Some Groundnut Genotypes in Zimbabwe[1]

Z.A. Chiteka[2]

Abstract

*Forty long-season groundnut (*Arachis hypogaea *L.) genotypes belonging to the subspecies* hypogaea *were evaluated for resistance to botrytis gray mold* (Botrytis cinerea) *at the Harare Research Station and the Gwebi Variety Testing Center. Disease infection was rated in two ways, either using a 0 to 6 scale to assess plant or crown infection (0 = No disease, and 6 = More than 70% of the crown affected) or by determining an infection index based on the number of affected stems. Compared with the susceptible control variety Flamingo, the most resistant genotypes gave higher seed yields at both Harare and Gwebi. The botrytis rating using the 0-6 scale was negatively correlated (P<0.001) with pod and seed yield at both sites (r = -0.518 to -0.457). This method was quicker and more practical than the use of the botrytis index. Several genotypes combined high yield with good resistance to botrytis.*

Sumário

Resistência ao Bolor Cinzento Botrytis em Alguns Genótipos de Amendoim no Zimbabwe. *Quarenta genótipos de amendoim de ciclo longo, pertencendo à subespécie* hypogaea *foram avaliados para a resistência ao bolor cinzento botrytis (*Botrytis cinerea*) na Estação de Investigação de Harare e no Centro de Testagem de Variedades de Gwebi. O grau de infecção da doença foi determinado de duas maneiras, usando dois métodos: a escala de 0 a 6 (0 = sem doença e 6 = mais de 70% da coroa afectada) e o indice de infecção, baseado no número de caules afectados. Comparada com o controlo susceptível, a variedade Flamingo, os genótipos mais resistentes produziram maiores rendimentos de grão em Harare (50% a 135%) e em Gwebi (20 a 65%). A avaliação do botrytis usando a escala de 0 a 6 estava negativamente correlacionada com o rendimento de vagens e grão em ambos os lugares (r = –0.518 a –0.457). Este método foi mais rápido e mais prático que o uso do indice de botrytis. Vários genótipos combinaram altos rendimentos com boa resistência ao botrytis. O genótipo mais resistente, 92/7/103, produziu um rendimento médio de grão de 4.09 t ha^{-1}, em Harare, e de 4.87 t ha^{-1}, em Gwebi.*

Introduction

Groundnut *(Arachis hypogaea* L.) is widely grown by large-scale and small-scale commercial and by communal-area farmers in Zimbabwe. Diseases and pests are major constraints to groundnut yield (Hildebrand 1980; Cole 1981; Chiteka 1985).

Both long-season varieties belonging to the sub-

1. This paper could not be presented as it was received late due to unforeseen circumstances.

2. Groundnut Breeder, Crop Breeding Institute, P.O. Box 8100, Causeway, Harare, Zimbabwe.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

species *hypogaea,* and short-season varieties belonging to the subspecies *fastigiata* are grown. The former are mostly cultivated by commercial farmers with supplementary irrigation, sown early (late September to late October), and harvested from February to March. The short-season varieties are sown with the rains in early November to mid-December and harvested from late February to March. The major diseases affecting groundnut yields in Zimbabwe are early leaf spot *(Cercospora arachidicola* Hori.), late leaf spot *[Phaeoisariopsis personam* (Berk & Curt.) v. Arx.], web blotch *(Phoma arachidicola),* and gray mold *(Botrytis cinerea* Pers. ex Fries). Early leaf spot is the most prevalent on both long- and short-season crops. Late leaf spot constitutes a small proportion of leaf spot lesions on highveld crops but up to 100% of leaf spot lesions on groundnut crops at an altitude of 450 m. Web blotch and gray mold are more prevalent and much more severe on long-season crops; short-season crops are rarely affected seriously. However, where short-season crops are grown near long-season genotypes, gray mold and web blotch may also attack commercial short-season genotypes in high altitude areas and in very wet seasons.

During the past three seasons, there was a high incidence of gray mold in groundnut trials grown without the use of fungicides. It has also been noted that gray mold caused considerable yield losses in long-season genotypes even when fungicides had been applied. Although gray mold, early leaf spot, web blotch, and late leaf spot can be controlled by fungicides (Cole 1981) production costs are increased and gross margins reduced. Besides, foreign currency is required to import fungicides and their use poses health hazards and increases environmental pollution. Cultivation of resistant varieties would be the most economical long-term measure.

Gray mold is a soilborne fungus disease affecting both the crown and the subterranean parts of the plant (Smith 1984). Infection starts on the above-ground parts of the plants. At first, brown necrotic lesions appear, which increase in size. Then the infection proceeds downwards to the underground parts of the plant. Affected parts turn brown and eventually black. Depending on the severity of the disease, the stage at which the plant is affected, and the degree of resistance of the genotype, the whole plant may be killed. Temperatures below 20°C with excessive rain over long periods are conducive to the development of gray mold. Excessively wet periods are common on the highveld of Zimbabwe especially during December, January, and February. Night temperatures below 20°C are common in high-altitude areas. Jackson and Bell (1969) and Smith (1984) stated that gray mold had not been reported to cause serious damage to commercial groundnut crops. On the other hand, this paper reports high yield losses attributable to gray mold in the case of susceptible genotypes. The objectives of the tests were:

A. to evaluate the productivity of some selected long-season groundnut varieties under high gray-mold disease pressure,
B. to screen for resistance to gray mold, and
C. to evaluate the efficacy of two methods of gray-mold damage rating on many genotypes.

Materials and Methods

Forty long-season groundnut varieties belonging to the subspecies *hypogaea* were sown in a preliminary yield trial at Harare Research Station (HRS) (altitude 1506 m) and at Gwebi Variety Testing Centre (GVTC) (altitude 1448 m). Flamingo, the most widely grown long-season variety, was included as a control along with Makulu Red and Egret. Standard cultural practices for long-season groundnuts (Hutchinson 1982) were followed except that fungicides were not applied. The plots comprised of 9 rows, 0.45 m apart, and were 3-m long. A net plot area of 7 rows x 2.4 m served for yield determination (discarding the two border rows and 0.3 m from both the ends of the rows). The design used was a randomized-complete block with three replicates. The trial at HRS was sown on 7 Oct 1988 and harvested on 17 Mar 1989 while the trial at GVTC was sown on 6 Oct 1988 and harvested on 15 Mar 1989. At 115 days after sowing, gray-mold infection was rated in both trials in two ways:

A. A gray-mold score using a 0-6 scale as described in Table 1 where 0 = No disease, and 6 = All stems affected (on more than half of the length with more than 75% of plant tissue heavily diseased).
B. Using a damage index determined as follows: in each plot two plants were selected at random. The following records were taken: total stem (branch) counts (TSC1 and TSC2) and the numbers of stems infected with gray mold (BSC1 and BSC2). Then the gray-mold index was calculated.

Gray-mold index =
[(TSC1/BSC1 + TSC2/BSC2)+0.2]/2x10.

Table 1. Rating scale 0 to 6 for *Botrytis cinerea* in groundnut.

0 =	No disease visible.
1 =	One to few necrotic lesions $plant^{-1}$.
3 =	One to two stems extensively damaged over more than half of the stem length.
4 =	Up to 25% of the crown severely damaged. heavy sporulation evident.
5 =	All stems affected and up to 50% of stems and foliage heavily diseased.
6 =	All stems severely affected over more than half of the length and 75-100% of the crown heavily diseased, heavy sporulation.

The constant 0.2 was added to avoid zero readings when computing correlations between plot observations. Plant density, shelling percentage, and seed size were also recorded.

Analyses of variance were carried out on pod yield, seed yield, and gray-mold scores. Relationships between the gray-mold score or the gray-mold damage index on the one hand and yield or yield components on the other were determined using the simple Pearson correlation procedure (Steel and Torrie 1980).

Results and Discussion

At HRS, 28 genotypes, and at GVTC, 15 genotypes outyielded cv Flamingo (Table 2).

There were significant differences among genotypes for gray-mold score ($P<0.001$) at both sites (Table 2.) The mean gray-mold rating at GVTC was lower than that at HRS indicating a lower gray-mold incidence. Generally the ranking of genotypes for the gray-mold incidence did not differ to any appreciable extent between the two locations. This indicates some degree of environment consistency. Genotypes that outyielded Flamingo also had lower gray-mold scores.

Analyses of variance of gray-mold damage indices are not presented because the nonadditivity test showed an abnormal distribution of data. No transformations were carried out. Means for the gray-mold index are shown in Table 2. Several high-yielding genotypes with low gray-mold score at both sites had higher gray-mold damage indices than the susceptible control variety Flamingo. This indicates that the gray-mold index was less reliable in ranking genotypes for gray-mold resistance. This was probably because damaged stem countings do not reflect the degree of damage.

Yield and yield components, except the number of seeds $ounce^{-1}$ (where 1 g = 0.03527 ounces) were negatively correlated *($P<0.01$)* with either of the two gray-mold ratings. Increasing gray-mold damage was thus accompanied by increasing yield reduction. Botrytis damage affected all yield components although the correlation was not significant *(P* > 0.05) for seed size. Probably the pods that are already formed become fully filled in spite of disease or debilitating factors but in this case no other pods are developed.

Yield or yield components were generally less correlated with gray-mold index than with gray-mold score. In both cases, however, there was a closer relationship between yields and botrytis rating than between yield components (shelling percentages and number of pods $plant^{-1}$) and botrytis rating.

Conclusion

During the 1988/89 cropping season, there was a higher incidence of gray mold at HRS than at G VTC. At both sites, genotypes with high yield and resistance to local strains of gray mold were identified. Classification of gray-mold resistance of genotypes using a 0-6 gray-mold rating scale led to more consistent results than using the gray-mold index. The gray-mold score was moderately correlated with seed and pod yields.

Table 3 shows the relationship between gray-mold score, or the gray-mold index on the one hand, and yield and yield components on the other. At both sites, pod and seed yields were moderately correlated ($P<0.001$) with the gray-mold score ($r = 0.44$ to 0.523). This indicates that the gray-mold score is a reliable measure of resistance to gray mold.

Table 2. Seed yields, gray mold scores (BCS), and gray mold indices (BCD for 40 long-season genotypes at Harare Research Station and Gwebi Variety Testing Center, Zimbabwe, 1988/89.

	Harare Research Station			Gwebi Variety Testing Centre		
Genotype	Yield (t ha^{-1})	BCS	BC1	Yield (t ha^{-1})	BCS	BC1
92/7/103	4.09	1.0	0.8	4.87	1.0	3.6
92/7/176	4.66	2.8	3.7	3.79	1.0	5.4
92/7/20	2.95	1.3	1.5	3.00	1.0	5.8
92/7/36	4.23	1.3	1.6	3.71	1.0	4.9
92/7/87	3.86	2.7	1.4	3.95	1.0	3.9
92/7/6	3.90	2.7	1.7	3.87	1.0	4.3
92/7/301	3.87	1.7	1.4	3.81	1.0	4.6
92/7/178	3.80	2.0	2.1	3.81	1.0	5.5
92/7/2	3.77	2.8	1.4	3.76	0.7	4.3
92/7/144	3.69	1.0	1.7	3.84	1.0	3.4
92/7/111	3.69	1.7	3.0	3.64	1.0	4.5
92/7/56	3.45	1.3	2.0	4.04	1.0	5.1
92/7/5	3.44	2.7	5.0	3.87	2.7	7.2
92/7/149	3.29	2.3	2.4	3.97	1.0	3.5
92/7/25	3.35	2.0	1.9	3.76	1.0	4.5
92/7/47	3.58	1.7	2.2	3.17	1.0	4.8
92/7/59	3.36	2.0	1.2	3.32	1.0	5.6
92/7/105	3.80	2.3	1.7	2.87	1.0	3.7
92/7/179	3.54	1.7	1.9	4.03	1.3	2.9
92/7/260	3.19	2.7	2.0	3.31	1.7	3.8
92/7/94	2.93	1.7	3.2	3.38	1.7	5.2
92/7/96	2.71	2.7	2.0	3.19	1.0	3.6
92/7/5	3.01	1.7	1.4	2.85	1.0	4.6
92/7/40	2.73	3.0	4.0	2.98	1.7	5.6
92/7/143	2.98	4.0	4.0	2.57	2.3	6.8
92/7/191	2.75	2.0	1.9	2.63	1.0	4.2
92/7/72	1.37	4.0	5.5	3.92	3.3	5.9
92/7/247	3.86	1.7	1.0	1.35	3.7	5.9
Egret	2.15	2.3	2.9	3.00	1.7	3.9
92/7/45	2.20	3.3	5.4	2.90	2.3	5.0
92/7/182	2.37	1.7	0.8	2.57	1.7	4.1
92/7/44	2.59	1.7	4.5	2.31	1.0	7.3
92/7/232	2.50	1.7	2.1	2.28	1.0	3.8
92/7/147	2.10	4.0	3.2	2.66	2.0	5.5
Flamingo	1.74	3.3	5.2	2.94	2.7	4.1
P161/7/2	1.93	3.0	4.6	2.66	2.0	5.3
Makulu Red	1.70	3.0	3.3	2.62	1.0	4.7
92/7/138	1.93	2.3	2.9	1.83	3.0	4.8
92/7/307	1.78	4.0	5.9	1.84	4.3	7.4
92/7/72	0.59	2.7	1.4	0.72	0.7	4.3
SE	±0.29	±0.46	-	±0.25	±0.46	-
Mean	2.99	2.4	2.7	3.14	1.5	4.8
CV(%)	17	33	-	14	53	-

Table 3. Correlations between botrytis ratings, yield, and yield components for 40 long-season groundnut genotypes grown at two sites, Zimbabwe, 1988/89.

	Botrytis score		Botrytis index	
Component	Gwebi Testing Centre	Research Station	Gwebi Variety Testing Centre	Harare Research Station
Pod yield	-0.523***	-0.444***	-0.342***	-0.451***
Seed yield	-0.518***	-0.457***	-0.372***	-0.431***
Shelling (%)	-0.273**	-0.362***	-0.288**	-0.272**
Seeds	-0.138^{n8}	-0.028^{n8}	-0.288^{n8}	-0.136^{n8}
Pods plant^{-1}	-0.375***	-0.444***	-0.276**	-0.439***

References

Chiteka, Z.A. 1985. The present and future status of groundnut breeding and research in Zimbabwe. Pages 125-133 *in* Proceedings of the Regional Groundnut Workshop for Southern Africa, 26-29 March 1984, Lilongwe, Malawi. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Cole, D.L. 1981. Diseases of groundnuts (*Arachis hypogaea* L.) 1. Fungicide spray effects on *Cercospora arachidicola* and *Phoma arachidicola* leaf infection, kernel yield and pod rots. Zimbabwe Journal of Agricultural Research 19:101-110.

Hildebrand, G.L. 1980. Groundnut production, utilization, research problems and further research needs in Zimbabwe. Pages 290-296 *in* Proceedings of the International Workshop on Groundnuts, 13-17 Oct 1980, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Hutchinson, G. (ed.). 1982. Groundnuts in Zimbabwe. Harare, Zimbabwe: Commercial Oilseeds Producers Association.

Jackson, C.R., and Bell, D.K. 1969. Diseases of peanut (groundnut) caused by fungi. Research Bulletin 56. Experiment Stations, GA, USA: The University of Georgia College of Agriculture. 137 pp.

Smith, D.H. 1984. Early and late leaf spots. Pages 5-7 *in* Compendium of Peanut Diseases (Porter, D.M., Smith, D.H., and Rodriguez-Kabana, R., eds). St Paul, MN, USA: American Phytopathological Society. 73 pp.

Steel, R.G., and Torrie, J.H. 1980. Principles and procedures of statistics: a biometrical approach. 2nd edn. New York, USA: McGraw-Hill. 633 pp.

Entomology

Damage and Yield Loss Caused by Insect Pests on Groundnut in Zambia

P.H. Sohati[1] and S. Sithanantham[1]

Abstract

Surveys of farmers' groundnut f*Arachis hypogaea* *L.) crops in different provinces of Zambia during the 1987/88 and 1988/89 cropping seasons indicated that sucking pests (mainly leafhoppers) caused more severe damage than defoliators or soil pests. Avoidable losses because of foliage (sucking and defoliating) pests during the 1988/89 cropping season was estimated at 5-31% compared to 2-19% for soil pests. The extent of yield loss caused by pests was found to differ depending on seasons and cultivars. Yield losses caused by pests tended to be more important in the valley than in the plateau. The need for more detailed studies to ascertain the economic importance of the pest groups is emphasized.*

Sumário

Danos e Perdas de Rendimento Causadas por Pragas de Insectos do Amendoim na Zambia. *Levantamentos de culturas de amendoim (*Arachis hypogaea *L.) dos agricultores, feitos em diferentes províncias da Zambia, durante as estações de cultivo de 1987/88 e 1988/89, indicaram que as pragas sugadoras (principalmente salta-folhas) causaram danos mais severos que os defoliadores ou as pragas do solo. As perdas evitáveis causadas por pragas das folhas (sugadores e defoliadores), durante a estação de cultivo de 1988/89, foram estimadas em 5-31%, em comparação com os 2-19% para as pragas do solo. A dimensão das perdas de rendimento causadas por pragas, tenderam a ser mais importantes no vale que no planalto. A necessidade de estudos mais detalhados, para confirmar a importância económica destes grupos de pragas é enfatizada.*

Introduction

Several insect pests are known to attack, groundnut *(Arachis hypogaea* L.) in Zambia. These can be grouped into sucking pests, defoliators, and soil pests (Sithanantham et al. 1989). Amin (1984) considered sucking pests (leafhoppers, aphids, thrips) to be economically important and estimated yield losses of 10-30% because of leafhoppers alone. On the other hand, Wightman (1986) regarded soil pests, especially termites and white grubs, to be more important, causing between 5-20% reduction in crop yield. More recently, studies have been taken up on the incidence of soil pests (including millipedes) and the extent of plant mortality or pod damage they cause (Sithanantham 1988; Wightman 1989). However, information on damages and yield losses caused by the three groups of pests in various parts of Zambia is still incomplete. The present paper summarizes recent results on these aspects in Zambia.

1. Legumes Entomologist, Food Legumes Research Team, Msekera Regional Research Team, P.O. Box 510089, Chipata, Zambia.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

Insect Damage Surveys

During the 1987/88 and 1988/89 cropping seasons, roving surveys were made to assess the severity of damage caused by the major pest groups. The survey included the Eastern Province, which is the principal groundnut-growing region, and also limited sampling in Luapula, and in the Northern, Southern, and Western Provinces. Each year the survey was taken up between late March and early April, when the crops were mostly at mid-podding stage. Farmers' fields at distances of about 20-30 km were chosen at random along motorable routes. In each field, four plots (1 m x 1 m) were sampled. In each plot, the damage by three pest groups was visually rated on a 1-9 scale, as described below:

1 = No apparent damage
3 = Light damage (below 10%)
5 = Moderate damage (11-25%)
7 = Severe damage (26-50%)
9 = Very severe damage (above 50%)

When assessing the damage caused by sucking pests, leaf tip yellowing (caused by leafhoppers) as well as crinkling and cupping (caused by aphids, thrips, white flies) was taken into account in rating. Extent of foliar damage (by grasshoppers, beetles, or caterpillars) was the criterion for defoliator damage rating while the severity of root/pod damage in five random plants plot^{-1} was the basis for soil pest rating (termites, white grubs, wireworms, *Dorylus* ants, millipedes).

The results (Table 1) show that damage by sucking pests tended to be generally more severe than that by the other two pest groups. Moderate to severe damage by sucking pests was observed in all districts of the Eastern Province except Chadiza. Among the other districts, Choma (Southern Province) and kaoma (Western Province) seemed to have suffered substantial damage by sucking pests. Defoliator damage was mostly mild to moderate, and seemed to be of some importance in the districts of Choma (Southern Province), Chipata North, and Chipata South (Eastern Province). Severity of soil pest damage was generally found to be similar to that caused by defoliators. The districts which appeared to suffer appreciable damage

Table 1. Relative severity of damage to groundnut crop by major pest groups in different Provinces of Zambia surveyed during 1987/88 and 1988/89.

			Severity rating (1-9 scale)[1]					
			Maximum			Mean		
Province	District	Number of farms surveyed	Sucking pests	Defoliators	Soil pests	Sucking pests	Defoliators	Soil pests
Eastern[2]	Chadiza	5	4	3	2	3	2	1
	Chipata north	2	5	3	1	5	3	1
	Chipata south	10	7	3	4	5	3	2
	Katete	2	6	2	3	6	2	3
	Lundazt	7	7	3	2	5	2	1
	Mambwe	4	6	2	2	5	2	2
	Petauke	2	5	2	4	4	2	3
Luapula[3]	Mansa	6	4	2	1	3	2	1
Northern[3]	Kasama	1	1	1	1	1	1	I
	Luwingu	2	4	2	1	4	2	1
	Mbala	2	1	1	1	1	1	1
Southern[3]	Choma	9	8	6	4	5	4	2
Western[3]	Kaoma	8	7	4	3	6	3	1
Overall maximum		60	8	6	4	6	4	3
Mean			5.3	2.6	2.2	4.1	2.2	1.5

1. Scored on a 1-9 scale: where 1 = No damage, and 9 = 50-100% foliage destroyed.
2. Surveyed in the 1987/88 season.
3. Surveyed in the 1988/89 season.

were Chipata South, Katete, and Petauke (ail Eastern Province), Choma (Southern Province), and Kaoma (Western Province).

These results confirm the opinion of Amin (1984) that sucking pests (especially leafhoppers) are of economic importance in Zambia. Although Wightman (1989) estimated soil pests also to be destructive in various parts of the country, the present survey did not reveal any appreciable damage. Possibly, this single-stage sampling survey tended to underestimate soil-pest damage, since crop mortality and fresh pod/root damage at late-maturity stages were not covered.

Avoidable Yield Losses because of Pests

To estimate avoidable loss because of the major pest groups, comparisons of seed yields were made between 'nonprotected' and 'protected' plots in replicated trials. These trials comprising different cultivars were conducted during the 1987/88 and 1988/89 cropping seasons at two research stations of the Eastern Province, one on the plateau (Msekera) and the other in the valley (Masumba). During 1988/89, an on-farm trial was also conducted.

In most of the trials the loss because of soil pests was assessed by comparing 'protected' plots receiving soil application of carbofuran or chlorpyrifos (1 kg a.i. ha^{-1}) or dieldrin (2 kg a.i. ha^{-1}) at sowing with nonprotected plots. For assessing the loss because of foliage pests (sucking and defoliating), protected plots were sprayed with dimethoate plus endosulfan (each at 0.07%) while 'nonprotected' plots received water spray. Avoidable loss was estimated as the reduction in seed yield in nonprotected plots compared with that in protected plots.

The range of avoidable loss because of soil pests across research sites and cultivars for the 1987/88 season was estimated as 11-30% (101-200 kg ha^{-1}) compared to 2-19% (13-109 kg ha^{-1}) for the 1988/89 season (Table 2). For the second season (1988/89), the

Table 2. Estimates of avoidable loss because of soil and foliage pests of groundnut in Eastern Province, Zambia, 1987/88 and 1988/89.

Location	Cultivar	Soil pests		Foliage pests	
		(%)	(kg ha^{-1})	(%)	(kg ha^{-1})
1987/88 (On-station)					
Masumba[1]	Makulu Red	30	200	-	-
	MGS 2	16	137	-	-
't' lest			4.46**		
Msekera[1]	Chalimbana	14	117	-	-
	MGS 2	11	101	-	-
't' test			4.16**		
1988/89 (On-station)					
Masumba[1]	Chalimbana	19	109	31	148
	Makulu Red	2	13	5	35
	MSG 2	2	14	6	36
't' test			2.25*	0.71	NS[2]
Msekera[1]	Chalimbana	16	76	23	144
	Makuiu Red	-	-	10	147
	MGS 2	-	-	21	226
	MSG 3	-	-	16	223
't' test					6.69**
1988/89 (On-farm)					
Kalichero[1]	MGS 2	21	78	-	-
	MGS 4	11	29	-	-

1. Msekera, Kalichero = plateau; Masumba = valley.
2. NS = Not significant.

comparative range in loss because of foliage pests was 5-31% (35-148 kg ha^{-1}). In both seasons, the extent of loss because of pests tended to be greater at the valley site (Masumba) than at the plateau site (Msekera). During the 1988/89 season, the loss because of soil pests as well as foliage pests was greater in Chalimbana (large-seeded, popular cultivar) than in Makulu Red (medium seed size, popular cultivar) and MGS 2 (improved, high-yielding cultivar). The only on-farm trial also showed substantial loss (11-21%) because of soil pests.

These data clearly indicate a considerable variability in yield loss between seasons, sites, and cultivars. The greater loss because of both pest groups observed in the valley can be because of increased pest incidence and/or greater stress suffered by plants under warm conditions. The reduced level of losses because of soil pests at Masumba during the second season may possibly be because of high rainfall, reducing soil-pest activity. The improved high-yielding cultivar MGS 2 appeared to suffer less than Chalimbana from pests of both groups. Apparently, this would be a bonus for the farmers, as the pest-caused loss can be minimized by just opting for the new cultivar.

It is important to mention that sometimes insecticidal protection, especially those against soil pests, had no effect on yields or even resulted in reduced seed yield. Insecticides may have interacted in different ways with soil types, affecting plant growth. They also may have had an influence on natural enemies of pests (e.g., ants) or on the plant's ability to compensate for damage.

References

Amin, P.W. 1984. Field notes on insect pests and vector problems of groundnut in SADCC countries. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. (Limited distribution.)

Sithanantham, S. 1988. Studies on soil pests associated with groundnuts in Zambia. Proceedings of the Tenth International Soil Zoology Colloquium, 7-13 Aug 1988, Bangalore, India. Bangalore, India: University of Agricultural Sciences. (Abstract.)

Sithanantham, S., Irving, N.S., and Sohati, P.H. 1989. Recent and ongoing research on insect pests of groundnut in Zambia. Pages 141-145 *in* Proceedings of the Third Regional Groundnut Workshop for Southern Africa, 13-18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Wightman, J.A. 1986. Groundnut pests in Zimbabwe, Malawi, and Zambia. Tour report. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. (Limited distribution.)

Wightman, J.A. 1989. Contribution of insects to low groundnut yields in southern Africa. Pages 129-140 *in* Proceedings of the Third Regional Groundnut Workshop for Southern Africa, 13-18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Screening for Resistance to Sucking Insects among Groundnut Genotypes in Zambia[1]

S. Sithanantham[2], P.H. Sohati[2], M.B. Syamasonta[3], and J. Kannaiyan[4]

Abstract

*Sucking insects, mainly leafhoppers, contribute to yield losses on groundnut (*Arachis hypogaea *L.) in Zambia. Many genotypes were screened in replicated plots at two locations-Msekera and Masumba-during the 1987/88 and 1988/89 cropping seasons. ICG 485, ICG 2271, ICG 5044, and ICG 5045 were distinctly less damaged by sucking insect pests titan many other genotypes. ICG 2271 is resistant to several pests, and as it has a good yield potential it may be a useful parent in hybridization. The germplasm screening at Msekera during the two seasons indicated three alternate branching lines (NC Ac 15740, NC Ac 10223, NC Ac 2230) and four sequential branching lines (EC 36892, PI 315680, ICGV 86309 (ICGS 87), and HYQ(CG)S 10} to be promising for low damage by sucking insects. Genotypes EC 36892 and NC Ac 10223 were least damaged by early and late leaf spot diseases.*

Sumário

Procura de Baixa Susceptibilidade a Pragas de Insectos Sugadores Entre Genótipos de Amendoim na Zambia. *Pragas de insectos sugadores, principalmente salta-folhas, são uma importante causa para o abaixamento do rendimento do amendoim (*Arachis hypogaea *L.) na Zambia. Muitos genótipos foram avaliados em talhões repetidos em dois locais - Msekera e Masumba - durante as estações de cultivo de 1987/88 e 1988/89. Determinou-se que ICG 485, ICG 2271, ICG 5044 e ICG 5045 foram claramente menos danificadas, por pragas de insectos sugadores, que muitos dos outros genótipos. ICG 2271 tem a vantagem adicional de ser resistente a várias pragas e, como tem um bom rendimento potencial, pode ser util como progenitor na hibridação. A classificação do germoplasma, cultivado em Msekera, durante duas estações, indicou três linhas de ramificação alterna (NC Ac 15740, NC Ac 10223 e NC Ac 2230) e quatro linhas de ramificação sequencial (EC 36892, PI 315680, ICGV 86309 = ICGS 87 e HYQ(CG)S 10) como promissoras pelos baixos danos causados pelas pragas de insectos sugadores. Os genótipos EC 36892 e NC Ac 10223 foram tambem pouco danificadas por doenças de manchas das folhas, temporã e tardia.*

1. The paper was presented by P.H. Sohati.
2. Legumes Entomologist, Food Legumes Research Team, Msekera Regional Research Team, P.O. Box 510089, Chipata, Zambia.
3. Groundnut Breeder and Coordinator at the above address.
4. Legume Pathologist at the above address.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

Introduction

Insect pests are serious constraints to groundnut *(Arachis hypogaea* L.) production in Zambia (Sandhu et al. 1985). Among the several insects infesting the crop, sucking pests, mainly leafhoppers *(Empoasca* spp), appear to cause appreciable yield losses (Amin 1984; Sithanantham et al. 1989). Since groundnut is grown mostly by small-scale farmers in the Southern African Development Coordination Conference (SADCC) region, cultivars resistant to insect pests are appropriate for minimizing the losses by insects (Sithanantham 1989). The results of a search for sources of resistance to sucking pests in Zambia are summarized in this report.

Materials and Methods

During two cropping seasons (1987/88 and 1988/89), many groundnut genotypes, including pest-resistant selections from ICRISAT Center (India) and high-yielding selections of the Zambian national program, were grown in pest-screening trials at two sites—Msekera (plateau) and Masumba (valley)—in the Eastern Province, Zambia. The genotypes were grown with local cultivars as controls, in randomized blocks with three replications. Each genotype was grown in a 4-m long row (a plot) with 75 cm between rows and 20 cm between plants. Two infestor rows were sown about 2 weeks earlier on both sides of the trial. The fertilizer applied was 'D' compound (10N:20P:10K:10S) at 150 kg ha^{-1} at sowing.The extent of damage by sucking pests was visually scored on a 1-9 scale at least once before the crop matured. The most important symptom was leaf-tip yellowing caused by leafhoppers. Minor damage by leaf thrips, white flies (*Bemisia tabaci),* and aphids *(Aphis craccivora),* leading to crinkling or cupping, was also included in the severity rating described below:

Rating	Leaflets damaged
1	No apparent damage
2	Up to 5%
3	6-10%
4	11-15%
5	16-20%
6	21-30%
7	31-40%
8	41-50%
9	Above 50%

In addition to the above score, severity rating for leaf spot diseases *[Cercospora arachidicola* Hori and *Phaeoisariopsis personata* (Berk. & Curt.) v. Arx.] (Kannaiyan et al. 1989) before maturity, and seed yield at harvest were recorded.

Similar observations were also recorded for the germplasm accessions grown in nonreplicated one-row plots at Msekera during both seasons.

Results and Discussion

The results of the pest-screening nursery (Table 1) showed that four genotypes—ICG 485, ICG 2271, ICG 5044, and ICG 5045—earned distinctly low ratings. Most of the damage in the nurseries was caused by leafhoppers, while thrips caused occasional damage. Resistance to leafhoppers and thrips has earlier been reported for three of these genotypes, i.e., ICG 2271, ICG 5044, and ICG 5045 (Amin 1987). ICG 2271 is known to be resistant also to soil pests (termites and pod borers), leaf miner, and bud necrosis disease (caused by tomato spotted wilt virus and transmitted by thrips). In the present study, this genotype showed good yield potential as well, tending to be better than the local control Chalimbana. However, the yield estimates had a high coefficient of variation, so their dependability needs verification. ICG 5044 and ICG 5045 arc also known to be resistant to termites (Amin 1987), which are important pests on this crop in Zambia.

The preliminary indications of rating among germplasm accessions (Table 2) suggest three among the alternately branching types (NC Ac 15740, NC Ac 10223, and NC Ac 2230) and four sequential branching entries [EC 36892, PI 315608, ICGS 87, and HYQ(CQ)S 10] to be potential sources with resistance to sucking pest damage. EC 36892 (ICGS 5240) also had a less severe rating for leaf spots. This genotype is resistant to aphids. Another genotype, NC Ac 2230 (ICG 504), has been already identified as resistant to leafhoppers and thrips (Amin 1987). The other promising genotypes identified at present apparently have not so far been reported as resistant to any sucking pest.

These studies have shown that several of the genotypes tested have resistance to sucking pests under Zambian conditions. Several of them possess additional advantages such as resistance to other insect pests and leaf spot diseases. We expect to look for such low susceptibility to sucking insect pests combined with acceptable levels resistance to leaf spot

Table 1. Sucking pest damage and seed yield of some promising groundnut genotypes identified in pest screening nurseries at two locations in Zambia, 1987/88 and 1988/89.

	Mean sucking pest rating (1-9 scale)[1]				Mean seed yield			
	1987/88		1988/89		1987/88 (g $plot^{-1}$)		1988/89 (kg ha^{-1})	
Genotype	MSE[2]	MAS[2]	MSE	MAS	MSE	MAS	MSE	MAS
ICG 485 (Gujarat Narrow Leaf)	3.5	1.0	1.0	3.5	3.7	3.9	31	243
ICG 2271 (NC Ac 343)	4.0	NT[2]	2.5	5.5	18.8	NT	518	752
ICG 5044 (NC Ac 2243)	3.0	3.0	3.0	5.0	3.5	3.6	21	209
ICG 5045(NC Ac 2243)	4.0	2.5	2.5	5.0	4.1	0.4	61	257
Controls								
Chaiimbana	6.5	6.0	4.5	7.0	17.2	7.4	209	489
Makulu Red	6.0	4.5	6.0	6.5	19.9	7.3	729	833
SE	±0.49	±0.90	±0.15	±0.30	±2.5	±4.9	±37.0	±31.8
Trial mean	4.5	2.4	4.0	6.1	12.3	6.4	282	577
(no. of entries)	(30)	(22)	(64)	(58)	-	-	-	-
CV(%)	15	54	17	8	29	109	74	130

1. Scored on the 1-9 scale, where 1 = No damage, and 9 = 50-100% foliage destroyed.
2. MSE = Msekera, MAS = Masumba, and NT = Not tested.

Table 2. Selections from groundnut germplasm collections at Msekera. Zambia, found to show low damage by sucking pests, 1987/88 and 1988/89.

	Sucking pest rating (1-9)[1]		Leaf spots (1-9)[1]		Seed yield ($t\ ha^{-1}$)		
Genotype	1987/88	1988/89	1987/88	1988/89	1987/88	1988/89	Seed type[2]
Alternate branching							
NC Ac 15740	3	3	5	8	NR[2]	0.171	L,Br
NC Ac 10223 (ICG 5728)	3	3	6	6	0.520	0.108	UP
NC Ac 2230 (ICG 5041)	3	3	8	8	0.433	0.054	M, P
Controls							
Makulu Red	NT[2]	5	8	6	1.173	0.583	M,R
Chalimbana	6	6	7	7	0.533	0.404	L,P
	8	7	9	9	1.427	1.425	
Trial mean	5	5	8	7	0.208	0.405	
Sequential branching							
EC 36892 (ICG 5240)	3	3	4	6	0.072	0.042	MS,P
PI 315680 (ICG 7883)	3	3	6	7	0.107	0.158	M,W
ICGS 87	3	3	7	8	0.178	0.117	M
HYQ(CG)S 10	3	3	7	6	0.079	0.163	L.R,Br
Controls							
Natal Common	4	7	7	8	0.079	0.296	S,Br
Comet	5	7	8	8	0.050	0.292	S,Br
Maximum for trial	8	7	9	8	0.518	0.533	
Trial mean	5	5	5	7	0.112	0.143	

1. Scored on a 1-9 scale, where 1 = No damage/disease, and 9 * 50-100% foliage destroyed.
2. NR = Not recorded: NT = Not tested; L - Large, M = Medium, S = Small; BR = Brown; P = Purple; R = Red; W = White.

diseases, so that breeders can use such broadbased sources of resistance with advantage. Confirmatory experiments are being planned to ascertain the stability of resistance among the promising genotypes identified so far.

References

Amin, P.W. 1984. Field notes on insect pests and vector problems of groundnut in SADCC countries. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. (Limited distribution.)

Amin, P.W. 1987. Advances in identification of stable sources of resistance to insect pests/vectors and their exploitation in groundnut improvement. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. (Limited distribution.)

Kannaiyan, J., Sandhu, R.S., Haciwa, H.C., and Reddy, M.S. 1989. Management of leaf spots of groundnut in Zambia. Pages 35-41 *in* Proceedings of the Third Regional Groundnut Workshop for Southern Africa, 13-18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Sandhu, R.S., Kelly, G., and Kannaiyan, J. 1985. Groundnut production and research: Problems and priorities in Zambia. Pages 107-113 *in* Proceedings of the Regional Groundnut Workshop for Southern Africa, 26-29 Mar 1984, Lilongwe, Malawi. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Sithanantham, S. 1989. Pest management on food legumes in Zambia—progress and prospects. Pages 14-26 *in* Proceedings of the Workshop on Strategy for Integrated Pest Management and Weed Control for Small Holder Farmers in SADCC Countries, 1-4 Aug 1988, Mbabane, Swaziland. Gaborone, Botswana: Southern African Centre for Cooperation in Agricultural Research.

Sithanantham, S., Irving, N.S., and Sohati, P.H. 1989. Recent and ongoing research on insect pests of groundnut in Zambia. Pages 141-145 *in* Proceedings of the Third Regional Groundnut Workshop, 13-18 Mar 1988, Lilongwe, Malawi. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

General Discussion on Entomology

Ndunguru: How were the yield losses because of pests separated from those because of diseases in that trial?

Sohati: By monitoring the incidence of pests on one side and diseases on the other by spraying with selective pesticides so that the crop loss could be clearly differentiated and attributed.

Mpiri: Did you control other problems such as diseases so that you could say with conviction that the losses experienced were because of insect pests only and not something else?

Sohati: What is normally done is to record the infestation of the insects before the diseases occur. In case of severe infection by diseases, particularly leaf spot, fungicides arc applied.

Omanga: In other grain legumes (cowpea, green gram, and pigeonpea), thrips cause a lot of damage to flowers. They eat floral parts resulting in flower drop. Have you observed any damage caused by thrips to groundnut flowers?

Sohati: This research is in its initial stages. Work was begun on foliar insect pests. However, many flowers have been collected for thrips count.

Busolo-Bulafu: During the crossing exercise, I used to find thrips in the emasculated flowers the following day when I wanted to pollinate. Quite often, the style/stigma was damaged and I attributed this to thrips. I do not know if I was right.

Sohati: Yes, it is quite possible.

Rao: Are there different species of thrips involved in groundnut insect-pest attack? If so, how do you differentiate their damage on the plant?

Sohati: So far the thrips species identified on groundnuts in Zambia are those belonging to the genus *Frankliniella.* Thrips cause the crinkling and cupping of leaves on groundnut.

Reuben: Would you go for a variety which is so susceptible to insect pests but still yields substantially higher? Can you distinguish between resistance and tolerance?

Sohati: A genotype that yields better, even though more susceptible than others, must be considered tolerant.

Hildebrand: I agree with this interpretation. At the end of the day, it is the yield that is important. Our philosophy at SADCC/ICRISAT Groundnut Project on breeding for ELS resistance is to select for yield under higher disease pressure.

Busolo-Bulafu: Can you comment on the reason for purple staining?

Hildebrand: This condition was found to occur on Makulu Red in Zimbabwe, more frequently in the dry than in the wet season, and it was not noticed in other varieties. No cause of this condition is known but it is thought to be physiological.

Country Reports

Recent Groundnut Research in Lesotho and Prospects for Future Development

S.S. Moima[1]

Abstract

The results of groundnut (Arachis hypogaca *L.) germplasm evaluation trials conducted during the 1987/88 and 1988/89 cropping seasons are reported. Pod and seed yields were higher in 1987/88 than in 1988/89 because of greater severity of diseases and weed (*Cyperus rotundus *L.) competition in 1988/89. Excessively wet conditions and low temperatures delayed the harvest and resulted in low yield in some lines. Genotypes ICGM 189 and ICGV-SM 83031 performed well in both seasons. Promising genotypes have been incorporated into the Lesotho national groundnut program for further evaluation.*

Sumário

Recente Investigação sobre Amendoim no Lesoto e Prospectos para o Futuro Desenvolvimento. *Os resultados dos ensaios de avaliação de germoplasma de amendoim (*Arachis hypogaea *L.), conduzidos durante as estações de cultivo de 1987/88 e 1988/89. são reportados. Os rendimentos de vagens e grão foram mais altos em 1987/88 que em 1988/89, devido ao mais intenso ataque de doenças e á maior competição de infestantes (*Cyperus rotundus *L.) em 1988/89. Condições excessivamente humidas e baixas temperaturas atrazaram a colheita e resultaram em baixo rendimento de algumas linhas.*

Os genótipos ICGM 189 e ICGV-SM 83031 comportaram-se bem em ambas as estações. Alguns dos genótipos promissores foram incorporados no programa nacional de amendoim do Lesoto para posterior avaliação.

Introduction

Groundnut *(Arachis hypogaea* L.) is an important crop in the semi-arid tropics (SAT) where its production exceeds that of any other legume and comprises 70% of world production. The crop is of great importance to smallholder farmers and makes a significant contribution towards dietary requirements in southern Africa. The seeds contain 25% protein and 50% edible oil and the haulms are a valuable and nutritious animal feed. The crop provides significant income to the rural farming community.

Lesotho has a temperate climate with well-marked seasons. Warm summers are experienced with a short growing season while winters are cold with frost and long periods of drought. Most of the rain (85%) falls between October and April with severe hail storms and heavy thundershowers of high intensity.

Groundnut Research

The groundnut improvement program in Lesotho continues to depend on plant introduction from interna-

1. Groundnut Program Leader and Agronomist, Agricultural Research Division, P.O. Box 829, Maseru, Lesotho.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

tional research centers and neighboring countries as a major source of germplasm. There has been no comprehensive groundnut improvement program in the country.

The objectives of the program are to evaluate the performance of newly introduced Spanish and Valencia groundnut cultivars under Lesotho's environmental conditions and to identify and select high-yielding and adapted genotypes for further testing. Performances of selected drought-tolerant, early-maturing germplasm accessions have also been evaluated recently.

SADCC Regional Groundnut Variety Trials

The Agronomy Section of the Research Division became a cooperator in the SADCC/ICRISAT Groundnut Project's regional network during the 1986/87 cropping season although evaluation of regional trials only commenced in 1987/88. Results of the 1987/88 and 1988/89 trials are discussed in this paper.

SADCC Regional Groundnut Variety Trials 1987/88

Sixteen Valencia and 36 Spanish type entries were grown in separate trials at the Maseru Research Farm.

The Valencia trial was sown on 6 Nov 1987 and the Spanish trial was sown on 4 Dec 1987. The design used was a 4 x 4 lattice design with four replicates for the Valencia trial and a 6 x 6 lattice with four replicates for the Spanish trial.

Significant pod and seed yield differences were recorded among genotypes in both trials (Table 1). However, both trials were adversely affected by unfavorable weather. Excessively wet conditions and low night temperatures resulted in delays in harvest, which reduced yields and shelling percentages of most entries.

The Valencia types—ICGM 189, ICGM 177, and ICGM 550—(Table 1) and the Spanish types—ICGV-SM 86051, ICGV-SM 85027, ICGV-SM 86066, and ICGV-SM 83031—performed well with pod and seed yields 60% higher than those of local controls (MS 8, MS 7, Malimba, and Spancross).

SADCC Regional Groundnut Variety Trials 1988/89

Sixteen Valencia and 14 Spanish type entries were grown at the Maseru Research Farm.

The Valencia trial was were sown on 16 Nov 1988 and the Spanish trial was sown on 18 Nov 1988. Significant pod and seed yield differences were recorded among genotypes in both trials. However, the trials were adversely affected by high infestation of nutsedge (*Cyperus rotundus* L.), early (ELS) and late (LLS) leaf spot diseases, and excessively wet conditions during harvest. Low plant densities, poor yields, and low shelling percentages were recorded on most entries.

The Valencia types—ICGM 189, ICGM 286, and ICGM 525—(Table 2) and the Spanish types—ICGV-SM 83031, ICGV-SM 86051, and ICGV-SM 85027—performed well with yield gains of over 100% over local controls.

International Early Groundnut Variety Trial 1988/89

Twenty-five early-maturing genotypes were sown in a trial at Maseru Research Farm on 17 Nov 1988. The design used was a 5 x 5 lattice with four replicates.

Significant pod and seed yield differences were recorded among entries. The trial was adversely affected by a severe infestation of nutsedge, and high incidence of diseases (ELS and LLS), rodents, and excessively wet conditions during harvest resulting in lower plant stands at emergence and harvest. Reduced plant densities resulted in low yields in some entries. ICGV 86092 and ICGV 86094 performed well. Yields were over 65% more than those of the local controls.

Preliminary Drought Tolerance Observation Nursery, 1988/89

Thirteen entries were sown in a nonreplicated observation nursery at the Maseru Research Farm on 17 Nov 1988.

Again the trial was affected by high infestation of nutsedge and high incidence of diseases (ELS and LLS), rodents, and excessively wet conditions during harvest. Low yields, poor shelling percentages, and smaller seeds were recorded on some entries.

Table 1. Performance of selected entries in the SADCC Regional Groundnut Variety Trial (valencia), Maseru, Lesotho, 1987/88.

Entry	Pod yield (t ha^{-1})	Seed yield (t ha^{-1})	Shelling (%)	100-seed mass (g)	Time to maturity (days)	Plant stand (%)	Seed color
ICGV 189	3.32	1.74	51	33	150	74	Red
ICGV-SM 83031	3.40	1.63	49	42	147	75	Red
ICGM 177	2.71	1.12	42	33	149	78	Red
ICGM 550	2.68	1.08	41	39	151	73	Purple
ICGM 285	2.01	1.06	46	33	149	80	Red
ICGM 286	1.73	0.95	50	36	149	72	Red
ICGM 525	3.00	0.91	32	34	151	72	Purple
ICGM 281	2.27	0.84	36	41	147	77	Purple
Controls							
MS 8	1.28	0.74	59	33	146	63	Tan
MS 7	1.65	0.88	51	35	148	72	Red
SE	±0.393	±0.232					
Trial mean	2.41	1.10	46	36	149	74	
CV(%)	38.2	42.2					

Table 2. Performance of entries in the SADCC Regional Groundnut Variety Trial (Valencia), Maseru, Lesotho, 1988/89.

Entry	Pod yield (t ha^{-1})	Seed yield (t ha^{-1})	Shelling (%)	100-seed mass (g)	Plant stand (%)	Time to maturity (days)	Mean diseases score[1]	
							ELS[2]	LLS[2]
ICGM 189	3.132	1.659	52.3	74	49.4	150	9	1
ICGM 286	2.198	0.997	45.4	53	57.0	145	9	1
ICGM 525	2.066	1.154	54.6	65	51.5	145	9	1
ICGM 197	2.000	0.821	40.8	60	58.2	145	9	1
ICGM 550	1.957	0.901	46.3	68	52.7	145	9	1
ICGM 285	1.951	1.047	53.2	63	47.9	145	9	1
ICGM 281	1.898	0.949	51.8	61	42.2	145	9	1
ICGM 559	1.746	0.734	43.2	79	47.1	145	9	1
ICGM 554	1.720	0.781	45.4	77	43.3	145	9	1
ICGM 284	1.575	0.879	54.2	60	47.9	150	9	1
ICGM-SM 83030	1.321	0.671	50.1	66	41.5	145	9	1
ICGM-SM 83031	1.208	0.595	50.4	78	38.7	145	9	1
ICGM 561	1.175	0.459	42.4	56	33.4	145	9	1
ICGM 177	0.740	0.360	49.3	62	32.9	145	9	1
Controls								
MS 8	0.122	0.058	47.2	45	12.3	145	9	1
MS 7	0.576	0.252	43.1	52	31.9	145	9	1
SE	±0.2130	±0.1554	6.7	-	±4.9	-	-	-
Trial mean	1.5866	0.7697	48.1	63.69	43.0	145.6	9	1
CV (%)	26.9	40.4	27.7	-	22.8	-	-	-

1. Scored on a 1-9 scale, where 1 = no disease, and 9 = 50-100% of foliage destroyed.
2. ELS = Early leaf spot *(Cercospora arachidicola)*, LLS = Late leaf spot (*Pnaeoisariopsis personata)*.

ICGV-SM 86595, ICGV-SM 86061, and ICGV-SM 86973 recorded seed yields of 1 t ha^{-1}.

Future Research and Development

The groundnut improvement program will continue to evaluate germplasm from international research centers and neighboring countries to select adapted and high-yielding varieties preferably with tolerance of diseases and insects. More emphasis will be placed on genotypes that will be more readily acceptable to the Basotho people. The SADCC/ICRISAT Groundnut Project material shows promise for use in Lesotho. There is a need to conduct further agronomic studies on date of sowing, plant density, nutrition, and weed control. There is a need for multilocational trials to evaluate yield stability, and for on-farm trials to assess performance of selected materials under farmers' conditions, before recommendations can be made.

Discussion

Chigwe: Referring to Table 2 of your paper, how do you explain the differences in the incidence of early leaf spot (ELS) and late leaf spot (LLS) among the genotypes tested?

Moima: This is how the genotypes responded to the two diseases under the particular environment.

Mande: It is necessary to consider the problem of 'pops' as one of the priorities in future research programs because from the results, the varieties have high pod mass and low seed mass resulting in low shelling percentages, showing that there was poor pod filling. This poor pod filling might be attributed to the 'pops' problem.

Doto: Do you have some explanations for the unusually high CV values? Could the high CVs be partly attributed to the problems of plant stand?

Moima: Yes.

Syamasonta: Low temperatures seem to increase the maturity period. Are you working with Dr Hildebrand, who is working on this problem?

Moima: No.

Groundnut Seed Production Project for Small-scale Farmers in Zambia[1]

J.M. Mulila-Mitti[2], M.B. Syamasonta[3], and J.K.R.S. Zimba[4]

Abstract

A small-scale, seed-growers project has been initiated in the Eastern Province, Zambia, to recruit and train small-scale farmers in the production of good quality groundnut (Arachis hypogaea *L.) seed, thereby improving its availability to Zambian farmers. The implementation of the project is described and present limitations are briefly discussed.*

Sumário

Projecto de Produção de Semente de Amendoim para Agricultores de Pequena Escala na Zambia. *Um projecto de produtores de sementes, de pequena escala, foi iniciado na Província Oriental, Zambia, para recrutar e treinar agricultores de pequena escala na produção de semente de amendoim* (**Arachis hypogaea** *L.) de boa qualidade e, consequentemente, melhorar a disponibilidade de semente para os agricultores zambianos. A implementação do projecto é descrita e as limitantes actuais brevemente discutidas.*

Introduction

The national marketed groundnut (*Arachis hypogaea* L.) production in Zambia stood at 24 000 t in 1967 and only 765 t in 1982. Although there has been a slight but consistent increase in the total groundnut production since 1982 (Table 1), marketed surplus has been small and erratic. The increase in groundnut production in Zambia has not kept pace with the increase in the population, creating a shortfall in the supply of groundnut and therefore increasing prices to maximum levels the urban consumer can afford. The shortage in groundnut production is reflected not only in the high consumer prices, but also in the difficulty the processors face to obtain raw material.

Table 1. Groundnut production and marketing in Zambia, 1980-86[1].

Year	Groundnut production (t)	Marketed groundnut (t)
1980	116558	4960
1981	55640	1455
1982	9372	765
1983	10980	1042
1984	13273	1156
1985	14517	2419
1986	18184	6280

1. Source: Zambia: Ministry of Agriculture and Water Development (1983).

1. The paper was presented by J.C. Musanya.
2. Food Legume Coordinator, Msekera Regional Research Team, P.O. Box 510089, Chipata, Zambia.
3. Groundnut Breeder and Coordinator at the above address.
4. Zamseed Project Manager, Zamseed Co. Ltd., P.O. Box 510695, Chipata, Zambia.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop *for* Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

While there continues to be great potential to export groundnuts, the processors cannot satisfy the local demand for groundnut products (Zambia: Ministry of Agriculture and Water Development 1983).

The inadequate supply of good quality. seed to growers has been one of the major factors responsible for reduced groundnut production in the country. The Zambia Seed Company (Zamseed), which is the sole producer of certified seed in the country, has never been able to satisfy the demand of growers for seed. Large-scale growers normally contracted by Zamseed for seed production are reluctant to grow groundnut because of the crop's high labor demand. The seed company is concerned that small-scale farmers will be unable to pay the high price for certified seed.

There are five released groundnut cultivars available for commercial production in Zambia. The large-seeded Chalimbana and the high-oil-yielding Makulu Red are both long-season cultivars, and are recommended for the major groundnut-producing areas of eastern and central plateau where rainfall is moderate. The short-season Comet and Natal Common are recommended for the light-textured soils of the Southern and Western Provinces where rainfall is low to moderate. In 1988, MGS 2 was released by the Research Branch to supplement Chalimbana. Although MGS 2 has smaller seeds they are more uniform. Also, it yields more than Chalimbana. MGS 4 (ICGV-SM 83708 or ICGMS 42) was approved for prerelease testing nationwide in 1987 and MGS 3 in 1989. These varieties have superior yield and seed qualities and have been found to possess better early leaf spot *(Cercospora arachidicola* Hori) tolerance than Makulu Red.

The expected impact from release of improved cultivars will not be achieved unless the groundnut seed-supply problem to the small-scale farmers is solved.

To alleviate the problem of seed supply to farmers, a small-scale seed growers* project has been initiated by the government, with funding from the Swedish International Development Agency (SIDA) Training Program, in the Ministry of Agriculture. The project is expected to continue for 3 years, commencing the 1989/90 season.

Project Background and Justification

Groundnuts, beans, rice, and soybean are crops that experience shortage of certified seed and a good potential exists for small-scale farmers to produce the seed. Cotton seed-growing schemes by small-scale farmers, which were introduced in 1975, have proved to be quite successful. Past experiences by Zamseed have shown that while small-scale seed production schemes are difficult to implement, the small-scale farmers have contributed significantly towards alleviating seed shortages.

A small-scale seed growers' project is therefore being implemented in the Eastern Province with major emphasis on groundnut seed production.

Objectives and Targets

The overall objectives of this project are to:

- improve knowledge and develop skills among small-scale farmers in seed production of groundnuts and beans,
- develop a system for input supply on credit, and delivery of the seed appropriate to the needs of the small-scale growers, and
- develop the organization and management of seed control and certification of crops produced by small-scale growers.

The project aims to recruit and train a minimum of 90 small-scale groundnut-seed growers in the 1989/90 cropping season. In the 1990/91 season a minimum of 180, and in the 1991/92 season a minimum of 270 growers should be producing groundnut as well as bean seed.

The project also plans to establish a revolving fund system whereby small-scale growers will be able to finance necessary inputs.

Method

The project is implemented jointly by Zamseed, Extension Branch, Research Branch, and the Seed Control and Certification Institute (SCCI). A Project Manager, employed by Zamseed and based in Chipata, is responsible for planning and coordinating activities among all the parties involved. The following activities are undertaken.

1. Project planning

A detailed workplan covering the agricultural season has to be prepared annually. This plan should indicate activities to be undertaken by the different parties involved and the time schedule. A procurement plan, training plan, and budget should accompany the workplan. The Project Manager is responsible for the preparation of this plan.

2. Recruitment of growers

Growers are recruited by the Project Manager in cooperation with the research and extension branches and SCCI in zones that are suitable for the production of the crop and are accessible. Seed farmers should be concentrated within zones to minimize costs involved in supervision and control of production and for delivery of inputs and the collection of seed produced. To be eligible for the scheme, growers should sow a minimum of 0.5 ha and a maximum of 1 ha.

Each selected grower enters into a production contract with the seed company and registers his crop with the SCCI.

3. Training

Training of growers is the responsibility of the Project Manager, who also consults research and extension, and SCCI officers for advice on crop husbandry practices and seed regulations. A plan to train and visit is drawn up by the Project Manager, in cooperation with the District Agricultural Officers concerned, at the beginning of the season to ensure that all growers are visited often enough.

The Project Manager is expected to hold presowing meetings in collaboration With the Extension Branch and the SCCI staff and with growers in each zone in November to early December. These meetings should focus upon the characteristics of varieties to be grown, choice of field, crop husbandry practices, and postharvest handling of the crop. Contractual obligations on the part of the grower, as well as on the part of Zamseed, should be highlighted at these meetings. The purpose and actual implementation of SCCI field inspections should also be clearly described.

The Project Manager and Extension Officers are expected to visit growers regularly to give advice, while breeders should visit growers during flowering and harvesting to check crop development and advise as necessary.

The Project Manager is also required to organize postharvest meetings to be attended by the extension branch and the SCCI officers enabling all growers to discuss their experiences of seed production and any problems encountered.

4. Input supply and financial arrangements

Zamseed supplies inputs for seed production to the growers. These include parent seed, fertilizer, pesticides, and bags. Inputs are delivered by Zamseed to growers at zonal points at a specified time as agreed between the Project Manager and growers.

The Project Manager keeps a record of the quantities of inputs delivered and the costs, including transport cost for each grower. Upon delivery of the seed, this amount is deducted from the seed crop payment.

During the 2nd year of seed crop cultivation the grower will, if feasible, be required to deposit part of the cost of inputs before delivery of the items.

5. Production and quality control

Seed production by growers has to comply with the contractual arrangements with Zamseed and should be in accordance with the Seeds Act.

The Project Manager, SCCI, Extension Officers, and breeders have a major responsibility in ensuring seed quality by advising growers throughout the season, so that good crop husbandry is practised, rogueing is carried out, and harvesting and postharvest operations methods are correctly implemented.

Seed inspectors are required to carry out timely and frequent inspections and advise growers on improved seed production.

6. Seed delivery and payments

Delivery of seed will take place as soon as sampling by the SCCI seed inspectors is carried out. Groundnut will be purchased unshelled. The bags will be weighed and provisionally sealed by the inspector and transported to Zamseed depot in Chipata. When the seed has been processed and test results are complete, labels will be provided by SCCI and the bags will be finally sealed.

Growers will be paid in cash according to established prices, and based upon the quality of seed after deducting the costs of the inputs and transport. Seed failing to reach required quality standards will be rejected.

7. Organization, monitoring, and evaluation

A project committee, consisting of the Zamseed Production Manager and representatives from the Extension Branch of SCCI and the Seed Training Program, is responsible for monitoring the project at the headquarters. The committee is responsible for approving the proposed work plan and budget submitted by the Project Manager for the forthcoming season.

The committee is also responsible for discussing and analyzing the quarterly reports on progress of project activities including problems encountered in project implemention as well as recommending to the Project Manager any necessary measures to be taken when required.

Discussion on Present Limitations

Although it is too early to evaluate the performance of the scheme, many limitations and difficulties can be foreseen.

1. Liaison and coordination

Liaison between Zamseed and the Research Branch in the monitoring of training activities has been inadequate. Plant pathologists have not been involved in any of the training sessions held to date. Training sessions have so far not been well coordinated. Training is recognized as the most important element in the success of this scheme. It is therefore important that there is a close liaison between parties involved in planning for training.

2. Price of certified seed

Since Zamseed is to market certified seed produced by the growers, the price is expected to be quite high and may not be easily affordable for most of the small-scale farmers.

There is a need to intensify extension services to demonstrate the advantages of using certified seed in addition to using correct agronomic practices. Unless farmers accept the benefits of using improved seed, they will not be willing to pay a high price.

3. Funding

The fate of this scheme after the 1991/92 season is not predictable. Three years of production in a small area will not make much impact on groundnut production nationwide. The government should plan on a long-term project covering all major groundnut-producing areas in the country.

Conclusion

The small-scale seed growers project initiated in the Eastern Province is a step in the right direction towards alleviating the problem of supply of improved groundnut seed to farmers.

If there is a closer liaison between parties involved and if training activities are well coordinated in the remaining 2 years of the project, the scheme should prove successful in promoting production of improved seed by small-scale farmers.

Reference

Zambia: Ministry of Agriculture and Water Development. 1983. Groundnut production and marketing in Eastern Province: A market analysis. Planning Division Special Study no. 1. Lusaka, Zambia: Ministry of Agriculture and Water Development. 88 pp.

Discussion

Subrahmanyam: Do you take into consideration eliminating some of the seedborne diseases, e.g., peanut mottle virus, in your seed-production plots in Zambia?

Musanya: Yes, we have a full-time pathologist looking into this aspect.

Doto: How do you account for the low volume of marketed production when the groundnut production was high in 1980 and 1981, and the increase in marketed production in 1986 when the production was not so high?

Musanya: Low volumes for the marketed production in 1980 and 1981, when production was high, were related to the price offered. That period coincided with the particularly low price offered for groundnut and most of the produce went to informal channels where the price offered was higher than the official one. In 1986, the marketed volume was higher than 1980 and 1981, even when production was not very high because by then steps had been taken by the government to offer a higher price for groundnuts which was attractive enough to farmers.

Ndunguru: We seem to be reporting production and marketed figures in the region using conventional sources while we know very well that these do not actually reflect the realities.

Agronomy/Physiology

Importance of Rotation with Groundnut for Cereal Productivity

G. Schmidt[1] and E. Frey[2]

Abstract

In a rotation experiment conducted from 1981 to 1986, preceding groundnut crops led consistently to high maize yields. On the other hand, a maize/groundnut intercrop and maize and sorghum sole crops proved to be poor preceding crops for cereals.

Maize test-crops grown without N on all plots of the rotation experiment during 1987 and 1988 revealed strong favorable residual effects of preceding groundnut. However, an appreciable residual effect of maize/groundnut intercropping was noticed in 1987 only. Previous maize crops led to poor test crop yields. Sorghum cultivation before or during 1986 was detrimental to maize productivity in 1987 and 1988.

Sumário

Importancia da Rotação com Amendoim para a Produtividade do Cereal. *Num experimento sobre rotações, conduzido de 1982 a 1986, o amendoim, como cultura precedente, levou o milho a produzir rendimentos consistentemente maiores. Por outro lado, a consociação milho/amendoim e as culturas puras de milho e mapira, provaram ser pobres culturas precedentes para os cereais.*

Culturas-teste de milho, cultivadas sem N em todos os talhões do experimento de rotações, durante 1987 e 1988, revelaram haver fortes efeitos residuais favoráveis do amendoim precedente. Contudo, um efeito residual apreciável da consociação milho/amendoim, apenas foi notado em 1987. O milho, como cultura precedente levou a pobres rendimentos da cultura teste. O cultivo de mapira, antes ou durante 1986, foi prejudicial para a produtividade do milho em 1987 e 988.

Introduction

As cereals are the staple diet of subsistence farmers, they feel obliged to concentrate on cereal production when land availability and soil fertility are decreasing. In many countries, south of the Sahara and elsewhere, increasing population pressure on the land has thus led to extended cereal monoculture. Small-scale farmers usually cannot afford to counteract the negative effects of crop succession by adequate fertilizer application.

Replacement of the old fallow system with predominant cereal production including rotations with legumes and other noncereals in central Europe as

1. Team Leader and Principal Groundnut Agronomist, SADCC/ICRISAT Groundnut Project, Chitedze Agricultural Research Station, P.O. Box 1096, Lilongwe, Malawi.
2. Agronomist, Nyankpala Agricultural Experiment Station, P.O. Box 483, Tamale, Ghana.

ICRISAT Conference Paper no. CP 624.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

from the middle of the previous century has been considered one of the most important factors responsible for the tremendous increase in cereal productivity in that area.

During recent years, cropping-systems research has been carried out in various African countries including northern Nigeria (Lombin 1981) and Ghana. In the northern and upper regions of Ghana, crop-rotation, intercropping, and alley-cropping experiments have been conducted since 1981 to identify cropping systems that will ensure the maintenance of high productivity of permanently cultivated soils. In this paper, beneficial residual effects of groundnut *(Arachis hypogaea* L.) cultivation on the productivity of the subsequent crop of maize *(Zea mays* L.) in an experiment lasting from 1981 to 1988 will be discussed.

Materials and Methods

The experiment was conducted at Nyankpala in the Guinea Savanna zone (9°25'N and 1°W, 200 m above sea level). There is one rainy season from April to October with a peak from July to September and the annual rainfall is 1069 mm. The soil is sandy loam (chromic Luvisol) over a skeletal phase developed over sandstone. Carbon (0.5%) and nitrogen (0.04%) contents are low and the pH is 6.3.

In 1981, maize, groundnut, maize/groundnut intercropping, yam *(Dioscorea rotundata* L.), and sor-

Table 1. Influence of preceding crops on the grain yield of maize at Nyankpala, Tamale, Ghana, in five seasons, 1982-86.

Preceding crop in rotation with maize	Nitrogen applied to maize ($kg\ ha^{-1}$)	Maize grain yield ($t\ ha^{-1}$) 1982	1983	1984	1985	1986
Maize	0	1.04	0.38	1.19	1.72	2.35
	60	2.80	1.58	4.72	4.47	3.74
	Mean	1.92	0.98	2.96	3.10	3.04
Groundnut	0	2.83	1.66	3.02	3.62	3.35
	60	4.12	3.20	6.36	5.55	4.06
	Mean	3.48	2.43	4.69	4.58	3.70
Maize/groundnut intercropping	0	0.94	0.86	1.45	2.64	2.98
	60	2.69	2.08	4.27	4.53	3.83
	Mean	1.82	1.47	2.86	3.58	3.40
Yam	0	2.30	0.84	1.66	2.04	2.70
	60	4.18	2.78	5.73	5.62	3.86
	Mean	3.24	1.81	3.69	3.83	3.28
Sorghum	0	0.75	0.26	0.58	1.40	2.07
	60	2.03	1.21	3.45	3.80	3.12
	Mean	1.39	0.74	2.01	2.60	2.59
SE	a[1]	±0.208	±0.146	±0.233	±0.145	±0.086
	b[1]	±0.079	±0.052	±0.112	±0.054	±0.076
	b/a[1]	±0.177	±0.117	±0.251	±0.121	±0.170
	ab[1]	±0.243	±0.168	±0.293	±0.168	±0.148
Mean	0	1.57	0.80	1.58	2.28	2.69
	60	3.16	2.17	4.91	4.79	3.72
	Mean	2.37	1.49	3.24	3.54	3.20
CV (%)	a[1]	25	28	20	12	8
	b[1]	15	16	15	7	11

1. a = Preceding crops (main plots); b=N application (subplots) levels; b/a = b within each a (or N levels within preceding crop treatments); ab = Interaction.

ghum [*Sorghum bicolor* (L.) Moench] were sown in adjoining strips. Spacings were 80 cm x 25 cm for maize, 60 cm x 15 cm for groundnut, 120 cm x 120 cm for yam, and 80 cm x 30 cm for sorghum (tall local). Intercropped maize and groundnut were sown in alternating rows 60 cm apart and at the sole-crop intrarow spacings. In 1982, the same crops were grown in strips at right angles, across those of 1981, so that all possible crop successions were realized. The direction of plant rows was not altered. Plots reserved for crop successions were divided into subplots, with and without N application. Thirty kg N ha^{-1} was applied to groundnut and 60 kg N ha^{-1} to all other crops. There were four replications. Annual repetition of these treatments until 1986 allowed evaluations of alternating horizontal and vertical crop sequences and N fertilizer effects.

During the 1987 and 1988 cropping seasons, maize without N fertilizer application was sown as a test crop on all the plots. For evaluations, the 1986 crops were the main plots in a split-split plot, the 1985 crops (grown in rotation with 1986 crops since 1981) were the subplots, and previous N treatments were the sub-subplots. Border effects were eliminated.

Prior to each season, 26 kg P_2O_5 ha^{-1} was applied as superphosphate and from 1984, 50 kg K ha^{-1} as KCl. Cereal residues were removed, but those of groundnut and yam were left in the experimental fields. Grain yields were calculated on a 12% moisture basis.

Table 2. Influence of various crop successions and nitrogen fertilizer application during 1981-86 on the grain yield of a maize test crop at Nyankpala, Tamale, Ghana, 1987.

		1985 crop in rotation with 1986 crop since 1981					
		Grain yields of maize ($t\ ha^{-1}$)					
1986 crop	N application[1] 1981-86	Maize	Maize/ groundnut	Groundnut	Yam	Sorghum	Mean
Maize	Not applied	0.81	0.93	1.18	0.92	0.43	0.86
	Applied	1.43	1.40	1.52	1.21	0.98	1.31
	Mean	1.12	1.17	1.35	1.07	0.70	1.08
Maize/groundnut	Not applied	1.72	1.80	1.83	1.71	1.15	1.64
	Applied	2.12	2.16	2.13	1.90	1.78	2.02
	Mean	1.92	1.98	1.98	1.81	1.47	1.83
Groundnut	Not applied	2.62	2.69	3.10	2.64	1.10	2.43
	Applied	3.00	2.97	3.39	3.03	2.12	2.90
	Mean	2.81	2.83	3.24	2.84	1.61	2.66
Yam	Not applied	0.91	1.32	1.89	0.88	0.28	1.05
	Applied	1.94	2.11	2.18	1.88	1.22	1.86
	Mean	1.42	1.71	2.03	1.38	0.75	1.46
Sorghum	Not applied	0.51	0.80	1.11	0.68	0.38	0.70
	Applied	1.07	1.23	1.66	1.20	0.85	1.20
	Mean	0.79	1.02.	1.39	0.94	0.62	0.95
Mean	Not applied	1.32	1.51	1.82	1.37	0.67	1.34
	Applied	1.91	1.97	2.18	1.84	1.39	1.86
	Mean	1.61	1.74	2.00	1.60	1.03	1.60
SE	a[2]	±0.073	b/a[2]	±0.120	ab[2]	±0.130	
	b[2]	± 0.054	c/a[2]	±0.047	ac[2]	±0.080	
	C[2]	± 0.021	c/a[2]	±0.047	bc[2]	±0.063	
					abc	±0.150	

1. 30 kg N ha^{-1} to groundnut; 60 kg N ha^{-1} to all other crops, 1987 no N application.
2. a = 1986 crops (main plots); b = 1985 crops (subplots); c = N application (sub-subplots).

Results and Discussion

Grain yields of maize obtained after various preceding crops between 1982 and 1986 are presented in Table 1.

In all the test seasons, maize yielded most when it followed groundnut and less when it followed maize or sorghum. The differences in yield were greatest when no nitrogen was added. The actual magnitude of the differences (average of five test seasons) was as follows: compared to maize following maize, yields of maize following groundnut were 2.2 times greater without nitrogen and 1.3 times greater with nitrogen. Similarly, compared to maize following sorghum, yields of maize following groundnut were 2.9 times greater without nitrogen and 1.7 times greater with nitrogen.

Maize/groundnut intercropping as preceding crops for maize was at first hardly superior to sole maize but improved subsequently and finally ranked between cereals and groundnut.

In 1987, the first test season for residual effects, maize yields were highest on the plots that had groundnut monoculture. The yields from plots that had groundnut in rotation with other crops, including maize, were only slightly lower than the highest (Table 2). However, yields were lower in plots that had sorghum in rotation with groundnut.

Table 3. Influence of various crop successions and nitrogen fertilizer application during 1981-86 on the productivity of a second maize test crop at Nyankpala, Tamale, Ghana, 1988.

		1985 crop in rotation with 1986 crop since 1981					
		Grain yields of maize ($t\ ha^{-1}$)					
1986 crop	N application[1] 1981-86	Maize	Maize groundnut	Groundnut	Yam	Sorghum	Mean
Maize	Not applied	1.00	0.92	1.00	0.98	0.41	0.86
	Applied	1.06	0.97	1.24	1.11	0.82	1.04
	Mean	1.03	0.95	1.12	1.04	0.61	0.95
Maize/groundnut	Not applied	1.04	1.02	0.74	1.00	0.55	0.87
	Applied	1.07	1.13	1.26	1.16	1.04	1.13
	Mean	1.05	1.08	1.00	1.08	0.79	1.00
Groundnut	Not applied	1.28	1.46	2.73	1.88	0.93	!.65
	Applied	1.32	1.82	2.92	2.14	1.22	1.88
	Mean	1.30	1.64	2.82	2.01	1.08	1.77
Yam	Not applied	0.68	1.02	1.41	0.76	0.22	0.82
	Applied	1.18	1.30	2.05	0.98	0.39	1.18
	Mean	0.93	1.16	1.73	0.87	0.30	1.00
Sorghum	Not applied	0.68	0.83	0.94	0.48	0.33	0.65
	Applied	1.16	0.84	1.13	0.43	0.66	0.85
	Mean	0.92	0.84	1.04	0.45	0.50	0.75
Mean	Not applied	0.93	1.05	1.36	1.02	0.49	0.97
	Applied	1.16	1.22	1.72	1.17	0.83	1.22
	Mean	1.04	1.13	1.54	1.09	0.66	1.09
SE	a[2]	±0.121	b/a[2]	±0.203	ab[2]	±0.218	
	b[2]	±0.091	c/a[2]	±0.057	ac[2]	±0.127	
	c[2]	±0.025	c/b[2]	±0.057	bc[2]	±0.099	
					abc[2]	±0.236	

1. 30 kg N ha^{-1} to groundnut; 60 kg N ha^{-1} to all other crops, 1987 and 1988 no N application.
2. a = 1986 crops (main plots); b = 1985 crops (subplots); c = N application (sub-subplots).

Yields were generally low where maize followed maize or sorghum directly. For these preceding crops, previous rotation with groundnut was favorable, but monoculture of sorghum or maize-sorghum rotation was unfavorable. Preceding maize/groundnut intercropping led to test crop yields that were between sole groundnut and sole maize.

In the second test season (1988), groundnut monoculture until 1986 was again the most favorable treatment (Table 3). The second best was yam-groundnut rotation and third, a rotation of maize/groundnut intercropping and groundnut. Rotation of groundnut and sorghum before 1986 tended to lead to low maize yields in 1988. These results show that groundnut cultivation, particularly repeated groundnut cultivation or yam-groundnut rotation, may increase the maize yield up to 2 or 3 years later. In the cases of groundnut rotation with maize or maize/groundnut intercropping, the favorable effect decreases when maize follows on the same land for a second time.

Negative effects of cereal successions are explained by very low nitrogen contents in cereal residues leading to pronounced nitrogen deficiency during decomposition (Schmidt and Frey 1988). However, a lasting negative effect of tall local sorghum on maize, even when other crops, including groundnut, follow the sorghum, is remarkable. Burgos-Leon et al. (1980) explained negative effects of sorghum on subsequent crops by allelopathy.

According to experience in various experiments, crop-rotation effects are strongest on light soils, in particular on soils with a poor nitrogen status. Groundnut does not need nitrogen fertilizer. If phosphorus fertilizer is not applied directly, this crop should at least be able to take advantage of residual phosphorus applied to preceding cereals. Replacing monoculture of maize by a maize-groundnut rotation may lead to such an increase in maize productivity that the same quantity of maize may be produced on the reduced area.

References

Burgos-Leon, W., Ganry, F., Nicou, R., Chopart, J.L., and Dommergues, Y. 1980. A case of soils exhausted by sorghum crops. Agronomie Tropicale 35(4):319-334.

Lombin, L.G. 1981. Continuous cultivation and soil productivity in the semi-arid savannah: The influence of crop rotation. Agronomy Journal 73(2):357-363.

Schmidt, G., and Frey, E. 1988. Crop rotation effects in savannah soil at the Nyankpala Agricultural Experiment Station. Nyankpala Agricultural Research Report 4. D 6992 Weikersheim, Federal Republic of Germany: Margraf Scientific Publishers. 37 pp.

Discussion

Rweyemamu : You mentioned that groundnut does not need any nitrogen fertilizer according to the experience in various experiments. Is this because the crop fixes enough N? If so, how much N is fixed by the crop in that area?

Schmidt : Studies have shown that in good years/seasons the groundnut crop does fix up to 70 kg N ha^{-1} a^{-1}. However, in bad years the crop can fix as low as 0-12 kg N ha^{-1} a^{-1}.

Mayeux : At which period was N applied? According to your results, do you think an application of potassium to sorghum can be recommended to expect a reasonable yield? Do you leave stover in the field after harvest?

Schmidt : N was applied at sowing as side-dressing. No experiment has been done in the way you suggested but it is certainly true that potassium can help sorghum production. Stover is removed from the field because of the difficulty to protect the field experiment from being burnt.

Ismael : You mentioned that groundnut preceded by groundnut and the application of fertilizer resulted in lower yield. Do you attribute this to weed infection? Did you notice any difference in canopy development compared to higher-yielding treatments?

Schmidt : We noticed luxuriant growth of weeds and attributed the lower yield to competition.

Subrahmanyam: Did you analyze the partitioning coefficients in groundnut after groundnut and N-fertilized groundnut crops treatments?

Schmidt: Apparently there were no differences in vegetative growth and yield in these treatments.

Improving the Maize/Cowpea/Groundnut Intercropping System in Maputo Province, Mozambique

A.L. Doto[1], C. Honwana[2], and ML Spittel[3]

Abstract

*Since 1988, maize/cowpea/groundnut intercropping has emerged as the predominant agricultural production system in Benfica and Machava districts of southern Mozambique, Previous knowledge relating to groundnut (*Arachis hypogaea *L.) production constraints was confirmed by two surveys conducted in 1988 and 1989.*

Changes in cropping patterns were observed and suggestions made to reduce production constraints. Research priorities were formulated, based on the information gathered, and research initiated to address these priorities. These research activities and the need for more quantitative data to be collected are discussed.

Sumário

Melhorando o Sistema de Consociação Milho/Feijão Nhemba/Amendoim na Província de Maputo, Moçambique. *Desde 1988 que a consociação milho/feijão nhemba/amendoim emergiu como o sistema de produção agrícola predominante nos distritos de Benfica e Machava, no Sul de Moçambique. O conhecimento anterior, relacionado com as limitantes para a produção de amendoim (*Arachis hypogaea *L.), foi ampliado atravéz de dois inquéritos conduzidos em 1988 e 1989.*

Com base na informação recolhida, as prioridades da investigação foram formuladas e iniciada a experimentação para se atingirem essas prioridades. Estas actividades da investigação e a necessidade recolha de dados mais quantitativos são discutidas.

Introduction

The area around Maputo, especially Benfica and Machava districts, is considered a low-potential area in terms of crop production. However, the pressure to produce more agricultural output from the same piece of land has been mounting—fueled by rapid population increase. Traditionally, cassava (*Manihot esculenta* Crantz), maize *(Zea mays* L.), cowpea [*Vigna unguiculata* (L.) Walp.], groundnut *(Arachis hypogaea* L.), and sweet potato [*Ipomoea batatas* (L.) Lam.] have been considered as the principal food crops in the area (van Leeuwen 1987; Heemskerk et al. 1987).

With the exception of sweet potato, the crops mentioned above are generally grown in mixtures, where the four crops are grown together in one field under rainfed conditions. Returns from the land have in gen-

1. Tropical Crop Specialist, Faculty of Agronomy and Forestry Engineering, C.P. 257, Maputo, Mozambique.
2. Assistant Lecturer at the above address.
3. Farming Systems Specialist at the above address.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

eral been below expectations and the need to increase and stabilize agricultural production has, in recent years, received attention at various levels.

A Farming Systems Research (FSR) project based at the Faculty of Agronomy and Forest Engineering in Maputo became operational in 1987. The project aims to identify key factors that limit agricultural production in the target area and develop ways to overcome these limitations.

Within the framework of the FSR project, a socioeconomic survey (Lundin 1988) was conducted during January 1988 to provide detailed baseline information about the target area (green belts of Benfica and Machava districts). This was followed up later with observations and discussions with farmers from January to June 1989.

In this paper, an attempt is made to integrate information accumulated from the 1988 survey and from the 1989 observations to:

a) describe in brief the predominant cropping system in the target area, pointing out the changes that have taken place over a short period; and
b) draw attention to factors considered as important in limiting crop production, in particular groundnut, and to generate discussion about possible alternatives open to researchers in addressing the situation described in this paper.

Description of the Study Area

The study area covers areas near Maputo City, locally designated as districts 6 (Benfica) and 7 (Machava). Mean annual rainfall ranges from 800 mm to 1000 mm, and is poorly distributed from September to March (Table 1).

Soils in the area are classified into two major types: the sandy soils on the ridges, and the light sandy loams to heavy clay soils at the foot of the valley. The sandy soils, dominant in the study area, are extremely unproductive with little organic matter (90% sand, 0.6-1.1% organic matter, 0.04-0.7% N, and 10 ppm P) (Spittel et al. 1988).

Cropping Systems

The survey by Lundin (1988) indicated that five crops can be considered as the major crops of the study area. The four which are generally grown in mixtures are cassava, maize, groundnut, and cowpea. Two cropping patterns emerged from the study (Fig. 1).

Cassava is normally planted in July and August, followed by groundnuts and maize with the onset of the first rains. Cowpea is added to the mixture during weeding. Maize is harvested from January, followed by groundnut in February, thus making available more space for cowpea. Beginning February, cowpea (generally a photosensitive prostrate type), rapidly expands to cover the space vacated by maize and groundnut. Mature cowpea pods are harvested in April and May.

Sweet potatoes are planted (by about 56% of the households) on a limited scale near homesteads, either as border crops or under cashew or mafurra (*Trichilia emetica)* trees. The sweet potato is planted from August or September and the crop is ready for harvest from December to February.

The 1988 survey indicated that farmers consider maize as the basic food crop (grown by 100% of households) and cassava as a security crop. On the other hand, groundnut (grown by 93% of households) is considered an essential ingredient in daily diets

Table 1. Climatic parameters for Maputo, Mozambique, 1987[1]. (Period of crop growth Oct-Apr.)

	Month											
Parameter	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Temperature (°C)	19	20	22	23	24	25	26	26	25	24	21	19
Precipitation (mm)	18	18	36	57	78	87	140	137	87	68	28	27
Potential evaporation (mm)	63	86	110	132	141	159	157	134	126	97	74	57

1. Source: van Leeuwen (1987).

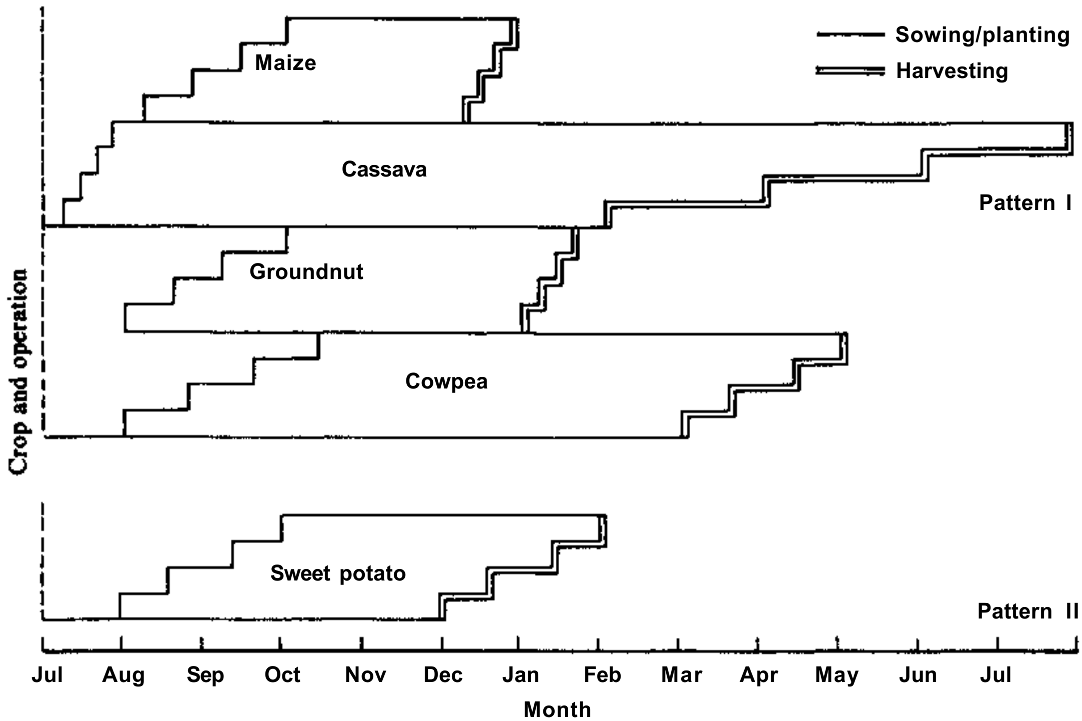


Figure 1. Predominant cropping patterns in Benfica and Machava districts, Mozambique, 1989. (Source: Lundin 1988.)

providing fats and protein. Cowpea (grown by 90% of households) leaves are highly valued as a source of protein and vitamins. In addition, cowpea is grown for its protein-rich pods and grain.

From 1989, we observed a significant reduction in cassava fields from 94% of the households indicated by the 1988 survey. The reduction in cassava is attributed to the threat posed by the cassava mealybug *(Phenococcus manihoti)* present around Maputo from 1987/88 (Spittel et al. 1988). If efforts to contain the mealybug problem do not produce positive results in the near future, there could be a complete disappearance of cassava from the cropping system. At the same time, the dominant maize/cowpea/groundnut intercropping pattern further threatens the survival of cassava.

This change could have far-reaching implications not only for the food security in the area, but also for the general cultural practices within the now three-component cropping pattern. One such immediate reaction, at least on part of planners, is to encourage the production of more sweet potato in the area.

Factors Limiting Production

As mentioned earlier, the agroclimatic conditions in the area pose limitations to increased crop production. Each of the components in the maize/cowpea/groundnut intercrop mixture invariably suffers from stress imposed by insufficient and erratic rainfall and nutrient deficiencies (van Leeuwen 1987; Spittel et al. 1988; Ramanaiah et al. 1989).

So far as groundnut is concerned, other factors also appear to play a significant role in limiting production. Among these, diseases and pests rank highly (Ramanaiah and Chilengue 1986; Ramanaiah et al. 1989). We confirmed, during our visits to the study area in 1989, that this situation had not changed.

We also confirmed that the majority of farmers sow groundnut during August and September, whereas studies on time of sowing suggest November to be the optimum. This aspect needs to be examined in relation to the overall cropping pattern. The farmer considers maize as the most important crop in the mixture. To avoid the losses because of stalk borer

(Chilo partellus) in November and December, the farmer prefers to sow maize before October. Groundnut, too, is sown at the same time. Much needs to be done at the system level to encourage changes in the time of sowing of groundnut/maize from August/September to around November.

The lack of seed reported in the Lundin (1988) survey, was clearly seen during the 1989 observations. Low groundnut plant densities in many fields were attributed to small seed stocks at the time of sowing. Many farmers also attributed the absence of groundnut in many maize/cowpea fields to the shortage of seed.

Research Priorities and Ongoing Research

Guided by the surveys, we have focused our research priorities on the following broad areas:

A. Research into ways of improving the soil in terms of water retention capacity and nutrient availability.
B. The formulation of appropriate practices to minimize losses because of diseases and insect pests.
C. Identification of suitable varieties and agronomic practices related to crop combinations in the three-crop system.

The work covers both on-station and on-farm research. Within the framework of these priorities, research activities in phases focus on the maize/cowpea/groundnut intercrop system as a unit and include the following:

A. Evaluation of different sources of organic matter for use in farmers' fields. Already there are indications as to which materials deserve further testing, first on-station, and finally on-farm.
B. Investigating the response of maize and groundnut to soil application of different levels of mafurra cake is under investigation. Mafurra cake has the effect of improving the soil organic matter content and increasing the yield of maize, but not that of groundnut. The lack of response of groundnut was attributed to increased shading effects of maize. Both maize and groundnut showed increased vegetative growth, which could have resulted in greater shading of groundnut by maize. Further trials are planned to evaluate wider spacing for maize and the effect of mafurra cake on sole groundnut.
C. Studies on relay-cropping systems involving *Leucaena* and pigeonpea as green manure crops with maize and groundnut as test crops. Problems related to establishment of *Leucaena* plants have been encountered.
D. Evaluation of the response of groundnut to P application in farmers' fields continues. Substantial yield increases have been achieved with P application, although the yield levels still remain low.
E. The strong association between maize and groundnut implies that changes in sowing time for maize would be necessary for the sowing of groundnut at the recommended time (November). Appropriate methods of maize stalk borer control would have to be found to make it attractive to sow maize in November. An on-farm trial to verify the efficacy of cypermethrin (mixed with sand) in controlling stalk borer is in progress.

Work is also in progress at the Faculty of Agronomy and Forest Engineering, Universidade Eduardo Mondlane, Maputo, to study in detail, each of the component crops in the maize/cowpea/groundnut intercropping system under the conditions prevailing in Maputo Province.

Conclusion

More quantitative data needs to be accumulated over many seasons before meaningful inferences can be drawn regarding each item of the research program.

References

Heemskerk, W., Simango J.R., and Leonardo, A. 1987. Resultados de investigacao de feijao nhemba. Nota Tecnica. Maputo Mozambique: Instituto Nacional de Investigacao Agronomica. (Limited distribution.)

Lundin, I.B. 1988. Relatorio final do inquerito socio economico e socio cultural realizado junto ao sector familiar nas zonas verdes da cidade de Maputo. Maputo, Mozambique: Mocambique Faculdade de Agronomia e Engenharia Florestal, Universidade Eduardo Mondlane.

Spittel, M., Chidiamassamba, A., Boff, M., Xavier, C., Hoogland, E., and Heberling, R. 1988. Relatorio sobre as actividades e resultados do Projecto de Pesquisa dos sistemas de Producao Agricola e Extensao nas zonas verdes de Maputo. Maputo, Mozambique: Univcrsidade Eduardo Mondlane/Gabinete das Zonas verdes de Maputo/Instituto Nacional de Investigacao Agronomica. (Limited distribution.)

Ramanaiah, K.V., and Chilengue, B.S. 1986. Annual report of the Groundnut Improvement Project 1985/1986. Maputo, Mozambique: Mocambique Faculdade de Agronomia c Engenharia Florestal, Universidade Eduardo Mondlane.

Ramanaiah, K.V., Freire, M.J., Chilengue, B.S., and Munguambe, A.V. 1989. Research on groundnuts in Mozambique. Pages 157-161 *in* Proceedings of the Third Regional Groundnut Workshop for Southern Africa, 13-18 Mar 1988, Lilongwe, Malawi, Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

van Leeuwen, J. 1987. Agricultura familiar numa parte da faixa costeira do Sul de Mocambique: Descricao e propostas para apoio e investigacao. Serie Agronomia N. 11. Maputo, Mozambique: Comunicacoes, Instituto Nacional de Investigacao Agronomica. (Limited distribution.)

Discussion

Omanga: I would like to know the crop arrangement you use in your three crop (maize/groundnul/cowpea) intercropping system.

Doto: This is a complex issue. In Maputo, we are handling two crops at a time, i.e., groundnut/maize and cowpea/groundnut.

Chigwe: In your observations on the stalk borer on maize, which species is more important? In Malawi, we have found that *Busseola fusca* is more important in the upland areas while *Chilo partellus* is more important at lower altitudes.

Doto: The most important species of stalk borer in the Maputo Province of Mozambique is *Chilo pattellus.*

Mamba: The effective cropping season begins in October and ends in April. However, cropping pattern-I shows that sowing of groundnut and maize begins in August to September. Is this not contrary to the effective cropping season?

Doto: Sowing depends on the onset of rains since rains could start in July or August or as late as November. Farmers, therefore, sow at any time if they consider that there is enough soil moisture.

Sibale: Please define what the source of mafurra cake is and the characteristics of the cake.

Doto: Mafurra is a tree. It produces a fruit that contains oil. Once the oil has been extracted, the cake is used to improve soil organic matter. The botanical name of the tree is *Trichilia emetica.*

Groundnut/Maize Intercrop: Effect of Spatial Arrangement on Yield and Its Components

W.P. Rwamugira[1] and R.D. Massawe[2]

Abstract

*The Pulses and Groundnut Project at the Sokoine University of Agriculture, Tanzania, has identified some high-yielding groundnut (*Arachis hypogaea *L.) lines in comparison to the locally released varieties. These high-yielding lines responded better to being grown in intercrop than the currently recommended varieties. Paired groundnut rows in the intercrop gave a higher yield advantage (because of greater light interception) than alternate single rows. The need for economic analysis of these spatial arrangements is highlighted.*

Sumário

Consociação Amendoim/Milho: Efeito dos Arranjos Espaciais no Rendimento e seus Componentes. *O Projecto de Amendoim e Leguminosas na Universidade de Agricultura de Sokoíne, Tanzania, identificou algumas linhas de amendoim (*Arachis hypogaea *L.) de alto rendimento, quando comparadas com as variedades libertadas localmente. Estas linhas de alto rendimento responderam melhor, ao serem cultivadas em consociação, do que as variedades actualmente recomendadas. Na consociação, linhas pareadas de amendoim produziram maiores rendimentos (devido a uma maior intercepção de luz) do que linhas simples alternas. A necessidade de uma análise económica destes arranjos espaciais é realçada.*

Introduction

Intercropping is defined as growing two or more crops simultaneously on the same piece of land (Andrews and Kassam 1976). It is a common feature of traditional agriculture in Tanzania.

Groundnut *(Arachis hypogaea* L.) is generally intercropped with cereals like sorghum [*Sorghum bicolor* (L.) Moench], maize *(Zea mays* L.), and bulrush millet (*Pennisetum typhoides)* but groundnut is of secondary importance in such a mixture (Mwenda et al. 1985). The major goals and advantages of such a cropping system have been well documented by several authors including Francis 1978, Willey 1979, and Gomez and Gomez 1983. The choice of types of crops to be grown as intercrops is dependent on physical factors (soil, temperature, and water regime), social factors (personal tastes and traditions), and economic factors (market prices and transport).

The Pulses and Groundnut Project at Sokoine University of Agriculture (SUA) has identified several high-yielding lines of groundnut but their agronomic behavior has to be further evaluated. Therefore, an experiment was conducted with the following objectives:

A. To evaluate the performance of promising lines in intercropping systems.

1. Agronomist, Pulses and Groundnut Project, Department of Crop Science and Production, Sokoine University of Agriculture, P.O. Box 3005, Chuo Kikuu, Morogoro, Tanzania.
2. Agronomist, Cooperative and Rural Development Bank, Dodoma, Tanzania.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru. A.P. 502 324, India: ICRISAT.

B. To determine the yield components that could be affected by such a cropping system.
C. To establish the best spatial arrangement.

Materials and Methods

A field experiment was conducted at Sokoine University Farm (525 m above sea level) during the 1989 long rainy season (Mar-Jul). A split-plot design with three replications was used. Four groundnut genotypes, i.e., MGC 163 (1/24), MGC 191 (2/91), MGC 92 (1/80), and Natal Common (the local control variety), were the main plot treatments while different cropping patterns were assigned to the subplots as shown below:

		Spacing (cm)		Plant population (plants ha^{-1})	
Treatment	Cropping pattern	Groundnut	Maize	Groundnut	Maize
Groundnut	Sole	50 x 10	-	200 000	-
Maize (*staha)*	Sole	-	60 x 25	-	66 000
Groundnut/maize intercrop	Single alternate rows of each crop (1:1)	50 x 10	50 x 50	200 000	40 000
Groundnut/maize intercrop	Single rows of maize alternating with paired groundnut rows (1:2)	50 x 10	100 x 25	200 000	40 000

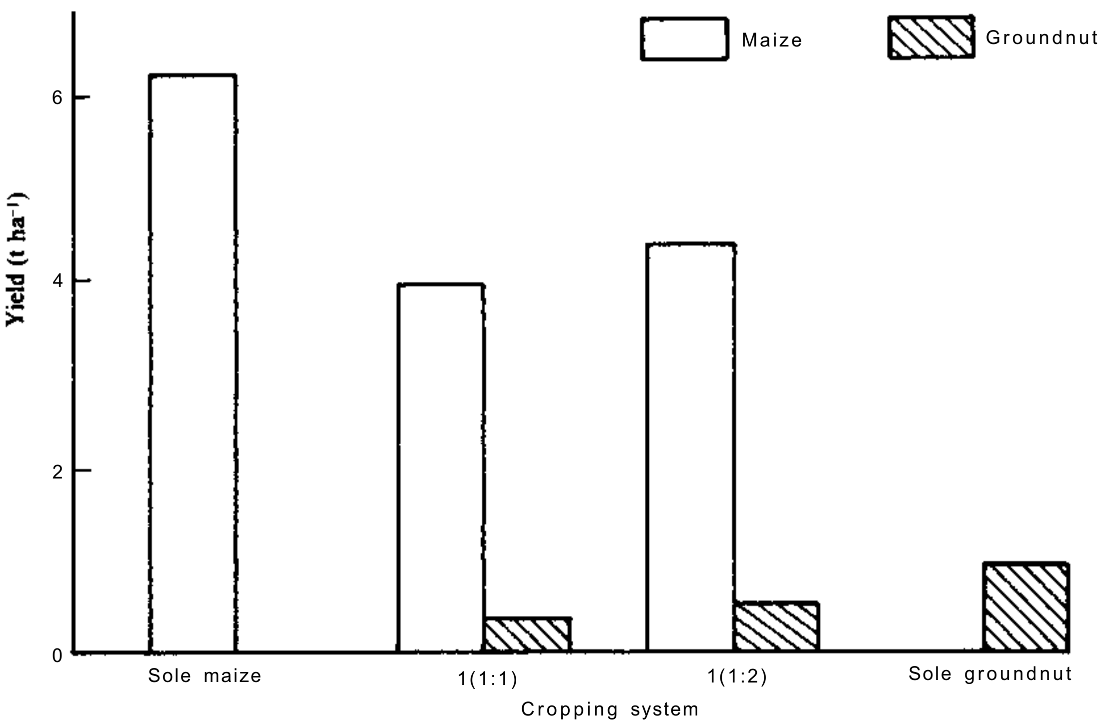


Figure 1. Mean groundnut and maize yields in sole and intercropping systems, Sokoine University Farm, Tanzania, 1989.

Results and Discussion

Generally, yields of component crops were reduced in the intercropping system. For maize, the mean sole crop yield was 6.28 t ha^{-1} compared with 4.225 t ha^{-1} in the intercropping system (Fig. 1). Yield reduction could be attributed to the reduced plant population in the intercropped plots (40 000 plants ha^{-1}). Yield components of maize such as cobs $plant^{-1}$ and 100-seed mass were not affected by the cropping system. These results suggest that maize was either not stressed by the presence of a companion crop or that it was able to recover after the crop was harvested.

In the case of groundnut there were no significant yield differences ($P<0.05$) among varieties (1/24, 2/91, 1/80, and Natal Common). However, yields of Natal Common were reduced by intercropping with maize. The yield reduction amounted to 59% in single alternate rows and 43% in paired alternate rows as compared to the sole crop. Intercropped groundnut grew taller than sole crop plants. The lower yields obtained in the single alternate rows may be explained by increased competition for both light and soil resources compared to the paired alternate rows.

The number of pegs $plant^{-1}$ and pods $plant^{-1}$ in intercropped plots was adversely affected by intercropping (Table 1). This could be because of the shading effect on groundnut during the latter part of the pegging and podding periods. Pegs formed earlier might have gained priority for pod formation and distribution of photosynthates.

When maize was intercropped, the highest yield advantage of 49% was achieved with line 1/24 and the least (32%) with Natal Common (Table 1). These results suggest that the identified promising lines could perform better in this cropping system than the local control variety. Between the two spatial arrangments used, a yield advantage of 29% was achieved by paired alternate groundnut rows compared to 5% in single alternate rows. It can be assumed that in the paired row arrangement, more light was available to groundnut, thus favoring photosynthesis. These re-

Table 1. Agronomic characteristics of four groundnut genotypes intercropped with maize under two spatial arrangements, Sokoine University Farm, Tanzania, 1989.

	Pegs $plant^{-1}$	Pods $plant^{-1}$	Seeds pod[1]	100-seed mass (g)	Seed yield (g m^{-2})	Seed yield (kg ha^{-1})	Shelling (%)	Land equivalent ratio
Treatment/genotypes								
2/91/Maize	22.77a[1]	16.11a	2.00a	33.35a	68.37a	683.70a	59.34ab	1.48
1/24/Maize	19.55a	15.33a	1.97a	33.16a	68.33a	683.30a	60.25a	1.49
1/80/Maize	21.55a	15.77a	1.93a	26.29b	66.78a	667.80a	54.52c	1.47
Natal Common/Maize	25.22a	12.88a	1.97a	24.83b	50.41b	504.10a	56.13ab	1.32
SE	±2.22	±1.26	±0.03	±0.52	±4.57	±45.71	±1.05	
Mean	22.27	15.02	1.96	29.40	63.47	634.70	57.56	
CV(%)	21.20	17.81	4.20	3.76	15.28	15.27	3.88	
Cropping pattern								
Single alternate rows (1:1)	20.08b	11.25b	1.95a	28.74a	29.21a	392.10c	57.33a	1.046
Paired groundnut: single maize row (2:1)	19.16b	15.25ab	2.00a	28.70a	54.85b	548.50b	57.76a	1.289
Groundnut (sole crop)	27.58a	18.58a	1.96a	30.78a	96.33a	963.30a	57.37a	
SE	±1.32	±1.40	±0.03	±0.93	±4.66	±46.65	±0.66	
Mean	22.27	15.02	1.30	29.40	63.47	634.70	57.56	
CV(%)	28.41	22.86	3.70	7.82	5.81	18.00	2.83	

1. Means within columns followed by the same letter do not differ significantly at 5% level at probability ($P<0.05$), as determined by Duncan's Multiple Range Test.

suits are similar to those reported by Natarajan (in press) that cereal yields could be maintained over a wide range of spatial arrangments notwithstanding an appreciable increase in legume yield.

In all the intercropping combinations, the land-equivalent ratios (LER) were greater than one indicating that it was more advantageous to grow the two crops as intercrops than growing them as sole crops. However, before any recommendation is made, we intend to conduct an economic analysis to find out the most economical cropping pattern.

Conclusions

In intercropping systems, the groundnut genotypes identified by the project could perform better than the control variety. Paired rows of groundnut alternating with a single row of maize led to a higher intercropping advantage or LER than single rows of groundnut. However, these results should be verified on farmers' fields and economic analysis should be done.

References

Andrews, D.J., and Kassam, A.H. 1976. The importance of multiple cropping in increasing world food supplies. Pages 1-10 *in* Multiple Cropping; Proceedings of a symposium. (Papendick, R.I., Sanchez, P.A., and Triplett, G.B., eds.). 677 South Segoe Road, Madison, WI 53711, USA: American Society of Agronomy/Crop Science Society of America/ Soil Science Society of America.

Francis, C.A. 1978. Multiple cropping potentials of beans and maize. HortScience 13:12-17.

Gomez, A.A., and Gomez, K.A. 1983. Multiple cropping in the humid tropics of Asia. Ottawa, Canada: International Development Research Centre. 248 pp.

Mwenda, F.F., Doto, A.L., Taylor, B.R., and Simons, J.H. 1985. Groundnut production, farming methods, and research in Tanzania. Pages 89-92 *in* Proceedings of the Regional Groundnut Workshop for Southern Africa, 26-29 Mar 1984, Lilongwe, Malawi. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Natarajan, M. (In press). Spatial arrangement of the component crops in developing intercropping systems: Some concepts and methodologies. Presented at the Workshop on Research Methods for Cereal/Legume Intercropping in Eastern and Southern Africa, 22-27 Jan 1989, Lilongwe, Malawi. P.O. Box MP 163, Mount Pleasant, Zimbabwe: Regional Program, Centro International de Mejoramiento de Maiz y Trigo (CIMMYT).

Willey, R.W. 1979. Intercropping: Its importance and research needs. Part I. Competition and yield advantages. Field Crop Abstracts 32:1-10.

Discussion

Sibale: Would you please consider studying other spatial arrangements which may not result in the reduction of the major crop because maize/groundnut intercrop yields are lower than in pure stands?

Rwamugira: This will be considered in future experiments.

Busolo-Bulafu: In your conclusion, you suggest that the identified groundnut lines could perform better in the intercropping system than the controls. Have you compared the control variety with the identified lines to see whether the control does better in pure stand so that we can attribute the better performance of the new lines to intercropping?

Rwamugira: Other colleagues have talked on different agronomic aspects and I was talking about intercropping, so that basically we come up with an agronomic package. But it is true that Natal Common gave the lowest yield though not statistically significant.

Omanga: Can you elaborate on the spacing used for the maize and groundnut rows?

Rwamugira: Row spacing between maize and groundnut is 25 cm and between two groundnut rows is 50 cm.

Freire: Which is the main crop? From your treatments it appears to be groundnut and not maize.

Rwamugira: For farmers, maize is reported to be the main crop. In our experiment, we took groundnut as the main crop.

Freire: Is there any market-oriented behavior on part of the farmers? If so, an economic evaluation is important, specially if the prices benefit one particular crop.

Rwamugira: Yes, there is such a behavior (groundnut fetching higher price than maize) and that is why we need to do an economic analysis to find out which crop should be produced in larger quantities.

Freire: Groundnut yields in intercropping amount to 41% (1:1) and 57% (1:2) of sole crop yield. Don't you think it would be better to reduce the groundnut population?

Rwamugira: That is an important suggestion and the point has been noted; but yield could still be improved by changing the spatial arrangement.

Mayeux: What were the fertilizer doses?

Rwamugira: 20 kg N ha^{-1}; 50 kg P_2O_5 ha^{-1} as triple superphosphate.

Evaluation of the Effect of Minjingu Rock Phosphate (MRP) on Groundnut Yield and Quality

C.L. Rweyemamu[1] and M.K. Nyanda[2]

Abstract

*A field experiment was conducted at the Sokoine University of Agriculture, Tanzania, to evaluate the effect of Minjingu Rock Phosphate (MRP) on yield and quality of groundnut (*Arachis hypogaea *L.) during the 1989 cropping season. The results indicate that the application of MRP at 75 kg P_2O_5 ha^{-1} had similar effects on yields and oil contents of three groundnut genotypes studied at the application of 50 kg P_2O_5 ha^{-1} in the form of triple superphosphate (TSP). The results indicate that the effect of 75 kg P_2O_5, applied as TSP, on yields and oil contents of the three groundnut genotypes studied did not differ appreciably.*

Sumário

Avaliação do Efeito do Fosfato de Rocha de Minjingu (MRP) no Rendimento e Qualidade do Amendoim. *Um ensaio de campo foi conduzido na Universidade de Agricultura de Sokoine, Tanzania, para avaliar o efeito do fosfato de rocha de Minjingu (MRP) no rendimento e qualidade do amendoim (*Arachis hypogaea *L.), durante a estação de cultivo de 1989. Os resultados indicam que, no respeitante ao rendimento e conteúdo de óleo dos três genótipos de amendoim estudados, a aplicação de MRP, perfazendo 75 kg ha^{-1} P_2O_5, teve efeitos similares à aplicação de 50 kg ha^{-1} P_2O_5, sob a forma de Superfosfato Triplo (TSP). Os resultados indicam que o efeito da aplicação de 75 kg ha^{-1} de P_2O_5, aplicado como TSP, no rendimento e conteúdo de óleo dos três genótipos estudados, não diferiu apreciávelmente.*

Introduction

In Tanzania, groundnut (*Arachis hypogaea* L.) is grown mainly by small-scale farmers (Mwenda et al. 1985; Doto and Mwenda 1987). Constraints to increased production include: shortage of improved seed, handhoe cultivation, and poor agronomic practices (Doto and Mwenda 1987). The crop is generally grown in Tanzania without fertilizer (Mwenda et al. 1985), although groundnut is known to require relatively large amounts of essential minerals (Chapman and Carter 1976). Phosphorus deficiency symptoms have been observed in many groundnut-growing areas. At present triple superphosphate (TSP) is the main source of phosphorus to crops in Tanzania. However, the fertilizer is expensive because its manufacture requires imported ingredients. It tends to be out of the reach of most small-scale farmers who

1. Lecturer (Agronomy), Department of Crop Science and Production, Sokoine University of Agriculture, P.O. Box 3005, Chuo Kikuu, Morogoro, Tanzania.
2. B.Sc. (Agriculture) Crop Science Option student, 1989 batch, at the above address.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

constitute most of the farming population (Mkeni et al. 1986). Also, when soluble P is applied to the soil it is often "fixed" or rendered unavailable under field conditions (Tisdale and Werner 1975).

Rock phosphates have in recent years received renewed attention as a source of P for plants especially in developing countries. In Tanzania, rock phosphates are known to exist at Minjingu near Lake Manyara (Mkeni et al. 1986). Other deposits have been identified at Songwe, Chamoto, Shengeri, and Panda hills, all located in the Mbeya region. Despite the existence of these deposits, rock phosphates are not currently used for direct application in Tanzania except by few farmers in West Kilimanjaro and Karatu (J.M.R. Semoka, Department of Soil Science, Sokoine University of Agriculture, 1990, personal communication). At present the Tanzanian government is encouraging the use of rock phosphates to reduce costs and increase P fertilizer availability to small farmers (Mkeni et al. 1986).

The objective of this study was to evaluate the effect of Minjingu Rock Phosphate (MRP) on groundnut seed yield, oil content, and oil production under Morogoro conditions.

Materials and Methods

The experiment was conducted at Sokoine University of Agriculture in Morogoro, Tanzania, during the 1989 cropping season (Feb-Jul). The altitude of the area is about 525 m, the latitude is 6°5'S, and the longitudes extends from 37° to 39° E. The soil type was Oxisol with a sandy clay-loam texture. The soil characteristics are shown in Table 1.

A completely randomized-block design with four replications was used. There were three groundnut lines and four P treatments. The groundnut lines entered were Bebiano Encarnado (MGC 242), Spanhoma (MGC 180/213), and 1/69 (MGC 105), and phosphorus treatments were no phosphorus, 50 kg P_2O_5 ha^{-1} as TSP, 50 kg P_2O_5 ha^{-1} as MRP, and 75 kg P_2O_5 ha^{-1} as MRP. The MRP had 30.1% P_2O_5 according to Mkeni et al. (1986). Both TSP and MRP were applied just before sowing, in rows, 5 cm away from the seed. The fertilizer was covered with soil to prevent it from being blown away by wind because of the fineness of MRP. Seed was sown 10-cm apart in 50-cm rows in plots of 4 m x 3 m. No *Rhizobiwn* inoculant was applied to the seed. The experiment was sown on 30 Mar 1989. The crop was grown under rainfed conditions. All plots received 20 kg N ha^{-1} as ammonium sulfate.

The experiment was kept weedfree throughout the growing season. No major insect and disease control measures were applied. However, bird scaring was necessary, especially at emergence and from pod formation to maturity.

The oil content was determined according to the Pomeranz and Meloan (1971, p. 316) Soxhlet extraction method and oil production (kg ha^{-1}) was calculated. Means were compared using Duncan's Multiple Range Test (Gomez and Gomez 1984).

Table 1. Some soil characteristics at the experimental site at sowing, Sokoine University of Agriculture, Morogoro, Tanzania, 1989[1].

Characteristic	Method of determination	Result	Remarks[2]
Soil pH	pH meter	5.8	Moderately acidic
Soil texture	Hydrometer		
Sand (%)		49	Sandy clay loam
Silt (%)		16	
Clay (%)		35	
Organic carbon (%)	Walkey-Black	1.73	Medium
Total nitrogen (%)	Micro-Kjeldahl	0.17	Medium
Available phosphorus (ppm)	Bray and Kurtz No. 1	6.2	Low
Exchangeable calcium [meq (100 g)$^{-1}$]	Ammonium acetate saturation	1.3	Low
Exchangeable potassium [meq (100 g)$^{-1}$]	Ammonium acetate saturation	0.54	Medium

1. Soils sampled at 0-15 cm depth.
2. According to MARI 1989.

Results and Discussion

Soil analyses indicated medium organic C and total N contents (Table 1). Available P was low and exchangeable K was medium while exchangeable Ca was also low according to classification of MARI (1989). The soil was moderately acidic with sandy clay-loam texture. The highest temperatures were experienced in March, while the highest rainfall was in April.

Common diseases were early leaf spot (*Cercospora arachidicola* Hori) and late leaf spot [*Phaeoisariopsis personata* (Berk. & Curt.) v. Arx.]. A few plants in all groundnut lines were infected by groundnut rosette virus while web blotch *(Phoma arachidicola),* which appeared only late during the season, was restricted to Spanhoma only. Termites (*Microtermes* spp) were serious pests. Common weeds were nutgrass *(Cyperus* spp), black jack (*Bidens pilosa),* and wandering jew (*Commelina bengalensis).* Frequent handhoeing and hand pulling of weeds proved effective.

Statistical analysis revealed no significant interaction between lines and amounts and sources of P. There were highly significant plant height differences among the three groundnut lines: Bebiano Encarnado was the tallest, followed by 1/69 and Spanhoma. Plant densities at harvest ranged from 53.5 to 65.5 plants m^{-2}. The expected plant density (20 plants m^{-2}) decreased by 25-30% mainly owing to termite damage. Spanhoma (MGC 180/213) with applied phosphorus had the lowest average number of nodules $plant^{-1}$ (92.9) while 1/69 (MGC 105) at 75 kg P_2O_5 ha^{-1} as MRP had the highest (132.5). The number of nodules appeared to increase by the application of phosphorus as MRP or TSP. However, it is known that many rhizobia belonging to the cowpea miscellany symbiose with groundnut but the nitrogen (N_2) fixation is then often inadequte.

There was no consistency in groundnut line effect on either the number of pegs $plant^{-1}$ or pods $plant^{-1}$. However, both variables were increased significantly by the application of P either as MRP or as TSP (Table 2). Line effects were highly significant on 100-sced mass (g). Line 1/69 (MGC 105) had the largest seeds with an average 100-seed mass of 31.3 g.

Application of phosphorus had a significant effect on yield as shown in Table 3. Seed yield was in-

Table 2. Effect of phosphorus sources and levels on yield components of groundnut, Sokolne University of Agriculture, Morogoro, Tanzania, 1989.

Genotype	Phosphorus level and source (kg P_2O_5 ha^{-1})	No.of pegs $plant^{-1}$	No. of pods $plant^{-1}$	No. of seeds pod^{-1}	100-seed mass (g)
Bebiano Encarnado	0	33.0 d[1]	22.8 c	1.7 a	23.8 b
(MGC 242)	50 TSP	41.5 abc	27.0 ab	1.6 a	25.7 b
	50 MRP	41.3 abc	25.4 abc	1.7 a	25.7 b
	75 MRP	41.7 abc	27.1 ab	1.8 a	23.4 b
Spanhoma	0	35.6 cd	24.4 bc	1.7 a	26.6 b
(MGC 180/213)	50 TSP	42.4 ab	28.5 a	1.7 a	25.8 b
	50 MRP	38.2 abc	26.3 abc	1.8 a	25.2 b
	75 MRP	38.6 abc	27.1 ab	1.8 a	26.9 b
1/69	0	35.6 cd	25.3 abc	1.9 a	31.4 a
(MGC 105)	50 TSP	40.5 abc	28.1 a	1.8 a	32.4 a
	50 MRP	36.4 bcd	25.0 abc	1.7 a	30.4 a
	75 MRP	43.9 a	27.1 ab	1.8 a	31.1 a
SE		±1.8	±1.1	±0.1	±1.1
Mean		39.1	26.2	1.7	27.4
CV (%)		9.4	8.3	9.2	8.3

1. Means in the same column followed by the same letter do not differ significantly at 5%. according to Duncan's Multiple Range Test.

Table 3. Effect of phosphorus levels/sources on groundnut seed yield, shelling percentage, oil content, and oil production, Sokoine University of Agriculture, Morogoro, Tanzania, 1989.

Genotype	Phosphorus level/source (kg P_2O_5 ha^{-1})	Seed yield (t ha^{-1})	Shelling (%)	Oil content (%)	Oil production (kg ha^{-1})
Bebiano Encarnado	0	0.638 c[1]	70.0 a	42.2 b	269.3 d-f
(MGC 242)	50 (TSP)	0.743 bc	59.5 d	44.7 a	332.2 de
	50 (MRP)	0.758 bc	66.7 ab	44.4 a	336.6 de
	75 (MRP)	0.786 bc	66.0 ab	43.4 ab	340.9 d
Spanhoma	0	0.749 bc	67.1 ab	40.5 c	303.5 d
(MGC 180/213)	50 (TSP)	1.068 a	63.0 bc	43.9 ab	468.8 a
	50 (MRP)	0.873 b	69.1 a	43.1 ab	376.4 cd
	75 (MRP)	0.912 ab	61.1 c	44.0 a	401.5 abc
1/69	0	0.960 ab	70.4 a	40.3 c	386.0 c
(MGC 105)	50 (TSP)	1.139 a	66.9 ab	42.0 b	478.5 a
	50 (MRP)	0.948 ab	65.5 b	43.5 ab	412.2 ab
	75 (MRP)	1.099 a	69.9 a	41.9 bc	460.6 a
SE		±0.153	±3.38	±1.3	±65.9
Mean		0.890	66.3	42.8	380.6
CV(%)		17.2	5.1	3.2	17.3

1. Means in the same column followed by the same letter are not significantly different at 5% according to Duncan's Multiple Range Test.

creased by the application of P either as MRP or as TSP. In the case of line 1/69 (MGC 105), application of 50 kg P_2O_5 ha^{-1} (TSP) led to highest seed yield followed by 75 kg P_2O_5 ha^{-1} as MRP. Genotype Spanhoma (MGC 180/123) gave a high yield of 1.0678 t ha^{-1} when P was applied at 50 kg P_2O_5 ha^{-1} as TSP. These results show that the application of phosphorus at the rate of 50 kg P_2O_5 ha^{-1} (TSP) did not always result in significantly increased seed yields, oil contents, and oil production compared to the MRP rates applied in the experiment. These results are in accordance with those reported by Rweyemamu (in press) working with common beans *(Phaseolus vulgaris* L.) and of I. Abdulwakil (Sokoine University of Agriculture, Tanzania, 1989, personal communication), who worked with cowpeas *(Vigna unguiculata* L.) at Morogoro, Tanzania.

Conclusions

Phosphorus application increased seed yield, oil content, and oil production. Both TSP and MRP were effective. The application of 50 kg P_2O_5 ha^{-1} as TSP gave similar results as the application of 75 kg P_2O_5 ha^{-1} as MRP. These results indicate that a replacement of TSP by MRP is justified in areas with acidic soils, low available P, and low exchangeable calcium as at Morogoro. There is a need to test the efficiency of MRP in various locations of Tanzania where groundnut is grown. Acid soils are found in several areas of the country (Urio and Kasseba 1973).

References

Chapman, S.R., and Carter, L.P. 1976. Crop production: principles and practices. San Francisco, USA: W.H. Freeman and Company. 566 pp.

Doto, A.L., and Mwenda, F.F. 1987. Groundnut production: present and future research thrust in Tanzania. Pages 77-80 *in* Proceedings of the Second Regional Groundnut Workshop for Southern Africa, 10-14 Feb 1989, Harare, Zimbabwe. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Gomez, K.A., and Gomez, A.A. 1984. Statistical procedures for agricultural research. 2nd edn. New York, USA: John Wiley.

MARI (Mlingano Agricultural Research Institute). 1989. National Soil Service (NSS) classification for general soil fertility evaluation. Tanga, Tanzania: MARI.

Mkeni, P.N., Semoka, J.M., and Bugaga, J.B. 1986. Evaluation of agronomic effectiveness of Minjingu Phosphate Rock as a source of phosphorous for maize (*Zea mays* L.) in four soils of Morogoro District, Tanzania. Pages 180-194 *in* Proceedings of the 8th Annual General Meeting of Soil Science Society of East Africa, 15-19 Dec 1989, Kampala, Uganda. Kawanda Research Station, Kampala, Uganda: US-AID/MFAD Project.

Mwenda, F.F., Doto, A.L., Taylor, B.R., and Simons, J.H. 1985. Groundnut production, farming methods, and research in Tanzania. Pages 89-92 *in* Proceedings of the Regional Groundnut Workshop for Southern Africa, 26-29 Mar 1984, Lilongwe, Malawi. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Pomeranz, Y., and Meloan, C.E. 1971. Food analysis: theory and practice. Westport, CT, USA: AVI Publishing Company.

Rweyemamu, C.L. (In press). Response of common bean (*Phaseolus vulgaris* L.) to Minjingu rock phosphate at SUA. Paper presented at the 8th Bean Workshop held at SUA, 27-29 Sep 1989. Sokoine, Tanzania: Sokoine University of Agriculture.

Tisdale, S.L., and Werner, W.L. 1975. Soil fertility and fertilizers. 3rd edn. New York, USA: Macmillan. 694 pp.

Urio, A.P., and Kasseba, A. 1973. Phosphate fraction in some Tanzanian soils. Geoderma 10:181-192.

Discussion

Shongwe: In view of the differences in the chemical composition of the phosphorus sources, can the differences in the treatments be attributed solely to P?

Rweyemamu: I recognize that there were other elements added to the soil where MRP was added, but I believe that the differences in the parameters measured are indeed due solely to P levels.

Syamasonta: Can the Minjingu Rock Phosphate be made available to farmers easily?

Rweyemamu: It can be made available to farmers very easily, but the type of phosphate depends on where the farmer is located, i.e., south, north, etc.

Subrahmanyam: What are the economic returns of rock phosphate application?

Rweyemamu: Economic analysis was not carried out.

Response of Four Groundnut Genotypes to Three Seedbed Types at Morogoro, Tanzania

C.L. Rweyemamu[1] and F.B. Boma[2]

Abstract

*During the 1988 cropping season four groundnut (*Arachis hypogaea* L.) genotypes—Ex-Njombe (MGC 74), 1/69 (MGC 105), Bebiano Encarnado (MGC 242), and Spanhoma (MGC 180)—were cultivated on three seedbed types: flat, ridges, and furrows. In an identical experiment during the 1989 cropping season, line 1/69 (MGC 105) was replaced by genotype New Mexico Valencia A (MGC 25).*

During the 1988 cropping season, with periods of moisture stress, furrows appeared to be advantageous as compared to ridges. Flat seedbed resulted in intermediate seed yields, not significantly different from those obtained with either of the other seedbed types. Oil production was highest with furrow cultivation. Spanhoma was the variety with the highest seed yield, followed by Bebiano Encarnado.

In the 1989 cropping season, with higher rainfall than 1988, flat seedbed resulted in significantly higher seed yields than ridges and ridges in higher yields than furrows. Spanhoma proved again to be the most productive variety, followed by Bebiano Encarnado and Ex-Njombe.

Sumário

Resposta de Quatro Genótipos de Amendoim a Três Tipos de Camas de Sementeira em Morogoro, Tanzania. *Durante a estação de cultivo de 1988, quatro genótipos de amendoim (*Arachis hypogaea* L.) - Ex-Njombe (MGC 74), 1/69 (MGC 105), Bebiano Encarnado (MGC 242) e Spanhoma (MGC 180) - foram cultivados em três tipos de camas de sementeira: plana, no camalhão e no sulco. Num ensaio identico, durante a estação de cultivo de 1989, a linha 1/69 (MGC 105) foi substituida pelo genótipo Novo México Valência A (MGC 25).*

Durante a estação de cultivo de 1988, com periodos de "stress" hidrico, a sementeira nos sulcos mostrou-se vantajosa, quando comparada com os camalhões. A sementeira em cama plana resultou em rendimentos de grão intermédios, não significativamente diferentes de qualquer dos outros tipos de camas de sementeira. A produção de óleo foi máxima na cultura em sulcos. Spanhoma foi a variedade com o rendimento de grão mais alto, seguida pelo Bebiano Encarnado.

Na estação de cultivo de 1989, com maior precipitação que em 1988, a sementeira em cama plana produziu maiores rendimentos de grão que em camalhões e estes mais que em sulcos. Spanhoma provou novamente ser a variedade mais produtiva, seguida por Bebiano Encarnado e Ex-Njombe.

1. Lecturer (Agronomy), Department of Crop Science and Production, Sokoine University of Agriculture, P.O. Box 3005, Chuo Kikuu, Morogoro, Tanzania.
2. B.Sc. (Agriculture) Crop Science Option student, 1988 batch, at the above address.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa. 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

Introduction

Several local groundnut (*Arachis hypogaea* L.) cultivars are grown in Tanzania. These may have become contaminated since they were first identified as cultivars. The crop is grown under rainfed conditions and sown on the flat seedbeds or on ridges (Mwenda et al. 1985). Sometimes groundnut is also grown in furrows especially when it is intercropped with maize, sorghum, millets, etc. Seedbed types may influence soil moisture conservation, root and peg penetration and hence, also pod formation. This study was initiated to evaluate the performance, under Morogoro conditions, of groundnut lines when grown on different seedbed types.

Materials and Methods

The experiment was conducted during the 1988 and 1989 (Feb-Jul) cropping seasons on dryland at the Sokoine University of Agriculture (SUA). SUA is located at Morogoro (6°S, 37°E, altitude 525 m) leeward in the foothills of Uluguru mountains. The SUA farm is in a typical rainshadow area. The average rainfall is about 800 mm and the soil an Oxisol, which is a kaolinitic sandy clay loam with a pH of 6.0. The predominant cation is K ; Ca and P contents are low. At the time of measurement, the available moisture was 15% while the bulk density of the top 15 cm was 1.2 g cm^{-3}. The design used was a split-plot with four replications. Seedbed types occupied main plots and groundnut lines occupied subplots. Subplots were 3.6 m x 2.0 m from which an area of 3.6 m^2 was harvested. Seedbed types were flat, ridge, and furrow. In 1988, the groundnut genotypes were Ex-Njombe (MGC 74), 1/69 (MGC 105), Bebiano Encarnado (MGC 242), and Spanhoma (MGC 180). The same groundnut genotypes were also used during the 1989 cropping season, except that 1/69 (MGC 105) was replaced by New Mexico Valencia A (MGC 25). All were bunch types. The experiments were sown on 22 Mar 1988 and on 29 Mar 1989. Seeds were sown by hand 10-cm apart. On flat seedbeds, seed was sown 10-cm apart in 60-cm rows. Triple superphosphate (TSP) (21 kg P ha^{-1}) was applied at sowing and ammonium sulfate (20 kg N ha^{-1}) was applied 2 weeks after sowing. Weeding between rows was done using handhoes, and weeds near the plants were pulled out. Apart from bird scaring at sowing, emergence, and during the pod-filling periods, no crop protection measures were undertaken in either season. After harvest, yield and yield components were measured on all plots. Oil contents were determined by Soxhlet extraction method as described by Pomeranz and Meloan (1971, p. 316). The data collected was statistically analyzed and means were compared using Duncan's Multiple Range Test as described by Steel and Torrie (1980).

Results and Discussion

Rainfall was about 20% higher and was better distributed in the 1989 cropping season than in 1988. A dry spell occurred during podding and seed-filling stages in 1988 (Table 1).

Table 1. Selected climatic data for Morogoro, Tanzania, 1988 and 1989[1].

		Mean air temperature (°C)						Mean radiation ($MJ\ m^{-2}$)		Total rainfall (mm)	
		Maximum		Minimum		Mean RH (%)					
Month/	Date	1988	1989	1988	1989	1988	1989	1988	1989	1988	1989
March	1-14	32.5	32.0[2]	22.0	21.0	63.3	54.0	18.9	17.8	21.8	77.7
March	15-31	31.8	30.9	21.2	21.1	56.2	64.0	18.9	17.2	43.9	68.7
April	1-14	31.7	39.0	21.3	20.6	62.7	72.7	17.2	14.3	76.3	168.9
April	15-30	29.4	29.2	20.7	20.6	68.6	65.8	14.3	13.7	28.4	81.5
May	1-14	28.7	28.3	19.9	20.2	70.5	71.1	14.0	12.2	104.3	33.2
May	15-31	28.7	28.3	18.7	18.8	67.7	65.0	14.6	12.8	28.4	79.5
June	1-14	18.4	26.8	14.3	16.6	52.5	65.0	15.2	12.5	0.0	8.5
June	15-30	28.4	27.8	14.0	16.3	50.0	56.0	14.8	15.4	3.3	2.4
Total rainfall										307.1	378.7

1. Data provided by Sokoine University of Agriculture Meteorogical Station.

Yield and yield components

Seedbed types influenced the yield components in both years (Table 2). However, seed yield plant^{-1} showed differences during the 1988 cropping season only. In 1989, the seedbed type had an effect on all components tested except on the number of seeds pod^{-1}. In 1988, the seed yield plant^{-1} was the highest in furrows; in 1989 the highest was on flat seedbeds. Groundnut genotypes differed significantly ($P<0.05$) in all the yield components studied. Groundnut genotype Spanhoma had the highest number of pegs and pods plant^{1} in both seasons.The low number of pods recorded for ridges during the adverse 1988 season could have been because of drought stress and failure of most pegs to reach the ground, penetrate it, and form pods as observed by Laurence (1974). Ridges led also to the lowest seed yield (g plant^{-1}) in both seasons. These results are in agreement with those reported by Tully et al. (1986) who observed that ridges favor soil dessication and lead to rapid temperature increase. IITA (1974) observed similar effects.

The highest seed yield ha^{-1} was in furrows (1151.5 kg ha^{-1}) during the adverse 1988 season and could have been because of rain-water accumulation in the furrows resulting in conserved moisture during the dry periods as reported by Weiss (1983). However,

Table 2. Main effects of groundnut lines and seedbed type on yield components at Sokoine University of Agriculture, Morogoro, Tanzania, 1988 and 1989.

Seedbed type/line	Number of pegs plant^{1}	Number of pods plant^{-1}	100-seed mass (g)	Number of seeds pod^{-1}	Seed yield plant^{-1} (g)
		1988			
Bat	46.5 a[1]	28.0 a	23.9 a	2.0 a	7.7 a
Ridge	40.6 a	24.7 a	23.4 a	2.0 a	6.8 b
Furrow	44.7 a	26.4 a	25.2 a	1.9 ab	7.8 a
Mean	43.9	26.4	24.2	1.9	7.4
CV (%)(a)	23.4	25.3	14.5	4.8	56.3
Ex-Njombe	40.6 b	26.3 a	25.4 a	2.0 a	7.2 b
1/69	39.4 b	23.3 b	21.9 b	2.0 a	5.6 c
Bebiano Encarnado	45.6 ab	26.9 a	22.7 b	2.0 a	7.3 b
Spanhoma	50.1 a	28.8 a	26.6 a	2.0 a	9.5 a
Mean	43.9	26.4	24.2	2.0 a	7.4
CV (%)(b)	19.3	20.9	11.0	0.3	20.4
		1989			
Flat	45.0 a	31.4 b	32.4 a	1.9 a	9.5 a
Ridge	39.8 ab	32.3 b	31.2 ab	1.8 a	8.2 ab
Furrow	36.8 b	38.1 a	30.5 b	2.1 a	9.2 a
Mean	40.5	33.9	31.3	1.9	8.9
CV (%)(b)	10.4	11.7	8.6	16.4	14.2
Ex-Njombe	40.4 ab	34.6 ab	30.5 c	2.1 a	9.6 a
New Mexico Valencia A	39.9 ab	32.7 b	31.2 b	2.0 a	8.7 b
Bebiano Encarnado	38.7 b	32.7 b	32.7 a	2.0 a	8.2 b
Spanhoma	43.0 a	35.6 a	31.5 ab	2.0 a	8.8 b
Mean	40.5	33.9	31.4	2.0	8.9
CV (%)(b)	4.5	4.3	5.2	12.1	6.5

1. Means in the same column followed by the same letter do not differ significantly at *5%*, according to Duncan's Multiple Range Test.

during the more favorable 1989 cropping season the furrows recorded the lowest seed yield (911.6 kg ha^{-1}). This might be because of low plant density caused by heavy rains during the 1st week of April (Table 1).

Oil content and oil production

The seedbed types did not significantly affect the oil content, indicating stability of this character under varying agricultural practices. Differences in oil production were mainly because of differences in yield (Table 3). These results agree with those of Mwenda (1985).

Conclusions

Groundnut genotypes Bebiano Encarnado and Spanhoma, grown on flat beds or in furrows (during the dry season), may contribute to increased groundnut production in Morogoro. Since furrow construction naturally results in a ridge-and-furrow system, this practice could be an important factor in developing intercropping systems, already both popular and economically important in Tanzania. However, there is a need for socio-economic studies on the use of flat beds or furrows in groundnut production before such recommendations are applied to the small-scale farmers' growing conditions in Morogoro district.

Table 3. Groundnut lines and seedbed type effects on yield, shelling percentage, and oil content, Sokoine University of Agriculture, Tanzania, 1988 and 1989.

Seedbed type/ groundnut genotype	Seed yield (t ha^{-1})	Shelling (%)	Oil content (%)	Oil production (kg ha^{-1})
		1988		
Flat	1.073 ab[1]	64.2 a	41.9 a	449.6 b
Ridge	0.943 b	64.4 a	39.8 ab	375.4 bc
	1.152 a	66.5 a	42.3 a	487.1 a
Mean	1.056	65.0	41.3	437.4
CV (%) (a)	0.050	16.6	40.3	14.7
Ex-Njombe	0.896 c	63.3 b	42.7 a	387.5 b
1/69	0.710 d	62.0 c	40.1 a	288.7 c
Bebiano Encarnado	1.119b	66.2 ab	42.9 a	479.9 ab
Spanhoma	1.499 a	68.7 a	39.6 a	593.6 a
Mean	1.056	65.0	41.2	437.4
CV (%)(b)	0.035	7.3	12.9	19.7
		1989		
Rat	1.171 a[1]	59.8 ab	44.4 a	520.1a
Ridge	1.030 b	61.5 a	43.7 a	449.9 ab
Furrow	0.912 c	62.5 a	41.8 ab	388.1 b
Mean	1.038	61.4	43.6	452.3
CV (%)(a)	0.025	20.6	21.7	15.3
Ex-Njombe	1.035 bc	63.2 a	43.1a	447.7b
New Mexico Valencia A	0.827 c	60.4 bc	42.8ab	356.0c
Bebiano Encarnado	1.051 b	58.9 c	44.6a	469.8ab
Spanhoma	1.237 a	63.1 a	43.9a	539.0a
Mean	1.038	61.4	43.6	553.2
CV (%)(b)	0.013	13.4	17.7	8.3

1. Means in the same column followed by the same letter do not differ significantly at 5%, according to Duncan's Multiple Range Test.

References

IITA (International Institute of Tropical Agriculture). 1974. Tropical Soil and Water Management. Technical Bulletin No. 1. Ibadan, Nigeria: International Institute of Tropical Agriculture.

Laurence, R.C.N. 1974. Population and spacing studies with Malawian groundnut cultivars. Experimental Agriculture 10(3):177-184.

Mwenda, F.F. 1985. Groundnut breeding and improvement programs in Tanzania. Pages 81-87 *in* Proceedings of Regional Groundnut Workshop for Southern Africa, 26-29 March 1984, Lilongwe, Malawi. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Mwenda, F.F., Doto, A.L., Taylor, B.R., and Simons, J.H. 1985. Groundnut production, farming methods, and research in Tanzania. Pages 89-92 *in* Proceedings of Regional Groundnut Workshop for Southern Africa, 26-29 Mar 1984, Lilongwe, Malawi. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Pomeranz, Y., and Meloan, C.E. 1971. Food analysis: theory and practice. Westport, CT, USA: AVI Publishing Company.

Steel, R.G.D., and Torrie, J.H. 1980. Principles and procedures of statistics, a biometrical approach. 2nd edn. New York, USA: McGraw-Hill.

Tully, T.J., McDonald Jr., M.B., and Beuerlein, J.E. 1986. Seed quality effects on soybean plants under conventional and ridge tillage. Seed Science and Technology 14:657-668.

Weiss, E.A. 1983. Oilseed crops. London, UK: Longman. 660 pp.

Discussion

Chigwe: From papers presented at this workshop including this one, it appears that there is great variation in the coefficients of variation in experiments, especially for seed yield. What is the optimum CV that can be accepted for reliable data?

Mayeux: For pod yield/seed yield a good CV is between 8% and 12%. If the CV is much higher, the scientist must think of reducing the plot size to reduce soil effect.

Mpiri: The CV value depends on the nature of the experiment. For example, in protection experiments, there is a lot of difference in CV values, depending on whether or not the treatment is controlled.

Reuben: I suggest that we do research to determine the appropriate sampling areas to minimize CVs and estimate proper yields on a per hectare basis.

Rweyemamu: I do agree with the suggestion. However, high CV values in the field trials are not necessarily because of the plot size alone. The high CV values in the field trials could be because of the variables being considered and the performance of the crop during the season.

Doto: What is the experience at SADCC/ICRISAT Groundnut Project regarding variation of CV with plot sizes?

Hildebrand: Ours are mostly varietal trials. We do not use very small plots (generally 7-20 m^2). We do not find much variability in CV but often, yields vary with plot size.

Chambi: Why did you apply nitrogen fertilizer in your experiment?

Rweyemamu: We applied nitrogen because the soil analysis 3 weeks before sowing showed that the soil nitrogen was low for optimal groundnut production in the Morogoro region.

Chambi: Have you noted a problem of nodulation of groundnut genotypes at Morogoro?

Rweyemamu: The experiments conducted at Morogoro have shown that there is no problem with groundnut nodulation. Sometimes the average number of nodules $plant^{-1}$ goes as high as 300. Since we do not apply any effective *Rhizobium* sp at sowing, we think the formed nodules could not be effective for nitrogen fixation in groundnuts.

Mamba: Why did you get a constant higher peg numbers $plant^{-1}$ on flat seedbed as compared to the other seedbed type?

Rweyemamu: Soil moisture might be the cause.

Effect of Plant Density on Groundnut Yield in Botswana

A. Mayeux[1]

Abstract

A Spanish type groundnut (Arachis hypogaea *L.) variety was sown under rainfed conditions at plant densities of 37000 plants ha^{-1} to 166000 plants ha^{-1} to evaluate plant density effects on reproductive and yield components and on water-use efficiency. Varying plant densities affected number of flowers produced but not flowering efficiency. Plant development and the number of different reproductive organs were disproportionate to plant densities. However, in terms of pod yield, lower plant densities could not achieve the potential of higher densities even under good-rainfall conditions. Competition for available moisture induces root growth, and plants grown in higher densities are better able to exploit available moisture by increased rooting depth. An optimal plant density between 75000 plants ha^{-1} to 100000 plants ha^{-1} was found to guarantee a good yield in terms of production and seed quality.*

Sumário

Efeito da Densidade de Plantas no Rendimento do Amendoim no Botswana. *Uma variedade de amendoim (* Arachis hypogaea *L.) do tipo "Spanish", foi semeada em condições de sequeiro em densidades de plantas de 37000 plantas ha^{-1} a 166000 plantas ha^{-1}, para se avaliarem os seus efeitos nos componentes reprodutivos e de rendimento e na eficiência do uso de água. A variação na densidade de plantas afectou o número de flores produzidas mas não a eficiência da floração. O desenvolvimento das plantas e o número dos diferentes orgãos reprodutivos não foi proporcional às densidades de plantas. Contudo, em termos de rendimento de vagens, as densidades de plantas mais baixas não puderam atingir o potencial das densidades mais altas, mesmo em condições de boa precipitação. A competição pela humidade disponível induz o crescimento radicular e as plantas cultivadas em densidades mais altas tem melhor habilidade de explorar a humidade disponível, devido ao aumento da profundidade das raízes. Determinou-se que a densidade de plantas óptima, está compreendida entre 75000 plantas ha^{-1} e 100000 plantas ha^{-1}, garantindo um bom rendimento em termos de produção e de qualidade de semente.*

Introduction

In Botswana, rainfall is the main limiting factor to obtain satisfactory groundnut (*Arachis hypogaea* L.) yields. Genetic improvement of varieties and regulation of water use are the two essential methods to stabilize production. Plant density is one crop-management technique that plays a role in water use.In a 3-year experiment that compared plant densities between 37 000 and 166 000 plants ha^{-1}, the best pod yields ha^{-1} were always obtained with the highest density, i.e., 166 000 plants ha^{-1}. However, the 3 years under study were marked by significant water deficits, which meant that the lower densities were unable to

1. Groundnut Agronomist, Sebele Research Station, Department of Agricultural Research, Post Bag 0033, Gaborone, Botswana.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru. A.P. 502 324, India: ICRISAT.

adequately compensate production with higher yields from each plant. Nevertheless, in terms of the production and quality, the best results were obtained with densities between 60 000 and 75 000 plants ha^{-1}, spaced, on an average, 20 cm apart.

Materials and Methods

In the 1988/89 cropping season, an experiment was conducted to investigate more closely three plant densities and two control densities as follows:

A1 : 60 cm x 10 cm = 166 600 plants ha-^{1} (control)
A2 : 50 cm x 20 cm = 100 000 plants ha^{-1}
A3 : 60 cm x 20 cm = 83 000 plants ha^{-1}
A4 : 75 cm x 20 cm = 66 000 plants ha^{-1}
A5 : 90 cm x 30 cm = 37 000 plants ha^{-1} (control)

The trial was conducted at the Sebele Research station on shallow sandy soil marked by a compact ferruginous zone, varying in thickness, about a meter below the surface. The trial was sown using a randomized complete block design with three replications, with plots of five 10-m long rows. Seed of cultivar Sellie (Spanish group) was sown manually 10 cm apart on 1 Dec 1988. The plots were thinned to the required spacing 20 days after sowing. Seeds were protected by a fungicide/insecticide mixture (captan and malathion). Fertilizer in the form of 100 kg ha^{-1} of single superphosphate (10.5% P) and 100 kg ha^{-1} of limestone ammonium nitrate (LAN) (28% N) were applied. Weeds were controlled regularly by manual hoeing. The water potential of the soil was monitored using a neutron probe calibrated at 10, 25, 40, 55, 70, ,85,100, and 115 cm with aluminium access tubes (45 mm in diameter) placed in the middle of each plot. Four plants were dug up each week from the area outside a 3-m radius access tube to monitor development of various growth and reproductive organs. Flowering was monitored each day on two tagged plants $plot^{-1}$.

Results and Discussion

Climatic conditions

The maximum temperature was relatively constant from sowing to harvesting, at around 30°C. The minimum temperature was also constant throughout the season, at between 18°C and 20°C. Daily pan evaporation was between 4 mm and 8 mm. Total rainfall was lower than the mean for the past 12 years, but distribution was good and compensated for this deficit.

Effect on vegetative growth and flowering

Flowering began 28 days after sowing in all the treatments. Peak flowering was reached on day 50, followed by a gradual reduction in flowering until day 75, in all the treatments, except A5, which maintained the same rate of flowering for an additional 20 days (Fig. 1). Population density had a significant effect (*P* < 0.01) on the number of flowers $plant^{-1}$. This ranged from 311 flowers $plant^{-1}$ in a density of 39 500 plants ha^{-1} to 108 flowers in a density of 140 200 plants ha^{-1}. Mean flowering activity $plant^{-1}$ was 2.7 flowers day^{-1} for A1 and 7.8 flowers day^{-1} for A5.

Table 1. Harvest quality of groundnut cv Sellie, Sebele Research Station, Botswana, 1988/89.

Plant density	Shelling (%)	100-pod mass (g)	100-seed mass (g)	Shelling of good seeds (%)
A1	74.0	74.5	30.8	70.7
A2	71.9	78.1	31.1	64.8
A3	72.7	69.4	29.0	65.8
A4	70.4	71.7	30.1	60.8
A5	69.0	71.3	29.2	59.5
Mean	71.6	73.0	30.0	64.3
CV (%)	2	7	6	6

Prolonged flowering (A5) because of density (more vigorous plants and good rainfall at this time of year) led to extended fruiting, and thus to greater unevenness in maturity of pods at harvest. Hence, harvest quality (shelling percentage and seed yield) was better for the shorter flowering periods (Table 1).The number of leaves produced was also inversely proportional to the density. However, treatment A3 resulted in more rapid and greater soil cover. The leaf area index (LAI) decreased, because of senescence and plant defoliation, from day 90 onwards in all the treatments (Fig. 1).

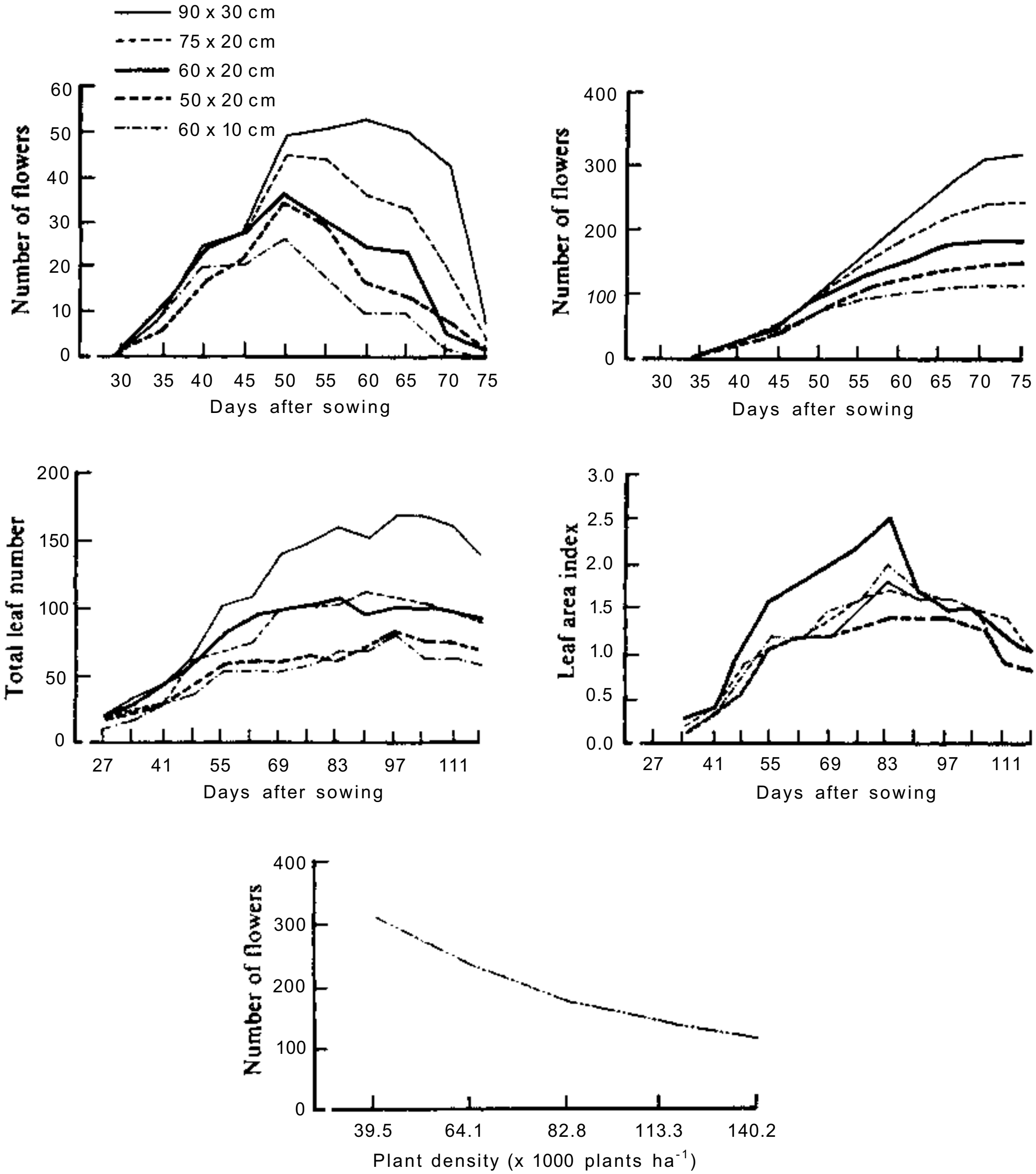


Figure 1. Effects of groundnut plant density on flowering, number of leaves, and leaf area index (estimated using a Delta-T Leaf Area Meter), Sebele Research Station, Botswana, 1988/89.

Effect on development of pegs, pods, and seeds

Figure 2 shows the changes in number of these organs according to density. Varying plant densities did not affect the time taken by the various organs to appear. Flowering efficiency (number of flowers produced per pod harvested) was more or less the same at all the densities (with a ratio about 2.8). The number of pods produced was proportional to the number of

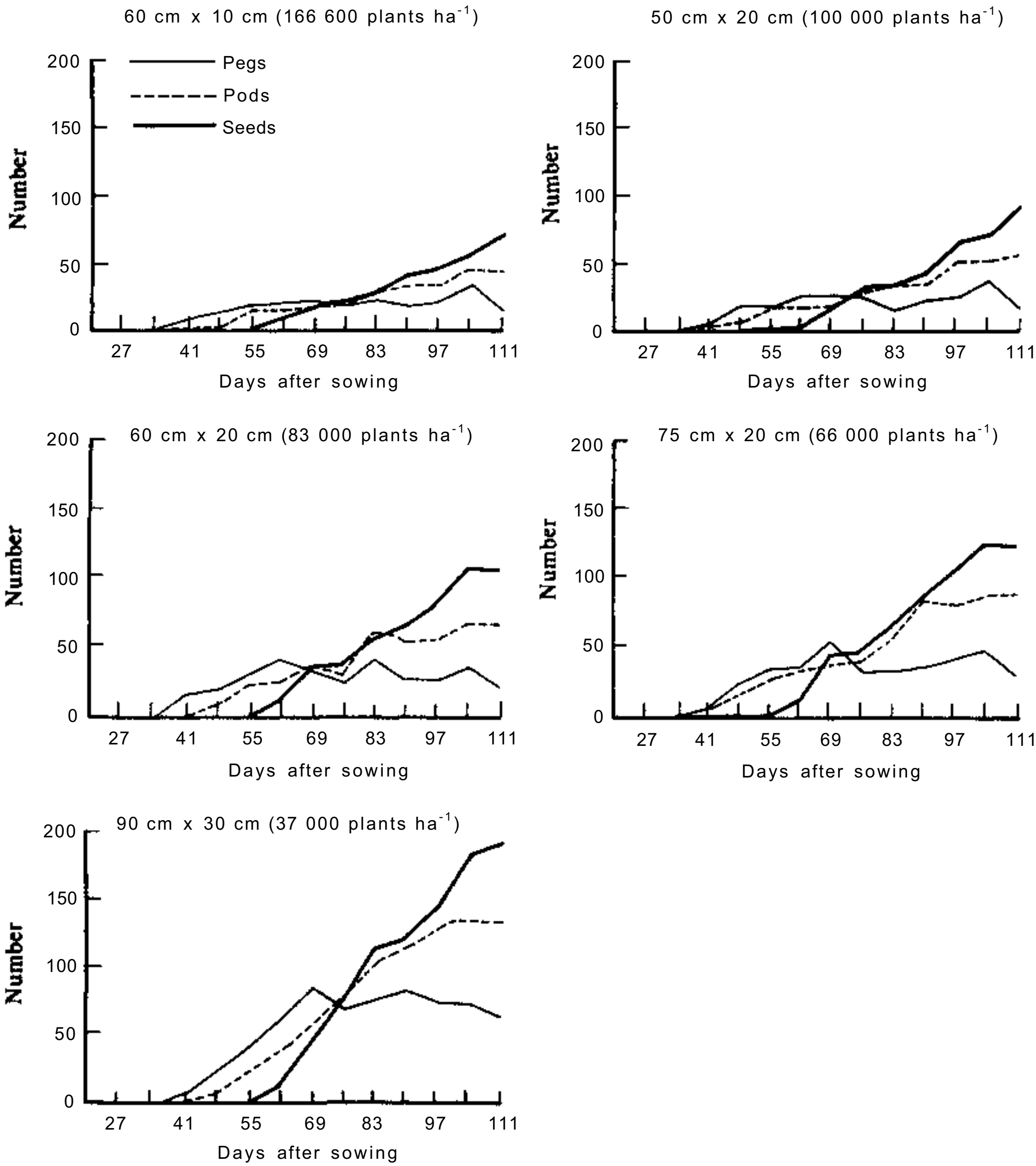


Figure 2. Effects of groundnut plant density on changes with time in the number of pegs, pods, and seeds, Sebele Research Station, Botswana, 1988/89.

flowers (42 pods for 108 flowers in treatment A1, and 134 pods for 311 flowers in treatment A5).

Effect on changes with time in stem, leaf, and pod mass

By day 50, accumulated dry matter was distributed almost equally between the leaves and the stems, with the exception of A2 (Table 2). Thereafter, dry matter accumulated in the pods, which accounted for 60% of plant total dry mass by day 110 in all the treatments. Figure 3 shows the effect of the different plant densities on various parts of the plant during the growth cycle.

Effect on yield

The haulm and pod yield response (Table 2) to plant density confirmed the results from previous seasons that the highest pod yield per hectare is obtained with the highest density, A1. Good rainfall enabled high compensation plant^{-1}, ranging from 22.2 g in Al to 63.8 g in A5. The physiological characteristics of Spanish varieties do, however, limit this compensation. With excellent rainfall, as was the case in the 1988/89 season, compensation enables the lowest densities to produce yields equivalent to those of the highest density. With good rainfall, the longer flowering period because of lower densities led to more uneven maturity and hence to significantly lower shelling percentages (Table 3).

Effect on water consumption

Good rainfall enabled normal development in all the treatments, and the high compensation (plant matter and production) in the lower densities can be traced back to water consumption, which was similar for all five treatments. Figure 4, however, shows a variation in water use from different soil depths. This leads to the following conclusions:

- At 55 cm, the profiles are almost identical for all the five densities. This shows that the lower densities make extensive use of this zone through more extensive root development. The root volume is similar for all treatments from day 40.
- At 85 cm, the profiles are different. Competition for available water stimulates root development, and plants in the higher densities develop a deeper root system.

Table 2. Effects of groundnut plant density on the changes with time in stem, leaf, and pod mass, Sebele Research Station, Botswana, 1988/89.

Days after sowing	Plant density	Total dry mass (g)	Distribution of dry mass (%)		
			Stems	Leaves	Pods
55	A1	17.2	38.5	42.2	8.6
	A2	15.2	29.8	47.6	12.3
	A3	32.1	35.0	45.9	9.7
	A4	29.8	41.2	39.4	10.1
	A5	46.7	40.5	43.9	7.5
83	A1	30.7	23.8	31.7	33.2
	A2	38.0	23.7	33.5	34.2
	A3	62.4	25.6	33.3	36.7
	A4	72.3	26.1	30.4	36.3
	A5	108.4	25.1	32.3	36.3
110	A1	49.2	15.6	21.4	60.0
	A2	53.5	15.7	19.6	62.1
	A3	70.3	14.8	20.3	61.9
	A4	78.0	16.9	18.6	60.7
	A5	151.3	19.9	19.3	57.2

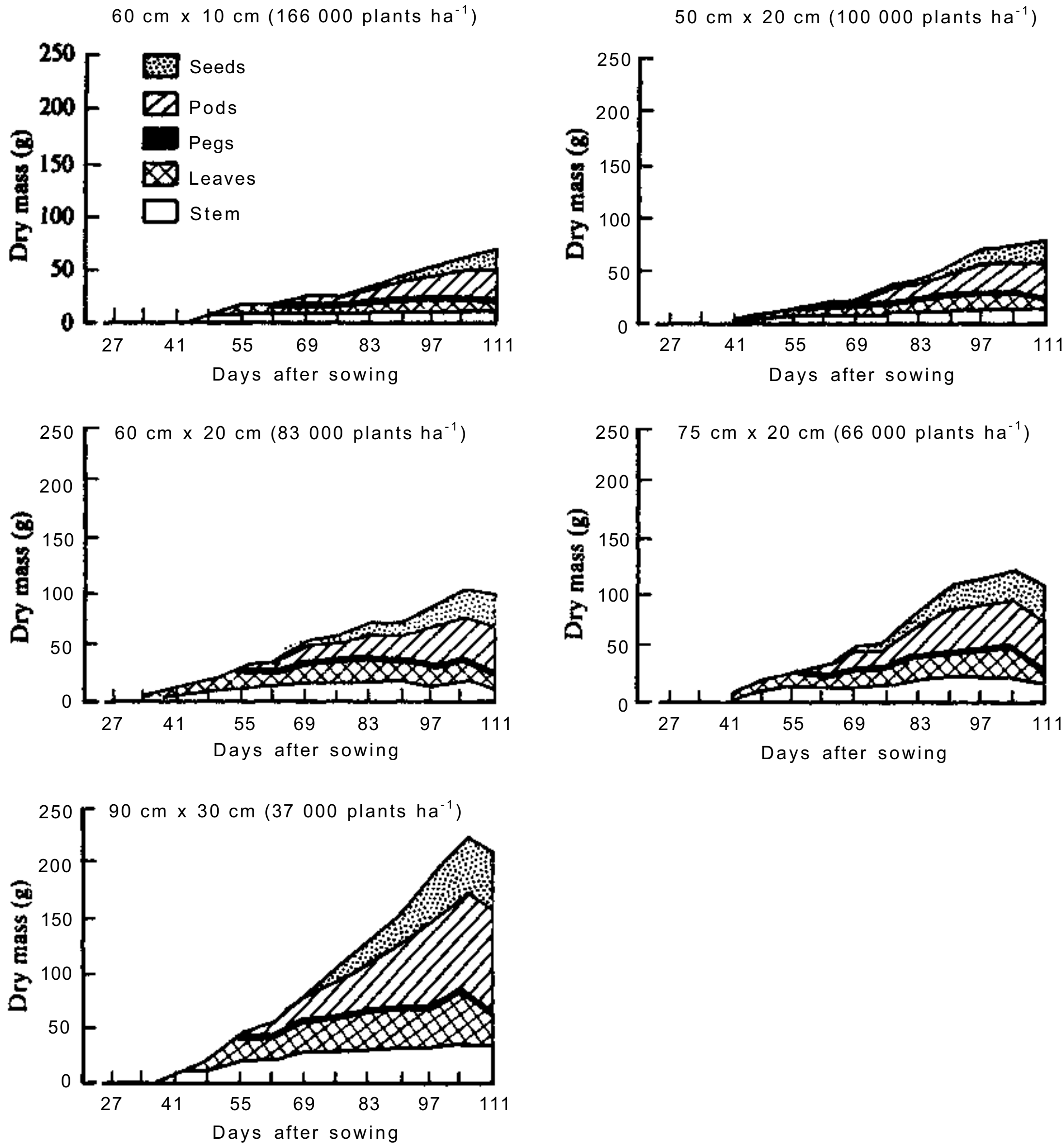


Figure 3. Effects of groundnut plant density on the changes with time in the stem, leaf, peg, pod, and seed mass, Sebele Research Station, Botswana, 1988/89.

Variations over time in stored water during the growth cycle for the various densities confirmed that the levels of water consumed are almost identical. If water efficiency is defined in terms of yield obtained in kg ha^{-1} per unit of water consumed in mm (evapotranspiration) in the profile considered (0-115 cm, no infiltration to the lower layer), it is possible to arrive at consumption rates indicated in Table 4.

Conclusions

Plant density does not affect groundnut flowering efficiency. However, flowering increases as density decreases. This increase is nevertheless limited by the physiological characteristics of cv Sellie and compensation is not sufficient for the lowest density (39 500 plants ha^{-1}) to match the highest density (140 200

Table 3. Yields of groundnut cv Sellie at Sebele Research Station, Botswana, 1988/89.

Plant density	Final stand	Forage yield (t ha^{-1})	Pod yield (t ha^{-1})	Pod yield (g $plant^{-1}$)	Pod density (pods m^{-2})
A1	137 300	3.95	2.99	22.2	700
A2	111 800	3.40	2.86	25.7	620
A3	87 400	3.96	2.83	32.4	508
A4	63 400	3.81	2.83	44.8	460
A5	38 200	4.10	2.45	63.8	516
Mean	87 600	3.84	2.79	37.8	560
CV (%)	13	12	13	19	20

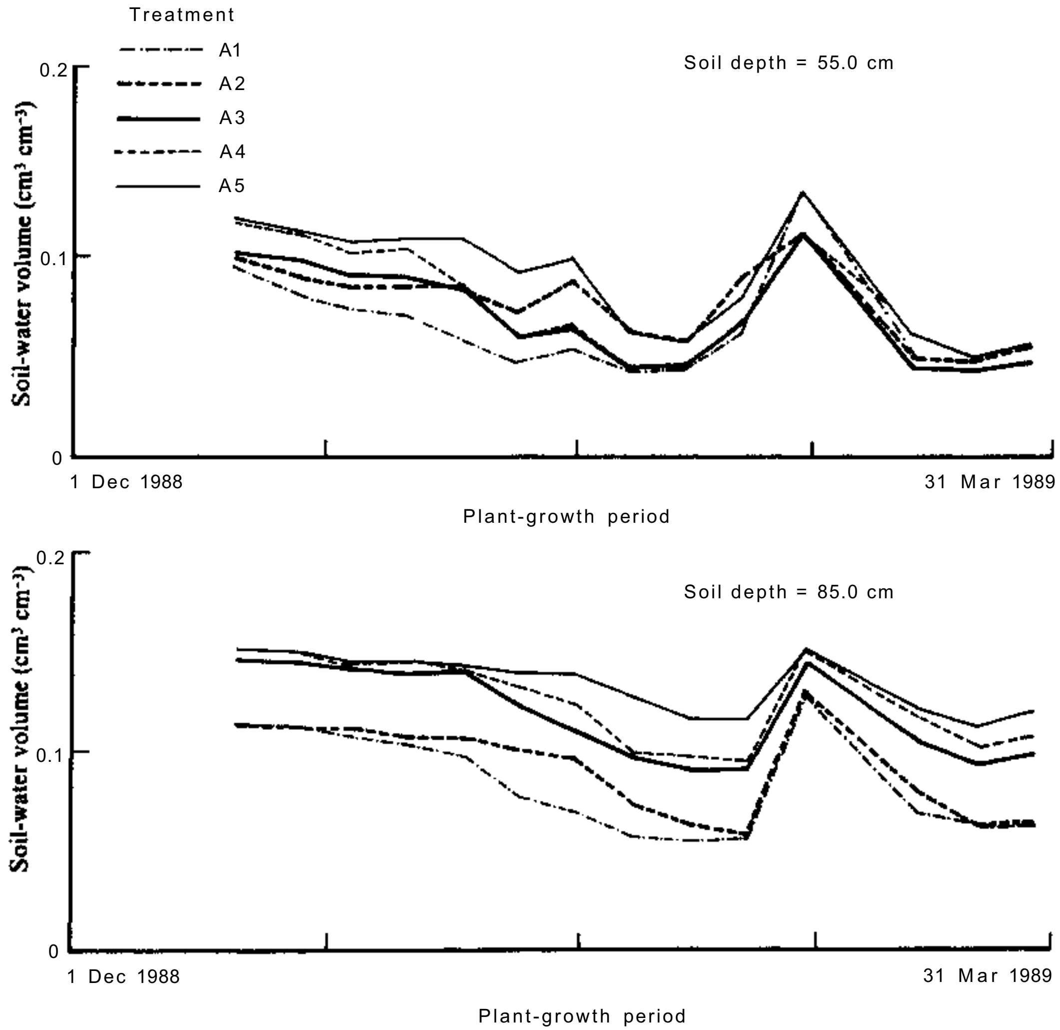


Figure 4. Effect groundnut plant density on changes with time of soil volumetric water, Sebele Research Station, Botswana, 1988/89.

Table 4. Total water used and water-use efficiency on a groundnut (cv Sellie) crop with a rainfall of 280 mm, Sebele Research Station, Botswana, 1988/89.

Plant density	Soil moisture variation[1] (mm)	Water consumption (mm)	Pod yield (t ha^{-1})	Forage yield (t ha^{-1})	Water-use efficiency on ponds (kg mm^{-1})	Water-use efficiency on forage (kg mm^{-1})
A1	-41.9	239.0	2.99	3.95	9.3	12.2
A2	-45.9	235.0	2.86	3.40	8.8	10.4
A3	-41.4	239.5	2.83	3.96	8.8	12.3
A4	-39.6	241.3	2.83	3.81	8.8	11.9
A5	-34.4	246.5	2.45	4.10	7.8	13.0

1. From sowing to harvest by evapotranspiration.

plants ha^{-1}) in terms of pod yield ha^{1}. The prolonged flowering period, associated with low densities, leads to pods of uneven maturity at harvest and hence to lower shelling percentages. In the case of normal rainfall, any savings in water by reducing density are minimal. Groundnut is very flexible as regards adaptation to soil moisture conditions, drawing water from a large area around the plant and developing a deeper root system if competition for surface area becomes severe. After 4 years of study (three subnormal and one normal rainfall season), it is recommended that groundnut be sown at densities between 70 000 and 100 000 plants ha^{-1}.

Discussion

Freire: I agree that with higher plant densities, higher yields are obtained. But, when dealing with small farmers, other factors might be taken into account: whether (a) labor belongs to the family and is not scarce, (b) land is not scarce, and (c) seeds are scarce (main constraint). In such cases, it might be better to sow larger areas at a lower population to obtain higher production at a lower seed rate.

Mayeux: In our experiment, we tried to optimize the use of resources and get an optimized economical result.

Rweyemamu: Your data show that the expected (maximum) plant population in A2 is 100 000, A3 is 83 000, and A5 is 37 000 plants ha^{-1}. Yet your results reveal that the final plant population ha^{-1} was higher than expected. Were more seeds sown than expected? Or did one seed produce more than one plant in some occasions?

Mayeux: In practice, it is always difficult to reach the theoretical plant density but I think these populations have been close enough to manage this trial correctly.

Laxman Singh: Do farmers in Botswana plant groundnut as a sole crop with mean plant population of 25 000 plants ha^{-1} ? If so, according to your conclusions, they can substantially increase groundnut yield by raising the plant density to 70 000 plants ha^{-1} at 75 cm x 20 cm (which is similar to 100 000 plant ha^{-1} at 60 cm x 10 cm). In a spacing of 75 cm x 20 cm, would you suggest or recommend an intercrop, whereby a farmer can get an optimum yield of groundnut and an additional intercrop?

Mayeux: The only crop that can be intercropped later in the season is cowpea but usually farmers broadcast cowpea seeds early in the season, mixed with sorghum. We tried also to get farmers to sow groundnut and even with large spacing between rows (for sowing another crop later). The strong root system of groundnut will prevent a good crop establishment by competing for water (under Botswana conditions).

Schmidt: Was the season begun with moisture available to the plants to a depth exceeding 1 m? Had a fallow period preceeded the trial to accumulate moisture?

Mayeux: Groundnut is generally sown a month after the beginning of the rainy season to avoid it maturing during the moist period towards the end of the season. During this month, moisture accumulates in the soil.

Some Factors Influencing Plant Density and Yield of Groundnut

M.J. Freire[1] and K.V. Ramanaiah[2]

Abstract

Studies on sowing depths, compaction, and seed dressing were conducted to solve the problem of low plant density, one of the contributors to groundnut (Arachis hypogaea *L.) production in southern Mozambique. On heavy soils, the depth of sowing had no effect on either plant density or yield. However, the compaction level appeared to be very important. Plant density and yield were improved when soil was compacted by human feet or with a car tyre. On the other hand, the need for soil compaction appeared to decrease with increased sowing depth. On sandy soils, the reverse was true. Sowing depth had a very strong effect on plant density and shoot yield plant^{1}, while the effect of compaction was nil or very weak. However, depth of sowing or compaction had no effect on pod yield. The highest plant densities and yields were recorded when groundnut was sown at a depth of 5-11 cm with compaction. Seed dressing showed very little or no effect on yield and its components, including plant density.*

Sumário

Alguns Factores que Influenciam a Densidade de Plantas e o Rendimento do Amendoim. *Estudos sobre profundidades de sementeira, compactação e tratamento quimico das sementes foram conduzidos para resolver o problema da baixa densidade de plantas, um dos factores que contribuem para o baixo rendimento do amendoim (***Arachis hypogaea** *L.) no Sul de Moçambique.*

Em solos pesados, a profundidade de sementeira não teve efeitos nem na densidade de plantas nem no rendimento. Contudo, o nível de compactação apareceu como muito importante. A densidade de plantas e o rendimento foram melhorados quando o solo foi compactado pelo pé humano ou por um pneu de carro. Por outro lado, a necessidade de compactação decresce com o aumento da profundidade de sementeira.

Em solos arenosos, o contrário foi verdade. A profundidade de sementeira teve um efeito muito forte na densidade de plantas e no rendimento de forragem planta^{-1}, enquanto que o efeito da compactação foi nulo ou muito fraco. Contudo, a profundidade de sementeira e a compactação não tiveram qualquer efeito no rendimento de vagens. As mais altas densidades de plantas e rendimentos foram observadas quando o amendoim foi semeado a uma profundidade de 5-11 cm com compactação.

O tratamento da semente mostrou um efeito muito fraco ou inexistente no rendimento e seus componentes, incluindo a densidade de plantas.

---

1. Groundnut Agronomist and Head, Department of Crop Production and Protection, Faculty of Agronomy and Forestry Engineering, Eduardo Mondlane University, C.P. 257, Maputo, Mozambique.
2. Groundnut Agronomist and Project Leader, IDRC Groundnut Project at the above address.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa. 19-23 Mar 1990, Arusha. Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

Introduction

One of the problems occurring both in farmers' fields and on research stations is low plant density at emergence and even lower at harvest, resulting in low yields.

Small-scale farmers, using hoes to sow groundnut (*Arachis hypogaea* L.), tend to place the seed at varying depths, from very shallow to very deep, often 20 cm or more, specially on sandy soils. Deep-placed seed may have insufficient vigor to germinate and emerge resulting in low plant densities.

Another possible reason for low plant densities is the mortality of seedlings, mainly because of soil-borne diseases. Seed dressing is not commonly practised in Mozambique.

Large differences in plant density were observed between farmers' fields and research trials in Maputo Province in 1984. The same seed lot was used to sow farmers' fields and research plots and sowing date did not differ by more than 2 days. Emergence on research plots was almost complete, while only 60-70% of seed germinated on farmers' fields.

During the same year, a preliminary evaluation was made by sowing groundnut at various depths varying from 2 to 18 cm; differences of up to 30% were observed.

To solve these problems, two experiments were carried out to study the influence of sowing depths, different levels of compaction, and seed dressing with fungicides on seedling establishment, plant growth, and yield. The main objective was to generate recommendations for farmers, which would enable increases in plant density and, therefore, yields.

Materials and Methods

Two experiments were carried out in southern Mozambique (Maputo Province) during the 1988/89 cropping season to study the following:

A. Effect of sowing depth and compaction

In this experiment a split-plot design with four replications was used. Sowing depths of 2, 5, 8, 11, and 15 cm were imposed as main treatments, and three levels of compaction were imposed as subtreatments. These were control, compaction with feet (farmers' practice), and uniform compaction using a car tyre. To ensure uniform sowing depth, a 10-cm-wide furrow was opened and, after placing the seed, soil was replaced and the surface leveled. The experiment was repeated at two sites under different conditions:

A. At Umbeluzi on a clay-loam soil under irrigation. This trial was sown on 20 Sep 1988 and harvested after 129 days on 26 Jan 1989.
B. At Marracuene on a sandy soil with a sowing irrigation. Subsequently, the rainfall was uniformly distributed. This trial was sown on 15 Sep 1988 and harvested after 138 days on 31 Jan 1989.

In both cases the variety used was Bebiano Branco.

B. Effect of seed dressing

The design used was a randomized-block with four replications. The seed-dressing treatments were as follows:

1) control.
2) Thiram (2.5 g kg^{-1} of seeds).
3) Mancozeb (Dithane M 45®) (2.5 g kg^{-1} of seeds) plus thiram (2.5 g kg^{1}).
4) Mancozeb (Dithane M 45®) (2.5 g kg^{-1}).

The trial was sown at Umbeluzi on 6 Jan 1989 and harvested after 111 days on 26 Apr 1989. The variety used was the breeding line Chico x NC Ac 17200. For both experiments plant density and yield and its components were recorded regularly at harvest.

Results and Discussion

Consideration of soil type is of crucial importance when evaluating the effects of sowing depth and soil compaction (Tables 1 and 2). Varying sowing depth from 2 to 15 cm had no significant effect on plant density or yield on heavy soils (Table 1). However, soil compaction markedly increased plant density and yield. The effect of compaction on plant density did however become less apparent with time after emergence, indicating a slower rate of establishment and development where seed was not compacted. One possible explanation for this result is that, on heavy soils, soil moisture is better distributed and is maintained longer, even at greater depths.In addition, soil compaction improves soil-seed contact allowing improved imbibition and seed germination. This is reflected in improved plant density when seeds are placed 5-11 cm deep and are compacted.

Table 1. Effect of sowing depth and compaction on plant density and pod dry mass of groundnut (cv Bebiano Branco) grown with irrigation on a clay-loam soil at Umbeluzi, Mozambique, 1988/89.

Treatment	Plant density (plants m^{-2})			Pod dry mass	
	13 DAS[1]	42 DAS	133 DAS	(g $plant^{-1}$)	(t ha^{-1})
Sowing depth (cm)					
2	12.2	16.4	18.4	12.8	1.99
5	14.1	17.0	17.7	11.8	1.98
8	14.2	18.6	19.9	11.2	2.22
11	16.5	19.1	19.7	12.2	2.30
15	13.2	17.4	17.9	10.8	1.95
SE	±3.06	±1.60	±2.14	±1.41	±0.171
Mean	14.0	17.7	18.7	11.8	2.09
CV (%)	30.8	12.8	16.8	17.0	11.6
Compaction					
Control (nil)	11.9	16.3	17.7	11.9	1.99
Foot	14.9	18.5	19.7	14.9	2.17
Tyre	15.3	18.3	18.7	15.3	2.11
SE	±0.76	±0.62	±1.59	±0.76	±0.097
Mean	14.0	17.7	18.7	14.0	2.08
CV (%)	17.1	11.1	26.8	17.1	14.6

1. DAS = Days after sowing.

Improvements in plant density and rate of development were reflected in increased yield although compaction appeared not to have any significant effect on number of pods $plant^{-1}$.

On sandy soils (Table 2) the results were very different. Soil compaction and interaction between soil compaction and sowing depth had no significant effect on plant density, pod, or shoot yield. Large differences in plant density were recorded among sowing depths. Sowing at 2-cm depth produced significantly lower plant densities throughout. All other treatments produced higher densities. Only the 15-cm sowing depth gave results similar to that of 2-cm depth when recorded 12 days after sowing (DAS).

It can be argued that when groundnut is sown at 2-cm depth, there is a greater probability of seedling death because of more rapid soil drying. The rate of soil drying is proportional to the sowing depth. The longer period taken by seedlings sown at 15 cm to attain satisfactory densities is a result of greater depth, while seedling vigor may be responsible for the slightly lower, but not significant, reductions in density when compared to the 5-11 cm sowing depths. The shoot yield plant"[1] at 2-cm depth is significantly higher than at depths of 5 to 15 cm. This may be a result of quicker seedling emergence.

Although yield $plant^{-1}$ and yield ha^{-1} did not differ significantly, reduced yields were recorded on shallow-sown treatments and are likely to have resulted from reduced plant density. Harvest index, shelling percentage, 100-seed mass, and number of pods $plant^{-1}$ were not affected.

No significant differences were recorded among seed-dressing treatments (Table 3). However, a tendency towards reduced density and yield without seed dressing suggests that seed dressing could be a feasible proposition.

Discussion

Rwamugira: It is interesting to note that compaction had no effect on light soils. I would imagine that when heavy soils are compacted, plant emergence

Table 2. Effect of sowing depth and compaction on plant density, pod dry yield, and shoot dry mass, of groundnut (cv Bebiano Branco) grown with irrigation for germination, on a sandy soil at Marracuene, Mozambique, 1988/89.

	Plant density (plants m^{-2})			Pod dry mass		Shoot dry mass
Treatment	12 DAS[1]	15 DAS	141 DAS	(g $plant^{-1}$)	(t ha^{-1})	(g $plant^{-1}$)
Sowing depth (cm)						
2	10.8	11.8	11.5	5.6	0.71	23.0
5	17.5	18.4	18.4	5.8	0.96	14.2
8	17.4	19.4	19.4	5.7	0.99	13.6
11	16.1	19.5	19.5	6.0	1.00	14.3
15	12.0	17.7	17.8	6.1	0.90	15.6
SE	±1.30	±1.35	±1.74	±0.67	±0.171	±5.23
Mean	14.8	17.4	17.3	5.8	0.91	16.1
CV(%)	12.5	11.0	14.2	16.4	26.5	13.7
Compaction	13.8	16.2	16.3	5.9	0.85	17.5
Control (nil)						
Foot	15.1	17.9	17.9	5.7	0.94	16.7
Tyre	15.4	18.0	17.7	5.9	0.95	14.1
SE	±1.29	±0.76	±0.74	±0.55	±0.065	±2.34
Mean	14.8	17.4	17.3	5.8	0.91	16.1
CV(%)	27.6	13.8	13.4	29.6	22.6	45.9

1. DAS = Days after sowing.

Table 3. Effect of seed dressing on pod dry mass, number of pod plant*[1], and plant density of groundnut (variety Chico x NC Ac 17200) grown with irrigation on a clay-loam soil at Umbeluzi, Mozambique, 1988/89.

	Pod dry mass		Number of pods	Plant density (plants m^{-2})		
Treatment	(g $plant^{-1}$)	(t ha^{-1})	$plant^{-1}$	11 DAS[1]	27 DAS	110 DAS
Thiram (2.5 g kg^{-1})	6.2	1.13	16.4	19.1	19.7	18.9
Thiram + mancozeb (2.5+2.5 g kg^{-1})	7.1	1.19	19.8	18.1	18.6	16.9
Mancozeb (2.5 g kg^{-1})	8.0	1.12	13.5	19.7	19.9	13.8
Control (nil)	6.0	0.77	12.4	17.4	17.4	12.9
SE	±1.80	±0.23	±1.80	±1.83	±1.83	±2.49
Mean	6.8	1.05	15.5	18.6	18.9	15.6
CV(%)	37.4	31.4	16.4	13.9	13.7	22.5

1. DAS = Days after sowing.

becomes difficult. What do you think are the factor(s) that contribute to high plant density when the soil is compact? What method(s) of soil compaction do you use?

Freire: On sandy soils compaction of soil surface occurs naturally after the rains. Specially on heavy soils, uncompacted soils do not provide a close soil-seed contact, resulting in poor seed germination and hence low plant density. Methods used include soil compaction by using a car tyre or persons stepping on the sown ditches.

Mpiri: How do you ensure uniformity when compacting with feet, while it is easier to ensure that by using a car tyre?

Freire: This is done using the same person all the time. He also wears gum boots to ensure sufficient compaction.

Shongwe: Do you have an idea of the bulk density of the soil after compaction?

Freire: No. We did not measure the bulk density of the soil after compaction.

Subrahmanyam: Deeper sowing may increase the incidence of seedling diseases as the etiolated plants are more susceptible to seedling diseases. Did you study the interaction of sowing depth and seedling diseases incidence and plant density and severity of foliar diseases in your experiments?

Freire: No, we did not look into these aspects.

Rao: Did you make any observation on the effect of seed rate in relation to sowing depths? Why did you use mancozeb (Dithane M45®), a fungicide which is usually applied as a spray, for seed treatment?

Freire: No observations on these factors were made. Reports elsewhere have shown the possibility of using mancozeb (Dithane M45®) as seed-treatment chemical. Also, it is an easily available fungicide.

Ndunguru: In the Gambia, the problem of stand declining with time is very serious. Partly it is related to seedling diseases and crop growth variability but seed viability is also suspect. How is seed stored in Mozambique?

Freire: Most of the seed used by the Mozambique Groundnut Project is stored in a room at ambient temperature, unshelled, and in bags. The seed is shelled and selected immediately before sowing to ensure good quality seed. Farmers tend to store seeds in tins, bags, and bottles, normally unshelled. Nearer to urban centers, traditional storage is no longer used.

Influence of Sowing Dates on Growth and Yield of Groundnuts in Tanzania

K.P. Sibuga[1], S.S. Songambele[2], and T.P.N. Kakema[2]

Abstract

*Field experiments were conducted at Sokoine University of Agriculture, Morogoro, Tanzania, to assess the influence of the sowing date on the growth and yield of promising groundnut (*Arachis hypogaea *L.) genotypes. Four sowing dates at 7-day intervals constituted the vertical factor, and seven groundnut genotypes the horizontal factor in a strip-plot design with four replications. In a dry season (1988), delayed sowing (21 days after the onset of rains) reduced average seed yields by 52%. In a wet season (1989) the average yield loss resulting from the same delay in sowing amounted to 75%.*

Sumário

Influência das Datas de Sementeira no Crescimento e Rendimento do Amendoim na Tanzania. *Ensaios de campo foram conduzidos na Universidade de Agricultura de Sokoíne, Morogoro, Tanzania, para determinar a influência da data de sementeira no crescimento e rendimento de genótipos promissores de amendoim (*Arachis hypogaea *L.). Quatro datas de sementeira, a intervalos de 7 dias, constituiram o factor vertical, e sete genótipos de amendoim o factor horizontal, num delineamento de talhões em faixas, com quatro repetições. Na estação seca (1988), o atrazo da sementeira (21 dias depois do início das chuvas) reduziu o rendimento médio de grão em 52%. Na estação humida (1989), a perda média de rendimento, como resultado do mesmo atrazo, atingiu os 75%.*

Introduction

The yield of groundnut *(Arachis hypogaea* L.) depends on the genetic potential of the cultivar. However, the extent to which this potential can be realized depends largely on the environment in which the crop grows. In Tanzania, the bulk of this crop is produced by small-scale farmers who often sow groundnuts only after the main cereal crops.

The current average yield of 600 kg dry pods ha^{-1} for Tanzania is considerably lower than the world average of 990 kg ha^{-1} (Nigam 1984). This has been partly ascribed to the use of cultivars of low-yielding potential and to adverse weather conditions (Nigam 1984; Preston et al. 1985). Drought stress has been reported to restrict peg penetration and calcium deficiency during the pod-filling phase resulting in unfilled pods (Nageswara Rao et al. 1985; Williams et al. 1986).

The crop is entirely rainfed. The major implement of cultivation is the handhoe. Rainfall intensity and distribution are important factors determining the

1. Senior Lecturer and Agronomist, Department of Crop Science and Production, Sokoine University of Agriculture, P.O. Box 3005, Chuo Kikuu, Morogoro, Tanzania.
2. B.Sc. (Agriculture) Crop Science Option student at the above address.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

yield of groundnut. Weather conditions also influence sowing dates and any delay in sowing from the optimal date may lead to reduced yield. This study was therefore carried out with the following objectives:

A. to assess the growth, development and yield of several promising lines of groundnuts, and
B. to evaluate the performance of these lines at different sowing dates.

Materials and Methods

The experiment was carried out at the Sokoine University of Agriculture (SUA) farm (6°S, 37°E, altitude 525 m) during the 1988 and 1989 cropping seasons (Mar-Jul). The physical and chemical characteristics of the soil at the experimental site are given in Table 1. The design used was a strip plot with four replications. The plot size was 3 m x 3 m. In the 1988 trial the horizontal factor (A) was made up by seven groundnut breeding lines (erect bunch) and the vertical factor (B) by four sowing dates at 7-day intervals (Table Ib). The four top-yielding lines of this trial were retained for further testing and three other varieties added in the 1989 trial. Before sowing, about 2-cm deep furrows spaced at 50 cm were made and phosphorus was applied at the rate of 50 kg P_2O_5 ha^{-1} as triple super phosphate (TSP). The fertilizer was covered with a thin layer of soil and 1 seed $hill^{-1}$ was sown at 10-cm distance, to give a plant density of 20 plants nr^2 (200 000 plants ha^{-1}). Gap filling was done 6 days after each sowing date. Weeds were controlled by three hand weedings at 3-week intervals. Various growth variables as well as seed yields were recorded.

Results and Discussion

General growth

The Leaf Area Index (LAI) was between 3.1 and 3.5 for the first three sowing dates and then declined drastically to about 0.5 for the crop sown 3 weeks after the onset of rain (Fig. 1), which received roughly

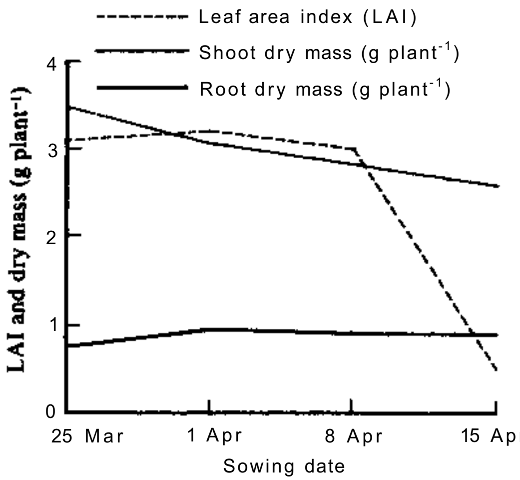


Figure 1. Leaf area index, root, and shoot dry mass of groundnut grown at Sokoine University of Agriculture Farm, Tanzania, 1989.

Table 1. Physical and chemical characteristics of the soil at the experimental site, sowing dates, and amounts of rainfall received during the seasons, Sokoine University of Agriculture, Morogoro, Tanzania, 1988 and 1989.

a) *Physical and chemical characteristics at trial site*

pH = 6.0	Exchangeable Ca [meq (100 g)$^{-1}$] = 1.25
Soil texture = sandy clay loam	Exchangeable K [meq (100 g)$^{-1}$] = 0.45
Organic carbon = 1.6%	
Total N = 0.11%	
Available P (ppm) = 6.2	

b) *Sowing dates (rainfall received, nun)*

1988	**1989**
March 17 (333.2)	March 25 (402.9)
March 24 (256.0)	April 1 (370.5)
March 31 (144.6)	April 8 (308.3)
April 7(126.6)	April 15(205.9)

half of the rainfall received by the crop sown first. A high LAI and shoot mass associated with early sowing was probably because of both increased leaf number and leaf size. These results are in agreement with those of Preston et al. (1985) who similarly associated drought during the growing season to increased leaf senescence leading to reduced LAI and low dry-matter production. Across sowing dates, significant varietal differences were observed among genotypes with line 1/24 recording the highest LAI and Natal Common the lowest. However, the absence of significant differences in shoot dry mass and the higher yield

Table 2. Yield and yield components of 10 groundnut genotypes sown on four dates at Sokoine University of Agriculture, Morogoro, Tanzania, 1988 and 1989.

Genotype/ sowing date	Number of nodules plant^{-1}	Number of filled pods plant^{-1} (as % of number of pegs)	Shelling (%)	100-seed mass (g)
		1988		
1/94	-	15(41.7)	64.0 b[1]	26.6
1/90	-	12 (40.9)	64.4 b	27.6 b
1/80	-	15(39.1)	67.1 a	24.9 c
Baka (Ex-Kyela)	-	14 (37.6)	63.4 b	30.6 a
1/24	-	12 (36.8)	65.4 ab	30.1 a
Ex-Njombe	-	13(38.8)	63.8 b	24.3 c
2/91	-	17(41.5)	67.0 a	28.8 ab
SE	-	±1.2	±0.7	±0.8
Mean	-	14	65.0	27.6
CV(%)	-	12.8	4.5	11.0
March 17	-	20 a[1] (40.0)	65.7	30.1 a
March 24	-	15 b (42.7)	65.7	26.4 b
March 31	-	14 bc (35.4)	64.0	26.9 b
April 7	-	7 c (42.2)	64.5	26.9 b
SE	-	±1.6	±1.6	±1.2
CV (%)		30.2	6.3	11.2
		1989		
1/80	84	15(56.2)	61.9	25.3 cd
Baka (Ex-Kyela)	84	14 (48.3)	63.0	31.3a
1/24	78	13(54.0)	66.7	29.8 ab
Tamnut 74	85	15(52.7)	65.6	24.2 d
2/91	80	14(49.1)	66.7	29.2 b
Spanhoma	73	14(54.0)	68.1	26.2 b
Natal Common	76	17(56.4)	67.0	26.4 c
SE	±4.6	±1.3	±2.3	±2.6
Mean	80	15	65.6	27.6
CV(%)	28	23	11	9
March 25	94	18(57.7)	64.7	30.4 a[1]
April 1	71	15(55.1)	66.4	28.1 b
April 8	63	13 (50.8)	64.9	26.4 bc
April 15	63	12(46.7)	66.3	25.3 c
SE	±14.7	±2.6	±0.9	±2.2
CV(%)		29	13	9

1. In each year values for genotypes or sowing dates, followed by the same letter do not differ significantly (*P* ≤ 0.05), according to Duncan's Multiple Range Test.

level of Natal Common suggest that large leaf areas were not necessarily an advantage. Mutual shading of leaves may be the reason. In 1989, differences in nodule counts among genotypes were not significant though Tamnut 74, 1/80, and Baka appeared to be very profusely nodulated (Table 2).

Yield and yield components

More pegs were formed during the 1988 cropping season than during 1989, but pod filling was more efficient during the latter when five genotypes recorded more than 50% podfill (Table 2).

These differences were attributed to variations in rainfall distribution. For all sowing dates in both years, except the last date in 1988, the crops received more than 60% of the total rainfall within the first 5 weeks (i.e., up to early pod-formation stage). However, during the next 4 weeks (including pod-filling stage), the 1988 crop at the first sowing date received only 6% of the total rainfall and at the second sowing only 5% of the total rainfall. In 1989, the first sowing received 26% and the second sowing 28% of the total rainfall. According to Boote et al. (1982) pod filling is favored by such factors as soil moisture as well as calcium and phosphorus availability. Thus, in 1988, both reduced soil moisture and suboptimal levels of calcium and phosphorus in the soil (Table 1) restricted pod filling. However, pod filling in 1989 was not appreciably better than in 1988. Shelling percentages were comparable in both trials (Table 2). In both years, the seed size was reduced by delay in sowing (Table 2). Baka recorded the highest 100-seed mass in both 1988 (30.6 g) and 1989 (31.3 g).

Groundnut sown within the first 7 days after the onset of rains gave high seed yields in 1988 and 1989. A delay in sowing by 21 days from the onset of rains reduced seed yields across the four sowing dates by 52% in 1988 and 75% in 1989. Such reductions in yield have been reported also by Patel and Golayinka (1988), who found that a reduced total rainfall led to

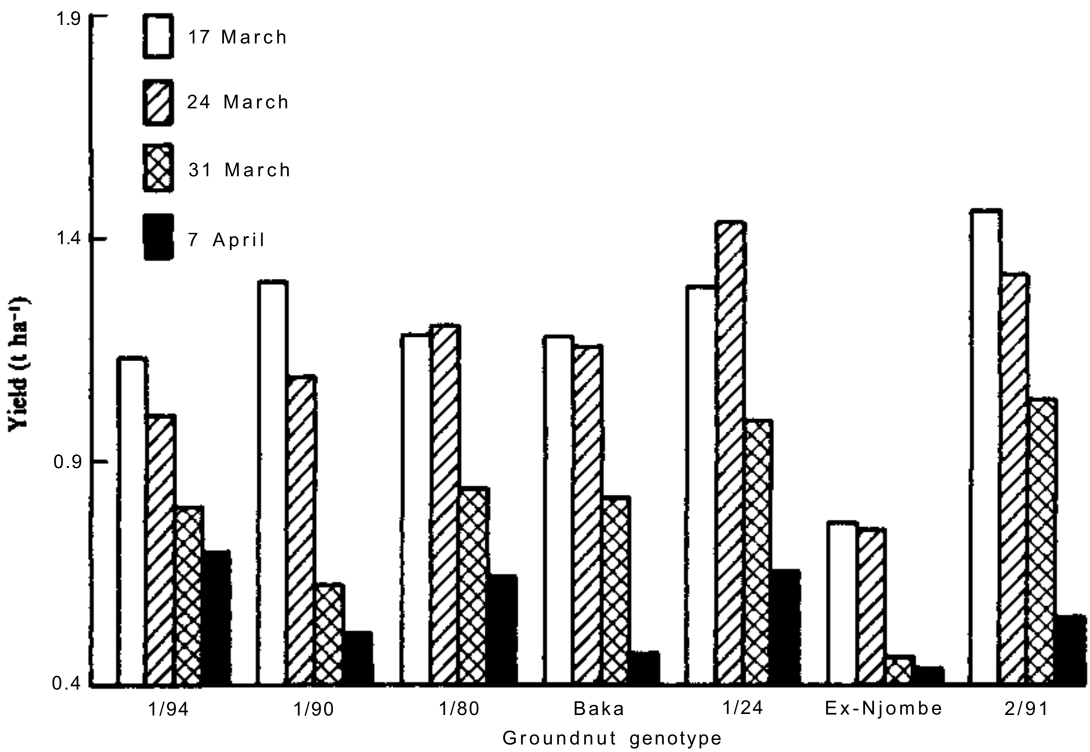


Figure 2. Seed yield of seven groundnut genotypes at different sowing dates, Sokoine University of Agriculture Farm, Tanzania, 1988.

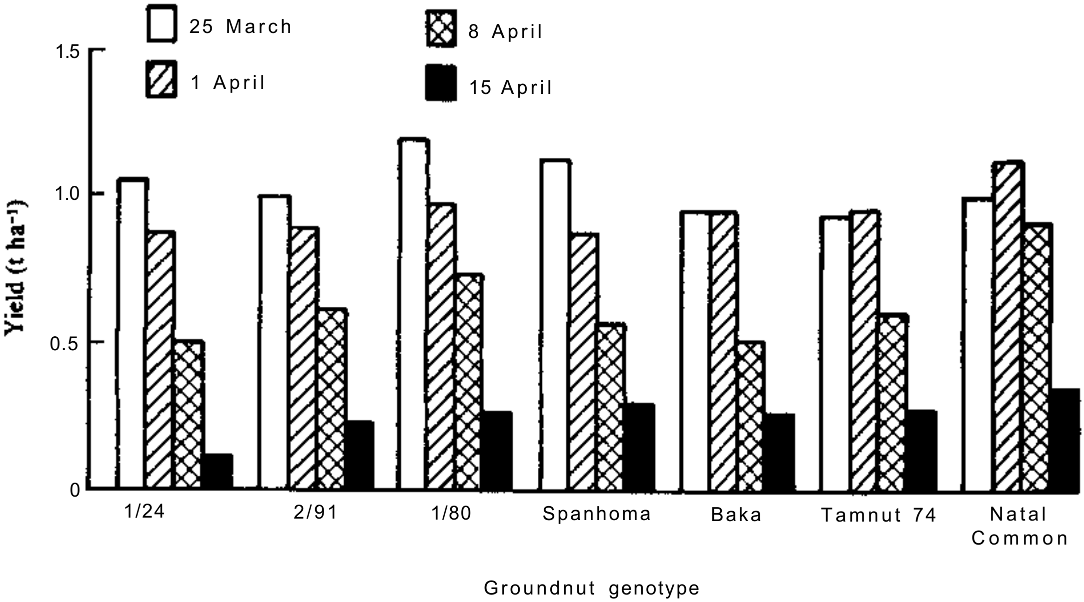


Figure 3. Seed yield of seven groundnut genotypes grown at different sowing dates at Sokoine University of Agriculture, Tanzania, 1989.

decreased dry-matter production and consequently adversely affected pod formation and pod fill. Yields were generally higher in 1988 (Fig. 2) as compared to 1989 (Fig. 3). It was noted that the crop received between 97% and 99% of the total rainfall during the first 9 weeks of growth in 1989 as compared to between 74% and 84% in 1988. However, during the last 4 weeks of growth, only 0.8-3.0% of the rainfall was received in 1989 as compared to 14-18% in 1988. Such dry conditions probably adversely affected seed filling in the 1989 crop. The drier soil at harvest most likely also caused yield losses because of incomplete retrieval of pods from the ground. The better performance of genotypes 1/24, 1/80, 2/91, and Baka during the drier year (1988), especially when sown within the first 2 weeks after the onset of rains, suggests that these genotypes are more tolerant to late-season drought stress. However, their adoption at specific locations would need to be ascertained. High seed yields were associated with high numbers of filled pods, high pod mass, high shelling percentage, and large seed size (significant positive correlations).

Acknowledgment

International Development Research Centre (Canada) funding to the Pulses and Groundnut Project at SUA is greatly appreciated.

References

Boote, K.J., Stansell, J.R., Schubert, A.M., and Stone, J.F. 1982. Irrigation, water use, and water relations, Pages 164-205 *in* Peanut Science and Technology (Pattee, H.E., and Young, C.T., eds.). Youkum, TX, USA: American Peanut Research and Education Society.

Nageswara Rao, R.C., Sardar Singh, Sivakumar, M.V.K., Srivastava, K.L., and Williams, J.H. 1985. Effect of water deficit at different growth phases of peanut: yield response. Agronomy Journal 77:782-786.

Nigam. S.N. 1984. Groundnuts in southern Africa: Its status and research requirements. Pages 143-152 *in* Proceedings of the Oilseeds Workshop, 3-8 Sept 1983, Cairo, Egypt (Riley, K.W., ed.). International Development Research Centre Manuscript Reports. Giza, Egypt: Field Crops Research Institute; and Ottawa, Canada: International Development Research Centre.

Patel, M.S., and Golayinka, B.A. 1988. Effect of water stress on yield attributes and yield of groundnuts. Indian Journal of Agricultural Science 58:701.

Preston, S.R., Taylor, B.R., and Simons, J.H. 1985. The choice of groundnut *(Arachis hypogaea)* varieties by small farmers in South-East Tanzania. II. Variety x spacing and variety x sowing date interactions. Experimental Agriculture 22:279-287.

Williams, J.H., Nageswara Rao, R.C., and Vasudeva Rao, M J . 1986. Breeding for drought tolerance on groundnut *(Arachis hypogaea* L.). Rages 207-222 *in* Proceedings of the Workshop on Varietal Improvement for Rice-based Farming Systems, 11-15 Mar 1985, Phitsanulok, Thailand. Los Banos, Laguna, the Philippines: International Rice Research Institute.

Discussion

Subrahmanyam: In most of the agronomy experiments presented at this workshop, the situation of diseases and insect pests in various treatments was not given. It is an important interaction and the data on diseases and pest should be collected. These will facilitate a better interpretation of the results.

Musanya: Were the determination of leaf area index and root and shoot dry mass for 1989 made only on groundnuts sown on those specific dates?

Sibuga: The determinations of the parameters were made on ail plants at 50% flowering across the sowing dates.

Syamasonta: Is there any relationship between the number of filled pods $plant^{-1}$ and shelling percentage?

Sibuga: The relationship seems to exist, but the inconsistencies observed in Table 2 for 1988 and 1989 need further investigations.

Reuben: In our trials of varietal evaluation and measurements of yield components, we found a positive relation, though not significant.

Groundnut Agronomy in Tanzania: the Importance of Timely Harvesting of Groundnut

E.M. Kafiriti[1]

Abstract

*Groundnuts (*Arachis hypogaea *L.) is an important oilseed crop in Tanzania, grown in areas with altitudes varying from sea level up to 1500 m altitude. Yields have remained low (average 600 kg ha^{-1} of dry pods) mainly because of lack of improved seed. Past experiments have demonstrated yield superiority of early-maturing Spanish types over late-maturing Virginia types. However, Spanish types require timely harvesting because they lack seed dormancy and sprouting frequently occurs if harvesting is delayed. Results presented indicate that delayed harvesting of both Spanish and Virginia types result in losses because of factors other than sprouting. Timely harvesting is therefore important for both types.*

Sumário

A Agronomia do Amendoim na Tanzania: A Importância do Arranque Atempado do Amendoim. *O amendoim (*Arachis hypogaea *L.) é uma importante cultura oleaginosa na Tanzania, cultivada em áreas com altitudes variando desde o nível do mar, até 1500 m acima do nível do mar. Os rendimentos têm-se mantido baixos (média de 600 kg ha^{-1} de vagens secas), principalmente devido à falta de semente melhorada. Ensaios do passado demonstraram a superioridade do rendimento das variedades "spanish", de maturação precoce, sobre as variedades "virginia", de maturação tardia. Contudo, as variedades do tipo "spanish" necessitam dum arranque em tempo, devido à falta de dormência das sementes e à sua frequente germinação no campo se o arranque é atrazado. Os resultados apresentados indicam que o atrazo do arranque, tanto nas variedades tipo "spanish" como do tipo "virginia", resultou em perdas de rendimento, devido a outros factores que não a sua germinação. Deste modo, o arranque atempado é importante para ambos os tipos.*

Introduction

Groundnut *(Arachis hypogaea* L.) is an important oilseed crop grown in almost every region of Tanzania from sea level up to 1 500 m above sea level. It is predominantly grown by resource-poor farmers and in association with cereals or cassava *(Manihot esculenta* Crantz). In mixtures, groundnut is considered secondary to the cereal. Yield levels are low; estimated average yields arc 600 kg ha^{-1} of dry pods. Lack of improved seed, poor agronomic practices, and pests and diseases are among the factors causing low yields. Farmers retain their own seed for sowing. The seed quality is usually low, resulting in poor yields plant^{-1} and insufficient plant densities.

Past research in Tanzania has demonstrated the superiority of early-maturing Spanish over late-maturing Virginia types. This resulted in the release of a

1. Research Agronomist, Oilseeds Research Programme, Research and Training Institute, Naliendele, P.O. Box 509, Mtwara. Tanzania.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1990. Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa. 19-23 Mar 1990, Arusha. Tanzania. Patancheru, A.P. 502 324, India: ICRISAT.

high-yielding Spanish cv Nyota (Spancross) for adoption. The two botanical groups (Spanish and Virginia) differ not only in growth habit and development but also in adaptability and management requirements. Spanish cultivars require better management, including timely sowing, correct spacing, good weed control, and above all, prompt harvesting at maturity than other types. Spanish types lack seed dormancy and often sprout in the field, if wet weather prevails at maturity (Martin et al. 1970).

Results of earlier work suggested that timely sowing is very important for maximizing yields. For example, in southeast Tanzania it is recommended that sowing should commence with the onset of rains in late December or in early January. Early-maturing cultivars sown during this period are ready for harvest in late March or early April. However, in this region the rainy season extends until late May and sometimes light showers can be expected even in early June. Therefore, harvesting takes place in conditions that may be conducive to sprouting. Considering that groundnut harvesting is labor intensive and most farmers cannot afford hired labor, timely harvesting is difficult to achieve.

In the 1984/85 and 1985/86 cropping seasons, a trial was conducted to assess yield losses resulting from delayed harvesting of groundnut.

Materials and Methods

The trial was carried out during the 1984/85 and 1985/86 seasons at Naliendele (10° 20'S, 40° 10'E, altitude 120 m, annual rainfall 1150 mm) and Nachingwea (10° 20'S, 38° 45'E, altitude 450 m, annual rainfall 1100 mm). According to the FAO classification, the soils are Ferralic Arenosols at Naliendele and Ferric Acrisols at Nachingwea (Bennet et al. 1979). Two cultivars, Nyota and Red Mwitunde, were used at both sites. Nyota is an early-maturing Spanish cultivar lacking seed dormancy whereas Red Mwitunde is late maturing with a strong seed dormancy.

Table L Effect of delayed harvesting on seed yield of two groundnut cultivars at Naliendele and Nachingwea, Tanzania, 1984/85.

	Seed yield (t ha^{-1})					
	Optimal time of	Delay in harvesting				
Variety	harvesting	7 days	14 days	21 days	28 days	Mean
			At Naliendele			
Nyota (Spancross)	2.037	1.971	1.671	1.576	1.548	1.761
Red Mwitunde	1.070	1.068	0.942	1.098	0.941	1.024
SE variety mean	±0.0409					
SE harvest time mean	±0.0647					
Mean	1.554	1.520	1.306	1.337	1.245	
CV (%)			13.1			
			At Nachingwea			
Nyota (Spancross)	0.995	0.697	0.651	0.847	0.766	0.791
Red Mwitunde	0.469	0.517	0.336	0.349	0.323	0.399
SE variety mean	±0.0271					
SE harvest time mean	±0.0437					
Mean	0.732	0.607	0.494	0.598	0.545	
CV (%)			20.5			

1. Optimal time to maturity, i.e., for Nyota 90 days after emergence, and for Red Mwitunde 120 days after emergence.

The design used was a factorial in randomized blocks with four replicates. Optimal time for harvesting based on physiological maturity is 90 days after emergence for Nyota and 120 days after emergence for Red Mwitunde. Subsequent harvests were at weekly intervals with the last harvest 28 days after the optimal date of harvest for each cultivar. Both cultivars were sown in rows 50 cm apart and seeds were spaced 10-cm apart within rows. The trial was sown on 3 Jan 1985 and 6 Jan 1986 at Naliendele, and on 4 Feb 1985 and 1 Feb 1986 at Nachingwea. Triple superphosphate was applied to the seedbed before sowing at a rate of 40 kg P_2O_5 ha^{-1}.

Results and Discussion

Seed yields are presented in Tables 1 and 2. In the 1984/85 season, rainfall was very erratic at both locations and at Nachingwea the trial was sown late. An abrupt end of the rains in mid-April affected yields, particularly in the case of Red Mwitunde. However, this weather favored Nyota. Varietal differences were observed with Nyota outyielding Red Mwitunde at all harvest dates. Delayed harvesting decreased yields of both cultivars at both locations. However, the magnitude of yield loss differed between the cultivars (Fig. 1). At Naliendale, Nyota suffered losses as follows: a delay of 1 week resulted in a 65 kg ha^{-1} loss; 2 weeks, 360 kg ha^{-1}; and 4 weeks, about 500 kg ha^{-1}. A delay of 1 week had no effect on Red Mwitunde. Delays of 2-4 weeks caused losses of about 130 kg ha^{-1}.

Similar results were obtained at Nachingwea. A delay of 1 week resulted in seed loss of 300 kg ha^{-1} in Nyota. Losses in subsequent harvests were not consistent. Wet soils at optimal maturity induced sprouting and yield losses in subsequent harvests were inconsistent. For Red Mwitunde, a delay of 1 week had no effect on yield but a delay of 4 weeks caused a yield loss of 175 kg ha^{-1}.

In the 1985/86 cropping season, varietal differences were significant ($P < 0.001$) at both sites with

Table 2. Effect of delayed harvesting on seed yield of two groundnut cultivars at Naliendele and Nachingwea, Tanzania, 1985/86.

	Seed yield (t ha^{-1})					
	Optimal time of	Delay in harvesting				
Variety	harvesting	7 days	14 days	21 days	28 days	Mean
			At Naliendele			
Nyota (Spancross)	0.773	0.668	0.662	0.457	0.577	0.627
Red Mwitunde	0.388	0.432	0.261	0.291	0.088	0.292
SE variety mean	±0.0703					
SE harvest time mean	NS[2]					
Mean	0.580	0.550	0.461	0.374	0.333	
CV (%)			43.0			
			At Nachingwea			
Nyota (Spancross)	1.115	1.335	1.127	1.041	1.031	1.130
Red Mwitunde	0.819	0.790	0.705	0.838	0.827	0.796
SE variety mean	±0.0515					
SE harvest time mean	NS[2]					
Mean	0.967	1.062	0.916	0.939	0.929	
CV (%)			15			

1. Optimal time to maturity, i.e., for Nyota 90 days after emergence, and for Red Mwitunde 120 days after emergence.

2. Not significant.

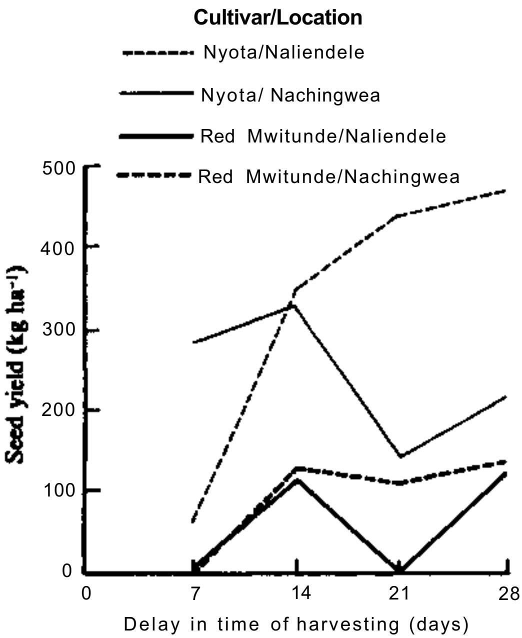


Figure 1. Effect of delayed harvesting on seed yield of two groundnut cultivars at Naliendele and Nachingwea, Tanzania, 1984/85.

Nyota outyielding Red Mwitunde again. Yield losses because of delayed harvesting were not significant but at Naliendele, yields of both cultivars declined steadily with delays in harvest. This was more noticeable in Red Mwitunde than in Nyota. Delayed harvesting at Nachingwea did not produce consistent effects. These results indicate that substantial yield loss can be expected if harvesting is delayed, especially when the weather is conducive to sprouting. Sprouting of Nyota increased with delayed harvest and this was very pronounced during the 1984/85 season when harvesting was done under conditions favoring sprouting. Red Mwitunde, which exhibits strong seed dormancy, showed yield losses with delayed harvesting caused by insect pests, such as termites and vermin.

Although not studied here, delayed harvesting, particularly under moist conditions, is likely to lead to increased incidence of *Aspergillus flavus* infection and subsequent production of aflatoxin (Mixon 1980). Harvesting at optimal maturity is one of the management practices aimed at reducing the degree of fungal invasion and aflatoxin contamination.

Conclusion

The importance of timely harvesting of groundnut cannot be over-emphasized. Any yield loss resulting from delayed harvesting will have a profound effect on farmers' income. Apart from sprouting, other adverse factors including pod rots, insect pests and vermin attacks are also accentuated by delayed harvesting. Therefore, timely harvesting is not only important when growing nondormant cultivars (e.g., Nyota) but is equally important in dormant cultivars (e.g., Red Mwitunde).

References

Bennet, J.G., Brown, L.C., Geddes, A.M.W., Hendy, C.R.C., Lavelle, A.M., Sewell, L.G., and Rose Innes, R. 1979. The Physical Environment. Mtwara/Lindi Regional Integrated Development Programme. Report of the Zonal Survey Team in Phase 2. Project Report 67. Volume 1. London, UK: Land Resources Development Centre.

Martin, J.H., Leonard, W.H., and Stamp, D.L. 1970. Peanuts *(Arachis hypogaea* L.). Pages 749-750 *in* Principles of Field Crop Production. New York, USA: Macmillan Publishing Co.

Mixon, A.C. 1980. Potential for aflatoxin contamination in peanuts (*Arachis hypogaea* L.) before and soon after harvest—A review. Journal of Environmental Quality 9(3):344-349.

Discussion

Ndunguru: How does the harvesting of groundnut conflict with the harvesting of other crops in areas near to your place of work?

Kafiriti: During harvesting of groundnuts there is competition for labor to sow crops such as cowpea, and to weed crops such as maize, sorghum, etc.

Rao: What is your definition of optimal time for harvesting groundnut in layman's terms?

Kafiriti: When pods are well filled and the inside of the pod is dark.

Hildebrand: Method of maturity determination used in Zimbabwe has been written up and published in the local agricultural press. I will send copies to all the national programs.

Busolo-Bulafu: I note from your paper that Nyota lacks seed dormancy while Red Mwitunde has seed dormancy. I would therefore expect Nyota to sprout more than Red Mwitunde and thus lose more seed. And yet your figures show Nyota to have higher yields even after 28 days. How do you explain this?

Kafiriti: The high yields in Nyota are inherent. On the other hand, Red Mwitunde is attacked by birds, vermin, etc., as it stays longer in the field after the others have been harvested.

Moima: Which is the best method of harvesting groundnut, digging or hand pulling?

Kafiriti: It is better to use a small hoe for the purpose.

Ismael: Apart from the sprouting problem when you delay harvesting, did you have any practical problem with the harvesting of the nuts because of depletion and hauim rotting?

Kafiriti: It depends on soil types. These are problems with sandy soil. In heavy soil, nuts can be left in the ground but it is acceptable for farmers to dig these out.

Subrahmanyam: Delayed harvesting of groundnut may predispose the pods to aflatoxin contamination. Work done in Nigeria, USA, India, etc., strongly supports this. Did you measure the levels of aflatoxin content in your samples?

Kafiriti: **No.**

Appendixes

Recommendations of the Meeting

Chairpersons

Dr P.K. Sibale

Dr K.P. Sibuga

Rapporteurs

Dr B.J. Ndunguru

Dr P. Subrahmanyam

In the plenary session, the representative of SACCAR, Dr D.M. Wanchinga, outlined the reporting structure of the SADCC, which calls for the formation of a Steering Committee for each Program/Project in the region. He further outlined the constitution and terms of reference of the Steering Committee. Therefore, the recommendations of this plenary session will be submitted to the Steering Committee, when properly constituted, for due consideration. It is hoped that this Committee, so constituted, holds its first meeting in August 1990 in Malawi.

1. During the plenary session, the 1988 Regional Workshop recommended the setting up of facilities at the Regional Project for oil-quality analysis. The meeting noted that these facilities have not been established. SACCAR had indicated that it would attempt to locate funding for this equipment. SACCAR was urged to continue to pursue this issue.
2. With regard to financial assistance to national programs, the meeting noted that although financial assistance had been provided to certain programs, an urgent need for assistance to conduct research programs still exists. The meeting recommended an increase in the amount of assistance to be made available.
3. With regard to the recommendation on training made in 1988, the suggestion that the ICRISAT Center in-service training be made more crop-based was resubmitted by the meeting at the plenary session for consideration. Notwithstanding the SADCC/GTZ scholarships made available by SACCAR, the need for postgraduate training still remains. During the plenary session, the meeting urged ICRISAT and SACCAR to pursue the search for additional sources of funds for postgraduate training.The meeting also noted that the need for a guide on breeding of groundnut remains and requested ICRISAT again to consider producing such a guide.
4. On the need for increased availability of early-maturing and drought-resistant groundnut germplasm, the meeting noted the recent emphasis on the evaluation and distribution of such material. The meeting also noted with satisfaction the recent devolution of the responsibility for 'pops' screening to Zambia, and late leaf spot and rust resistance screening to Swaziland.The meeting urged the Regional Project to place emphasis on the incorporation of seed dormancy in early-maturing varieties.The meeting urged an early appointment to fill the vacant position of plant pathologist.
5. The meeting agreed that the venues for Workshops would be decided by the Steering Committee and that, when the Workshop was held away from the Regional Project base, the contact point would be the Director of Agricultural Research of the host country.

   The meeting suggested that every other Workshop be held at the Regional Project base and that the 1992 Workshop be held at Lilongwe.
6. The meeting noted that the need for short-term consultancies provided by ICRISAT Center, as requested in 1988, still exists. In addition there is an urgent need for assistance to Lesotho with regard to problems experienced in growing groundnuts.
7. The meeting noted that as a result of budgetary constraints it has not been possible to fund additional research posts at present. The meeting recommended that the Steering Committee follows up the 1988 recommendations and that SACCAR looks for additional funding.
8. The meeting noted that no further progress had been made in the establishment of aflatoxin-testing facilities at the Regional Project and this recommendation is resubmitted for urgent consideration.
9. The meeting noted that accommodation at the Regional Project for visiting scientists was still an important requirement. The meeting felt that the Steering Committee should consider ways to solve this problem.
10. The meeting recommended that when constraints prevent the adoption of technology, funds should be made available by the Regional Project to assist national programs in technology transfer.

11. To ensure continuity of regional groundnut research, the meeting recommended the appointment to the Regional Project of additional scientific staff, from within the region, to positions intermediate between that of principal scientists and technical officers.
12. The meeting recommended that fellowships be provided to allow national program scientists to spend 1- to 2-year periods in the Regional Project to gain experience and to assist principal scientists in their programs. In addition, it was suggested that interprogram exchange of national scientists be facilitated.
13. The meeting urged the Regional Project to explore, with SACCAR, the possibility of conducting computer training courses for groundnut scientists and technicians of the region.

Participants

C M . Busolo-Bulafu
Groundnut Breeder
Namulonge Research Station
P.O. Box 7084
Kampala
Uganda

L. Carlstrom
Sementes de Mozambique Limitada (SEMOC)
C.P. 2402
Maputo
Mozambique

J.Y. Chambi
Breeder
Sugarcane Research Institute
P.O. Box 30031
Kibaha
Tanzania

C.F.B. Chigwe
Senior Plant Breeder
University of Malawi
Bunda College of Agriculture
P.O. Box 219
Lilongwe
Malawi

H.M. Chinganga
Senior Scientific Officer (Research Administration)
Research and Training Division
P.O. Box 2066
Dar-Es-Salaam
Tanzania

A.L. Doto
Tropical Crop Specialist
Faculty of Agronomy and Forestry Engineering
C.P. 257
Maputo
Mozambique

M.J. Freire
Groundnut Agronomist and Head
Department of Crop Production and Protection
Faculty of Agronomy and Forestry Engineering
Eduardo Mondlane University
C.P. 257
Maputo
Mozambique

H.C. Haciwa
Legume Pathologist
Food Legumes Research Team
Msekera Regional Research Station
P.O. Box 510089
Chipata
Zambia

F.M. Ismael
Scientific Officer (Agronomist)
Mauritius Sugar Industry Research Institute
Reduit
Mauritius

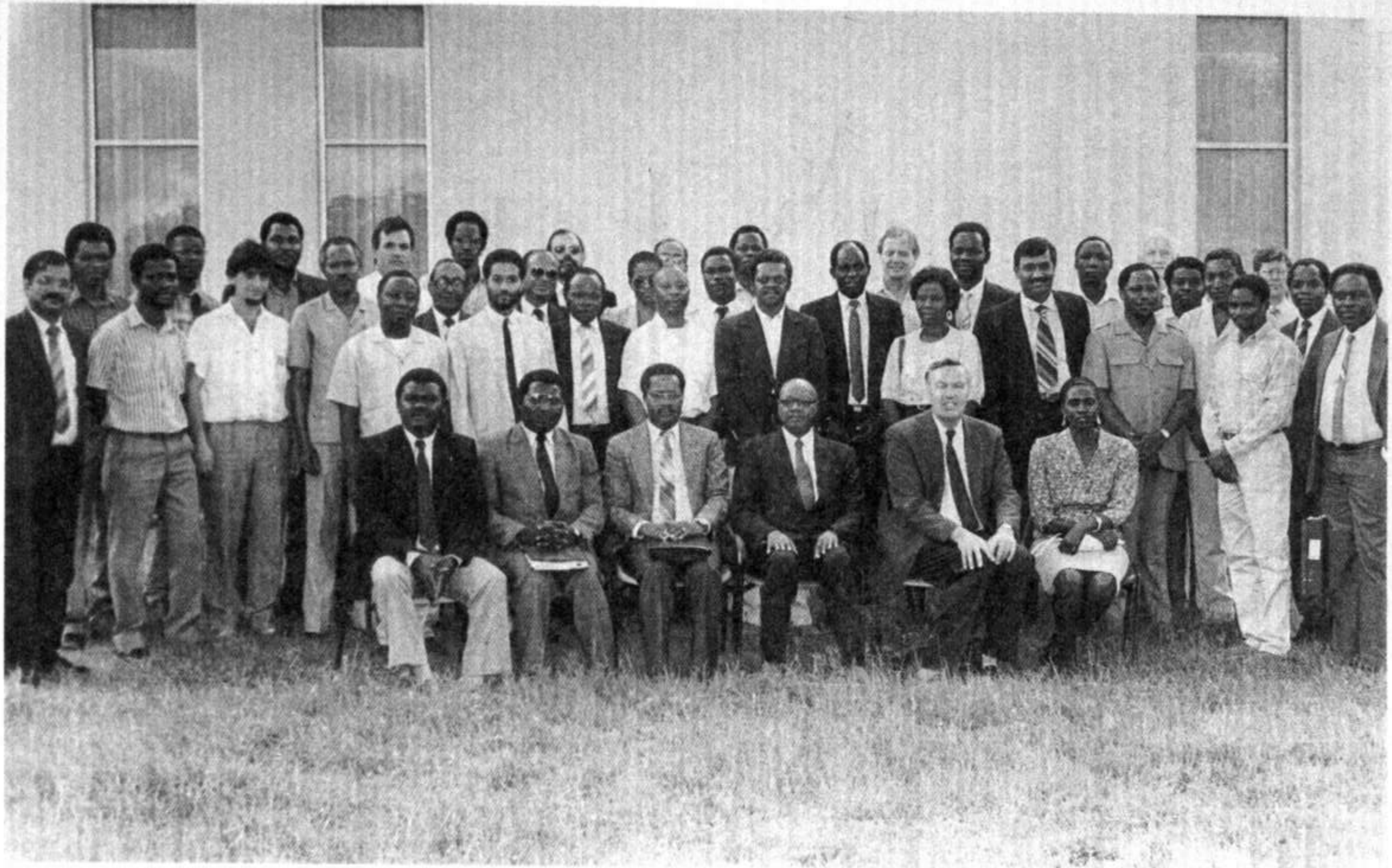
E.M. Kafiriti
Research Agronomist
Oilseeds Research Programme
Research and Training Institute
Naliendele
P.O. Box 509
Mtwara
Tanzania

K. Kanenga
Food Legume Agronomist
Msekera Regional Research Station
P.O. Box 510089
Chipata
Zambia

A.D.R. Kcr
IDRC Senior Programme Officer
P.O. Box 62084
Nairobi
Kenya

Z.I. Mamba
Food Grain Legume Agronomist
Malkerns Agricultural Research Station
P.O. Box 4
Malkerns
Swaziland

H.K. Mande
Groundnut Breeder
Chitedze Agricultural Research Station
P.O. Box 158
Lilongwe
Malawi



Seated (left to right): P.K. Sibale, D.M. Wanchinga, F.M. Shao, L. Rimisho, G. Schmidt, K.P. Sibuga.

Standing (left to right): J.J. Abraham, P.H. Sohati, H.K. Mande, H.C. Haciwa, M.J. Freire, M.S. Mkhabela, F.F. Mwenda, A. Mayeux, H.M. Chinganga, Y.P. Rao, E.M. Kafiriti, F.M. Ismael, Laxman Singh, G.L. Hildebrand, C.M. Busolo-Bulafu, V.S. Swaminathan (behind Moima), K. Kanenga, B.J. Ndunguru, G.N. Shongwe, C.F.B. Chigwe, L. Carlstrom, W.P. Rwamugira, P.A. Omanga, P. Subrahmanyam, M.B. Syamasonta, J.M. Haki, A.D.R. Ker, M.G. Mpiri, J.Y. Chambi, J.C. Musanya, D.J. Allen, A.L. Doto, C.L. Rweyemamu.

A. Mayeux
Groundnut Agronomist
Sebele Research Station
Department of Agricultural Research
Post Bag 0033
Gaborone
Botswana

M.S. Mkhabela
Lecturer
Crop Production Department
Faculty of Agriculture
University of Swaziland
P.O. Luyengo
Swaziland

S.S. Moima
Groundnut Program Leader and Agronomist
Agricultural Research Division
P.O. Box 829
Maseru
Lesotho

M.G. Mpiri
Breeder
Research and Training Institute
Naliendele
P.O. Box 509
Mtwara
Tanzania

F.F. Mwenda
Senior Breeder
Research and Training Institute
Naliendele
P.O. Box 509
Mtwara
Tanzania

J.C. Musanya
Food Legume Coordinator
Msekera Regional Research Team
P.O. Box 510089
Chipata
Zambia

W.P. Nalyongo
Groundnut Breeder
Serere Research Station
Ministry of Agriculture
c/o. Adaptive Research Programme
P.O. Box 90
Tororo
Uganda

P.A. Omanga
Plant Breeder (Pulses)
National Dryland Farming
Research Center (NDFRC)
Katumani
P.O. Box 340
Malhakos
Kenya

S.O.W.M. Reuben
Lecturer in Plant Breeding
Department of Crop Science and Production
Sokoine University of Agriculture
P.O. Box 3005
Morogoro
Tanzania

Y.P. Rao
Professor
Crop Production Department
Faculty of Agriculture
University of Swaziland
P.O. Luyengo
Swaziland

W.P. Rwamugira
Agronomist
Pulses and Groundnut Project
Department of Crop Science and Production
Sokoine University of Agriculture
P.O. Box 3005
Chuo Kikuu
Morogoro
Tanzania

C.L. Rweyemamu
Lecturer (Agronomy)
Department of Crop Science and Production
Sokoine University of Agriculture
P.O. Box 3005
Chuo Kikuu
Morogoro
Tanzania

F.M. Shao
Chief Research Officer
Research and Training Division
MALD
P.O. Box 2066 DSM
Tanzania

G.N. Shongwe
Faculty of Agriculture
University of Swaziland
P.O. Luyengo
Swaziland

P.K. Sibale
Deputy Chief Agricultural Research Officer
Chitedze Research Station
P.O. Box 158
Lilongwe
Malawi

K.P. Sibuga
Senior Lecturer and Agronomist
Department of Crop Science and Production
Sokoine University of Agriculture
P.O. Box 3005
Chuo Kikuu
Morogoro
Tanzania

P.H. Sohati
Legumes Entomologist
Food Legumes Research Team
Msekera Regional Research Team
P.O. Box 510089
Chipata
Zambia

M.B. Syamasonta
Groundnut Breeder and Coordinator
Msekera Regional Research Station
P.O. Box 510089
Chipata
Zambia

D.M. Wanchinga
Manpower and Training Officer
SACCAR
Post Bag 00108
Gaborone
Botswana

From SADCC/ICRISAT Groundnut Project
Chitedze Agricultural Research Station
P.O. Box 1096 Lilongwe
Malawi:

G.L. Hildebrand
Principal Groundnut Breeder

G. Schmidt
Team Leader and Principal Groundnut Agronomist

V.S. Swaminathan
Administrative Officer

From ICRISAT Center
Patancheru
Andhra Pradesh 502 324
India:

J.J. Abraham
Editor
Information Services

P. Subrahmanyam
Senior Groundnut Pathologist

From ICRISAT Sahelian Center
B.P. 12404
Niamey
Niger (via Paris):

B.J. Ndunguru
Principal Groundnut Agronomist and Team Leader

From ICRISAT/Eastern Africa Cereals and Legumes Program
c/o OAU/STRC
J.P. 31 SAFGRAD
P.O. Box 39063
Nairobi
Kenya:

Laxman Singh
Principal Pigeonpea Agronomist

RA-00154.

Acknowledgments

Keyboarding assistance from D.C. Venkaiah of Legumes Program and C.P. Jaiswal of Statistics Unit and proof-reading assistance from Yateendra Joshi and Renu Rao are gratefully acknowledged.

ICRISAT

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

ISBN 92-9066-187-9 Printed at ICRISAT Center ICR 90-0027