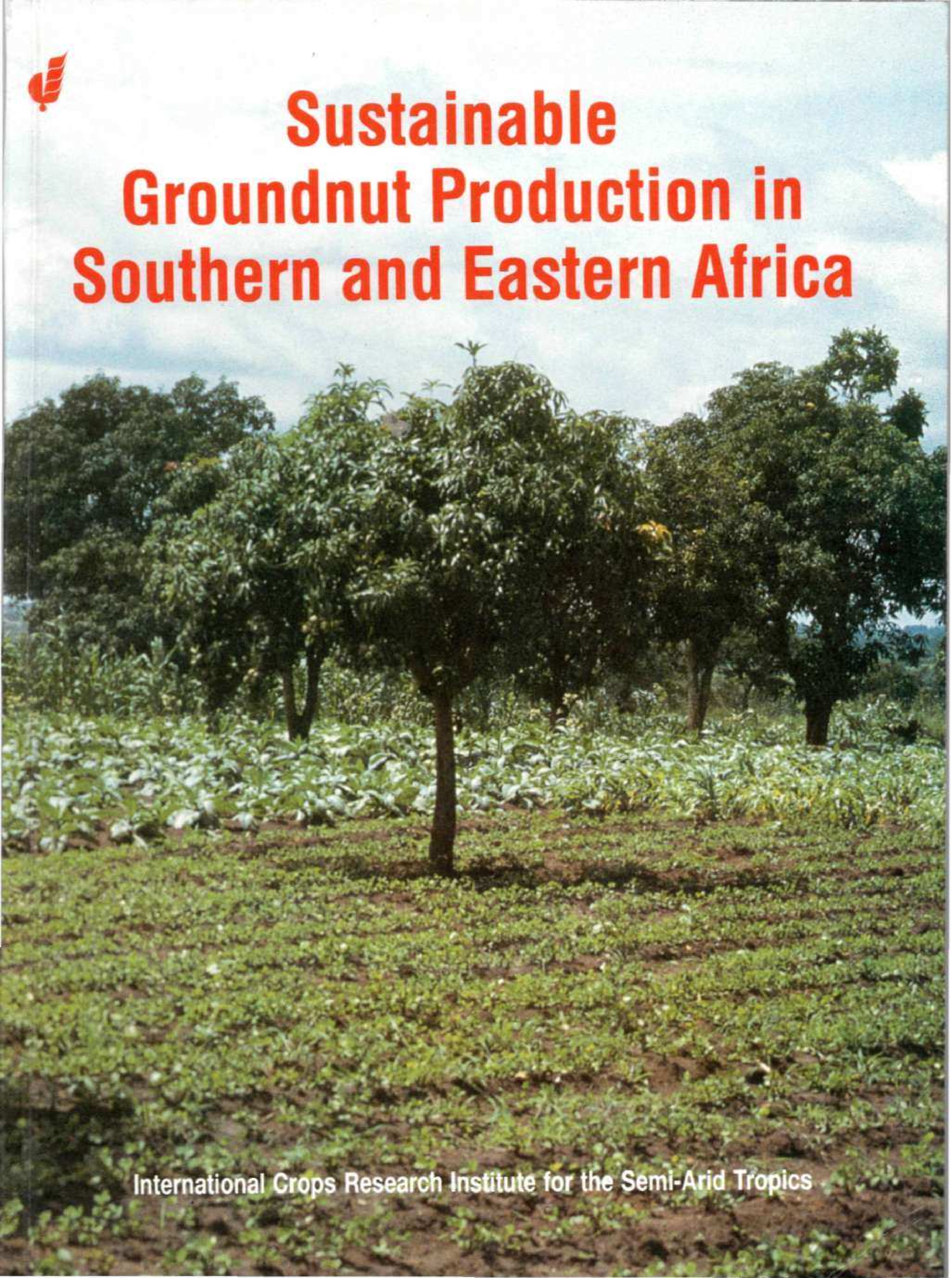
Sustainable Groundnut Production in Southern and Eastern Africa



International Crops Research Institute for the Semi-Arid Tropics

Abstract

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Sustainable agricultural practices are essential in order to conserve the natural resource base while improving productivity. Thirty three delegates from 11 countries in southern and eastern Africa (including South Africa), and from ICRISAT and the Southern African Centre for Cooperation in Agriculture and Natural Resources Research and Training (SACCAR), participated in this Workshop. Recent research on groundnut was reviewed, through presentations that discussed the role of four broad disciplines—genetic enhancement, crop protection, agronomy, and technology transfer—in sustainable groundnut production. The Workshop recommendations are summarized; priority areas include characterization of drought-prone environments, establishment of drought nurseries, surveys on pests, diseases, and aflatoxin contamination, on-farm trials, and more effective technology transfer.

Sumário

Sustentavel produção do amendoim na Africa do Sul e na Africa Oriental. Practicas agriculturais que são sustentaveis são essenciais para conservar a base natural dos recursos quando se melhora a productividade. Trinta e trêis representantes das onze nações da Africa Oriental e Africa Austral (incluindo Africa do Sul) do ICRISAT e o SACCAR, participaram nessa conferência. Investigações recentes sobre o amendoim foram revistas, através das apresentações que discutiram o papel das quatro disciplinas—melhoramento genético, proteção das culturas, agronómia, e transferência da technologia—para a sustentavel produção do amendoim. As recomendações feitas nessa conferência são sumarizadas; áreas de prioridade incluem a caracterização dos ambientes da seca, estabelicimento das sementeiras para resistencia à seca, inquéritos sobre as pestes, doençãs e contaminação da aflatoxina, ensaios dos campos e uma mais efetiva transferência da tecnologia.

Sustainable Groundnut Production in Southern and Eastern Africa

Proceedings of a Workshop

5-7 Jul 1994

Mbabane, Swaziland

Edited by

B J Ndunguru, G L Hildebrand, and P Subrahmanyam

ICRISAT

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

1994

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Introductory Session

Welcome Address

L K Mughogho[1]

Mr Chairman, ladies, and gentlemen: on behalf of ICRISAT and on my own behalf, it is my pleasure to welcome you to this Workshop on Sustainable Groundnut Production in Southern and Eastern Africa, hosted by the Ministry of Agriculture and Cooperatives of the Royal Kingdom of Swaziland. I am sure you will agree that the warmth of their hospitality has made us forget the unusually cold weather this week.

Regional groundnut workshops have been conducted—very successfully—since 1984, in Malawi and in other countries in southern Africa. We now have formal representation from eastern Africa as well; and this can only strengthen our research efforts to improve groundnut farming in the southern and eastern Africa region. The emphasis at these meetings has been on interaction, both at the formal level, through presentations, and informally, with participants exchanging information, ideas, and material, and developing a spirit of camaraderie. It is this spirit, I believe, that has allowed us to work together so successfully for the benefit of Africa's smallholder farmers.

This Workshop is special in several ways. This is the first time that, in the true spirit of collaboration with NARS, the national program in Swaziland has played the major role in hosting and organizing this workshop. It is also the first time that the Republic of South Africa (which will formally be joining SADC in August) is being officially represented at these groundnut workshops. I would like to extend them a special welcome, and trust that this will be the beginning of a long and fruitful association.

Progress in smallholder agriculture can only be built upon a bedrock of strong linkages between all those involved in the generation, transfer, and adoption of technology—researchers, extension specialists, farmers, the private sector, and nongovernmental organizations. It is heartening that the invitees to this workshop included people from all five groups.

ICRISAT, which manages the SADC/ICRISAT Groundnut Project and is sponsoring this Workshop, has representatives from its three regional programs: western and central Africa (our Sahelian Center), southern and eastern Africa, and Asia. And in all, the national programs of 11 countries are represented here today.

Ladies and gentlemen, welcome once again to the Workshop, and to what I am sure will be three very stimulating days.

1. Executive Director. ICRISAT Southern and Eastern Africa Region, P 0 Box 776, Bulawayo, Zimbabwe.

Introduction

C T Nkwanyana[1]

Mr Chairman, Mr Principal Secretary, representatives of ICRISAT, colleagues, ladies and gentlemen: on behalf of the Southern African Centre for Cooperation in Agriculture and Natural Resources Research and Training (SACCAR) of the Southern African Development Community (SADC), I wish to welcome you all to this Workshop on sustainable groundnut production in southern and eastern Africa.

The research and training sector is a component of the food, agriculture, and natural resources (FANR) sector of SADC. The overall objective of the FANR sector is to increase agricultural productivity and ensure food security at the regional, national, and household levels, while ensuring the sustainable use, effective management, and conservation of natural resources—soil, water, fish, forests, and wildlife. SACCAR's regional strategy on research and training is to strengthen the national agricultural research systems (NARS) of member states, to improve their capacity to plan, manage, monitor, and evaluate specific research projects that can generate technologies to improve agricultural productivity. This is achieved through a two-pronged approach, involving both 'core' activities and regional, collaborative, research initiatives (including the SADC/ICRISAT Groundnut Project).

SACCAR activities

SACCAR's core activities relate to information exchange. We run workshops and conduct studies on subjects of regional importance, and provide research grants to young scientists from the SADC region under regional, collaborative research programs. NARS are strengthened through technology development and transfer, germplasm development, information exchange, and training.

The projects are meant to complement—and not compete with—national activities. From our experience, countries that benefit most from regional collaboration are those with clearly laid out research masterplans and clearly identified national priorities. These masterplans can also help member states to coordinate donor support. Donors can then direct funds at priority areas identified in the research masterplans, rather than funding their 'pet' projects. Masterplans can also help to ensure wider participation (e.g., by universities and the private sector) in research activities, by identifying priority areas and specific research needs.

The other issue I wish to touch upon is impact assessment. Because research is a long-term endeavor and usually does not yield immediate benefits, budget allocations are often insufficient. NARS are sometimes to blame for this, because we have not been able to convincingly demonstrate the benefits of research to those who allocate financial resources. At the regional level we also need to account for the funds that donors and member states provide. Therefore, with USAID funding, a post of impact assessment advisor has been created at SACCAR. The objectives are to:

- Develop capacity at SACCAR to undertake impact assessment and establish a database for monitoring and evaluation;
- Develop capacity at NARS level for these activities;
- Collaborate with executing agencies and donors on impact assessment of the regional project;
- Develop a framework (indicators, what data should be collected, etc.) for impact assessment.

In conclusion, I wish to thank the Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) for funding this project, and the Government of Swaziland for hosting the Workshop.

Thank you.

1 Southern African Centre for Cooperation in Agriculture and Natural Resources Research and Training (SACCAR) of SADC, Private Bag 00108, Gaborone, Botswana.

Opening Address

N M Nkambune[1]

Introduction

Mr Chairman, distinguished guests, ladies and gentlemen: on behalf of the Government of the Kingdom of Swaziland and on my own behalf, I welcome you all to this Workshop on Sustainable Groundnut Production in Southern and Eastern Africa. I feel honored to have been invited to the official opening ceremony.

Groundnuts are grown extensively in most countries in the region, and are of major importance to smallholder farmers, being their principal source of cash income. The current shortages of vegetable oils and foreign exchange bear witness to the importance of this crop in our rural economies. Production in the region, however, has declined in recent years. The major constraints are diseases (in all countries except Botswana and Namibia, where rainfall is the major limiting factor) and the lack of suitable varieties. Yields are low, ranging from 400 to 700 kg ha^{-1}, in marked contrast to yields of 4 t ha^{-1} obtained on research stations and large-scale farms. There is thus considerable potential for increasing smallholder groundnut yields in the region, and thereby improving food security. I am told that these issues are being addressed by the SADC/ICRISAT Groundnut Project and the national agricultural research systems (NARS) in both southern and eastern Africa. This is commendable, and it is my hope that these constraints will one day be minimized, and yields increased as a result.

Agriculture and the environment

Disease control and the use of high-yielding varieties cannot on their own ensure sustainable production—soil conservation also has a vital role. Soil erosion is a major problem in the region; vast quantities of topsoil are washed away into the sea each year due to improper land management. This not only reduces yield but destroys the very land base from which production must fake place. I therefore urge you to include soil conservation measures as an integral part of your research programs.

In many countries today, there is a growing awareness of environmental degradation. Some donor agencies have even changed their focus from developmental projects towards those that emphasize protection of the environment. I would therefore urge scientists in our region to identify environmentally friendly chemicals for controlling pests, and to give greater attention to biological control methods and improvement of cultural practices. I believe that this combination of approaches is the best option.

Research strategies and project planning

Nevertheless, let us not deceive ourselves that a breakthrough can come about without meaningful investment in technology. We in the developing countries cannot afford to downplay the role of technological interventions in our quest for a 'green revolution'. If we examine closely the reasons behind the remarkable successes in agriculture in the industrialized countries, we find that it is intensive research that has made a difference. It is high time that governments in our region accept this reality, and demonstrate their commitment by allocating resources for research.

Research must not be carried out routinely, without clearly defining what we want to do. Our agricultural research strategies must be clearly defined and well targeted, in response to pressing socioeconomic needs. One aspect is to direct research specifically towards meeting the needs and aspirations of farmers with limited resources. Historically, smallholder farmers in this region have not adequately benefitted from agricultural

1. Principal Secretary, Ministry of Agriculture, Food and Cooperatives, Royal Kingdom of Swaziland.

research, because the research was not specific to their needs. It is therefore gratifying to note that the SADC/ICRISAT Groundnut Project focuses on these resource-poor smallholder farmers who, unfortunately, form the majority in all SADC member states. It is also my hope that the presentations and discussions at this Workshop will place more emphasis on the research needs of these farmers.

Allow me to turn to another issue that is also related to the Groundnut Project. I understand that annual Review and Planning Meetings involving the SADC/ICRISAT Groundnut Project team and the NARS were instituted in 1993. These fora offer excellent opportunities for the two groups to meet and plan their research activities on a collaborative basis. Both the NARS and the Project benefit, in that work is conducted on activities of common interest throughout the region. It also shows that the project, although donor-funded, is not donor-driven. Furthermore, I believe that the active involvement of NARS in the planning process gives them the courage and enthusiasm to implement their projects effectively.

It has been observed that excluding the implementers from the planning process results in very poor implementation of projects. This is usually because the implementers lack the confidence to carry out projects designed by planning departments. As a result most blueprints from planning departments end up gathering dust on shelves. This should not be allowed to happen in the region. I wish all the research projects in the region would follow your example.

Conclusion

We are told that the population of the SADC region is increasing at an alarming rate, that it will rise to 100 million by the year 2000. Meanwhile, off-farm employment opportunities are decreasing and farmers' cash incomes are dwindling. It is therefore your duty as scientists to tackle all the problems that constrain productivity and reduce income levels in the smallholder farming sector. There must be a concerted effort to augment income levels from the land. Attention should be given to such other alternatives as high-value cash crops, irrigated pastures, animal-based production systems, etc.

In conclusion I would like to express my great appreciation to the organizers of this Workshop for choosing Swaziland as the venue. I hope you will enjoy your stay, and that you will also have the chance to see our humble surroundings. I would also fike to direct my gratitude to the sponsors, whose support has enabled this Workshop to take place. With these remarks, Mr. Chairman, it is now my pleasure to declare this Workshop officially open.

Genetic Enhancement

Genetic Enhancement of Groundnut: Its Role in Sustainable Agriculture

G L Hildebrand and P Subrahmanyam[1]

Abstract

It is imperative that food production is increased in developing countries—without a loss in sustainability—to improve the nutritional status and general well-being of low-income people. One way of increasing productivity and improving sustainability is through the use of improved cultivars, and in this paper we discuss the role that genetic enhancement of groundnut may play in improving the sustainability of agriculture in southern Africa.

In collaboration with NARS scientists, the SADCI1CR1SAT Groundnut Project has endeavored to improve the adaptability of groundnut cultivars, and to incorporate, where possible, resistance to biotic and abiotic factors that reduce yields. This will improve groundnut yield stability across environments. Progress has been made in the improvement of yield and quality of Virginia cultivars suitable for confectionery use. ICGMS 42, which has high yield potential and acceptable confectionery quality, has been released in Malawi and Zambia. Rosette resistance has been transferred to high-yielding, agronomically acceptable, Virginia breeding lines which may also be suitable for those areas where ICGMS 42 is grown.

A number of Spanish breeding lines have performed well in areas where the rainfall season is too short for Virginia cultivars, and short-duration genotypes, adapted to drier conditions in such countries as Botswana and Namibia, have been identified. JL 24 has shown remarkable adaptability to large areas of the region, while ICGV 86061, ICGV-SM 87064, and ICGV-SM 87079 have performed well in Namibia, and have been selected for on-farm evaluation prior to possible release. Progress is now also being made in transferring rosette resistance to short-duration genotypes that are better adapted to drier environments, and recently identified sources of resistance to early leaf spot are being used in the hybridization program.

We believe that genetic enhancement of groundnut can play a major role in improving the stability and sustainability of groundnut production in southern Africa.

Sumario

Melhoramento genético do amendoim: seu papel na agricultura sustentavel. *É imperativo que a produçäö dos alimentos seja aumentada nos países em desenvolvimento para melhorar o 'status' nutricional e o bem estar geral da populaçäo da baixa renda. Uma maneira dos aumentar a produtividade e melhorar a sustentabilidade da agricultura, é através do uso de cultivares melhorados e, neste artigo, discutimos o papel que o melhoramento genético do amendoim pode ter no melhoramento da sustentabilidade da agricultura na Africa Austral.*

1. SADC / ICRISAT Groundnut Project. P 0 Box 1096, Lilongwe, Malawi.

ICRISAT Conference Paper no. CP 956.

Hildebrand, G.L., and Subrahmanyam, P. 1994. Genetic enhancement of groundnut: its role in sustainable agriculture. Pages 9-13 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop. 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand, G.L.. and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Em colaboraçäõ com os cientistas dos Sistemas de Investigação Agrícola Nacionais (NARS), o Projecto do Amendoim do SADC/ICRISAT têm trabalhado para melhorar a adaptabilidade dos cultivares do amendoim e, onde possível, incorporar resistência a factores bióticos e abióticos, que reduzem o rendimento nos campos dos agricultores. Deste modo, a estabilidade do rendimento do amendoim, nos vários ambientes, será melhorada. Progressos têm sido feitos no melhoramento no rendimento e na qualidade dos cultivares Virginia, que säõ adequados para uso na doçaria. ICGMS 42, que tem alto rendimento potencial e qualidade aceitável para a doçaria, foi libertado no Malawi e na Zambia. Resistência à roseta foi transferida para linhas de melhoramento, tipo Virginia, com alto rendimento, agronomicamente aceitáveis, as quais podem também ser adequadas nas áreas onde o ICGMS 42 é cultivado.

Algumas linhas do melhoramento do tipo Spanish mostraram bom comportamento em áreas onde a estaçäõ das chuvas é demasiado curta para cultivares Virginia, e os genótipos da curta duraçäõ, adaptados a condições secas em países como o Botswana e Namibia, foram já identificados. JL 24 mostrou particular adaptabilidade para várias áreas da regiäõ, enquanto que o ICGV 86061, ICGV-SM 87064, e ICGV-SM 87079 têm tido bom comportamento na Namibia, e foram seleccionados para avaliação nos campos dos agricultores, antes da sua possível libertação.

Progresso está agora a ser feito na transferência da resistência à roseta para genótipos de curta duraçäõ, adaptados para ambientes mais secos, e fontes recentemente identificadas de resistência à mancha precoce da folha estão sendo usadas no programa da hibridação.

Nós acreditamos que o melhoramento genético do amendoim pode jogar um papel importante no melhoramento da estabilidade e sustentabilidade da produçäõ do amendoim e da agricultura na África Austral.

Introduction

Can agricultural systems in the semi-arid tropics satisfy increasing demands for food, fuel, and fiber at sustainable production levels and at acceptable economic and environmental costs?

In sub-Saharan Africa, rainfall has decreased substantially, with a more irregular distribution. The sustainability of agriculture in the semi-arid tropics, a marginal ecoregion, is threatened by global environmental changes, including increases in population, expected to exceed 6 billion by the year 2000 (ICRISAT 1992). It is imperative that food production is increased in developing countries to improve the nutritional status and general well-being of low-income people.

Soil degradation is seen as the most significant threat to sustainable agriculture, and clearly, improved soil and water management at all levels, farm, regional, and global, will be the key to sustainable agriculture.

In this paper we share our views on the role that genetic enhancement of groundnut can play in improving agricultural sustainability in southern Africa.

Groundnut is of major importance to smallholder farmers in southern Africa. It is an important source of protein and high-grade fat, a food source that does not even need processing. Groundnut contributes significantly to household food security, and since many smallholder farmers in the region are women, it has an important bearing on the gender issue.

Yields on smallholder farms are low, varying between 400 and 700 kg ha^{-1}, in marked contrast to yields of over 4 t ha^{-1} obtained on research stations and by large-scale commercial enterprises in the region. There is considerable potential, therefore, for increasing smallholder yields in the region. Agroecological conditions vary widely in southern Africa: correspondingly, there are a number of production constraints. However, two affect all countries: diseases, and the lack of suitable cultivars adapted to specific environments, particularly to areas where rainfall is unreliable.

Diseases

A large number of diseases have been reported, but only a few are economically important (Subrahmanyam 1991).

Early leaf spot is widely distributed and occurs annually, in epidemic proportions, in most groundnut-producing countries. Yield losses are substantial. Rosette is the most important virus disease of groundnut in Africa, and although rosette epidemics are sporadic, yield losses approach 100% whenever they do occur (Bock 1987). Rust and late leaf spot are economically important only in some countries in the region, and normally occur together, mainly in low-altitude areas.

Adaptation

There is an urgent need for adapted cultivars that are acceptable for various preferences and end uses.

General adaptation. Considerable progress has been made in the improvement of cultivar adaptability, and a number of adapted cultivars that have been introduced or developed locally, have been released for cultivation in some southern African countries.

Yield and quality. There is considerable potential for exporting confectionery grade groundnut, and increased production will result in greater foreign currency earnings. Virginia-type cultivars, which are the most suitable for confectionery use, can be grown under rainfed conditions in the plateau areas of central Malawi, the Eastern Province of Zambia, and in parts of Mozambique, and are therefore suited to smallholder production. However, in other countries, the growing-season length of Virginia cultivars often exceeds rainfall-season length, and these cultivars may require irrigation.

In order to take advantage of the present high world prices, exporting countries have to ensure a consistent supply of large, high-quality groundnuts, free from risk of aflatoxin and pesticide residue contamination. The shelf life of processed groundnut products is an increasingly important factor in exports, and is determined by stability of the oil, which in turn depends on saturation level and fatty acid composition.

Adaptation to areas of low and unreliable rainfall. Low rainfall and short growing seasons are a major constraint to groundnut production. The 10 SADC (Southern African Development Community) countries represent about 26% of the area of sub-Saharan Africa, and support more than 79 million people (16% of the sub-Saharan African population). Agroecological conditions vary widely across the region, but all SADC countries have areas situated between the 350 and 450 mm isohyets. For example, 70% of Botswana, most of Namibia, 25% of Zimbabwe, and 15% of Mozambique fall in these areas.

Although it is well known that delayed sowing results in reduced groundnut yield, smallholder farmers in the region are often unable to sow early because of crop priorities and sequences, and the lack of labor and other resources.

There are two aspects to improving adaptation to areas of low and unreliable rainfall:

- Drought avoidance through breeding for short duration—short-duration cultivars should be more productive in areas where the rainfall season is short, e.g., Botswana and Namibia, where the rainy season often lasts for less than 100 days. Such cultivars would benefit Lesotho also, where, because of latitude and altitude effects, Spanish cultivars may take up to 190 days to reach maturity.
- Breeding for drought tolerance—with more frequent droughts, the need for drought-tolerant cultivars has become greater. Drought tolerance and improved water-use efficiency would increase productivity in areas where rainfall is unreliable, or where the rainy season may end prematurely.

The availability of cultivars adapted to the drier parts of the region should ensure higher and more stable yields, and could lead to expansion of production into areas previously unsuitable because of low rainfall. These areas often have shallow, light, sandy soils, which are generally fragile. The introduction of a legume into the farming system will improve sustainability by improving soil fertility.

How can enhanced groundnut germplasm contribute to sustainable agriculture in southern Africa?

The broad objective of most crop improvement programs is to develop enhanced germplasm capable of producing higher and more stable yields across environments. Increasing groundnut yields would improve the profitability of the crop, resulting in increased area grown, improved food supply, more cash earnings, and a higher proportion of legume in the cropping system. Earnings from groundnut could contribute to increased fertilizer use on other crops in the farming system. The improvement of stress tolerance would stabilize yields across environments and seasons, preventing drastic or complete yield loss in environments in which these stresses occur.

Some examples of how germplasm enhancement research by the SADC/1CRISAT Groundnut Project, in collaboration with NARS, may contribute to sustainability, are discussed below.

Tolerance to biotic stresses—diseases

Although fungal diseases (notably leaf spots and rust) occur regularly, they assume varying degrees of severity depending on environmental conditions. Genetic resistance to diseases will not only stabilize yields across environments, but also reduce overall losses. Similarly, genetic resistance to rosette disease will prevent drastic yield reductions in years when epidemics occur.

Integrated disease management is now accepted as the most effective—and sustainable—means of controlling diseases, especially in low-input smallholder agriculture. For example, recent studies in the region have shown that strategically timed single applications of chlorothalonil, especially when used in conjunction with such cultural practices as early sowing and crop rotation, can effectively control early leaf spot and thereby reduce yield losses (Subrahmanyam et al. 1993). Genetic enhancement is the most important component of integrated disease management. Its use in combination with appropriate cultural methods would contribute to reduced chemical use and improved sustainability of groundnut production.

In Malawi, several new sources of early leaf spot resistance have been identified in South American germplasm. Five of these are being used in the breeding program. Twelve high-yielding breeding lines resistant to rust and/or late leaf spot, developed at ICRISAT Asia Center, have been selected, and are available for evaluation in southern Africa.

Until 1987, only long-duration sources of rosette resistance were available for use as parents in the SADC / ICRISAT hybridization program. Several high-yielding, agronomically acceptable, Virginia bunch genotypes have been developed using these sources (Chiteka et al. 1992), but these are not adapted to areas of low rainfall. A total of 54 advanced Virginia breeding lines have been confirmed as being resistant to rosette, and are available to NARS for evaluation. Some of these have been evaluated in regional trials conducted in a number of SADC countries, and in on-farm trials in Malawi.

Progress has been slow in transferring rosette resistance to short-duration breeding lines (Hildebrand and Subrahmanyam 1994), but 17 breeding lines are undergoing final evaluation and a number of these will be available for evaluation in the near future. We have recently identified new sources of resistance, including 12 short-duration Spanish types that will help to hasten the transfer of resistance to short-duration cultivars.

Tolerance to abiotic stresses

Adaptation to areas of low and unreliable rainfall. Considerable emphasis has been placed by the ICRISAT Asia Center breeding program on developing short-duration, drought-tolerant genotypes, and numerous breeding lines have been introduced into southern Africa for evaluation. Screening and selection of this material has been undertaken in collaboration with NARS in countries where low rainfall is a major constraint, particularly Botswana and Namibia. A number of genotypes have performed well under these conditions. Three advanced breeding lines (ICGV 86061, ICGV-SM 87064, and ICGV-SM 87079) were selected for possible release and were entered in on-farm trials for final pre-release evaluation in Namibia in 1993/94.

Adaptation

ICGMS 42, which was developed by the Project, has the potential for producing high yields and has exhibited remarkable yield stability throughout southern Africa. It was released in Malawi in 1990, and in Zambia in 1991. ICGMS 42 has been confirmed by international buyers as being very acceptable for export for confectionery use. The adoption of ICGMS 42 is reported elsewhere in these Proceedings.

JL 24, a popular Indian cultivar introduced by the SADC/ICRISAT Groundnut Project, was first evaluated in regional trials in 1983/84. It proved particularly well adapted to conditions in the Lower Shire Valley in Malawi, and was proposed for release in Malawi in 1988. JL 24 showed a 47% yield advantage over Malimba in 13 trials over a 4-year period.

ICGMS 5, first evaluated in regional trials in 1983/84, was approved for pre-release multiplication in Zambia in 1992. In 10 trials in Zambia from 1983/84 to 1987/88, ICGMS 5, now named Chipego, showed a 12% yield advantage over Comet.

Three ICRISAT Valencia germplasm accessions, ICGMs 189, 285, and 550, have been identified for on-farm evaluation in Lesotho. One or more may be released. ICGM 550 has the added advantage of being resistant to rust.

Eight advanced breeding lines have been selected for on-farm evaluation in Swaziland—ICGMS 42; ICGV-SMs 85045, 86045, 86715 (recently released in Mauritius as Veronica), 86720, and 87004, introduced through SADC regional trials; one ICRISAT germplasm accession, ICG 221; and ICGV 87157 (ICG (FDRS) 4). One or more of these may be released.

Outlook

These achievements indicate considerable potential for improving the stability of groundnut production, and we believe that the answer to our opening question must be Yes. We believe that enhancement of groundnut germplasm can, and will, contribute to improving the sustainability of agriculture in southern Africa.

References

Bock, K.R. 1987. Rosette and early leaf spot diseases: a review of research progress, 1984/85. Pages 5-14 *in* Proceedings of the Second Regional Groundnut Workshop for Southern Africa, 10-14 Feb 1986, Harare, Zimbabwe (Bock, K.R., Cole, D.L., Wightman, J.A., and Nigam, S.N., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Chiteka, Z.A., Cole, D.L., Freire, M.J., Mamba, Z.I., Mande, H.K., Marais, D.J.M., Mayeux, A., Moima, S.S., Mwenda, F.F., Rao, Y.P., Sibuga, K.P., Syamasonta, M.B., Schmidt, G., Hildebrand, G.L., and Subrahmanyam, P. 1992. Groundnut research in the SADCC Region, 1980-90. Pages 113-129 *in* Groundnut—a global perspective: proceedings of an International Workshop, 25-29 Nov 1991, ICRISAT Center, India (Nigam, S.N., ed.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Hildebrand, G.L., and Subrahmanyam, P. 1994. Groundnut rosette virus: progress in transferring rosette disease resistance to short-duration cultivars. Pages 34-35 *in* Working together on groundnut virus diseases: summary and recommendations of a meeting of international working groups on groundnut virus diseases, 15-19 Aug 1993, Scottish Crop Research Institute, Dundee, UK (Reddy, D.V.R., McDonald, D., and Moss, J.P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). 1992. ICRISAT Medium Term Plan, 1994-98. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. (Limited distribution.)

Subrahmanyam, P. 1991. Diseases of groundnut in the SADCC region. Pages 14-17 *in* Report of the First Steering Committee Meeting of the SADCC / ICRISAT Groundnut Project, 16-17 Apr 1991, Chitedze Agricultural Research Station, Malawi. Lilongwe, Malawi: SADC / ICRISAT Groundnut Project. (Limited distribution.)

Subrahmanyam, P., and Hildebrand, G.L. 1993. Current research on the management of early leaf spot of groundnut at the SADC/ICRISAT Groundnut Project. Pages 49-50 *in* Summary Proceedings of the Third ICRISAT Regional Groundnut Meeting for West Africa, 14-17 Sep 1992, Ouagadougou, Burkina Faso (Waliyar, F., Ntare, B.R., and Williams, J.H., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Discussion

Zengeni. Is ICRISAT germplasm used in Zimbabwe?

Hildebrand. Yes, but locally-bred varieties frequently perform well, sometimes better than some ICRISAT groundnut germplasm.

Sohati. You have not listed insect pests among the major constraints to groundnut production. Are they not a problem in the SADC region?

Hildebrand. Insect pests are a constraint, but are not as important as some of the other constraints (e.g., diseases). Pest problems are not widespread in the SADC region.

Alibaba. Groundnut varieties have been and continue to be released after research. How available to farmers are these improved varieties?

Hildebrand. Availability is a major constraint and will have to be addressed. Hopefully, this aspect will be covered during the Technology Transfer session of this workshop.

The Role of Genetic Enhancement in Sustainable Groundnut Production in Western Africa

B R Ntare and F Waliyar[1]

Abstract

The progress made towards sustainable groundnut production in western Africa is reviewed. Other issues discussed include the contribution of genetically enhanced groundnut to sustainable production systems and strategies to realize this contribution. These include, strengthening the capacity of national research systems to improve groundnut productivity, reduce losses from pests and diseases, and improve water- and nutrient-use efficiency.

Sumario

O papel do melhoramento genético na sustentabilidade da produtividade do amendoim na Africa Ocidental. *O progresso feito em direçäõ à sustentabilidade da produçäõ do amendoim na Africa Ocidental é apresentado. Outros aspectos discutidos incluem a contribuiçäõ do amendoim genéticamente melhorado nos sistemas da produçäo sustentáveis e as estratégias para alcançar esta contribuiçäõ. Estas incluem o reforço da capacidade dos Sistemas de Investigaçäo Nacionais (NARS) para melhorar a produtividade do amendoim, reduzir perdas provocadas por pragas e doenças, melhorar a eficiência do uso da água e nutrientes.*

Introduction

In western Africa, the sustainability of groundnut production has been challenged by disease problems and frequent drought, which cause large-scale damage and yield losses. The ability to control groundnut diseases and minimize the effects of drought would have significant economic impact.

Groundnut diseases reduce yield and quality, and increase the cost of production wherever the crop is grown (Wynne et al. 1991). Because of the economic impact of diseases, considerable effort has gone into developing chemical and non-chemical strategies. In most of western Africa, chemicals are neither readily available nor affordable. Chemical control also increases production costs, and is becoming controversial because of environmental and food safety concerns.

Genetic enhancement, which involves crossing to create segregating material from which desirable genotypes can be selected, can contribute to sustainable farming practice. Breeding for sustainability is largely a process of fitting cultivars to an environment, instead of altering the environment by adding such inputs as fertilizers and pesticides. Thus, most of the genetic enhancement objectives pertaining to sustainable agriculture emphasize tolerance to biotic stresses (diseases, insects, weeds, other species), abiotic stresses (drought, heat), and chemicals (adverse soils).

The demand for varietal technology is increasing in low-input systems in sub-Saharan Africa because many farmers cannot afford the financial risks associated with purchased inputs. Groundnut production that can be sustained with locally available resources, rather than with inputs from outside, will require

1. ICRISAT Western and Central Africa Regional Program, Sahelian Center, BP 12404, Niamey, Niger.

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genetic pest/disease resistance. Groundnut genotypes that possess these attributes should contribute to the development of an agricultural system that is self-sustaining, environmentally benign, and yet sufficiently productive to meet the increasing demand for groundnut.

This paper reviews the progress made in western Africa towards sustainable groundnut production through genetic enhancement, discusses the expected contribution to sustainable production, and proposes strategies to realize this contribution.

Progress

Since the establishment of ICRISAT's groundnut program in 1976, breeding for disease resistance has received high priority. The justification for this decision was based on the worldwide importance of diseases. The emphasis has been on the major diseases, though breeding for locally important diseases (e.g., rosette virus in Africa) has also received considerable attention. Host-plant resistance is seen as the most practical way to stabilize yields. Varieties with multiple disease resistance would reduce production costs and risks, and thereby make groundnut more profitable to farmers and less expensive for consumers.

Foliar diseases

Considerable effort has gone into identifying sources of resistance to rust (*Puccinia arachidis)* and early *{Cercospora arachidicola)* and late (*Phaeoisariopsis personata)* leaf spots. Numerous sources of resistance have been identified and confirmed for the major foliar diseases. Breeding for disease resistance using some of these sources has been reviewed (Wynne et al. 1991). The resistances exploited by the breeding program at ICRISAT Asia Center, India, were effective in western Africa and could result in considerable improvements in pod and fodder yields (Table 1).

Early leaf spot. The incidence of early leaf spot is increasing in western Africa. Therefore, a major breeding objective is to incorporate resistance to the disease into commercially acceptable varieties. Of the germplasm lines evaluated under heavy infection of early leaf spot, several have been identified as resistant and are maintaining their resistance in the region (Waliyar et al. 1993). The yield potential of these lines is reasonable (Table 2).

Table 1. Pod yield ($t\,ha^{-1}$) of groundnut varieties treated with fungicide Corvet C M® to control foliar diseases, three locations in western Africa, 1990.

Genotype	Bengou (Niger)	Ina (Benin)	Foulaya (Guinee)
28-206	4.78 (61)[1]	3.47 (77)	2.28 (41)
55-437	4.28 (49)	2.14 (84)	1.80 (37)
47-16	3.94 (48)	2.89 (78)	2.14 (101)
ICGS 11	4.75 (39)	3.53 (56)	2.05 (21)
ICG (FDRS) 4	3.00 (39)	2.66 (5)	2.50 (32)
ICG (FDRS) 10	4.13 (28)	3.74 (66)	2.66 (47)

1. Numbers in parentheses show percentage yield increase over untreated control.

Source: ICRISAT West African Programs Annual Report 1991

Late leaf spot. Identified sources of resistance to late leaf spot (eg. ICGs 2716, 6330, 6340, 7013, 10889, and 10976) have maintained their resistance under field conditions at several locations in western Africa. Some of the lines have good agronomic characteristics. Two high-yielding, disease-resistant cultivars, ICGV 87160 (Reddy et al. 1992) and ICGV 86590 (Reddy et al. 1993), bred at ICRISAT, have been released in India. The former cultivar has also been released in Myanmar as Yezin 5. We have advanced ICGV 87160 (ICG (FDRS) 10) and another promising elite germplasm, ICG (FDRS) 4, to on-farm testing in southern Niger.

Table 2. Pod yield of lines resistant to early leaf spot, two locations in western Africa, rainy season 1991.

	Bengou (Niger)		Niangoloko (Burkina Faso)	
	Disease score[1]	Yield ($t\,ha^{-1}$)	Disease score	Yield ($t\,ha^{-1}$)
ICG 6284	3.0	1.56	2.0	1.43
ICG 7878	3.6	1.89	2.0	1.36
ICG 8298	2.9	3.12	3.0	1.38
ICG 8339	3.2	1.26	2.7	1.15
ICG 10900	4.0	2.43	3.0	1.52
55-437	8.5	2.95	7.7	1.09

1. Disease score on a 1-9 scale, where 1 = no symptoms, 9 - highly susceptible.

Source: ICRISAT West African Programs Annual Report 1991

Rust. Data from hot spots in western Africa show that more than 50 germplasm lines are highly resistant to rust, but only a few of them have acceptable pod characteristics (Waliyar et al. 1993). Only one line (ICG 7878) gives reasonable pod yields. These broadly resistant lines are being used in hybridization programs to develop agronomically acceptable cultivars.

Viruses

The yield stability of groundnut in Africa, particularly in western Africa, is imperiled by rosette virus. To provide farmers with effective, inexpensive means of protecting the crop from this threat, ICRISAT has given high priority to the development of resistant germplasm. This is a joint activity with the Institute of Agricultural Research (IAR) in Nigeria and the SADC / ICRISAT Groundnut Project in Malawi. Promising short-duration progenies with rosette resistance are being evaluated this year by IAR.

Table 3. Percentage of groundnut seed infected by *Aspergillus flavus* in Niger, 1989-92.

Genotype	1989	1990	1991	1992
Resistance sources				
55-437	2	3	18	8
J 11	5	4	17	6
4-F-71513-1	11	10	16	19
A-47223	7	8	8	15
U-4-47-7	8	7	40	1
Breeding lines				
ICGV 87084	10	16	26	17
ICGV 87094	7	17	40	19
ICGV 87107	6	17	30	12
ICGV 87109	11	20	34	17
ICGV 87110	7	6	42	13
Susceptible controls				
28-206	53	31	48	*
Var 27	64	54	57	47

* not tested

Aflatoxin

Aflatoxin contamination of groundnut, which is caused by the *Aspergillus* group of fungi, is a serious quality and human health problem. The problem is particularly severe in drought-prone zones of the Sahel. However, the existing varieties (e.g., 55-437 and 73-30) have good levels of resistance. Many sources of resistance have been reported (Mehan 1989). These include PI 337409, PI 337394 F, UF 71513, J 11, Ah 7223, and U-4-47-7. Some of these have been used in the development of many breeding lines that combine resistance traits (equal to those of the resistant parents) with high yield. Resistance in the breeding lines has remained stable over the years at several locations in western Africa, with slight inter-year variations (e.g., 1991; Table 3) (Waliyar et al. 1993). The resistant cultivars will contribute to product quality and health, thus lowering hazards. This should also result in better nutrition and higher incomes.

Durability of genetic resistance

The use of genetic resistance has not always resulted in long-term control of diseases. The development of long-term, sustainable solutions to recurring disease and pest problems will therefore lie not only in the development of genetically resistant varieties, but also in the careful use and management of such varieties. Resistance is often short-lived; in some of the worst cases resistance has broken down within a few seasons. Clearly, we would like to know how to develop crops or cropping systems that have durable resistance, because crop breeding is an expensive and time-consuming process. While it is beyond the scope of this paper to discuss durable resistance, we need to ask one question: Is there durable resistance in groundnut? Hard data is not yet available. Nonetheless, the available data indicate that there is a possibility of achieving durable resistance to rust and late leaf spot.

Drought

Unpredictable and unreliable rainfall distribution, and the recent change in weather conditions, have shortened the growing season in western Africa, rendering the existing long-duration cultivars unsuitable. To counteract these effects short-duration cultivars (80-100 days to maturity) have been introduced and are showing promise in short-season, drought-prone environments. Genetic enhancement efforts provide new short-duration genotypes that match the short growing season characteristic of semi-arid environments, thus reducing the risk factor, increasing yield potentials, and providing the basis for sustainable production.

Yield potential

Yield increases due to genetic enhancement have been calculated in USA, where annual yield increases of 14.7 kg ha^{-1} were attributed to genetic improvement in the large-seeded Virginia types (Mozingo et al. 1987). A similar exercise with recently released ICRISAT cultivars in India indicated a genetic gain of 1.3-3.2 % per year (Nigam et al. 1991). In western Africa, introduced cultivars have been released in Ghana (e.g., ICGS 114 was released as Sikarezie in 1989) and in Guinee (e.g., ICGV 86105 was released as VP 20 in 1992). Other promising lines are undergoing on-farm testing in Sierra Leone and Gambia.

Expected contribution of genetic enhancement to sustainable production systems

- Improved groundnut cultivars that will not require the use of pesticides will contribute to the quality of the environment and the harvested crop;
- Improved cultivars that are more efficient in scavenging nutrients from the soil and can utilize nutrients more efficiently, will reduce fertilizer costs and improve groundwater quality;
- Cultivars with greater water-use efficiency, and tolerant to periodic drought stress, will reduce irrigation costs and stabilize yields;
- Groundnut improves soil fertility through nitrogen fixation, and reduces soil erosion from raindrop action because of its closed canopy;
- Development of a wide range of cultivars with different maturity durations will allow the exploitation of rotation niches and the development of alternative cropping systems;
- Sustainable groundnut production will help meet the world's demand for vegetable oil;
- Improved dual-purpose (hay and pods) cultivars will promote nutrient recycling through the use of residues as livestock feed.

Research strategies

To fully realize the potential contributions of genetic enhancement to sustainable groundnut production, the following need to be reinforced:

Strengthening national programs. National programs in western Africa have different priorities and different levels of expertise. Many countries have limited resources, and the interaction between research, extension, and farmers is often weak. To deal with these problems, the objective will be to continue to strengthen national program capacity to improve groundnut productivity in diverse cropping systems. The strategies to accomplish these objectives are to:

- Deliver to NARS genetic material (parents, segregating populations, or finished lines, according to their needs);
- Link NARS more closely into research networks to solve problems of common concern and exchange research results;
- Strengthen NARS capacity to involve farmers in technology evaluation and setting of research priorities;
- Stimulate NARS to develop sustainable and productive crop management systems.

Pests and diseases. Although considerable progress has been made on reducing pest- and disease-related losses, further effort is needed to:

- Broaden the genetic base of resistance;
- Identify sources of resistance (where lacking) and incorporate the genes conditioning resistance into acceptable cultivars;
- Develop integrated control strategies to complement genetic resistance while reducing pesticide application.

Nutrient- and water-use efficiency. To relieve nutrient and drought constraints and improve nutrient- and water-use efficiency, three strategies are needed.

- Breed genotypes with improved ability to fix nitrogen;
- Identify mechanisms and develop screening methods for tolerance to low calcium/phosphorus and acid soils;
- Generate groundnut genotypes with improved adaptation to water stress.

Yield potential. With the increasing availability of groundnut varieties with multiple disease and insect resistance, there is a growing demand by NARS to increase the yield potential of groundnut. Little progress, however, has been made in this area, especially on short-duration varieties with multiple disease resistance, suitable for drought-prone areas. Efforts to solve this problem have begun, and include:

- Greater emphasis on selection for yield in breeding nurseries;
- Exploring the genetic variation across gene pools as a means to optimize the utilization of genes controlling yield;
- Attempting growth habit modifications to produce more productive plant types;
- Studying yield-maximizing physiological traits (e.g., partitioning, crop growth rate, maturity, calcium nutrition) to determine which factors can be optimized for higher yield potential.

Conclusions

Increased productivity potential in groundnut genotypes for low-input cropping systems is critical to the development of an agricultural system that is self-sustaining, environmentally benign, and yet sufficiently productive to meet the increasing demand for groundnut. The key to increased production under these conditions will be the evaluation, identification, and use of selection and testing environments, a more quantitative understanding of stability, and a better understanding of the components of tolerance to biotic and abiotic stress.

With the new potential of microbial genetics and biotechnology, additional methods will be available to plant breeders to more quickly manipulate germplasm and assemble new genetic combinations. This will enhance the genetic potential to respond to different cropping systems with new hybrids.

Many of the traits that improve adaptation and yield potential in conventional systems are useful in enhancing the sustainability of those systems as well. Such characteristics as insect and disease resistance, ability to withstand adverse temperature and moisture stress, and other survival traits will confer stability to yield expression and allow crop cultivars to contribute to sustainability.

Genetic enhancement will continue to be an exciting and important dimension of the improvement of cropping systems, and will certainly contribute to the sustainability of crop production in the future.

References

Mehan, V.K. 1989. Screening groundnut for resistance to seed invasion by *Aspergillus* and to aflatoxin production. Pages 323-334 *in* Aflatoxin contamination of groundnut: proceedings of the International Workshop, 6-9 Oct 1987, ICRISAT Center, India (McDonald, D., and Mehan, V.K., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Mozingo, R.W., Coffelt, T.A., and Wynne, J.C. 1987. Genetic improvement in large-seeded Virginia type peanut cultivars since 1944. Crop Science 27:228-231.

Nigam, S.N., Dwivedi, S.L., and Gibbons, R.W. 1991. Groundnut breeding: constraints, achievements and future possibilities. Plant Breeding Abstracts 61(10): 127-136.

Reddy, L.J., Nigam, S.N., Subrahmanyam, P., Reddy, A.G.S., McDonald, D., Gibbons, R.W., and Pentaiah, V. 1992. Registration of ICGV 87160 peanut cultivar. Crop Science 32:1075.

Reddy, LJ., Nigam, S.N., Subrahmanyam, P., Reddy, A.G.S., McDonald, D., Gibbons, R.W., and Pentaiah, V. 1993. Registration of ICGV 86590 peanut cultivar. Crop Science 33:357-358.

Waliyar, F., Bosc, J.P., and Bonkoungou, S. 1993. Sources of resistance to foliar disease of groundnut and their stability in West Africa. Oleagineaux 48:283-287.

Waliyar, F., and Hassane, H. 1993. Aflatoxin contamination of groundnut in Niger. Pages 53-54 *in* Summary Proceedings of the Third ICRISAT Regional Groundnut Workshop for West Africa, 14-17 Sep 1992, Ougadougou, Burkina Faso (Waliyar, F., Ntare, B.R., and Williams, J.H., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Wynne, J.C, Baute, M.K., and Nigam, S.N. 1991. Breeding for disease resistance in peanut (*Arachis hypogaea* L.). Annual Review of Phytopathology 29:279-303.

Discussion

Subrahmanyam. The negative correlation between yield and resistance to foliar diseases is true in the case of the germplasm lines from Peru, but not for the foliar diseases resistance breeding lines. The linkages between yield and resistance are now being overcome in the breeding program.

Ntare. Yes, I agree.

Chiyembekeza. One of the strategies you mentioned was to select for yield in the breeding nurseries. How do you plan to achieve that, since yield per se has low heritability?

Ntare. Selection for yield is done at a later stage in most breeding programs, mainly because seed becomes a limiting factor. In situations where adequate seed is available in the early generations, it would be possible to select for yield.

Maphanyane. Could you clarify what 'high partitioning before onset of drought' refers to, i.e., flowering-to-maturity period, or rate of dry weight accumulation during pod development and seed filling.

Ntare. Measurement of partitioning gives some indication of the efficiency with which the plant produces pods. The important period for high partitioning is from pod initiation to maturity. It is important to note that partitioning can be measured nondestructively.

ICGMS 42: A Contribution to Sustainable Agriculture in Southern Africa

G L Hildebrand[1], A J Chiyembekeza[2], and M B Syamasonta[3]

Abstract

Groundnut is an important crop in southern Africa, but yields are low and producing the crop has long been considered uneconomic. An important objective of groundnut improvement programs in the region is to improve productivity, while ensuring that this is not done at the expense of sustainable agriculture. Cultivar improvement is possibly the cheapest, most reliable, and environmentally safest method of increasing productivity.

ICGMS 42, an advanced groundnut breeding line developed by ICRISAT, has performed well in trials conducted since 1983/84 in southern Africa, and has been released for cultivation in Malawi and Zambia. It has also been selected for on-farm evaluation in Swaziland. In 70 trials conducted in 5 SADC countries, ICGMS 42 has shown a yield advantage of 23% over the environmental mean yield, and the yield advantage is relatively consistent across environments. In Malawi and Zambia, ICGMS 42 has shown a similar yield advantage over the environmental mean yield. It could thus contribute significantly to food production and household food security in these countries, and we believe that it serves as a good example of how genetic enhancement can contribute to yield stability, sustainability of groundnut production, and to agriculture as a whole.

Sumario

ICGMS 42: uma contribuição a sustentabilidade da agricultura. *O amendoim é uma cultura importante na África Austral, mas os rendimentos são baixos e a sua produção tem sido, desde há muito, considerada não económica. Um importante objectivo dos programas do melhoramento do amendoim na região é de melhorar a produtividade do amendoim, mas garantindo que isto não é feito a expensas da sustentabilidade da agricultura. O melhoramento dos cultivares é, possivelmente, o método do melhoramento da produtividade mais barato, mais confiável, e mais seguro para o ambiente.*

ICGMS 42, uma linha avançada do melhoramento do amendoim, desenvolvida pelo ICRISAT, teve um bom comportamento em ensaios conduzidos na África Austral desde 1983/84, e foi libertada para cultivõ no Malawi e na Zambia. ICGMS 42 foi também seleccionada para avaliaçãõ em pleno campo na Súazilandia. Em 70 ensaios conduzidos em 5 países do SADC, ICGMS 42 mostrou vantagens no rendimento na ordem dos 23% acima dõ rendimento médio do ambiente, e a vantagem no rendimento é relativamente consistente nos vários ambientes. Em Malawi e Zambia, o ICGMS 42 mostrou uma vantagem do rendimento sobre a média ambiental semelhante. Assim, em média, nesses países, o ICGMS 42 pode contribuir significativamente para a produçãõ dos alimentos e para a segurança alimentar da familia, e acreditamos que o ICGMS 42 serve como um bom exemplo de como o melhoramento genético pode contribuir para a estabilidade do rendimento, sustentabilidade da produçãõ do amendoim, e para a agricultura no seu todo.

1. SADC / ICRISAT Groundnut Project, P 0 Box 1096, Lilongwe, Malawi.
2. Chitedze Agricultural Research Station, P 0 Box 158. Lilongwe, Malawi.
3. Msekera Regional Research Station, P 0 Box 510089, Chipata, Zambia.

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Introduction

Groundnut is of major importance to smallholder farmers in southern Africa and is the main legume grown in large areas of Angola, Malawi, Mozambique, Tanzania, Zambia, and Zimbabwe. It is not only the principal source of protein and oil but also a major source of smallholder cash income. Producing groundnut in southern Africa has long been considered uneconomic, due to low prices and high production costs. Increased productivity would improve the profitability of groundnut, resulting in increased area grown, improved food supply and cash earnings, and a higher proportion of legume in the cropping system.

It is therefore important to improve productivity of groundnut. However, it is not sufficient merely to increase productivity and yields; it must be ensured that in doing so, degradation of natural resources is arrested, and that soil and water resources are conserved and improved. Bosemark (1993) suggested that better adapted crop varieties are the cheapest, most reliable, and environmentally safest way to increase productivity and secure the worlds' food supply.

In this paper we discuss how genetic enhancement and the development of improved cultivars can contribute to the stability and sustainability of groundnut production. We report on the performance of one cultivar, ICGMS 42, that has shown wide adaptability in the southern Africa region.

Adaptation

The lack of suitable varieties, adapted to the many and varied agroecological conditions, with acceptability for various preferences and end uses, has long been considered a major constraint in southern Africa. Considerable research effort has been directed at cultivar improvement. National groundnut breeding programs in some southern African countries have made considerable progress in catering to this need. A number of cultivars have been introduced or developed locally, and have been released for cultivation.

Some countries in the region have the potential for exporting confectionery-grade groundnut. Recently, however, exports have declined drastically due to a decline in production and difficulties in maintaining continuity of supply. At the same time, standards required by importing countries with respect to oil quality and aflatoxin contamination have become more stringent.

In most countries, virginia-type cultivars cannot be grown without irrigation, but in the plateau areas of central Malawi and in the Eastern Province of Zambia the rainy season is usually long enough to grow such cultivars without irrigation. Virginia cultivars are the most suitable for confectionery use, and are suited to smallholder production in these countries.

Origin of ICGMS 42

ICGMS 42, also known as ICGV-SM 83708, was selected from a cross between USA 20 and TMV 10. The cross was made at ICRISAT Asia Center, Patancheru, India, and introduced by the SADC / ICRISAT Groundnut Project as an advanced breeding line in 1982. The breeding line was numbered ICGMS 42 and was entered in six regional trials in Malawi, Mozambique, Zambia, and Zimbabwe in 1983/84. It performed well in these trials and was selected for further evaluation in four regional trials in Malawi, Zambia, and Zimbabwe in 1984/85.

The potential of ICGMS 42 was soon recognized in a number of countries, and it was entered in national trials for further evaluation. In Malawi, during the 7-year period 1983/84 to 1989/90, ICGMS 42 outyielded all the Malawi standard varieties except in trials at Makoka (1987/88) and Chitala (1988/89) Research Stations. ICGMS 42 yielded 12% higher than the local control, and 29% higher than the trial mean in 25 trials at the Chitedze, Chitala, Makoka, and Meru Research Stations. In five of these trials, ICGMS 42 had a yield advantage of 13% over Chalimbana.

Release in Malawi and Zambia

On the basis of its performance in regional and national trials in Malawi, an application was made to the Variety Release Committee in 1990 for approval for the pre-release of ICGMS 42 in Malawi. Pre-release was approved in Jul 1990, and substantive release was approved in Sep 1990. The cultivar was subsequently named CG 7.

In Zambia, ICGMS 42 had a 13% yield advantage over Makulu Red in 19 trials at five locations over a period of 5 years (Syamasonta 1992). Consequently, an application was made to the Variety Release Committee in 1989 for approval for pre-release seed multiplication. Substantive release was approved in 1991 and the cultivar was named MGV 4.

Processors in Europe have confirmed that, although it has smaller seeds than Chalimbana, ICGMS

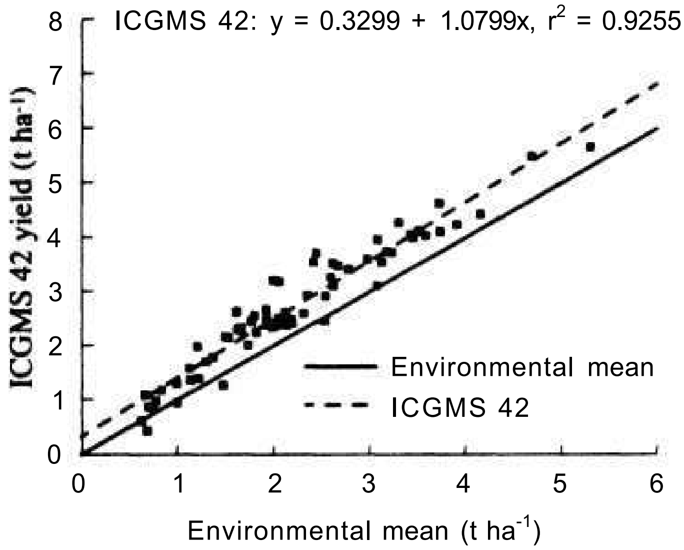

Figure 1. Performance of ICGMS 42 relative to environmental mean yield in 5 SADC countries, 1983/84 to 1993/94.

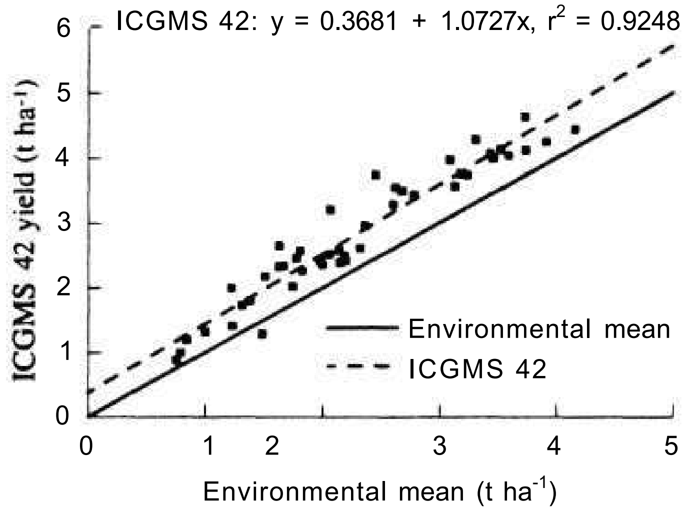

Figure 2. Performance of ICGMS 42 relative to environmental mean yield in Malawi, 1983/84 to 1993/94.

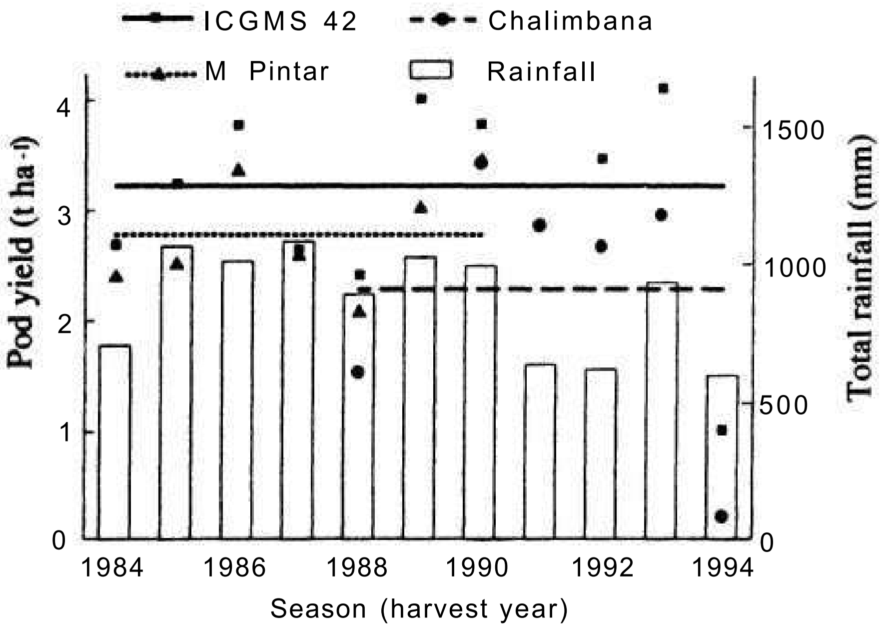

Figure 3. Performance of ICGMS 42 relative to local controls at Chitedze, Malawi, 1983/84 to 1993/94.

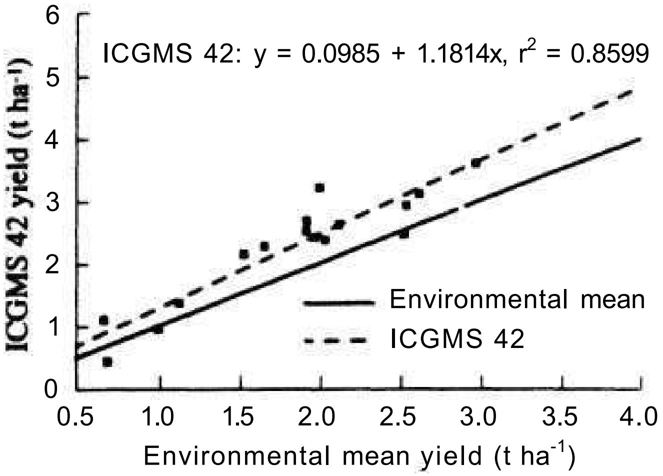

Figure 4. Performance of ICGMS 42 relative to environmental mean yield in Zambia, 1983/84 to 1993/94.

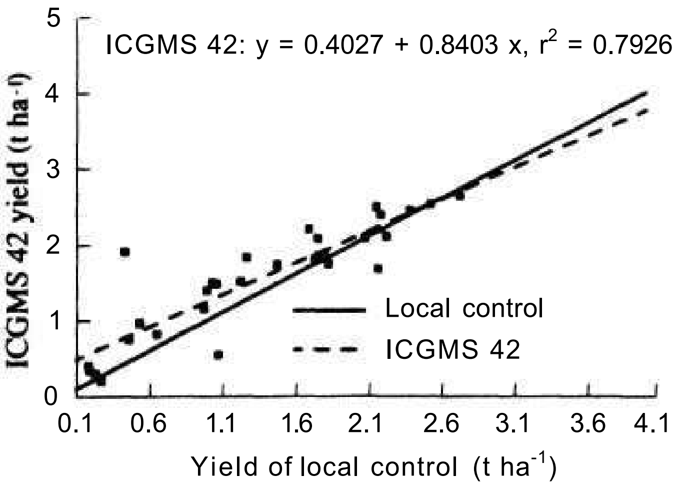

Figure 5. Performance of ICGMS 42 relative to local control, Zambia, 1983/84 to 1993/94.

42 is acceptable for confectionery use. In the absence of exportable surpluses of Chalimbana, processors have imported Florunner from the USA. ICGMS 42 is similar in seed size to Florunner, and has the potential to replace Florunner in this market. Of particular value are the uniformity of seed size and shape, and acceptable oil quality. The oleic / linoleic (O/L) fatty acid ratio of ICGMS 42 (1.8:1) is higher than that of any other cultivar released in Malawi.

Yield stability

ICGMS 42 has continued to perform well in a number of countries and has shown remarkable stability across environments. It has been evaluated in a total of 70 trials in five SADC countries since 1983/84. When compared to the trial mean, which is often used as an indication of the yield potential of a cultivar in a particular environment, ICGMS 42 has shown a yield advantage of 23% over the environmental mean (Fig. 1). In 45 trials conducted in Malawi since 1983/84, including one trial at Chitedze Agricultural Research Station during the drought in 1993/94, ICGMS 42 has shown a yield advantage of 23% over the environmental mean (Fig. 2). In trials conducted at Chitedze since 1983/84, it has shown greater stability across seasons than some of the local control cultivars (Fig. 3).

During the same period, ICGMS 42 was included in 16 trials in Zambia, where overall, it had a yield advantage of 23% over the environmental mean (Fig. 4). In 30 trials, for which only local control yield data were available, ICGMS 42 yielded 13% higher than the local control (Fig. 5). ICGMS 42 has also performed well in Swaziland, where it has been selected for on-farm evaluation.

Conclusions

In most of the cases cited, ICGMS 42 has yielded higher than the environmental mean or the local control. It would therefore contribute significantly to food production and household food security. We believe that this is an outstanding example of how genetic enhancement can contribute to yield stability and sustainability of groundnut production, and to agriculture as a whole.

References

Bosemark, N.O. 1993. The need for a comprehensive plant breeding strategy. Pages 525-533 *in* Plant breeding: principles and prospects (Hayward, M.D., Bosemark, N.O., and Romagosa, I., eds.). London, UK: Chapman and Hall.

Syamasonta, M.B. 1992. Groundnut production and research in Zambia. Pages 53-56 *in* Proceedings of the Fifth Regional Groundnut Workshop for Southern Africa, 9-12 Mar 1992, Lilongwe, Malawi (Nageswara Rao, R.C., and Subrahmanyam, P., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

The Role of Genetic Enhancement in the Sustainability of Groundnut Production

C M Busolo-Bulafu[1]

Abstract

*Groundnut (*Arachis hypogaea*) is the most widespread and has the potential of being the most important food legume in the world. It is the second most widely grown legume in Uganda, after beans. Demand has increased substantially because of an increased awareness of protein shortages in many developing countries. It is therefore desirable to develop improved varieties that can provide high yields on a sustainable basis. This paper briefly discusses the role that genetic enhancement can play in ensuring the sustainability of groundnut production.*

Sumario

***O papel do melhoramento genético na sustentabilidade da produção do amendoim.** O amendoim (*Arachis hypogaea*) é a leguminosa mais disseminada e tem o potencial para ser a mais importante leguminosa alimentar do mundo. É a segunda leguminosa mais cultivada no Uganda, logo depois do feijão. O uso do amendoim como cultura alimentar e de rendimento aumentou consideravelmente, devido ao aumento da sensibilidade para a carência das proteínas em muitos países em desenvolvimento. Assim, é desejável desenvolver variedades melhoradas do alto rendimento, que possam assegurar sustentabilidade do rendimento. De modo a conseguir altos rendimentos e qualidade, constrangimentos que limitam a produçãõ do amendoim devem ser enfretados. Este artigo discute brevemente o papel que o melhoramento genético pode ter na sustentabilidade da produçãõ do amendoim.*

Introduction

Groundnut *(Arachis hypogaea)* has been described as the most widespread and potentially the most important food legume in the world (Norden et al. 1982). In Uganda, it is the most widely grown grain legume after the common bean *(Phaseolus vulgaris).* However, several constraints lower or limit groundnut productivity and quality. These include: diseases (e.g., rosette virus, leaf spots, bacterial wilt, rust, and stem rot), pests (aphids, thrips, and termites), drought stress, long maturity periods, low soil fertility, and a lack of high-yielding varieties.

In many countries including Uganda, most of the varieties traditionally grown by farmers are landraces adapted more for survival than for high productivity. Yields from such varieties average 800 kg ha^{-1} compared to 2.5 t ha^{-1} obtained in countries with developed agriculture (Gibbons 1987). Genetic enhancement plays a crucial role in improving yields and ensuring the sustainability of production.

Groundnut breeders around the world are continuously trying to develop improved varieties with higher yields, pest and disease resistance, and tolerance to environmental stresses. To achieve these goals, the genetic base of the crop has to be widened

1. Serere Agricultural Research Institute, P O Soroti, Uganda.

Busoto-Bulafu, C.M. 1994. The role of genetic enhancement in the sustainability of groundnut production. Pages 24-25 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand, G.L., and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

using various methods. Genetic enhancement thus involves either adding new genes (from outside) to an existing genepool (which may be narrow), or creating variability using the existing genetic base through various methods.

Genetic variability

There are three basic sources of genetic variability that plant breeders can exploit: the hereditary differences that exist among cultivated cultivars, differences that may be created artificially through the use of mutagenic agents, and differences among the wild relatives of cultivated species. Material from these sources can be further manipulated to enhance the genetic base.

Germplasm collections and plant introduction

A germplasm collection is usually the starting point for any genetic enhancement program. It may be built up through collection expeditions or by obtaining material from other programs, networks, international institutes, etc. To allow its effective use, the collection must be sufficiently diverse and adequately cataloged: The germplasm must be stored and maintained either in low-temperature storage in genebanks or regenerated actively at suitable intervals.

Materials from such collections can be either released directly for cultivation, after evaluation and testing, or used in breeding programs to develop new, improved varieties. Several wild species have potentially promising roles in the genetic improvement of the groundnut cultigen, especially as sources of disease resistance.

Hybridization

Although groundnut is essentially self-pollinating, some out-crossing usually occurs, resulting in natural hybrids. This provides genetic variability, although it may affect genetic purity. Natural hybrids, when identified and evaluated, can be important in varietal improvement. However, most of the groundnut varieties grown commercially in many countries were developed through artificial hybridization. Variability created in this way is expected to be the main means of groundnut improvement in the future.

Mutagenesis

Genetic variability in groundnut resulting from the use of induced mutations has been reported. The advantages of induced mutations are that mutants can often be produced at high frequency, relatively quickly, and in selected genetic backgrounds. Several mutant groundnut varieties have been produced in various countries, especially in India and the USA (Gregory 1966).

References

Norden, A.J., Smith, O.D., and Gorbet, D.W. 1982. Breeding of the cultivated peanut. Pages 95-122 *in* Peanut science and technology (Pattee, H.E., and Young, C.T., eds.). Yoakum, Texas, USA: American Peanut Research and Education Society.

Gibbons, R.W. 1987. An international approach to peanut improvement. Proceedings, American Peanut Research and Education Society 9:97-10Q.

Gregory, W.C. 1966. Mutation breeding. Pages 189-218 *in* Plant breeding. Ames, Iowa, USA: Iowa State University Press.

Discussion

Subrahmanyam. How have ICRISAT-bred rosette-resistant lines performed in Uganda?

Busolo-Bulafu. We have tested them for two seasons. Several lines are performing very satisfactorily in terms of both yield and rosette resistance.

Selecting Groundnut Varieties for Southern Mozambique

M J Freire and M Botao[1]

Abstract

More than 120 varieties, both local and introduced, were tested in 65 varietal trials conducted during 1980/81 to 1991/92 in southern Mozambique, mainly in the provinces of Maputo and Inhambane. The data were analyzed using linear regression. Varieties were grouped based on biplot, using the intercept a as a measure of global performance and the slope b as a measure of stability. On the basis of this analysis, 10 varieties are recommended for the 'smallholder family sector' and 7 varieties for the 'modern sector'. Some varieties have been identified for use in the breeding program because they offer a low risk of total failure under poor environments, and have a high capacity to respond to additional inputs.

Sumario

A selecçãõ das variedades do amendoim para o sul do Moçambique. *Dados do periodo de 1980/81 a 1991/92, provenientes de mais de 120 variedades locais foram introduzidas, testadas em 65 ensaios realizados no sul de Moçambique, principalmente nas Provincias de Maputo e Inhambane, foram analisados com o uso do método de regressãõ linear. A comparaçãõ das variedades foi baseada na análise dum diagrama de dispersão, onde se usou a intersecçaõ como medida do Perfomance Global e o declive como medida de Estabilidade. A partir dos resultados, 10 variedades foram recomendadas para o sector familiar e 7 variedades para o sector moderno. Algumas variedades foram identificadas para uso no programa do melhoramento genético, devido ao seu baixo risco da perda total em ambientes pobres e pela sua alta capacidade de resposta a insumos adicionais.*

Introduction

From 1980/81 to 1991/92, 65 varietal trials were conducted in southern Mozambique, mainly in the provinces of Maputo (56 trials) and Inhambane (8 trials). More than 120 varieties, both local and introduced, were tested; each trial included between 4 and 36 entries. The experiments were conducted using randomized block and lattice designs, depending on the number of varieties, in conditions varying from rainfed to irrigated. A few trials were fertilized with superphosphate and some sprayed against pests and diseases. The soils varied from sandy to sandy-loams.

Apart from the variation already mentioned, the same set of varieties was not repeated more than twice. It was therefore not possible to analyze variation between years and locations using pooled ANOVA. The data from the environments (location x year) was analyzed using linear regression, with the objective of identifying and recommending suitable varieties adapted to the 'smallholder family sector' and the 'modern sector'. Two different methods were evaluated for their potential future use.

A Materials and methods

In order to compare all the varieties tested in the various trials, the variety means were regressed against an 'environment indicator'. The trial general

1. Faculty of Agronomy and Forestry Engineering, University Eduardo Mondlane, C P 257, Maputo, Mozambique.

Freire, M.J., and **Botao, M.** 1994. Selecting groundnut varieties for southern Mozambique. Pages 26-31 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand, G.L., and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

mean, and the mean of the cultivar Bebiano Branco (wherever it was tested) were used as environment indicators. Bebiano Branco was selected as an indicator because it is presently the only recommended variety for southern Mozambique, is well adapted to local conditions, was selected from a landrace, and is a good yielder.

To compare different varieties both the intercept a (global performance) and the slope b (stability) were used. For b a critical value of b - 1 was established. If b >1 the variety is unstable and responds well to improvements in the environment. Varieties with b <1 are more stable, and changes in the environment tend to cause little change in crop yield. It was also assumed that a good variety should have a high b (>1), especially if it is to be recommended for the 'modern sector'.

The critical value for global performance is a = 0; a can be considered an indicator of risk of total crop failure, a >0 indicates that in poor environments the variety still has the capacity to produce some yield. Varieties with a <0 face a higher risk of total failure in poor environments. As a basis for selection, it was assumed that the higher the (positive) value of a the better is the variety for the 'family sector'.

The next step was to plot all the computed values on a scatter diagram with a = 0 and b = 1 as axes. Four quadrants were defined as follows:

- Quadrant I (a >0, b >1) = varieties suitable for all 'sectors';
- Quadrant II (a >0, b <1) = varieties suitable for the 'family sector'.
- Quadrant III (a <0, b <1) = varieties to be discarded;
- Quadrant IV (a <0, b >1) = varieties suitable for the 'modern sector'.

Results and discussion

Tables 1 and 2 present the details of regression equations for selected varieties computed with both methods (Variety vs Bebiano Branco and Variety vs General Trial Mean) with at least 6 degrees of freedom. As the tables show, the independent variable used explains 70-95% of the observed variation in yield. The scatter diagrams (Figs. 1 and 2) show a tendency for the varieties to appear spread over an oblique strip, with a higher frequency in Quadrants II and IV, implying that there are not many varieties that can satisfy the needs of both the 'family' and the 'modern' sectors. Therefore, it can be inferred that, in general, varieties that can withstand poor environments and face lower risk of total failure do not respond well to improvements in the environment (e.g., fertilizer, sprays).

Because Bebiano Branco was not always included in the trials, the number of points from the General Mean method is larger, and thus more varieties can be evaluated.

In the scatter diagrams (Figs. 1 and 2) the points obtained from the Variety vs Bebiano Branco regressions are located at a slightly lower level than those obtained from Variety vs General Mean regression, implying that the first method is more selective. In reality, in the first method the axes are displaced to a higher point, leaving more material in, Quadrant III to be rejected and more in Quadrant IV (Table 3).

Table 1. Details of the regression equations Variety vs Bebiano Branco with six or more error degrees of freedom.

Variety	df	R^2 adj	Sign	Const (a)	b calc	Quadrant
Te 3	6	0.885	***	190.01	0.56	II
55 - 437	7	0.843	***	80.93	0.67	II
Valencia	10	0.853	***	126.14	0.81	II
Starr	10	0.872	***	30.04	0.90	II
Chinginguiri A	7	0.882	***	-70.26	0.97	IV, (III)
South East	6	0.702	**	-31.88	1.01	IV
Ah 139	8	0.926	***	-107.00	1.05	IV
B. Encarnado	15	0.914	***	-98.92	1.06	IV
Natal Comum	16	0.875	***	-110.41	1.12	IV

** significant at 1% level, *** significant at 0.1% level, df = error degrees of freedom, adj - adjusted, Sign - level of significance of R^2 adj, Const - constant, computed intercept, Calc = calculated.

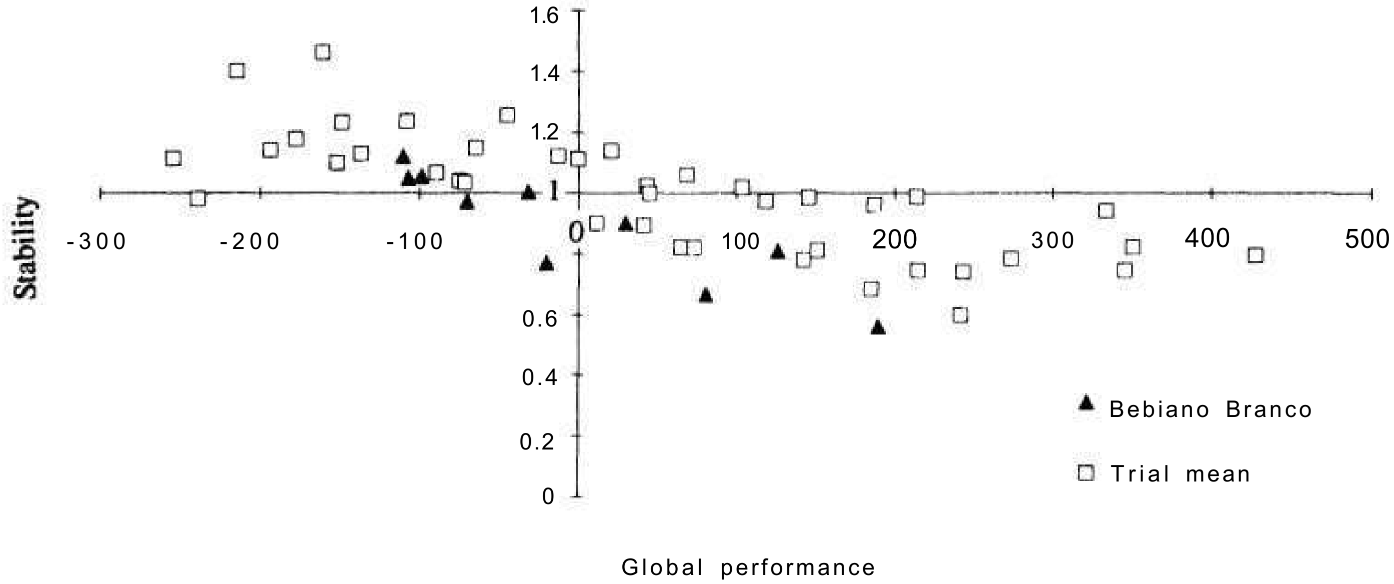

Figure 1. Grouping of groundnut varieties on the basis of calculated a and b values, with 6 or more error degrees of freedom.

It is noteworthy that, in Table 2, Bebiano Branco appears in Quadrant I, confirming its adaptation and the validity of its release for all farming sectors, and particularly the 'family sector'. The fact that Natal Comum appears in Quadrant IV with both methods confirms previous evidence showing that this variety is particularly suited to the 'modern sector', where high inputs are used.

In some cases a variety obtained different scores (i.e., was located in different quadrants) under the two methods. These cases occur either when the error degrees of freedom in the Variety vs Bebiano Branco method are fewer than six, or when the point is located near the axis (Tables 1-3).

Conclusions and recommendations

On the basis of the results the following conclusions and recommendations can be made:

- Both methods are useful, but Variety vs Bebiano Branco seems to be better for breeding purposes because it offers higher selectivity. Therefore, it is recommended that Bebiano Branco be included in all future varietal trials;

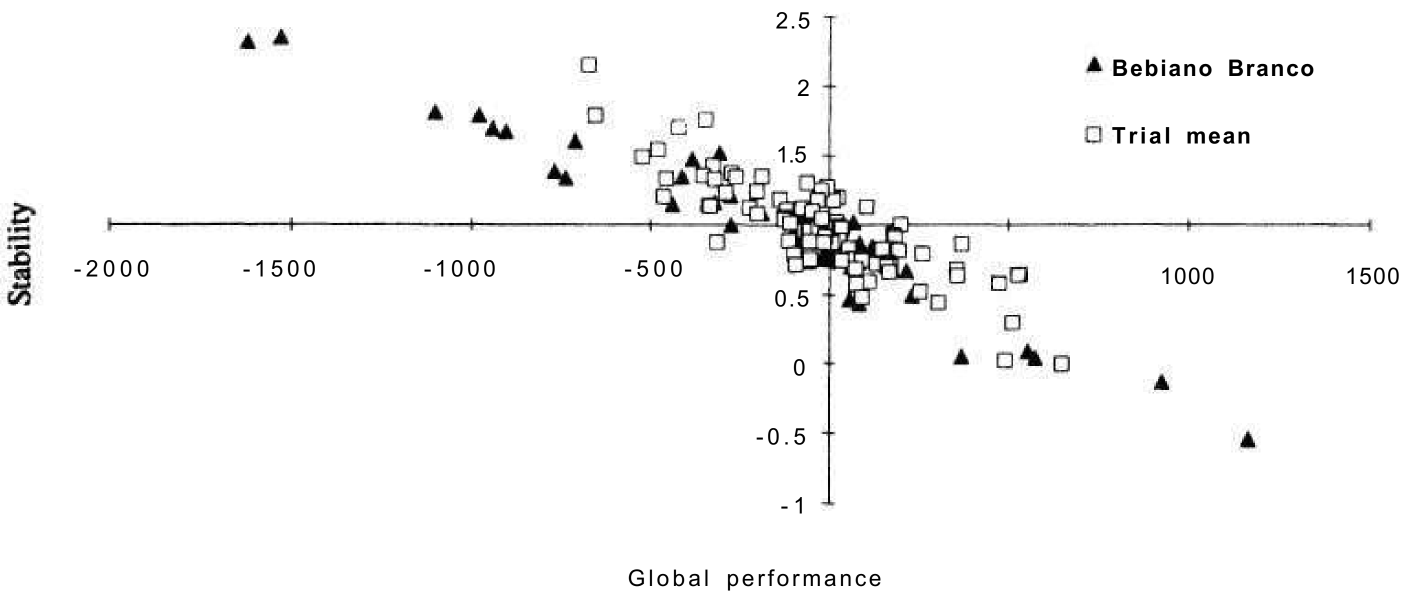

Figure 2. Grouping of groundnut varieties on the basis of calculated a and b values, with 2-5 error degrees of freedom.

Table 2. Details of the regression equations Variety vs Trial Mean with six or more error degrees of freedom.

Variety	df	R^2 adj	Sign	Const (a)	b calc	Quadrant
B. Branco	42	0.893	***	103.96	1.02	I
ICGMS 9	8	0.947	***	43.66	1.02	I
ICGM 285	10	0.740	***	68.76	1.06	I
B. Encarnado	17	0.925	***	0.01	1.11	I
Guipombo	6	0.942	***	21.20	1.14	I
Te 3	6	0.828	***	242.45	0.60	II
ICGM 189	8	0.461	*	243.63	0.74	II
Valencia	15	0.845	***	215.17	0.75	II
Kh 149 A	13	0.787	***	142.58	0.78	II
ICGMS 22	8	0.607	**	428.08	0.79	II
Starr	14	0.852	***	151.39	0.81	II
55 - 437	7	0.870	***	73.27	0.82	II
ICGM 286	9	0.377	*	350.97	0.82	II
Mafassane Br.	7	0.901	***	41.82	0.89	II
Morrumbene Br.	8	0.874	***	11.74	0.90	II
ICGMS 2	8	0.786	***	187.48	0.96	II
ICGM 284	9	0.646	**	118.75	0.97	I (II)
Malimba	10	0.745	***	145.78	0.99	I (II
ICGMS 21	7	0.800	***	214.20	0.99	I (II)
ICGM 522	6	0.841	***	44.91	1.00	II
ICGM 554	7	0.860	***	-238.47	0.98	IV (III)
ICGM 177	9	0.909	***	-71.79	1.04	IV
Chinginguiri A	9	0.943	***	-74.92	1.04	IV
Ah 139	10	0.945	***	-89.34	1.07	IV
ICGM 561	9	0.718	***	-254.07	1.11	IV
ICGMS 5	8	0.870	***	-12.73	1.12	IV
ICGM 525	8	0.695	**	-136.79	1.13	IV
ICGM 550	10	0.680	***	-193.38	1.14	IV
Natal Comum	16	0.930	***	-64.40	1.15	IV
ICGM 281	7	0.971	***	-177.26	1.18	IV
ICGMS 31	17	0.844	***	-148.90	1.23	IV
ICGMS 68	6	0.967	***	-108.32	1.23	IV
South East	6	0.735	**	-44.75	1.26	IV
ICGMS 12	6	0.905	***	-214.22	1.40	IV
ICGMS 11	8	0.909	***	-160.40	1.46	IV

** significant at 1% level, *** significant at 0.1% level, df - error degrees of freedom, adj - adjusted, Sign - level of significance of R^2 adj, Const - constant, computed intercept, Calc = calculated.

- Varieties with less than 6 error degrees of freedom, especially those falling in Quadrant I, require further testing before they can be analyzed as described above;
- Varieties Guipombo, Bebiano Encarnado, Malimba, ICGMs 284, 285 and 522, and ICGMSs 2, 9 and 21, tend to be well adapted to southern Mozambique and have high yield potentials, at least similar to that of Bebiano Branco;
- In general, local varieties and those provenient from ICRISAT (Southern and Eastern Africa Region) are the ones best adapted to conditions in southern Mozambique.
- Varieties Kh 149A, ICGM 286, ICGM 189, ICGMS 22, Starr, Morrumbene Branco, 55-437, Mafassane Branco, Valencia, and Te 3 are recommended for the 'family sector' because of the low risk of total failure;

Table 3. Comparison of the quadrant distribution of varieties with the two methods used (df = error degrees of freedom).

Variety	Yield (kg ha^{-1})	Base for regression			
		Bebiano Branco		Trial average	
		df	Quadrant	df	Quadrant
55-437	676	7	II	7	II
Te 3	704	6	II	6	II
Valencia	900	10	II	15	II
Starr	900	10	II	14	II
Mafassane Branco	1046	2	II	7	II
Morrumbene Branco	1075	4	II	8	II
Chinginguiri A	1031	7	IV (III)	9	IV
ICGMS 9	1012	3	IV	8	I
B. Encarnado	1046	15	IV	17	I
Guipombo	1488	4	IV	6	I
ICGM 522	997	2	IV	6	II
ICGMS 2	1097	3	IV	8	II
ICGMS 21	1179	3	IV	7	I (II)
South East	792	6	IV	6	IV
Natal Comum	842	16	IV	16	IV
Ah 139	1003	8	IV	10	IV
ICGMS 5	1049	2	IV	8	IV
ICGMS 68	1067	2	IV	6	IV
ICGMS 31	1095	4	IV	17	IV
ICGMS 11	1113	2	IV	8	IV
ICGMS 12	1156	2	IV	6	IV
B. Branco	934			42	I
ICGM 285	1133			10	I
Kh 149 A	938			13	II
ICGM 284	1039			9	I (II)
ICGM 189	1058			8	II
Malimba	1061			10	I (ID
ICGM 286	1244			9	II
ICGMS 22	1257			8	II
ICGM 554	844			7	IV (III)
ICGM 561	870			9	IV
ICGM 550	1043			10	IV
ICGM 177	1052			9	IV
ICGM 525	1091			8	IV
ICGM 281	1122			7	IV

- ICGMSs 11, 12, 31, and 68, South East, ICGM 281, and Natal Comurn are recommended for the 'modern sector' because of their high b values. ICGMs 177, 525, 550, 554, and 561, ICGMS 5, Ah 139, Chinginguiri A, and Bebiano Encarnado can also be included in this group although they have b values slightly lower than the previous varieties;
- In order to have another base for comparison and because of its general performance, Natal Comum is recommended for inclusion in all future varietal trials together with Bebiano Branco;
- Starr, 55-437, Valencia, and Te 3 are recommended for use in breeding programs as sources of low risk of total failure. Bebiano Encarnado, Natal Comum, and South East are recommended for use as sources of high capacity to respond to inputs.

Reference

Botao, M. 1994. Selecao de Variedades de Amendoim (*Arachis hypogaea* L.) para o Sul de Mocambique, a partir de ensaios nao repetidos, 1980/81-1991/92. Thesis of *Licenciatura.* Faculty of Agronomy and Forestry Engineering, University Eduardo Mondlane.

Discussion

Subrahmanyam. What do you mean by low risk of total failure? Is it only against drought or other stress factors also?

Freire. It refers to low risk under low-input conditions. The stresses may include drought and other yield-reducing factors (e.g., diseases).

Hildebrand. Did disease resistance (of some ICGM lines) contribute to the adaptation of these lines in your trials?

Freire. It is hard to say, since the trials were conducted under widely differing levels of disease, drought, inputs, etc. However, the resistance is likely to have contributed to stability.

Swanevelder. I am not clear whether the variety you used is Natal Common, or a more recent selection, or even Sellie. Natal Common was replaced by Sellie around 1977. Subsequently, mixtures were available until we introduced a scheme for certified seed. Seed obtained from South Africa after about 1983 will be Sellie, although it may have been despatched in containers marked Natal Common!

Freire. I am not sure. The cultivar we used has been grown in Mozambique for some time, perhaps before Sellie was released; I do not know the exact dates.

Selecting Groundnuts for Adaptation to Drought under Rainfed Conditions in Botswana

G S Maphanyane[1]

Abstract

Groundnut breeding lines selected for adaptation to drought stress under rainfed conditions were included in multilocational trials in Botswana for several years to compare their performance with that of locally-grown cultivars. The largest variation across locations and years was environmental, with minimal variation due to genotype and GxE interaction. All genotypes responded to changes in environmental conditions, with an indication that seasonal rainfall patterns were important in determining genotypic performance under rainfed conditions. Selection for drought adaptation under rainfed conditions, though commonly practiced, could be misleading, since it may not reflect the ability of the genotype if the stress occurs during the critical stages of plant development. More efficient selection would require simulated drought conditions, and the use of other indirect selection methods that give a good indication of drought adaptation.

Sumario

Selecção do amendoim para a adaptação à seca em condições de sequeiro no Botswana. *Linhas melhoradas do amendoim, seleccionadas pela sua adaptação ao stress hídrico em condições de sequeiro, foram incluidas em ensaios multilocais durante vários anos, para a comparação do seu comportamento com o e dos cultivares localmente cultivados. Os resultados indicam que a maior parte da variaçäõ entre locais e anos é causada pelo ambiente, com uma variação minima causada pelos genótipos e pela interaccäõ G × E. Todos os genótipos responderam a mudançäs nas condiçöẽs ambientais, indicando que os padröes sasonais das chuvas são importantes na determinação do perfomance genitípico em condições de sequeiro. A selecçäõ para a adaptação à seca em condições de sequeiro, embora seja normalmente realizada, não é apropriada, uma vez que pode não reflectir a habilidade dos genótipos, se o stress ocorre nos periodos críticos do desenvolvimento da planta. Uma selecçäõ mais eficaz requer a simulação das condiçöẽs de seca e o uso de métodos indirectos da selecção, os quais däo uma boa indicaçäõ da adaptação à seca.*

Introduction

Traditional groundnut production in Botswana was characterized by highly diverse populations and mixed cropping, both of which reduced the effects of biotic and abiotic stresses. These systems have changed drastically due to the introduction of high-yielding varieties to enhance the value of groundnut as a cash crop and increase uniformity in pod type and seed size, and thereby promote mechanized groundnut processing. As a result, the heterogeneity that was characteristic of traditional landraces has been lost, thus reducing the diversity that may have contributed to the sustainability of traditional systems.

1. Department of Agricultural Research, Private Bag 0033, Gaborone, Botswana.

Maphanyane, G.S. 1994. Selecting groundnuts for adaptation to drought under rainfed conditions in Botswana. Pages 32-36 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand, G.L., and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

In many parts of Botswana, the major constraint to groundnut production is limited moisture due to intermittent drought that sometimes occurs at the critical stages of plant development. Other problems associated with drought are sprouting due to lack of dormancy (which is accelerated by premature drying due to drought), termite damage, and late maturity if the growing season is reduced by poor rainfall distribution or late onset of rains. Often, the result is severe yield reduction or even complete crop loss.

Presently, direct methods of improving the environment for better production under drought conditions are limited to the provision of irrigation, but the long-term sustainability of this method is questionable, especially where underground water is used for irrigation. Groundnut yields as high as 3-4 t ha^{-1} have been reported under irrigated conditions in Botswana (MADAR 1991, 1992, 1993). However, for small farmers who are the major groundnut producers, irrigation is limited by lack of resources.

An alternative approach to ensuring the sustainability of groundnut production in low-rainfall areas is to breed varieties specifically for acceptable yield under low-moisture conditions. There is also a need to incorporate traits that will alleviate the associated problems that presently cause crop losses and reductions in yield.

Since 1986, breeding efforts in Botswana have been directed at combining drought tolerance, seed dormancy, and earliness. The objectives were to breed for:

- Physiological and morphological adaptation to drought, using a wide genetic background of parents with traits that confer drought tolerance (e.g., diverse root systems, maintenance of membrane integrity under heat stress, and ability to withstand moisture stress under field conditions);
- Earliness as a drought-escape mechanism, using the popular short-duration cultivar Chico (105 days to maturity in this environment) as one of the parents.

In addition, seed dormancy was to be incorporated into short-duration varieties, to prevent premature sprouting with end-of-season rains.

Population development

Several varieties selected for drought adaptation and good yield were crossed with each other to create a population with a diverse genetic background (MADAR 1988). Some of the characters considered were: earliness, extensive root system, ability to maintain kernel quality (without reference to yield) under drought conditions, and yield superiority over locally grown varieties. This was followed by field selection for several generations.

Selection approach

Selection was done under field conditions, which represented a drought-stressed environment due to frequent intermittent drought in Botswana. Because of a lack of manpower and equipment to measure physiological and morphological characteristics indicative of drought tolerance, selection was based on grain yield under rainfed conditions. Although the crop was exposed to a combination of stresses, it was assumed that water stress was the main reason for low yield. The resulting breeding lines were subsequently evaluated in multilocational trials for several years.

Results of selection

Analysis of variance was performed on the trial data. The results indicated that the largest variation across years was environmental (87%), with the genotypes contributing only 1%, and Genotype x Environment (G x E) interactions 4%. However, the differences among the genotypes and G x E interaction were not significant. The breeding lines performed at the same level or slightly better than the locally grown varieties (Sellie and 55-437), and responded to seasonal changes in the same way (Table 1).

Sowing date in relation to the seasonal rainfall pattern seems to be important in determining varietal performance (Fig. 1). Deviations from the normal seasonal pattern that caused drought stress to coincide with the critical stages of plant development, resulted in poor performance by all genotypes. The problem with using the natural environment for selection is illustrated by the failure of all varieties in 1991/92 and 1992/93, irrespective of whether or not they were selected for drought tolerance. In essence, selection under rainfed conditions can give misleading results, because in years when rainfall is favorable, both 'drought-tolerant' and 'susceptible' varieties could perform similarly; while in unfavorable years, all varieties may tend to fail.

Similar responses were observed in a multilocational trial during the 1993/94 season (Table 2). Environmental variation was large (95%), with genotype contributing 4% and G x E interactions 9%. The performance of advanced breeding lines varied across locations in accordance with rainfall pattern — there

Table 1. Pod yield of genotypes selected for good performance at Sebele, Botswana, 1989-94.

	Pod yield (kg ha^{-1})					
Genotype	1989/90	1990/91	1991/92	1992/93	1993/94	Mean (kg ha^{-1})
Flower- 11	1277	2412	287	385	1882	1248
Sellie	1059	1868	97	387	1858	53
55-437	1123	2227	155	541	1874	1184
GC 8 -13	1351	1866	197	627	1901	1188
GC 8-35	1318	1998	114	433	1926	1157
S 45	1740	1804	102	694	1816	1231
S46	1532	1640	155	772	1880	1196
ICGS-31	1337	1663	-	479	1932	1056
Mean	1342	1935	142	540	1860	1164
Rainfall (mm)	233	497	138	215	344	285

Source: Ministry of Agriculture. Department of Agricultural Research

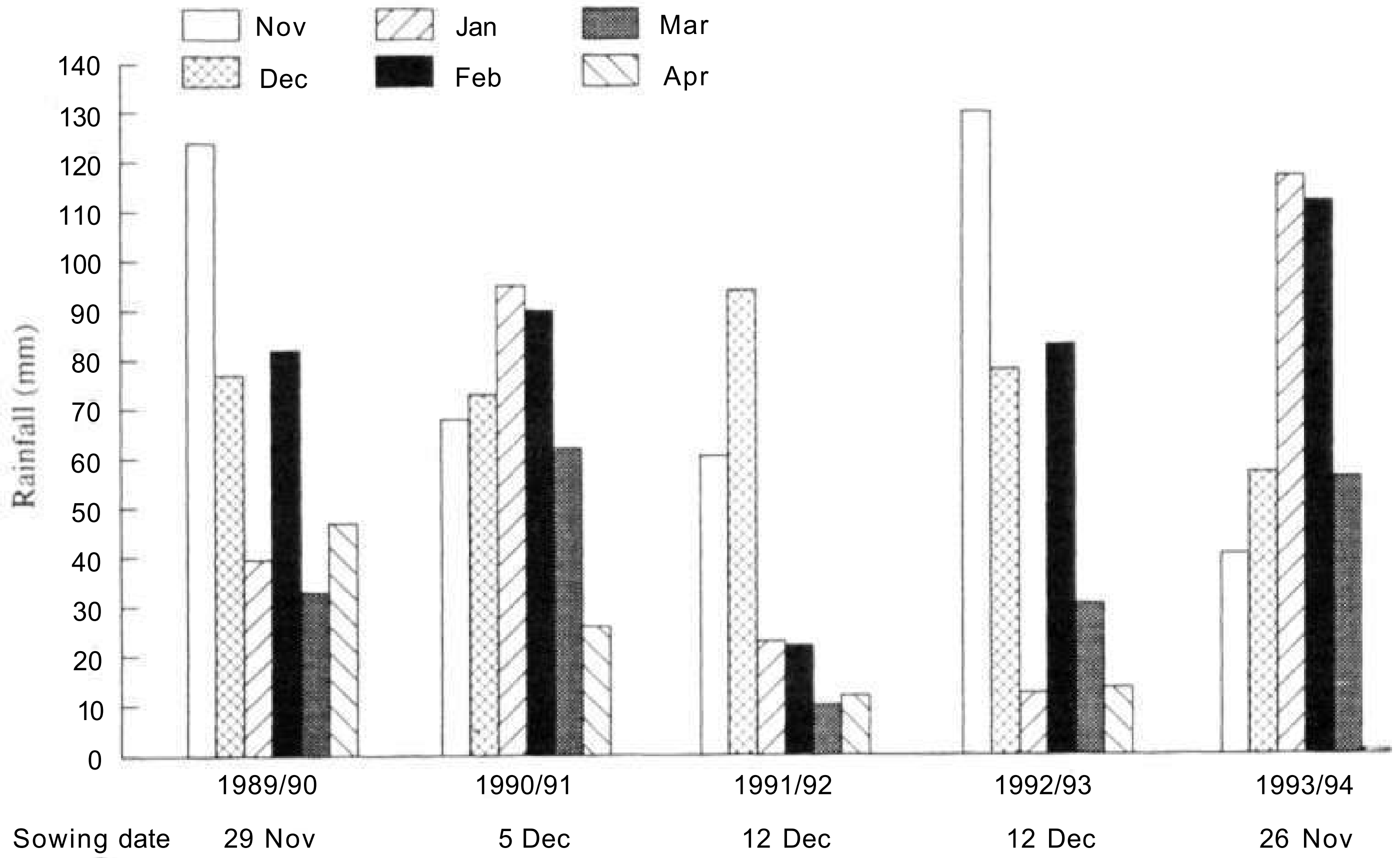

Figure 1. Seasonal rainfall distribution at Sebele, Botswana, 1989-94.

were no indications that genotypes selected for drought tolerance were superior in years of favorable rainfall (Table 2, Fig. 2).

The results also seem to indicate that during selection, the rainfall pattern in relation to sowing date was favorable, with no drought during the critical periods of plant growth, resulting in good performance. For better or more efficient selection, therefore, it is necessary to impose simulated drought conditions (especially during the critical growth stages) on the genotypes under trial, rather than relying merely on natural rainfed conditions.

Fussell et al. (1991) suggested that selection for drought tolerance should be targeted at the critical stages of crop development, since production under natural stress environment is not a good indicator of stress tolerance. This is in agreement with our results.

Table 2. Pod yield of genotypes selected for good performance under drought conditions across four locations, Botswana, 1993/94.

Genotype	Pod yield ($kg\ ha^{-1}$) Goodhope	Sebele	Mahalapye	Pandamatenga	Mean ($kg\ ha^{-1}$)
Flower-11	2300	1876	1015	719	1235
Sellie	2676	2064	812	359	1760
55-437	2465	1959	926	561	1406
GC 8 - 13	2308	1880	1011	712	1361
GC 8-35	2063	1757	1144	948	1513
S 45	2669	2061	816	365	1551
S46	2464	1958	927	562	1559
ICGS 31	2141	1796	1101	X72	1436
Mean	2386	1919	969	637	1478
(CV = 17%, SED = ± 375)					
Rainfall (mm)	454	384	205	544	397

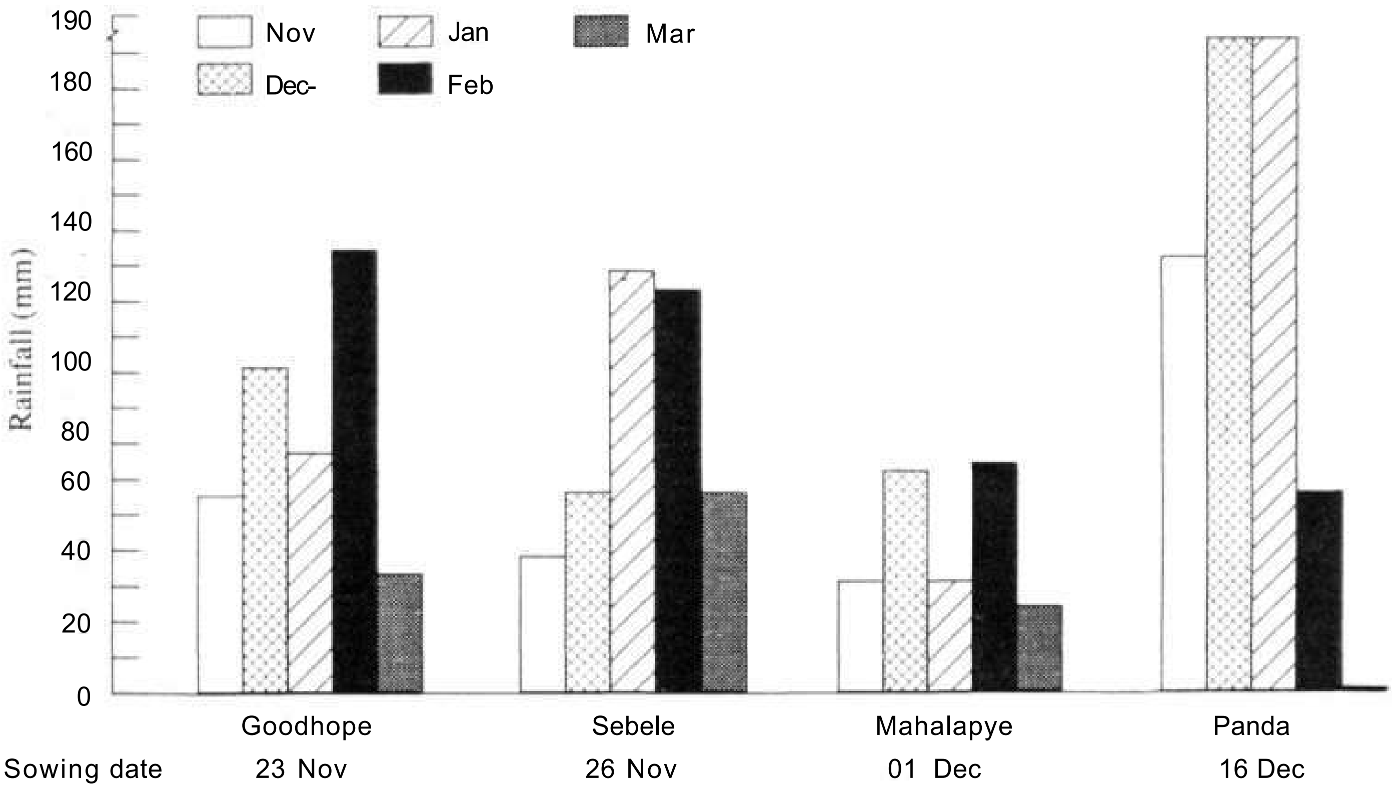

Figure 2. Rainfall distribution at four locations in Botswana, 1993/94 season.

Chapman ct al. (1993a,b,c) observed that the genotypes most responsive to changes in the environment are not necessarily productive under stress conditions. They suggested that high harvest index, early and rapid pod growth, and the pattern of sink establishment and continued peg elongation after stress is relieved, are some of the important indicators of yield under water deficiency.

To improve production under water stress, it might be necessary to select for early flowering while holding maturity duration constant.

Among the genotypes included in the trial, there was a 5-day reduction in maturity period with GC 8-13 and GC 8-35, which may be reflected in their performance across locations. Some of the genotypes have the potential for release for cultivation, and could provide farmers a choice of varieties that perform as well as or slightly better than locally grown ones.

Future strategy

Although there have been increased breeding efforts to address the problem of drought, selection for drought tolerance remains a problem because there are no simple traits that can be used for field screening and selection. Maintaining a wide genetic background will continue to be our strategy in population development. However, the selection approach has to change to incorporate simulated drought environment and other possible indirect selection methods, as suggested elsewhere (Fussell et al. 1991, Chapman et al. 1993a,b,c).

References

Ministry of Agriculture, Department of Agricultural Research (MADAR). 1988. Annual report 1988 for the Division of Arable Crops Research. Gaborone, Botswana: Goverment Printer. (Limited distribution.)

Ministry of Agriculture, Department of Agricultural Research (MADAR). 1991. Annual report 1991 for the Division of Arable Crops Research. Gaborone, Botswana: Goverment Printer. (Limited distribution.)

Ministry of Agriculture, Department of Agricultural Research (MADAR). 1992. Annual report 1992 for the Division of Arable Crops Research. Gaborone, Botswana: Goverment Printer. (Limited distribution.)

Ministry of Agriculture, Department of Agricultural Research (MADAR). 1993. Annual report 1993 for the Division of Arable Crops Research. Gaborone, Botswana: Goverment Printer. (Limited distribution.)

Chapman, S.C., Ludlow, M.M., Blarney, F.P.C., and Fischer, K.S. 1993a. Effect of drought during early reproductive development on growth of cultivars of groundnut (*Arachis hypogaea* L.). II. Biomass production, pod development and yield. Field Crops Research 32:211-225.

Chapman, S.C., Ludlow, M.M., Blarney, F.P.C., and Fischer, K.S. 1993b. Effect of drought during early reproductive development on the dynamics of yield development of cultivars of groundnut (*Arachis hypogaea* L.). Field Crops Research 32:227-242.

Chapman, S.C., Ludlow, M.M., Blarney, F.P.C., and Fischer, K.S. 1993c. Effect of drought during pod filling on utilization of water and on growth of cultivars of groundnut (*Arachis hypogaea* L.). Field Crops Research 32:243-255.

Fussell, L.K., Bidinger, F.R., and Bieler, P. 1991. Crop physiology and breeding for drought tolerance: research and development. Field Crops Research 27:183-199.

Discussion

Ndunguru. One of the reasons for the high adaptability of 55-437 is its tolerance to heat stress, and not necessarily to drought. This has recently been established at ICRISAT Sahelian Center (ISC) in Niger.

Chiyembekeza. I would like to hear from our colleagues in the Sahel how they have tackled the problem of drought.

Ntare. Drought is a serious problem in the Sahel. The end of the rainy season is fairly predictable in western Africa, but not the beginning. We are therefore trying to look at rainfall probabilities in order to determine when to sow. We look for genotypes that are more efficient in water use, rather than selecting for drought tolerance per se.

Ndunguru. The use of some of the simple techniques developed at ISC could also help drought tolerance work in southern Africa.

Freire. Can we conclude that by conducting a sufficiently large number of trials/tests we will eventually obtain a suitable drought-resistant variety?

Maphanyane. No. Increasing the number of trials would not address the basic problem; we would simply be continuing to select for normal conditions. We must find a way to impose drought stress during the critical stages.

Ntare. With such low rainfall (250-500 mm) in the groundnut areas in Botswana, do you think groundnut production will be sustainable? In some countries such as Senegal, farmers in low-rainfall areas have been advised to grow other crops, e.g., cowpea.

Maphanyane. Farmers grow groundnuts in such areas and will continue to do so even if advised otherwise, since groundnut is a major source of income. We will therefore continue to try and develop varieties adapted to these low-rainfall areas.

The Performance of ICRISAT Groundnut Germplasm at Sigaro, Zimbabwe

S Zengeni[1]

Abstract

A trial was conducted in the 1993 / 94 season to evaluate the performance of 10 groundnut varieties from SADC / ICRISAT under Zimbabwean conditions. The varieties were: ICGV-SMs 89001, 90006, 90007, and 90009, and ICGVs 86929, 86934, 87387, 87403, 87480, and 88332. Two other varieties (Natal Common and Makulu Red), selected for their good local performances, were included as controls. Six characters were studied: pod and seed yields, seed mass, seed color, days to maturity, and reaction to early leaf spot infection. Quality was also assessed, in terms of percentages of sound and mature, moldy, sprouted, shrivelled, and discolored seed. The main emphasis was on yield and its dependence on the other characters. ICGV-SM 89001 was the highest yielder, followed by Makulu Red. In general the ICRISAT varieties gave high yields, with higher seed mass than the controls. However, they showed higher percentages of moldy and shrivelled seeds. Cercospora infection was generally low in all genotypes except Natal Common, which was severely infected.

Sumario

***O Comportamento da germoplasma do amendoim do ICRISAT em Sigaro, Zimbabwe.** Um ensaio foi conduzido em 1993/94, para avaliar o comportamento das 10 variedades do amendoim, vindas do SADC/ICRISAT, em condições zimbabweanas. As variedades incluem ICGV-SMs 89001, 90006, 90007 e 90009, e ICGVs 86929, 86934, 87387, 87403, 87480 e 88332. Duas variedades 'locais' (Natal Common e Makulu Red) seleccionadas pelo seu bom comportamento no local, foram incluidas como controlo. Seis caracteristicas foram estudadas; rendimento da vagem e da semente, massa de 100 sementes, cor da semente, dias para a maturação e reacção à infecção pela mancha precoce da folha. A qualidade foi também determinada em termos da percentagem de sementes cheias, maduras, bolorentas, germinadas, enrugadas e descoloridas. Enfase foi colocado no rendimento e na sua dependência nas outras caracteristicas. ICGV-SM 89001 produziu os maiores rendimentos, seguido pelo Makulu Red. Em geral as variedades do ICRISAT tiveram altos rendimentos, com maior massa das sementes que as variedades locais. Contudo, elas mostraram maior percentagem de sementes bolorentas e enrugadas. Na maioria dos genótipos a infecção de cercospora foi baixa, exceptuando-se o Natal Comum, que foi severamente infectado.*

Introduction

The Zimbabwe Government Crop Breeding Institute (CBI) conducts research on groundnut breeding and germplasm development. In order to supplement their efforts, and especially in view of the financial and manpower constraints faced by the CBI, there is a need for tangible support from both private seed companies and international organizations like ICRISAT. The demand (domestic and regional) for high-quality

1. National Tested Seeds, P 0 Box 2705, Harare, Zimbabwe.

Zengeni, S. 1994. The performance of ICRISAT groundnut germplasm at Sigaro, Zimbabwe. Pages 37-40 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand, G.L., and Subrahmanyam. P., eds.). Patancheru 502 324, Andhra Pradesh. India: International Crops Research Institute for the Semi-Arid Tropics.

groundnut seed generally exceeds supply. National Tested Seeds sells groundnut seed to a variety of buyers in Mozambique and Angola. Our clients are interested in high-yielding varieties that are resistant to or tolerant of the biotic and abiotic stresses prevailing in these countries. It is in this context that groundnut varieties were sourced from the SADC / ICRISAT Groundnut Project in Malawi and tested at our facility at Sigaro farm.

The objective of the trial was to evaluate the performance of these varieties and compare them with two local controls, initially at Sigaro and later at other sites in Zimbabwe. The ultimate goal was to produce them commercially for areas where they would be suitable.

Materials and methods

Ten groundnut cultivars were obtained from the SADC/ICRISAT Groundnut Project: ICGV-SMs 89001, 90006, 90007, and 9009; and ICGVs 86929, 86934, 87387, 87403, 87480, and 88332. These were planted on 29 Oct 1993 at Sigaro farm, located 35 km from Harare. Two of our best-selling local varieties, Natal Common and Makulu Red, were included as controls in the trial.

The experiment was sown in a fairly uniform field at Sigaro farm, on red clay loamy soil. The environment was kept fairly uniform so that the variations observed would be largely due to genotypic differences.

The entries were sown in a randomized complete block design with three replications. Plot size was 7.2 m^2; spacings were 45 cm interrow and 15 cm within-row. There were four rows per plot, with a perfect stand of about 29 plants row^{-1} and 116 plants $plot^{-1}$. The estimated plant density was 163 000 ha^{-1}.

General agronomic practices included the application of compound D (8 N: 14 P_2O_5 : 7 K_2O) at a rate of 300 kg ha^{-1}. The fertilizer was broadcast and disced in deeply before plowing. Gypsum @ 200 kg ha^{-1} was applied along the tops of the rows at early flowering. Two guard rows surrounded the trial to reduce edge effects. The trial was hoe-weeded thrice during the growing period to keep it weed-free.

Results and discussion

The performance of the 12 varieties is summarized in Table 1. Both pod and seed yields were generally high. This could be attributed partly to favorable agronomic inputs and the availability of adequate moisture during the critical growth phases. ICGV-SM 89001 gave the highest yield, followed by Makulu Red. Natal Common gave a relatively low yield, ranking eighth. The yields recorded at Sigaro compare favorably with yield data of other ICRISAT genotypes that were evaluated in 1991/92 at the Agricultural Research Trust Farm, Zimbabwe (ICRISAT 1992), another area with high agricultural potential.

The varieties were assessed for quality in terms of percentages of sound and mature, moldy, sprouted, shrivelled, and discolored seed. There were relatively high levels of moldy and shrivelled seed, particularly in the ICRISAT genotypes. The high percentages of moldy seed may have resulted from high soil moisture regimes during the grain-filling stage.

Disease reaction to early leaf spot was estimated 65 and 110 days after sowing. Makulu Red showed the highest tolerance to early leaf spot while Natal Common was the most susceptible entry.

These results are preliminary; further evaluation is required. The ICRISAT varieties have been retained for this purpose, and will be evaluated at two sites in the 1994/95 season. In future trials, it may be appropriate to include more controls.

Acknowledgments

The author thanks Godfree Chigeza for technical assistance; special acknowledgement to Willie Ranby for permission to conduct the trials, and for his constant encouragement.

Reference

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). 1992. Report of results of SADC/ICRISAT Groundnut Variety Trials 1991/92. Lilongwe, Malawi: SADC/ICRISAT Groundnut Project. (Limited distribution.)

Discussion

Hildebrand. How many days after sowing was the ICGV-SM 89001 crop lifted? The low shelling percentage and poor grounding indicate that the cultivar may have been lifted too late.

Zengeni. I do not have the data available here.

Table 1. Performance of 12 groundnut varieties in a trial at Sigaro, Zimbabwe, main season 1993/94.

Variety	Pod yield (t ha-1)	Seed yield (t ha-1)	100-seed mass[1] (g)	Days to maturity	Mean ELS score[2] 65 DAS[3]	Mean ELS score[2] 110 DAS	Sound mature seed (%)	Moldy seed (%)	Sprouted seed (%)	Shrivelled seed (%)	Discolored seed (%)	Seed color
ICGV-SM 90006	4.17	2.32	64	124	2.0	3.0	51	22	0	17	10	Red
ICGV-SM 90007	3.01	1.48	61	128	2.0	3.3	41	36	1	13	9	Tan
ICGV-SM 90009	3.82	2.22	62	124	1.7	3.3	51	28	0	16	5	Tan
ICGV 86929	4.91	2.89	64	124	2.7	4.0	44	13	1	31	11	Tan
ICGV 86934	4.72	2.78	61	126	1.3	3.3	47	26	0	15	12	Tan
ICGV 87387	3.24	1.62	45	125	2.0	3.3	34	29	1	28	6	Tan
ICGV 87403	4.01	2.55	44	124	1.3	2.7	48	22	0	19	11	Red
ICGV 87480	4.86	3.13	45	124	2.3	4.3	49	18	0	24	9	Red
ICGV 88332	4.05	2.55	68	133	2.3	3.3	47	28	0	15	10	Tan
ICGV-SM 89001	6.02	3.96	66	133	1.7	3.3	41	20	2	32	5	Tan
Natal Common	4.63	2.53	41	124	3.7	5.0	66	10	11	8	5	Tan
Makulu Red	5.44	3.13	59	166	1.0	1.3	82	6	0	11	1	Red
SE (mean)	±0.176	±0.130	±1.7	±1.9								
Trial mean	4.41	2.59	56.8	129								
CV (%)	4.5	9	5.2	7								

1. 100-seed mass measured from a random sample of sound, mature seeds.
2. ELS = Early leaf spot, scored on a 1–5 scale, where 1 = no disease, 5 = 90–100% foliage damage.
3. DAS = days after sowing.

Chiyembekeza. Considering that irrigation was used, and that you applied compound D fertilizer and gypsum at flowering, can you explain why the shelling percentage for ICGV-SM 89001 was so low even though it gave the highest yield in the trial?

Zengeni. I am not very sure why, because this was the first season we conducted the trial.

Hildebrand. I suspect the genotype was harvested late, hence my question on lifting dates. Delayed harvest may have led to loss/deterioration due to the sprouting of mature pods, and immature pods would have contributed to the low shelling percentage.

Subrahmanyam. You have recorded a high percentage of moldy seed in some of the ICRISAT genotypes. Is this due to over-maturity?

Zengeni. Yes, it seems to be due to late lifting.

Groundnut Evaluation in Mozambique: Preliminary Results for the 1993/94 Season in Maputo Province

FJ Arias and M Libombo[1]

Abstract

Groundnut is the most important of the grain legumes grown in Mozambique. In 1993, it was defined as a priority crop, and research efforts, which began in 1991, were intensified. This report summarizes the field experimental work on groundnut carried out at the Ricatla Experimental Station in southern Mozambique during the 1993/94 season. The objective was to improve productivity by individual selection from the local cultivar Bebiano Branco, together with the screening of four nurseries from ICRISAT and one from South Africa. The trials were carried out under low-rainfall conditions on sandy loam soils.

Sumario

Avaliações do amendoim em Mozambique: resultados preliminarios, para a estação de 1993/94 na provincia do Maputo. *Amendoim é o mais importante leguminoso cultivado em Mozambique. Em 1993, o amendoim foi definido como a cultura principal, e os esforços da investigação que comecaram em 1991 foram intensificados. Esse relatório é un sumário dos ensaios do campo sobre amendoim realizados na Estação de Investigação em Ricatla, Sul de Mozambique durante a estação de 1993/94. Os objetivos erão o melhoramento da produtividade atravéz da seleção individual do cultivar local Bebiano Branco em conjunto com a avaliação de quatro sementeiras do ICRISAT e uma de Africa Austral. Os ensaios foram conduzidos nas condições da precipitação baixa nos solos arenosos com marga.*

Introduction

In Mozambique, groundnut occupies the largest area among the grain legumes. It is grown for food in southern Mozambique; in the northern parts of the country it is both a food and a cash crop. The crop is grown and managed almost exclusively (>98%) by the family sector, under rainfed conditions and with minimal inputs. Lack of seed is a major constraint.

In 1991, the Instituto Nacional de Investigacao Agronomica (INIA), Mozambique, initiated research on groundnut selection/breeding. In 1993, INIA defined groundnut as a priority crop, with a correspondingly greater research emphasis. INIA's research objectives are primarily to develop suitable varieties and economical cultural practices for smallholder farmers. This report summarizes the field experimental work on groundnut carried out at the Ricatla Experimental Station in southern Mozambique during the 1993/94 season. This work was conducted jointly by INIA, the Food and Agricultural Organization of the United Nations (FAO), and the SADC / ICRISAT Groundnut Project, Malawi.

The Ricatla Experimental Station, located 28 km north of Maputo, covers groundnut research for southern Mozambique. The soils at the station are very sandy loam soils, representative of the main groundnut areas in the region.

1. Legumes Programme. Instituto Nacional de Investigacao Agr6nomica (INIA). C P 3658, Maputo. Mozambique.

Arias, F.J., and **Libombo, M.** 1994. Groundnut evaluation in Mozambique: preliminary results for the 1993/94 season in Maputo Province. Pages 41-42 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru. B.J., Hildebrand, G.L., and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Research results for 1993/94

Although grain yields obtained on the experimental plots were low, as is expected for the soil type and the semi-arid environment, the results indicate clearly that the local variety Bebiano Branco might be a good genetic source to look at in the preliminary stages of the research program.

The results (of experiments and screening) presented here are preliminary. Although no definite conclusions can be drawn, we hope that this work will form a base for further research, and perhaps stimulate additional technical and logistic support from different organizations.

Field experiments

All field experiments were conducted under rainfed conditions. Trial no. 1 (individual plant selection, see below) had total of 126 mm rainfall during the growing cycle, while all other trials had only 102 mm. No fertilizers were applied. One preventive general spray of cypermethrin was applied at the ripening stage.

Individual plant selection. Eighty single plant progenies selected from Bebiano Branco, 7 from Chibanzo, and 13 from Inhambane Vermelho, were evaluated for grain and pod yields. The trial was sown in rows 3 m in length, with a spacing of 50 x 20 cm and two pods per site. The trial mean for grain yield (all progenies) was 91 g row^{-1} equivalent to 606 kg ha^{-1}. Average yield for five control rows of the original Bebiano Branco population was 90 g row^{-1}.

Nearly one-fourth of the progenies either did not germinate or showed poor germination. In the remaining lines, yields ranged from 20 to 238 g row^{-1}, and shelling percentage from 23 (in the line that gave the lowest yield) to 77%. Twenty lines that yielded 25% more than the average for control lines, will be tested in a replicated yield trial for further selection. The average shelling percentage was 56%, which is considered acceptable for these conditions. We conclude that from this genetic 'nucleus', further selections can be made that have the potential for cultivation under these poor conditions.

Grain yield evaluation of selected materials. Seventeen previously selected (first advance) lines of B. Branco and three new lines of red groundnut collected in Inhambane Province, were tested for grain yield. The trial had three replications. Plot size was four rows, 4 m in length, spacing 50 x 20 cm, with two pods per site. Inhambane Zinmenume (the red groundnut) was a runner type variety that flowered very late and produced no grain at all. In the remaining 19 lines yields ranged from 69 to 314 kg ha^{-1}, and shelling percentage from 34 to 63%. Yields were lower than in the previous trial, probably because of lower rainfall. Eight lines yielded above 200 kg ha^{-1}, and deserve further testing.

Screening of drought-tolerant genotypes. Twenty drought-tolerant genotypes were tested for grain yield on 8 m^2 plots. Spacing was 50 x 20 cm. Average seed yield was 227 kg ha^{-1}, which is not too bad for the environmental conditions of the trial. However, all varieties except B. Branco had small seeds and suffered from poor pod-filling, possibly as a result of water stress, calcium deficiency in the soil, or a combination of the two factors. This result raises doubts about the adaptability of these genotypes to the poor local environment. It was noteworthy that B. Branco was not affected as badly in these plots.

Screening of short-duration genotypes. Twenty-five short-duration genotypes were screened, using the same methodology as described above, but with plot sizes of 4 m^2. These genotypes performed similarly to the drought-tolerant genotypes. Grain yields in this trial ranged from 24 to 339 g $plot^{-1}$, and pod yields from 53 to 501 g $plot^1$.

South African varieties. A yield trial was conducted on six South African varieties (Jasper, Harts, Sellie, Agaat, Kwarts, and Robbie) contributed by the Southern African Regional Council for Conservation and Utilization of Soil (SARCCUS). There were four replications, and plot sizes were 8 m^2. All six varieties gave very poor quality grain, with yields of 64-98 kg ha^1; these varieties are obviously not adapted to the fragile environment in which they were tested.

Discussion

Swanevelder. Were the harvesting dates different in the different trials?

Libombo. Since the varieties had different maturity durations, the harvesting dates were different.

Busolo-Bulafu. Groundnut yields in Africa are often low; many people have obtained only 700-800 kg ha^{-1} on research stations. But your yields appear lower still. What were the growing conditions and soil types?

Libombo. The soil was poor and sandy, and the rainfall was low (163 mm). That was the main reason for the low yields.

Freire. Ricatla Research Station has probably the poorest soil of any research station in Mozambique. The soil is white sand dunes with very low organic matter content. The water table is about 5 m deep, leaving no possibility for plant roots to reach it.

Crop Protection

Integrated Disease Management: An Important Component in Sustaining Groundnut Production in the SADC Region

P Subrahmanyam and G L Hildebrand[1]

Abstract

A number of groundnut diseases have been reported from the Southern African Development Community (SADC) region, of which the most important are early and late leaf spots, rust, web blotch, and rosette. Integrated disease management, involving the combined use of several components—resistant genotypes, cultural practices, and the judicious use of chemicals—can effectively reduce disease severity and contribute to increased productivity and sustainability. In this paper we discuss the various options available for effective management of groundnut diseases, and the necessity to integrate these management options to achieve sustainable production in the region.

Control measures (including improved management practices) are available for many of these diseases, but are often not implemented due to sowing sequences, differential crop priorities, and limited land holdings. The most effective solution would be to develop genotypes with resistance to major diseases, and make these genotypes available to farmers. Groundnut genotypes with resistance to early and late leaf spots, rust, rosette (both long- and short-duration genotypes), and aflatoxin contamination are available at the SADC I ICRISAT Groundnut Project for regional evaluation.

Sumário

Um maneio integrado das doenças: um componente importante para suster produção do amendoim na região de SADC. *Certas doenças do amendoim foram reportadas da região de SADC, das quais as mais importantes são mancha temporá, mancha tardia, ferrugen, e roseta. Um maneio integrado das doenças envolvendo um uso combinado dos vários componentes—genótipos resistentes, praticas culturais e um uso judicioso dos químicos—pode efetivamente reduzir a severidade das docnças e contribuir num aumento da produtividade e sustentabilidade. Nesse artigo nós diseutimos as varias opções disponíveis para um maneio efetivo das doenças do amendoim e a necessidade de integrar essas opções para realizar uma produção sustentavel nessa região.*

Para muitas dessas doenças métodos do controlo (incluindo as praticas melhoradas do mancio) estão a dispor, porem não são implementados devido as seqüências de semeança e predios limitados.

A mais efetiva solução seria o desenvolvimento dos genótipos com resistência a mancha temporá mancha tardia, ferrugem, roseta (genótipos de longa e curta duração) e contaminação de aflatoxina estão disponíveis no SADC/ICRISAT Projeto do amendoim para avaliação regional.

1. SADC / ICRISAT Groundnut Project. P 0 Box 1096, Lilongwe, Malawi.

ICRISAT Conference Paper no. CP 959.

Subrahmanyam, P., and Hildebrand, G.L. 1994. Integrated disease management: an important component in sustaining groundnut production in the SADC region. Pages 45-50 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand, G.L., and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Introduction

Sustainable agriculture is the successful management of resources for agriculture to satisfy increasing food needs, while maintaining or enhancing the quality of the environment and conserving natural resources (TAC 1989). The traditional form of subsistence agriculture remained sustainable for generations in many parts of the world. However, because of rapid population growth and greater food demands, this system is no longer viable. More land was required for agriculture to meet the food requirements of the growing population. This has led to massive deforestation, degradation of arable land, and extensive loss of biodiversity. Intensive cultivation, faulty irrigation methods, unstable farming systems, indiscriminate use of chemicals (fertilizers and pesticides), all have adversely affected the productivity and stability of crop production. Although remarkable technological achievements have been made since the 1950s in increasing agricultural production, some of these technologies are not environment-friendly. Among other factors, the indiscriminate use of chemicals to control pests is a serious threat to the environment.

In recent years, there has been considerable emphasis, in both developed and developing countries, on the use of integrated pest management (IPM) strategies for sustaining agricultural production. These strategies involve host-plant resistance, cultural practices, the judicious use of chemicals, especially botanical pesticides, and biological control agents. In this paper we discuss the various options available for effective management of groundnut diseases, and the necessity to integrate these management options for achieving sustainable production in the Southern African Development Community (SADC) region.

Groundnut diseases in the SADC region

Diseases are regarded as major constraints to the production of groundnut (*Arachis hypogaea)* in the SADC region. A large number of groundnut diseases have been reported from the region. Most of these diseases are widespread, but only a few are economically important on a regional basis (Subrahmanyam 1991).

Early leaf spot. Early leaf spot (*Cercospora arachidicola* Hori.) (ELS) is the most serious and destructive groundnut disease in the region. It is widely distributed and occurs in epidemic proportions in most groundnut-producing countries. Yield losses are generally substantial (Subrahmanyam et al. in press). For instance, in Malawi, mean annual production losses due to ELS alone are estimated at about US$ 5 million (Babu, Subrahmanyam, and N'gongola, unpublished).

All the groundnut cultivars grown in the region are susceptible to ELS. Considerable effort has been directed at fungicidal control of the disease (Chiteka et al. 1992), while progress in breeding for resistance has been slow due to a lack of adequate resistance levels in the available germplasm. The SADC / ICRISAT Groundnut Project in Malawi has recently identified some high-yielding genotypes with resistance to ELS; these genotypes are available for evaluation in the region. Fungicidal control, using either one or two sprays of chlorothalonil, was found to be economical and very effective. Crop rotation and early sowing are effective in delaying disease onset and reducing disease severity (Subrahmanyam et al. in press).

Late leaf spot. Late leaf spot (*Phaeoisariopsis personata* (Berk, and Curt.) v. Arx) occurs mainly in low-altitude areas, and is economically important in the Lake Shore and Shire Valley areas of Malawi, in coastal southern Tanzania, southern Mozambique, Swaziland, and Zambia (Subrahmanyam 1991). Several high-yielding, resistant breeding lines have recently been identified by the SADC/ICRISAT Groundnut Project, and are available for evaluation. Chemicals that are effective against ELS are also effective in controlling late leaf spot. As with ELS, crop rotation and early sowing are effective in delaying disease onset and reducing disease severity (McDonald et al. 1985).

Rust. Rust, caused by *Puccinia arachidis* Speg., occurs sporadically in several countries in the region, along with late leaf spot, mainly in low-altitude areas (Cole 1987). Fungicides such as chlorothalonil are very effective in controlling rust and other foliar diseases. Several high-yielding, rust-resistant breeding lines have recently been identified at the SADC/ICRISAT Groundnut Project, and are available for evaluation in the region. Groundnut rust is short-lived in infected crop debris; it is therefore desirable to have a clear break in time between successive groundnut crops, to reduce or eliminate viable inoculum. Volunteer groundnut plants and ground-keepers should be eradicated to eliminate the primary sources of inoculum (Subrahmanyam and McDonald 1983).

Web blotch. Web blotch (*Phoma arachidicola* Marasas, Pauer and Boerema) has been reported in Angola, Lesotho, Malawi, Swaziland, Zambia, and Zimbabwe. It is one of the most important foliar diseases of groundnut in Zimbabwe, where it occurs mainly on long-duration crops. Yield losses of about 40% due to combined attacks of web blotch and leaf spots (especially ELS) have been reported in Zimbabwe.

Web blotch can be controlled by using certain fungicides (e.g., procymidone and tebuconazole), but a large number of sprays is required for effective control. Several sources of resistance have been identified, and high-yielding breeding lines (e.g., C 346/5/8, C 347/5/6, and P 105/3/7) incorporating this resistance have been developed in Zimbabwe. Crop rotation and the eradication of infected crop debris and volunteer groundnut plants may be useful in eliminating the primary sources of inoculum (Subrahmanyam et al. 1994).

Seedling diseases. Seedling diseases caused by a variety of seedborne and soilborne fungi—*Aspergillus niger* van Tieghem, *A. flavus, Rhizoctonia solani* Kuhn, *Macrophomina phaseolina* (Tassi.) Goid, and species of *Rhizopus, Pythium,* and *Fusarium*—are widespread and important in almost all countries in the region.

Seedling diseases can be effectively and economically controlled by seed dressing with fungicides. Adequate information is available on the use of fungicides (e.g., thiram, captan, mancozeb, and benlate) in the region. Only high-quality seed should be used. Deep sowing should be avoided, as etiolated seedlings are more susceptible to infection. Deep plowing and crop rotation are useful in reducing disease incidence.

Groundnut rosette. Rosette is widely recognized as a major constraint to groundnut production in the region. Disease epidemics are sporadic, but can cause yield losses approaching 100% when they do occur (Bock 1987). Sowing as early as possible after the onset of the rains, and at optimum population densities, can effectively control groundnut rosette. The eradication of ground-keepers and of volunteer groundnut plants can help to prevent the perpetuation of virus inoculum during the off-season. Intercropping groundnut with other crops decreases rosette incidence. Excellent progress has been made in developing high-yielding, rosette-resistant, long-duration genotypes (Chiteka et al. 1992). Recently, several resistant short-duration genotypes have been developed at the SADC/ICRISAT Groundnut Project, and are available for evaluation (Hildebrand et al. in press).

The options available for the management of various groundnut diseases are listed in Table 1.

Integrated Disease Management

The effective management of diseases is important if stability and sustainability of groundnut production is to be achieved in the SADC region. Integrated disease management (IDM) is believed to be the most productive, equitable, stable, sustainable, and environment-friendly means to that end. It involves several components—resistant genotypes, cultural practices, and the judicious use of chemicals—which, when used in combination, should prove highly effective in reducing disease severity and contribute to increased productivity.

The relative emphasis on the use of various IDM components varies with the disease. For instance, seedling diseases can easily be controlled by using good-quality seed treated with a suitable chemical before sowing; host-plant resistance is less of a priority. Rosette can be controlled using host-plant resistance; resistant genotypes sown early at optimum population densities will show reduced disease incidence and provide higher yields.

Considerable research effort has already been directed at chemical control of foliar diseases, especially in Malawi, Swaziland, Tanzania, Zambia, and Zimbabwe. Chemical control is economical and very effective in optimum-rainfall situations or under irrigated conditions. However, a large number of sprays is needed to achieve satisfactory disease control. Fungicide control will not be economically feasible for resource-poor smallholder farmers in rainfed systems unless the number of applications is considerably reduced. Chemical control using a large number of sprays may also lead to negative returns in drought years (Subrahmanyam and Hildebrand, unpublished), with serious economic and sociological consequences. The cost and availability of chemicals and sprayers, and the risk of yield reduction associated with moisture stress in rainfed systems, have discouraged farmers from investing in chemical control. The indiscriminate use of chemicals leads to serious health and environmental hazards; repeated applications of certain chemicals may result in the evolution of fungicide-tolerant pathogen strains. In recent years, however, research conducted by the SADC/ICRISAT Groundnut Project and by the NARS in Zambia has shown that damage by groundnut foliar diseases can be considerably reduced by a single application of a suitable chemical.

Table 1. Options available for the management of various groundnut diseases in the SADC region.

Management option	Major disease (s) controlled[1]	Remarks
Presowing		
1. Crop rotation	ELS, LLS, WB, pod rots, seedling diseases, bacterial wilt, nematode diseases	Highly effective against various diseases. Improves soil fertility.
2. Break between successive crops	Rust	Eliminates or reduces viable inoculum.
3. Removal of volunteer groundnut plants	ELS, LLS, WB, rosette	May not be important in some countries because of grazing.
4. Removal of infected crop residues	ELS, LLS, WB	Cumbersome practice; may not not be very effective.
5. Deep plowing to bury infected crop residues	ELS, LLS, WB, stem and pod rots, charcoal rot	Suitable for mechanized farming.
6. Good drainage	Root and pod rots, bacterial wilt	Waterlogging intensifies disease incidence.
At sowing		
1. Selection of good quality seed	Seedling diseases	Handpicking of undamaged, mature, non-moldy seed.
2. Seed dressing	Seedling diseases	Treatment with suitable fungicides.
3. Optimum depth	Seedling diseases	Etiolated seedlings are vulnerable to infection.
4. Early sowing	ELS, LLS, rust, rosette	Highly effective in reducing disease incidence/severity.
5. Intercropping	ELS, LLS, rust	
6. Varietal mixture	LLS, possibly other foliar diseases	May not be suitable when produce is sold in commercial markets.
Post-sowing		
1. Optimum plant stand	Rosette	Can be achieved by selecting good quality seed, seed dressing, and sowing at optimum depth.
2. One spray of fungicide	ELS, LLS	Effective and economical; but chemicals and sprayers may not be available.
3. Resistant genotypes	ELS, LLS, rust, rosette, WB, AFL	High-yielding, resistant genotypes available.
4. Harvest at optimum maturity	Pod rots, AFL	Reduces incidence of pod rots and aflatoxin contamination.
5. Rapid drying	AFL	Sun drying.
6. Proper storage	Concealed damage, seed molds, AFL	Storage under damp-proof, insect-free conditions.

1. ELS/LLS = early/late leaf spot, WB = web blotch, AFL = aflatoxin contamination

Cultural practices such as crop rotation and early sowing can greatly reduce the severity of foliar diseases. However, these simple cultural practices remain largely non-implemented in the region due to sowing sequences, differential crop priorities, and limited land holdings. Groundnut is accorded relatively low priority in the sowing sequence in many countries in the region.

The most effective solution would be to develop genotypes with resistance to major diseases, and make these genotypes available to farmers. Groundnut genotypes with resistance to early and late leaf spots, rust, rosette (both long- and short-duration genotypes), and aflatoxin contamination are available at the SADC / ICRISAT Groundnut Project for regional evaluation.

References

Bock, K.R. 1987. Rosette and early leaf spot diseases: a review of research progress, 1984/85. Pages 5-14 *in* Proceedings of the Second Regional Groundnut Workshop for Southern Africa, 10-14 Feb 1986, Harare, Zimbabwe (Bock, K.R., Cole, D.L., Wightman, J.A., and Nigam, S.N., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Chiteka, Z.A., Cole, D.L., Freire, M.J., Mamba, Z.I., Mande, H.K., Marais, DJ.M., Mayeux, A., Moima, S.S., Mwenda, F.F., Rao, Y.P., Sibuga, K.P., Syamasonta, M.B., Schmidt, G., Hildebrand, G.L., and Subrahmanyam, P. 1992. Groundnut research in the SADCC Region, 1980-90. Pages 113-129 *in* Groundnut—a global perspective: proceedings of an International Workshop, 25-29 Nov 1991, ICRISAT Center, Patancheru (Nigam, S.N., ed.). Patancheru A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Cole, D.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, ICRISAT Center, India (McDonald, D., Subrahmanyam, P., and Wightman, J.A., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Hildebrand, G.L., Subrahmanyam, P., and Ndunguru, B.J. In press. Breeding for groundnut rosette disease resistance in southern Africa. *In* Proceedings of the First Crop Science Conference for Eastern and Southern Africa, 14-18 Jun 1993, Kampala, Uganda (in press).

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.

Subrahmanyam, P. 1991. Diseases of groundnut in the SADCC region. Pages 14-17 *in* Report of the First Steering Committee Meeting of the SADC/ICRISAT Groundnut Project, 16-17 Apr 1991, Lilongwe, Malawi. Lilongwe, Malawi: SADC/ICRISAT Groundnut Project. (Limited distribution.)

Subrahmanyam, P., Hildebrand, G.L., and **Ndunguru, B.J.** In press. Integrated management of early leaf spot of groundnut in the SADC region. *In* Proceedings of the First Crop Science Conference for Eastern and Southern Africa, 14-18 Jun 1993, Kampala, Uganda (in press).

Subrahmanyam, P., Hildebrand, G.L., Taber, R.A., Cole, D.L., Smith, D.H., and McDonald, D. 1994. Web blotch disease of groundnut. Information Bulletin no. 43. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics and Griffin, GA 30223, USA: Peanut Collaborative Research Support Program. 20 pp.

Subrahmanyam, P., and McDonald, D. 1983. Rust disease of groundnut. Information Bulletin no. 13. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 20 pp.

Technical Advisory Committee (TAC). 1989. Sustainable agricultural production: implications for international agricultural research. FAO Research and Technology Paper 4. Rome, Italy: Food and Agriculture Organization of the United Nations. 131 pp.

Discussion

Maliro. 1. Can spraying be dispensed with altogether in some years? This would require the development of disease models, which would help make decisions on spraying. 2. Was there any pattern in seed yields as related to spraying?

Cole, Subrahmanyam. The available disease models are not sufficiently accurate to be used as a basis for making decisions on spraying. Although spraying should undoubtedly improve yields, analysis of our data showed no clear patterns. For example, in 1993/94 sprayed plots in both Malawi (Subrahmanyam) and Zimbabwe (Cole) yielded *less* than unsprayed plots.

Zengeni. You mentioned the importance of plant density in disease management. What densities are recommended, and how will this reduce disease severity?

Subrahmanyam. Rosette disease incidence has been shown to be more severe where plant densities are below those recommended. Recommended plant densities depend on the cultivar grown, but spacings are generally 50 x 10 cm for short-duration, and 50 x 20 cm for long-duration genotypes. Seed quality and seed treatment are also important.

Ntare. Plant population is advocated as a means of reducing rosette incidence. What is the mechanism? Does plant density modify the microclimate, and therefore its suitability to the aphid?

Subrahmanyam. Reports in the literature confirm this. More widely spaced plants tend to support a higher concentration of aphids. Colonies are reduced in closely spaced plants.

Chavula. To what extent do farmers use seed dressing to improve germination and plant density?

Chiyembekeza. Farmers are reluctant to spend more money on seed dressing, or on any input that will increase the cost of growing groundnut.

Freire. In seed production, should rosetted plants be rogued to reduce further spread?

Subrahmanyam. In normal conditions rogueing is not advisable as the plants are often shaken; this may cause aphids to spread faster.

An Integrated Approach to the Management of Groundnut Diseases

M G Mpiri[1]

Abstract

Diseases contribute significantly to yield losses in groundnut: losses of up to 70% resulting from a combination of leaf spots (Cercospora arachidicola *and* Phaeoisariopsis personata) *and rust* (Puccinia arachidis,) *have been documented. Several control measures (e.g., host-plant resistance, chemical control) have been developed against various diseases. This paper argues for efforts that involve the use of several such methods in combination, after a careful ecological analysis of the disease problem and the field situation. This approach is more likely to be stable than efforts relying on a single technique. A practitioner must have at his disposal a range of appropriate technologies and adjust the mix according to his perception of the problem.*

Sumario

Método integrado para no maneio das doenças do amendoim. *As doenças contribuem significativamente para a redução o rendimento do amendoim. Perdas de até 70% resultando de uma combinação das manchas das folhas (*Cercospora arachidicola *e* Phaeoisariopsis personata*) e a ferrugem (*Puccinia arachidis*) foram documentadas. Medidas do controlo são necessárias para minimizar essas perdas e muitas têm sido desenvolvidas. Este artigo discute a necessidade de esforços que envolvam várias técnicas. Este método tem maior possibilidade de ser estável, que esforços dependendo de uma única técnica, caso os patógenos superem um particular método de controlo (ex. resistência da planta hospedeira, controlo químico). Embora uma cuidadosa análise ecológica dum um problema, tal como ele ocorre, seja necessária, também é necessária a compreenção de toda a complexidade da situação de campo. O agricultor deve ter à sua disposição uma variedade de técnicas apropriadas e ajustar o 'mix' cultural de acordo com a sua percepção do problema.*

Introduction

Diseases are among the major limitations worldwide to the production of groundnut (*Arachis hypogaea).* The two most widespread and serious diseases in southern Africa are early leaf spot (*Cercospora arachidicola)* and late leaf spot (*Phaeoisariopsis personata).* Individually or together they cause losses in pod yield of over 50%; and where rust (*Puccinia arachidis)* assumes epidemic proportions, losses may reach or exceed 70%. Several other diseases, e.g., rosette, bud necrosis, and web blotch (*Phoma arachidicola*), also occur. These assume economic importance in years when incidence is severe.

There has been considerable research on management strategies to reduce crop losses. Successful disease management may involve one or several techniques. A combination of several techniques is more likely to succeed than any single technique, for several reasons. Combinations are usually more stable; they retard the evolution of pathogen strains that are more virulent or more resistant to chemicals. Cultural manipulation, which is an important part of such combinatorial techniques, can help to reduce initial

1. Oilseeds Research Programme, Agricultural Research and Training Institute, Naliendele, P 0 Box 509, Mtwara, Tanzania.

Mpiri, M.G. 1994. An integrated approach to the management of groundnut diseases. Pages 51-53 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane. Swaziland (Ndunguru, B.J., Hildebrand, G.L., and Subrahmanyam. P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

pathogen population and inhibit pathogen growth. This paper describes some control measures which, when used in combination, can provide stable and effective disease control in groundnut.

Components of Integrated Disease Management

Integrated disease management is a broad, ecological approach involving several mutually compatible control technologies. Several factors have made such an approach necessary—the development of pathogen resistance to chemicals, and new economic, environmental, and legal constraints. Broadly, integrated management involves four components:

- Host-plant resistance
- Biological control
- Cultural control
- Chemical control

Host-plant resistance. Resistance is that character of a plant which suppresses pathogen and disease development. Plant resistance can be expressed to varying degrees, but even resistance that does not completely prevent pathogenesis can suppress diseases adequately in plants. Low-level resistance usually needs to be supported with additional techniques to suppress disease to tolerable levels.

The use of resistant genotypes is a highly effective approach. It requires no further action by the farmer during the growing period, is not disruptive to the environment, and is generally compatible with other disease management techniques. Resistance alone is sometimes sufficient to suppress disease to tolerable levels.

Genotypes resistant to some important groundnut diseases (e.g., late leaf spot and rust) are available; some have multiple resistance. In resistant genotypes, disease appears late, builds up slowly, and results in little damage to the foliage.

Biological control. In this method pathogen activity is reduced through the use of other living organisms (e.g., hyper-parasites), resulting in a reduction of disease incidence and severity. The beneficial species is cultured, and later released or sprayed over the target area. This is a more or less permanent measure (since these agents are natural enemies of the pathogen and are therefore self-perpetuating), usually causes no adverse effects, and has few of the disadvantages of chemical control.

Several examples of successful bio-control are available in the literature. McDonald et al. (1985) reported that the mycoparasites *Dicyma pulvinata* and *Verticillium lecani* parasitized the leaf spot pathogens; Subrahmanyam and McDonald (1987) have reported the pathogenicity of *V. lecani, Penicillium islandicum, Eudarluca caricis,* and *Acremonium persicinum* on *Puccinia arachidis,* showing a considerable reduction in rust development.

Cultural control. This involves deliberate manipulation of the crop environment to make it less favorable to harmful organisms—for example, by disrupting their reproductive cycles, eliminating their food sources, or encouraging their natural enemies. Included in this method are such practices as intercropping, crop rotation, field sanitation, manipulation of sowing date, etc. Some of these techniques provide only small benefits when used individually, but when integrated with other techniques, they significantly improve disease management.

Chemical control. Chemical application is a highly effective technique, and can produce very visible results. Untreated plants may be severely diseased, and those treated with chemicals nearly symptomless. Chemicals inhibit pathogenesis by suppressing pathogen growth before or after infection. Although some individuals within the pathogen population are likely to be highly resistant to the chemical, adequate disease suppression is usually possible. However, there is a possibility of undesirable side effects, e.g., environmental contamination, or the development of fungicide-resistant pathogen populations. Chemicals should therefore be used only after the need is clearly demonstrated.

Discussion

One of the limitations of the earlier approach to disease management was that it relied on methods in isolation. For effective management, however, the various control measures outlined above must be used in appropriate combinations. For example, leaf spots can be suppressed by adjusting irrigation practices to avoid long periods of leaf wetness, and by using a resistant cultivar sown at moderate plant density. If the disease remains severe, chemical control may be considered.

Misari et al. (1988) have successfully developed an integrated disease management strategy against groundnut rosette in Nigeria, combining cultural practices (close spacing and early sowing) with the use of systemic insecticides to control the aphid vector, *Aphis craccivora.* It is far more difficult to formulate a similar strategy for groundnut in southern and eastern Africa, where the crop is grown under extremely varied climatic and agronomic conditions.

The best approach would be a careful ecological analysis of a problem as it occurs. Appropriate strategies could then be planned, depending on the complexity of the field situation. Carefully planned integrated control programs will ensure not only increased groundnut production but also its sustainability over the long term.

References

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.

Misari, S.M., Ansa, O.A., Demski, J.W., Casper, O.F.R., and Breley, E. 1987. Groundnut rosette: epidemiology and management in Nigeria. Pages 15-16 *in* Coordinated research on groundnut rosette virus disease: summary proceedings of the Consultative Group Meeting, 8-10 Mar 1987, Lilongwe, Malawi (McDonald, D., Reddy, D.V.R., Wightman, J.A., and Nigam, S.N., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Subrahmanyam, P., and McDonald, D. 1987. Groundnut rust disease: epidemiology and control. Pages 27-39 *in* Groundnut rust disease: proceedings of a Discussion Group Meeting, 24-28 Sep 1984, ICRISAT Center, India (McDonald, D., Subrahmanyam, P., and Wightman, J.A., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-arid Tropics.

Implementation of a Cultivar Resistance Coding System for Minimizing Yield and Quality Losses in Groundnut

P S van Wyk[1]

Abstract

*Five pathogens—*Sclerotinia minor, Sclerotium rolfsii, Chalara elegans, Ditylenchus destructor, *and* Botrytis cinerea*—are known to contribute to losses in quality following minor infestations of groundnut fields. The identification of the causal organism responsible for certain lesion types is facilitated by an identification chart. The resistance of 30 groundnut cultivars to infection by each of these pathogens has been determined, and the results simplified to a 0-3 rating scale. This rating score appears after each cultivar name in a specific order, denoting resistance to each individual pathogen. The cultivar resistance coding system is supplemented by a manual that describes additional control measures in cases where resistance is insufficient. This coding system is believed to contribute to the control of quality losses resulting from minor infestations.*

Sumário

Implementação dum sistema de codificação da resistência dos cultivares para minimizar a perda no rendimento e qualidade no amendoim. *Sabe-se que cinco patógenos—*Sclerotinia minor, Sclerotium rolfsii, Chalara elegans, Ditylenchus destructor, *e* Botrytis cinerea*—contribuem para as perdas de qualidade após infecções menores nos campos do amendoim. A identificação do organismo causador responsável por certos tipos de lesões é facilitada por uma carta de identificação. A resistência de 30 cultivares de amendoim à infecção por cada um desses patógenos foi determindada e os resultados simplificados numa escala de 0 a 3. Esta avaliação aparece depois do nome do cada cultivar numa ordem específica, indicando a resistência a cada um dos patógenos. O sistema de codificação da resistência dos cultivares é sumplementado por uma lista de medidas de controlo adicional, nos casos onde a resistência é insuficiente. Crê-se que este sistema de codificação contribui no controlo das perdas da qualidade resultantes das infestações menores.*

Introduction

Losses in yield and quality resulting from major outbreaks of diseases and pests are usually recognized by farmers. Researchers and extension workers are alerted, and remedial measures can be promptly initiated. In contrast, minor infestations usually cause only minor losses in quality, and during the growing season these infestations pass unnoticed. Only when losses in quality result in downgrading of the crop does a producer become aware of the problem.

The grading system currently in use in South Africa for groundnut evaluates the level of unsound, blemished, and soiled (UBS) kernels in the sample. Samples with a UBS level of <10% qualify for Choice Edible grade, 10-20% for Standard Edible grade, and those with UBS >20% for Crushing grade. It is likely that a loss in quality of less than 10% will pass unnoticed, especially since the price will not be affected. However, such losses can amount to over R 20 million (= US$ 5.6 million) per year in direct losses as these kernels are discarded before sale. The additional cost

1. Oil and Protein Seed Centre, Grain Crops Institute, Private Bag X 1251, Potchefstroom, 2520, Republic of South Africa.

van Wyk, P.S. 1994. Implementation of a cultivar resistance coding system for minimizing yield and quality losses in groundnut. Pages 54-56 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand. G.L., and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh. India: International Crops Research Institute for the Semi-Arid Tropics.

of hand- or machine-sorting may drastically increase this figure.

This paper describes a system devised and now widely used in South Africa, to minimize losses resulting from minor infestations. The system involves various components, but centers largely on specific educational measures that allow farmers and extension agents (using identification charts and disease control manuals) to identify/diagnose problems and take effective remedial measures.

Identification of the causes for downgrading

The UBS component of the graded sample consists of kernels with a diversity of lesions and injuries. These injuries are a 'fingerprint' of the diseases and pests that were present during the growing season. The sample must therefore be analyzed, for which purpose the kernels are separated into groups with similar lesions or abnormalities. The causes for each type of lesion have been identified, and a pictorial diagnostic chart, 'Factors influencing the grading of groundnuts', has recently been compiled for use by grading officers.

Seven major factors contribute to downgrading: diseases during the growing season, handling, sprouting, aflatoxins, late lifting, cultivation/fertilization, and stacking management. Two of these aspects are discussed in this paper: diseases during the season, and the manner in which cultivar resistance coding can minimize losses.

The coding system

Five pathogens have been identified that infect groundnut and contribute to downgrading: *Sclerotinia minor, Sclerotium rolfsii, Chalara elegans, Ditylenchus destructor,* and *Botrytis cinerea.* Thirty groundnut cultivars and lines were evaluated under field conditions for resistance to these five pathogens. The data from these experiments (usually published in tabular form, showing percentage mortality, e.g., Table 1) never seems to 'reach' the farmer. The reason is most probably that the presentation, although suitable for researchers, is inappropriate for farmers, because it does not provide the information (solutions) they require.

The data from resistance trials were therefore simplified to a rating system of 0-3 where 0 = resistant, 3 = highly susceptible. The rating system corresponds to the grading system: 0 - UBS 0, 1 = UBS <10%, 2 = UBS 10-20%, 3 = UBS >20%.

Table 1. Percentage of plants of different cultivars killed by *Sclerotinia minor* (average of two replications).

Cultivar	Plants killed (%)	Cultivar	Plants killed (%)
N. Common	44.4	PC 180K4	15.8
PAN 9212	30.6	US 40-1	15.8
Norden	27.8	PC 177K1	14.8
PC 183K2	25.0	PI 295233	13.9
PC 113K19	23.2	PC 176K1	13.9
Seleksie 5	23.2	PC 175K1	13.0
Atilla	20.4	Agaat	13.0
PC 188K3	20.4	PC 186K2	11.1
Selmani	20.4	Harts	11.1
Bateleur	19.5	Sellie	10.2
PC 178K7	19.4	PC 181K3R	10.2
PC 172K1	17.6	Jasper	9.3
Anel	17.5	Kwarts	9.3
PC 181K2	16.7	Akwa	3.7
PC 178K5	15.8	Robbie	1.9

LSD (5%) - 16.1, LSD (1%) - 21.7

Each cultivar was rated for resistance to each of the five pathogens. The notation used in the coding system has the pathogens in the following fixed order: *S. minor, S. rolfsii, C. elegans, D. destructor, B. cinerea.* Thus each cultivar was 'coded', with a number to accompany the name. For example, cv Harts 22031 (i.e., resistance rating 2 against *S. minor, 2* against 5. *rolfsii,* 0 against *C. elegans,* 3 against *D. destructor,* 1 against *B. cinerea).*

Disease control manual

The coding system is supplemented with a control manual that can be used by the farmer. It explains the codes for each cultivar, and lists the recommended control measures against each of the five pathogens. *Sclerotinia* stem rot (the first numeral in the code) serves as an example.

Cultivar code 03333—this cultivar is resistant to *S. minor.* Normal practices including seed treatment are recommended.

Cultivar code 13333—this cultivar is highly tolerant of disease development. If the disease level in previous years has not exceeded 10%, deep plowing, avoiding susceptible rotation crops, and at least 2 years of rotation with non-susceptible hosts, will check increase of disease incidence. If the disease level in previous years exceeded 10% an additional chemical treatment is suggested as soon as infection is detected.

Cultivar code 23333—this cultivar is moderately tolerant. If disease levels in previous years have not exceeded 10%, deep plowing, a 3-year crop rotation with non-hosts, and a chemical treatment are suggested. If levels of more than 10% have been recorded in previous years a longer period of rotation, or alternatively an inoculum reduction treatment, is recommended. (The inoculum reduction treatment involves a combination of mechanical, chemical, and biological treatments currently in the process of development.)

Cultivar code 33333—this cultivar is highly susceptible. If no alternative cultivar is available, extended periods of rotation and chemical treatment are suggested on fields with low inoculum levels. In fields with higher levels of inoculum a reduction treatment and chemical treatment are suggested, in addition to extended periods of rotation with non-host crops.

Conclusion

We believe that the coding system supplemented with the diagnostic chart (for identifying the pathogen responsible for each type of lesion or injury to the kernels) and the manual describing the measures to be taken at farm level, can assist in disease monitoring. It can help control disease increase in certain fields and, in the long term, can reduce losses that would otherwise pass unnoticed.

Discussion

Subrahmanyam. The cultivar coding system is very impressive, and should work very well in a system where low grading is associated with a single disease. How about situations where you have more than one disease?

van Wyk. We focus on whichever disease causes the largest problems. For minor diseases, we suggest other management practices to contain the problem.

The Effect of Reducing the Number of Fungicide Sprays on Foliar Disease Control and Yield of Groundnut

Desiree L Cole[1]

Abstract

It is desirable to minimize the use of pesticides in agriculture, since they contribute to environmental pollution and leave undesirable residues on produce. Pesticides are also extremely costly in Zimbabwe. Up to 1986, six fungicide sprays were recommended for foliar disease control on long-duration groundnuts, which are grown mainly by large-scale farmers. This spray regime maximized yields. However, halving the number of sprays had a relatively small impact, because the yield reduction was largely compensated by reduced input costs. Two sprays had little effect on disease control and made no significant contribution to yield increase. This was true for both long- and short-duration groundnuts. The recommended spray program is now 3-4 sprays applied at fortnightly intervals, starting when the first cercospora lesions are evident.

Experiments are in progress to optimize fungicidal disease control by manipulating the timing of sprays and decreasing their number without compromising yield and quality. Yields of short-duration groundnut, grown by small-scale farmers, can be significantly increased by spraying four times at fortnightly intervals, starting 8 weeks after sowing. However, small-scale farmers rarely spray their groundnuts because of the costs involved. The possibility of reducing the number of sprays to two was investigated, but two sprays increased short-duration Plover yield by only 600 kg ha^{-1} as against a very cost-effective 2200 kg ha^{-1} increase with four sprays.

Insect control is very important, but the emphasis has always been on scouting and applying insecticides as necessary.

Sumário

O efeito da restriçãõ no número das pulverizações com fungicidas no controlo das doenças das folhas e o rendimento do amendoim. *E desejável minimizar o uso de pesticidas na agricultura, uma vez que eles contribuem na poluiçaõ do meio ambiente e deixam residuos indesejáveis nos produtos. Os pesticidas sãõ extremamente caros em Zimbabwe. Até 1986, seis pulverizações com fungicidas eram recomendadas para o controlo das doenças foliares do amendoim de longa duraçaõ; este regime de pulverizasções maximizava rendimentos. Porém reduzindo o número de pulveriraçóes a metade teve um impacto relativamente pequeno, porque a reduçäõ dos rendimentos, foi largamente compessada pela reduçäõ dos custos dos insumos. Duass pulveriraçóes tiveram poucõ ou nenhum efeito no controlo das doenças e näo contribuiram significativamente para o aumento dos rendimentos. Isto foi verdadeiro tanto para o amendoim da longa como da curta duraçäo. Agora, o programa das pulverizações recomendado é de 3 a 4 pulverizações com intervalos de 15 dias, começando quando os primeiros sintomas de cercospora säõ evidentes.*

Estäõ em progresso experimentos para optimizar o controlo das doenças causadas por fungos, através da manipulação da data das pulverizações e reduzindo o seu número, sem comprometer os

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1. Crop Science Department, University of Zimbabwe, P 0 Box MP 167, Mount Pleasant, Harare, Zimbabwe.

Cole, D.L. 1994. The effect of reducing the number of fungicide sprays on foliar disease control and yield of groundnut. Pages 57-61 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand. G.L.. and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

rendimentos e a qualidade. O amendoim da curta duracao (145-150 dias) e cultivado por pequenos agricultores. Os rendimentos podem ser significativamente aumentados pulverizando 4 vezes com intervalos de 15 dias, comegando 8 semanas depois da plantacao porem, por causa dos custos envolvidos, os pequenos agricultores raramente pulverizam o seu amendoim. A possibilidade de reduzir as pulverizacoes para duasfoi investigada; mas, duas pulverizacoes apenas aumentaram o rendimento de Plover em 600 kg contra aumento de 2200 kg ha^{-1} obtido com quatro pulverizacoes, que e altamente custo-efectivo. O controlo dos insectos e muito importante mas a enfase tern sido sempre colocada na inspeccao e pulverizacao com insecticidas apenas quando necessario.

Introduction

The trend nowadays is towards reduced application of pesticides. Not only do they contribute to environmental pollution and leave undesirable residues on produce, but in Zimbabwe they are also extremely costly. Up to 1986, six sprays of fungicide to control foliar diseases were recommended for long-duration (175-180 days to maturity) groundnuts, grown mainly by large-scale commercial farmers (Cole 1986). The recommended spray program is now 3-4 sprays applied at fortnightly intervals, starting when the first cercospora lesions are evident (Cole 1988). This recommendation was based on a series of experiments designed to manipulate the timing of sprays and decrease their number without compromising yield and quality. These experiments are still ongoing.

Short-duration groundnuts (145-150 days) are grown by small-scale farmers. Cole (unpublished) found that four fungicide sprays at 2-week intervals, starting 8 weeks after sowing, increased yields significantly. However, small-scale farmers rarely spray their groundnuts because of the costs involved. The possibility of reducing the number of sprays to two was investigated.

Insect control is very important, but the emphasis has always been on scouting and applying insecticides only when necessary (Cole 1988). This paper therefore focuses on what has been done to reduce fungicide application in the control of groundnut foliar diseases.

Materials and methods

A total of seven trials were conducted. Four trials included long-duration groundnuts Flamingo and P 84 / 5 / 244; two included the medium-duration variety Swallow, and one a short-duration groundnut, Plover. In 1988/89, all experiments were done on University of Zimbabwe (UZ) campus (altitude 1480 m, latitude 31° S, longitude 17°45' E) on heavy red clay.

In Experiment 1, Flamingo was sprayed either twice (11 and 17 weeks after sowing), thrice (12, 14, and 18 weeks), or six times (10, 12, 14,16,18, and 20 weeks after sowing). The fungicides applied were vondozeb + thiophanate (Dithane M45® 43% fw 2.5 L + Topsin 500 50% wp, 0.25 kg), bitertanol + Agridex (Baycor 30% ec, 0.6 L + Agridex, 0.6 L) and tebuconazole (Folicur 25% ec, 1.5 L). All fungicides wese applied @ 250 L water ha^{-1} using a knapsack sprayer fitted with three Delavan HB 10 70° nozzles on a boom.

In Experiment 2, P 84/5/244, a line with resistance to web blotch, was sprayed with procymidone (Sumislex 50% df, 1.5 kg) either three times or six times, at the same intervals as Flamingo. The trials were harvested 25 weeks after sowing.

In Experiment 3, Plover received either 2 sprays (9 and 14 weeks after sowing) or 4 sprays (7, 9, 11, and 13 weeks). Harvest was 19.5 weeks after sowing.

In the 1989/90 season each experiment was done at two sites: UZ farm (8 km east of Harare, altitude 1480 m, latitude 31°S, longitude 17°45' E) and UZ campus plots in Harare. Both sites have heavy red clay soils. Flamingo groundnuts (Experiments 4 and 5) received either two sprays (12 and 18 weeks after sowing) three sprays (11, 15, and 19 weeks) or six sprays (11, 13, 15, 17, 19, and 21 weeks after sowing).

The three fungicides applied were bitertanol (Baycor, 30% ec 0.6 L) + 0.6 L Agridex, tebuconazole (Folicur, 25% ec 0.6 L) and procymidone (Sumislex, 50% df, 1.5 kg).

Experiments 6 and 7 were sown to Swallow. Tebuconazole was sprayed at the same intervals as for Flamingo in Experiments 4 and 5.

Results

In Experiment 1, three sprays of the fungicides were as effective as six (Table 1). All the sprayed plots yielded better than the unsprayed, but not always significantly so. Tebuconazole increased yield by 1000

Table 1. Pod yield of three groundnut cultivars under different spray regimes, University of Zimbabwe campus, Zimbabwe, 1988/89.

Cultivar	Fungicide	Number of sprays	Pod yield ($kg\ ha^{-1}$)
Flamingo	None[1]	0	3043
	All 3 fungicides (mean)	2	3628
		3	3988
		6	3811
	Vondozeb + thiophanate (mean)	2,3,6	3659
	Bitertanol (mean)	2,3,6	3693
	Tebuconazole (mean)	2,3,6	4074
	SE		±218.3
P 84/5/244	None	0	5212
	Procymidone	3	6050
	Procymidone	6	5779
	SE		±185.4
	Procymidone (mean)	3,6	5915
Plover	None	0	2894
	Tebuconazole	2	3460
	Tebuconazole	4	5029
	SE		±229.2
	Tebuconazole (mean)	2,4	4245

1. The control was analyzed separately; SE of ± 218.3 is for the other six values.

kg ha^{-1}, a significant improvement over unsprayed plots.

Two or three sprays reduced disease significantly, but there was least disease in the plots that received six sprays. Tebuconazole, followed by bitertanol, were the most effective in controlling cercospora leaf spot. Vondozeb + thiophanate spray resulted in higher yields than in the unsprayed plots, but did not provide much control of cercospora leaf spot. Web blotch was controlled by tebuconazole and bitertanol, but not by vondozeb + thiophanate. Six sprays kept disease levels around 10%, but even two sprays nearly halved the disease level.

Plants that were sprayed six times with tebuconazole or bitertanol were least defoliated, and still had 63 and 75% respectively of their leaf at harvest. Those that received three sprays were only marginally more defoliated, whereas unsprayed plants lost more than 95% of their leaf.

Overall, disease and defoliation levels on P 84/5/244 were low, and three sprays were as effective as six. Three sprays of procymidone increased the yield by 700 kg ha^{-1} over the unsprayed plots. Botrytis was also controlled, with only the occasional stem infected on plots sprayed three times, and none on those sprayed six times.

In Experiment 3, plots that received two sprays of tebuconazole showed a yield increase of 600 kg ha^{-1}; those that received four sprays yielded 2200 kg ha^{-1} more than the unsprayed plots. Two sprays gave fair control of cercospora leaf spot, but not web blotch, while plots sprayed four times had significantly less cercospora leaf spot and web blotch than the unsprayed plots. Overall, sprayed plots retained more than 78% of their leaf, while unsprayed plots lost more than 80%.

Unsprayed Flamingo in Experiment 4 was heavily defoliated (89%), but defoliation was reduced to 57% with tebuconazole and bitertanol, and to 68% with procymidone. Procymidone did not control cercospora leaf spot, but very successfully contained web blotch. Two sprays had no beneficial effect on yield, but yields were greater in plots that received three and six sprays (Table 2).

All unsprayed plots of Flamingo (Experiment 5) on the farm were heavily defoliated (77.5%), but those sprayed with procymidone lost only 39% of their leaf. Defoliation was negatively correlated with the number of sprays, but plots that received three sprays were still significantly less defoliated than the unsprayed ones. The yield from plots sprayed three times was not significantly less than from those that received six sprays.

Plots of Swallow (Experiment 6) that received six sprays of tebuconazole had significantly less cercospora leaf spot than any other treatment, but at 0.6 L ha^{-1} tebuconazole was not very effective in controlling web blotch. Plots that had received six sprays were least defoliated (59.5% of leaf lost) but even those that received three sprays were significantly less defoliated (68%) than the unsprayed plots (84% of leaf lost).

In Swallow plots on the UZ farm (Experiment 7) there was little difference in the incidence of cercospora leaf spot between plots that received six sprays and those that received three. Defoliation was heavy on ail plots, and unsprayed plots were nearly completely defoliated (93%) at harvest. Although plots sprayed six times had the highest yield, the difference in yield between plots sprayed three times and those sprayed six times was not significant.

Discussion

The maximum yields were obtained when six sprays of fungicide were used on long- and medium-duration groundnut and four sprays on short-duration groundnut. However, halving the number of sprays on long-duration groundnuts had a relatively small impact on yield reduction (about 300 kg ha^{-1}, worth US$ 858) when considered in the light of reduced input costs (three sprays of tebuconazole cost $ 720 ha^{-1}) and decreased fungicide use (1.8 L ha^{-1} saved), but two sprays had little effect on disease control and made no significant contribution to yield increase. However, Kannaiyan et al. (1989) found that one spray of thiophanate-methyl + maneb increased the yield by 24% on long-duration groundnuts in Zambia.

Plover yield increased by 2200 kg ha^{-1} with four sprays of tebuconazole, which makes it economical to spray if all other inputs are in place. However, in the communal areas there are very low inputs into the crop and yields are correspondingly poor. In the commercial farming sector, because the seeding rate needs to be doubled to attain a yield similiar to long-duration yields, short-duration groundnuts are seldom grown; but the potential exists for increasing yield through disease control.

Table 2. Pod yield of two groundnut cultivars under different spray regimes at two locations, Zimbabwe, 1989/90.

Cultivar	Fungicide	Number of sprays	Pod yield (kg ha^{-1}) UZ Campus[1]	Pod yield (kg ha^{-1}) UZ Farm
Flamingo	None[2]	0	4403	5371
	All 3 fungicides (mean)	2	4434	5663
		3	5268	6275
		6	4858	6542
	Bitertanol + agridex (mean)	2,3,6	4995	5966
	Tebuconazole (mean)	2,3,6	4938	6058
	Procymidone (mean)	2,3,6	4628	6457
	SE		±905.8	±526.7
Swallow	None	0	3420	3731
	Tebuconazole	2	4085	3993
		3	4287	4531
		6	4361	4646
	SE		±483.5	±186.5
	Tebuconazole (mean)	2,3,6	4244	4390

1. UZ = University of Zimbabwe.
2. The control was analyzed separately; SEs of ± 905.8 and 526.7 are for the other six values.

In these experiments, the application of fungicide was spread out over the season. If the sprays are applied early in the season the initial infection, which is mainly cercospora leaf spot, would be reduced, but this leaves the plant very vulnerable to increased web blotch infection.

In the disease control practices recommended to farmers in the Oilseeds Handbook (Cole 1988), the emphasis is on integrated disease management. The Handbook mentions the importance of a good stand in the prevention of rosette virus disease, and the importance of scouting in the early control of stem diseases like botrytis gray mold, *Sclerotinia sclerotiorum,* and *Sclerotium rolfsii.* When these diseases occur, infected plants can be spot-sprayed and further spread arrested. All the technology for integrated disease control of groundnuts exists, and is applied by large-scale commercial farmers. What we need to do is to find ways for small-scale farmers to implement these technologies. Ultimately, the aim must be to develop cultivars resistant to the diseases, and then persuade farmers to adopt such cultivars. As groundnut as a profitable crop slowly regains favor, more research will be done on integrated pest management.

References

Kannaiyan, J., Sandhu, R.S., Haciwa, C.H., and Reddy, M.S. 1989. Manangement 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 (Bock, K.R., Cole, D.L., Hildebrand, G.L., Nigam, S.N., and Wightman, J.A., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Cole, D.L. 1986. The relation of kernel maturity with defoliation in groundnut (*Arachis hypogaea* L.). Zimbabwe Journal of Agricultural Research 24:43-47.

Cole, D.L. 1988. Groundnut diseases. Pages 34-42 *in* Oilseeds Handbook. Harare, Zimbabwe: Commercial Oilseeds Producers Association.

Discussion

Mamba. Are small-scale farmers using fungicide, and will fungicide use be sufficiently economical to sustain future groundnut production?

Cole. Small-scale farmers in Zimbabwe do not use fungicide as it is not economical. However, the suggested rates of application are very low, and therefore relatively inexpensive and environment-friendly, and could contribute to sustainability.

Subrahmanyam. The results from Zimbabwe, Zambia, and Malawi on the use of fewer fungicide applications for control of foliar diseases are very similar. This technology should be further evaluated in on-farm trials, which could possibly be organized on a regional basis.

Chiyembekeza. What criteria did you use to decide when to apply the first fungicide spray?

Cole. The first spray was applied when the first lesions were observed.

Chavula. You suggest that spraying should commence only after the first lesions are seen. However, in Malawi, the first spray is recommended even before this stage, as it is feared that damage will have already been done. Dr Subrahmanyam may wish to comment on the Malawi recommendation.

Subrahmanyam. In Malawi, we give the first spray when the crop shows about 20% leaf area damage. The extent of damage is established by using simple schematic diagrams, which are available for use by national programs.

Chiyembekeza. It is not economical to begin spraying before the disease is evident. The Malawi recommendation was made because it was feared farmers would not recognize the disease until it was too late. As farmers become more knowledgeable, they will more easily recognize the diseases, and management of spraying schedules will improve.

van Wyk. In South Africa, spraying practices depend on the area involved. In areas where there is a high risk of leaf spot incidence, a fixed program of 3-4 sprays is recommended. In low-risk areas, farmers are advised to spray on inspection.

Zengeni. Dr Cole mentioned the incidence of a number of diseases and pests at the two locations. What were these diseases and pests?

Cole. Botrytis, cercospora leaf spot, and white grubs were relatively widespread.

Soil Insect Pests of Groundnut in South Africa, and their Effect on Yield and Quality

C F van Eeden[1]

Abstract

The groundnut insect fauna of South Africa is poorly known. In a field study conducted during 1986-90, 23 pest species and 19 potentially beneficial insect species were identified. Five categories of subterranean insect damage to groundnut were identified. Pod scarification was the most common type of damage, and contributed significantly to the occurrence of defective kernels. The most prominent of these defects were UBS (unsound, blemished, and soiled) kernels, usually resulting from soil water penetrating the shells at the site of injury. Colonization by certain fungi was also enhanced by insect damage to pod shells. The effect of insecticide application on yield and grading quality was slight, but a favorable cost/benefit ratio was obtained with all treatments.

Sumario

Pragas de insectos do solo e o seu efeito no rendimento e na qualidade do amendoim na Africa do Sul. *A fauna dos insectos do amendoim na Africa do Sul é pouco conhecida. Num estudo do campo conduzido durante 1986–90, foram identificadas 23 espécies de pragas e 19 espécies potencialmente benéficas. Cinco categorias do danos causados por insectos do solo foram identificadas. A escarificação da vagem foi o tipo de dano mais comum, tendo contribuido significativamente para a ocorrência de gräos difeituosos. Gräos UBS (mal formados, manchados e sujos) resultantes da penetração da água do solo na vagem, através do local do dano é o defeito mais proeminente. A colonização dos gräos por certos fungos, foi agudizada pelos danos causados por insectos nas vagens. O efeito da aplicaçãõ dos insecticidas, quer no rendimento quer na qualidade do gräo, foi ligeiro, mas uma razão custo/benefício favorável foi obtida com todos os tratamentos.*

Introduction

Groundnut entomology has long been neglected in South Africa. Most previous reports on groundnut insects were incidental in nature (Le Roux 1965, Sellschop 1965, Dirkse Van Schalkwyk 1968), the exception being a study of the groundnut aphid *Aphis craccivora* by Myburgh (1971). Since producers, breeders, and agronomists all noticed insect damage to groundnut, especially to the pods, and realized the need for entomology research in this field, a research program was initiated in 1986. The aims of this program were to:

- Establish the type and extent of insect damage;
- Identify which insects were responsible;
- Estimate the effect of the damage on yield and grading quality;
- Formulate viable control measures where necessary.

The highlights of this program are presented in this paper.

Materials and methods

The nature and abundance of the groundnut insect fauna were assessed by weekly sampling over 5 years

1. Highveld Agricultural Development Institute, Private Bag X804. Potchefstroom. Republic of South Africa.

van Eeden, C.F. 1994. Soil insect pests of groundnut in South Africa, and their effect on yield and quality. Pages 62-65 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J.. Hildebrand, G.L., and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

in four commercial groundnut fields, using four sampling techniques: soil sampling, pitfall trapping, sweeping, and malaise traps. Simultaneously, plant samples were taken and the pods examined for insect damage. The critical time of damage was established and the most important insect group at the critical time determined. The visible effect of shell damage on the kernels was described, and invisible fungus infection investigated. The effect of several chemicals (and the economic viability of their use) on the yield and grading quality of kernels was investigated.

Results and discussion

Twenty-three pest species (mainly Coleoptera) and 19 potentially beneficial insect species were identified (van Eeden et al. 1991). The Curculionidae (mostly *Protostrophus amplicollis)* were the most prominent group of epigeal pests, with a prominence value (PV) of 963.8; the Scarabaeidae were the most prominent subterranean group (PV = 103.9). The most prominent epigeal predators were the Labiduridae (PV = 6786.8), and the Carabidae the most prominent subterranean predators (PV = 52.1).

The prominence value is an index indicating the abundance and timespan of occurrence of a particular taxon. It was calculated as $PV = D \times \sqrt{F} \div 10$, where D = population density and F = frequency of occurrence. The total number of individuals belonging to a specific taxonomic group found in all samples over the season was indicative of population density. Frequency of occurrence was indicated by how often a specific taxon was encountered in the total number of samples per season. Prominence values allowed us to rank different taxons in the complex of insects according to their prominence, thus giving an index of abundance and timespan of occurrence of each taxonomic group within the complex.

Five categories of subterranean damage to groundnut were identified: damage to newly sown seed, peg damage, damage to young developing pods, pod shell damage, and kernel damage. Pod scarification was the most common type of damage in this study, accounting for 12% of all pods. However, termites were conspicuously absent; according to McDonald and Harkness (1963), termites cause pod scarification in Nigeria. False wireworms caused mostly pod scarification in the study area, confirming the findings of Feakin (1973).

Although scarified pods yielded sound kernels in some cases, pod scarification contributed significantly to such kernel defects as ablactated (prematurely weaned), prematurely germinated, fungus-infected, and UBS (unsound, blemished, and soiled) kernels. UBS kernels were blemished mostly by water stains, owing to soil water penetration of pods at the site of injury.

In a laboratory study, no significant differences in fungal colonization of shells were found between damaged and sound pods. However, fungal colonization of kernels was significantly higher in damaged pods (1991: 28.6 and 6.5 colonies per 100 plates, $P<0.001$; 1992: 63.7 and 7.4 colonies per 100 plates, $P = 0.001$). *Sclerotium rolfsii, Aspergillus* spp, *Fusarium* spp, and *Penicillium* spp appeared to benefit most (in terms of increased colonization) from insect damage to the pod shells. It became evident that, in South Africa, insect damage affects grading quality more than it affects yield.

In chemical trials over 3 years, yield increases resulting from insecticide application were disappointing in general. In spite of a general increase in yield for all treatments the results were not significant ($P = 0.05$) in 1991/92, when the greatest yields were obtained. Significant yield increases were obtained with benfuracarb LS in 1990/91, and benfuracarb EC, oxamyl, fenamiphos, and terbufos treatments in 1992/93. Although the last three compounds also reduced Scarabaeidae larval numbers during 1991/92 and 1992/93, significant yield increases were obtained with them only in 1992/93, which was the poorer season, indicating that damage by Scarabaeidae might be more detrimental to yield in less favorable seasons. Since these three compounds are nematicides, the increase in yield possibly resulted from nematode control in 1992/93.

No significant differences ($P = 0.05$) in grading quality were observed between the control and the treatments in either 1990/91 or 1991/92. The best result obtained in 1990/91 was with furathiocarb (156 g edible kernels 200 g^{-1} vs 144 g in the untreated control). In 1991/92 the best result was obtained with furathiocarb + benfuracarb EC (165 g vs 161 g in the untreated control). In 1992/93 both benfuracarb LS and terbufos treatments yielded significantly less ($P= 0.05$) edible kernels (143 and 146 g 200 g^{-1}) than the control (156 g). A possible explanation for the poor results obtained on grading quality might be that some severely damaged pods in the untreated control deteriorated and were not recovered at harvest. Since grading quality was assessed on subsamples of pods at harvest, the detrimental effect of pod damage on grading quality could be more obvious in treated plots.

Although insecticide application resulted in no consistent increases in either yield or grading quality, a consistent increase in net profit was obtained with

Table 1. Economic benefit from the use of insecticides, measured in terms of extra profits over untreated control, South Africa, 1990-93.

	Economic benefit (R ha^{-1})			
Treatment	1990/91	1991/92	1992/93	Average
Furathiocarb FS	1025.22	0.00	208.25	411.16
Thiodicarb FS	361.02	89.56	172.05	207.54
Benfuracarb LS	844.43	68.52	46.61	319.85
Furathiocarb FS + benfuracarb EC	124.60	783.84	143.76	350.73
Benfuracarb EC	251.15	73.22	406.99	243.79
Lambda-cyhalothrin EC	169.88	0.00	300.69	156.86
Oxamyl SL	*	66.78	190.52	128.65
Fenamiphos EC	*	374.00	165.01	269.51
Imidachloprid WS	*	267.84	166.37	217.11
Terbufos GR	*	259.93	337.42	298.68
Gamma-BHC DS	195.43	*	*	195.43
Mean	424.53	153.05	213.77	263.78

* Chemical compound not used.

all the chemicals used (Table 1). These increases were probably due to the additive effect of slight improvements in both yield and grading quality. General recommendations on the use of insecticides on groundnut would, however, be risky at this stage.

Conclusions

Under normal conditions insect pest populations are too low to warrant the use of chemical control to improve yield and/or quality. However, further research into the timing of insecticide application (e.g., at pegging or 90 days after sowing) and type of chemical is needed. An effective scouting procedure for soil insects needs to be developed in order to calculate threshold values, and to facilitate proper decision making.

References

Dirkse Van Schalkwyk, H.A. 1968. A monograph of the genus *Protostrophus* Marshall (Col: Curculionidae, Brachyderinae). Entomology Memoirs Vol 15. Department of Agricultural Technical Services, Pretoria.

Feakin, S.D. 1973. Pest control in groundnut. Pest Articles News Summary 2:101-186.

Le Roux, P.M. 1965. Voorkoming van besoedeling van grondbone met aflatoksien tydens verbouing. Suid Afrikaanse Mediese Tydskrif 64:776-777.

McDonald, D., and Harkness, C. 1963. Growth of *Aspergillus flavus* and production of aflatoxin in groundnut-Part II. Tropical Science 5:143-154.

Myburgh, A.J. 1971. Biological and population studies on *Aphis craccivora* Koch (Hemiptera: Aphididae). MSc thesis, University of Pretoria.

Sellschop, J.P.F. 1965. Field observations on conditions conducive to the contamination of groundnut with the mould *Aspergillus flavus* Link ex Fries. South African Medical Journal 64:774-776.

van Eeden, C.F., van Rensburg, J.B.J., and van der Linde, T.C. de K. 1991. A check list of insects occurring in groundnut (*Arachis hypogaea)* fields in the Highveld region. Phytophylactica 23(4):255-259.

Discussion

Zengeni. Could you comment on the economic importance of the CMR beetle, which is widespread where I work, at Sigaro in Zimbabwe.

van Eeden. The pest is not of economic significance in our area.

Cole. You mentioned white grubs as being an important pest. Did you find root damage associated with white grub infestation? In Zimbabwe, the first sign of white grub infestation is small, stunted plants as a result of damage. Pod damage appears to be secondary.

van Eeden. We have not seen any root damage.

Subrahmanyam. Did you estimate the levels of aflatoxin contamination in damaged and undamaged pods? Pre-harvest pod damage is known to predispose groundnut pods to *Aspergillus flavus* invasion and aflatoxin contamination.

van Eeden. We did not assess aflatoxin levels, but we did look at predisposition of damaged pods to *A. flavus* invasion. Although *A, flavus* (and *A. parasiticus)* infestation levels were increased significantly by insect damage, pod damage resulted in much greater *A. niger* infestation; but this species does not produce aflatoxin.

Ntare. In West Africa, termites and millipedes are the principal soil pests of groundnut. The damage they cause to pods (scarification) predisposes pods to *A. flavus* invasion and subsequent aflatoxin contamination. It is interesting to note that you do not have similar problems in South Africa.

van Eeden. I work mainly in the cooler regions of South Africa, where we do not see termites. However, in the warmer areas they are reported to be a problem.

Strategies for Control of the Peanut Pod Nematode on Groundnut in South Africa

C Venter[1]

Abstract

*The peanut pod nematode (*Ditylenchus destructor *Thome) causes severe quality losses in groundnut in South Africa, with correspondingly significant economic losses. The nematode has a specialized disease cycle on the groundnut plant, which must be understood when planning control strategies. Prior to sowing, nematode build up in the soil can be prevented using general weed and fungal control. The soil can also be treated with registered nematicides. Nematophagous fungi are currently being studied for use as biocontrol agents. Resistant cultivars should be used. Low-toxicity products are also being screened for use in seed treatments. The nematicides registered for use at pegging should be effective in controlling the nematode until the pods have lignified. Timely harvesting should yield hull stubble and seed free of survival stages of the nematode. The selection of disease-free seed for sowing is another key control strategy. Although some of these control strategies are already available, the nematode is not yet under control at a national level. Those strategies not yet available must be developed and used in a broad program of integrated control.*

Sumário

Estratégias para o controlo do nemátodo da vagem do amendoim na Africa do Sul. *O nematodo da vagem do amendoim (*Ditylenchus destructor *Thorne) causa severas perdas de qualidade no amendoim na Africa do Sul e consequentemente significativas perdas economicas.Este nematodo tem um ciclo especializado na planta do amendoim, o qual deve ser conhecido aquando da planificação das estratégias de controlo. Antes da plantaçäo, um incremento na populaçäo de nematodos no solo pode ser prevenido usando métodos de controlo gerais para as infestantes ou fungos. O solo também pode ser tratado com nematicidas registradas. Fungos nematofagos estäo actualmente a ser estudados para uso como agentes bio-controladores. Cultivares resistentes devem ser usados. Produtos de baixa toxicidade para serem usados no tratamento de sementes, também estäo a ser testados. Os nematicidas registados para uso no periodo de formaçäo das hastes, devem ser efectivos no controlo de nemotados até que as vagens linhifiquem. Colheita atempada deve produzir material livre de estágios de sobrevivência do nemátodo. A selecção de material livre de doenças para a plantaçäo, é a estratégia chave no controlo de doenças de transmissäo por semente. Embora, algumas destas estratégias de controlo estejam disponíveis, o nematodo ainda näo está sob controlo a nível nacional. As estratégias, ainda näo disponíveis devem ser desenvolvidas e usadas num amplo programa de controlo integrado.*

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1. Oil and Protein Seeds Centre, Grain Crops Institute, Private Bag X 1251. Potchefstroom, 2520, South Africa.

Venter, C. 1994. Strategies for control of the peanut pod nematode on groundnut in South Africa. Pages 66-68 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand, G.L., and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Introduction

Economic impact. The peanut pod nematode (*Ditylenchus destructor* Thorne) is currently the most important nematode pest on groundnut in South Africa. It has been found in all the major groundnut production areas, and causes more than R 15 million (= US$ 4.2 million) worth of damage every year. Although the nematode may be found in the soil and in groundnut roots, 90% of the population is found within the pods at harvest. It causes a bruise-like discoloration of the hull, the kernel testa becomes discolored (blemished), and the kernels may sprout within the closed pod (unsound). The percentage of blemished and unsound kernels in a consignment delivered by a farmer is a major factor in determining the grade of groundnut in South Africa. Choice Edible grade is worth approximately R 1500 t^{-1}, Standard Edible grade approximately R 1200 t^{-1} (a price decrease of 15%), and Crushing grade about R 500 t^{-1} (a 65% price decrease). This downgrading of produce is the major economic impact of the nematode.

Disease cycle. The peanut pod nematode may survive the winter in hull stubble in the soil. Clean groundnut seed sown in this infested soil may therefore become affected. The nematode is also seedborne, surviving in large numbers as eggs in the seed testa. Sowing infested seed, even in clean soil, will also result in damage.

The nematodes survive in the soil until the groundnut pegs enter the soil and enlarge into pods. The nematodes then penetrate the developing pod at the peg connection and migrate through the soft tissues of the hull, and eventually into the developing seed. Once the nematodes are in the pod they are out of reach of nematicides or natural enemies restricted to the soil.

During maturation of the pods, part of the mesocarp of the hull becomes lignified. This occurs around 91 days after sowing in the cultivar Sellie. After this stage the nematode appears to be unable to penetrate into the inner tissues of the pod, and the kernels are protected.

As the disease cycle ends the nematode lays eggs in increasing numbers in the hulls and seeds, and enters anhydrobiosis (an over-wintering survival mechanism). Pod stubble left in the field becomes a primary source of re-infestation the next season. Similarly, the survival of the nematode in groundnut seed is also a primary factor in its spread from field to field.

Presowing control strategies

Nematicides (available). Three nematicides are currently registered in South Africa for use on groundnut at sowing: Counter® (turbofos), Nemacur® (phenamiphos), and Temik® (aldicarb). These nematicides can be rather expensive, and may be inconsistent in the control they provide, particularly under dryland groundnut production.

Sanitation methods (available). Hosts for the nematode include weeds, fungi, and volunteer plants (of groundnut and other crops). Weeds include white goosefoot (*Chenopodium album),* goose grass (*Eleusine indica),* purple nutsedge *(Cyperus rotundus),* jimson weed (*Datura stramonium),* feathertop chloris (*Chloris virgata),* cocklebur *(Xanthium strumarium),* and khaki weed (*Tagetes minuta).* Volunteer plants include those of wheat, sunflower, lupin, drybean, cowpea, soybean, alfalfa, cotton, tobacco, pea, and particularly maize and grain sorghum. The nematode can also feed on a wide range of genera (and 64 species) of both pathogenic and non-pathogenic fungi, including *Chalara, Penicillium, Phytophthora, Aspergillus,* and *Fusarium.* General control of weeds, volunteer plants, and fungi is important in controlling the presowing build up of the nematode. Greenhouse trials have shown that a population of only 50 nematodes plant^{-1} (inoculated 3 weeks after sowing) can give a downgraded yield.

Biological control (under development). Farmers in the northern Cape region of South Africa, who have grown groundnut in monoculture for up to 30 years, claim that the peanut pod nematode has spontaneously disappeared and is no longer a problem in these fields. With the hope that these soils had become suppressive as a result of the build up of nematophagous fungi, tests were carried out to isolate these fungi from these and other soils.

Sixteen fungi were identified. Of the four species that can be cultured, *Monacrosporium cystosporum* (Drechsler) Subrom. appears to be the most aggressive against the peanut pod nematode, trapping the nematodes in a three-dimensional trap network. This fungus has also been isolated from nematodes extracted from groundnut hulls, indicating that it is capable of spreading into the groundnut pod. This is a promising observation, since the nematode is able to escape the other natural enemies confined to the soil simply by penetrating the pod, where it can multiply freely. *Monacrosporium cystosporum* should therefore receive attention in future research on developing a commercial biocontrol product.

Control strategies at sowing

Resistant cultivars (available). The cv Sellie, and other cultivars that were available when the peanut pod nematode was discovered, are very susceptible to the nematode. Recently, however, a fairly nematode-tolerant cultivar, Kwarts, has been released for commercial use. Seed is now being multiplied to meet farmers' needs. Other groundnut lines that show promise of resistance include: PI 295233, US 40-1, PC 205 DB, and SW 1.

Seed treatment (under development). Currently, several low-toxicity products are being tested for their efficiency as seed treatments in controlling the peanut pod nematode. Promising products will be tested for the most efficient application rate, and eventually be developed for integration into a control program.

Control strategies at pegging

Nematicides (available). Two nematicides are currently registered in South Africa for use on groundnut at or around the pegging stage: Temik® (aldicarb) at 35 days after sowing, and Vydate® (oxamyl) at pegging. These products are active for about 42 days after application, and should therefore protect the pods and kernels until the pods have lignified. By 84 days after application the residue disappears and the groundnuts can safely be eaten.

Control strategies during maturation

Enhanced pod lignification (under development). The mesocarp of the hull gradually lignifies with maturity, until it is fully lignified around 91 days after sowing. The lignified layer in the hull then forms a barrier through which late nematode infestations cannot penetrate. Many factors may enhance pod lignification, including additional calcium and other fertilizer supplements, and some hormone treatments. Currently, trials are being carried out to test the efficiency of these supplements in reducing late nematode infestations.

Control strategies at harvest

Timely harvest (available). The survival mechanisms of the peanut pod nematode are initiated with ripening of the pods. Increased numbers of eggs are found with delayed harvest. Timely harvesting will allow the hulls and kernels to dry before eggs are laid; such hull stubble and seed (for sowing) will therefore be largely free of survival stages of the nematode.

Avoiding harvest waste (available). Many farmers delay harvesting to allow maximum kernel fill, particularly when symptoms of nematode infestation are not prominent. The danger then exists that the hull stubble will be a source of re-infestation. All postharvest waste and shell debris left on the field during harvest should be removed from the field, wherever possible.

Control strategies during seed selection

One of the key strategies in the control of any seedborne disease must be the production of disease-free seed.

Staining of symptomless seed (under development). Many kernels are lightly infested and do not yet show symptoms. Greenhouse trials have shown that an infestation of only 20 nematodes seed^{-1} can downgrade yields. Even lightly infested kernels must therefore be discarded. A method is currently being developed to stain the chemical products of nematode damage, in the kernel testa. This stain will be used to identify seed that is infested but shows no symptoms of infestation.

Conclusions

Although a range of effective control strategies is available, the peanut pod nematode is not under control at a national level in South Africa. It is evident that a wider range of strategies in a broad program of integrated control must be developed. These should include cultivars with greater resistance, biological control methods, production of disease-free seed, and the development of effective seed treatments.

Discussion

Luhana. You mentioned the use of biological nematode control, for example using a fungus. Will the fungus not reduce pod and seed quality if it penetrates the pod?

Venter. Biocontrol is a fairly new field. We still need to establish the effects of the use of such measures.

Natural Plant Products for Control of Groundnut Pests in Zambia

P H Sohati[1] and S Sithanantham[2]

Abstract

Field experiments were carried out during 1990-94 at Msekera Research Station, Zambia, to compare the recommended chemical insecticides with two botanicals, against the soil pests of groundnut (Arachis hypogaea). *Furadan 10* G® *and Dursban® were applied to the soil as granules either as single doses* (*1 kg a.i. ha*$^{-1}$) *at sowing or two split doses (0.5 kg a.i. ha*$^{-1}$ *each*) *at sowing and 8 weeks later as a side-furrow application. Dursban® was also tested as pre-sowing seed treatment (6 mL a.i. kg*$^{-1}$ *seed). The botanicals tested were* Toona ciliata *as leaf powder* (*60 kg ha*$^{-1}$) *and as leaf extract (100 mL of 100% leaf extract kg*$^{-1}$ *seed), and* Tephrosia vogelii *leaf powder* (*60 kg a.i. ha*$^{-1}$). *All the chemical insecticides were effective against termites and pod borers except in the 1992/93 season. Among the botanicals,* T. ciliata *leaf extract as seed treatment showed the potential to substitute for chemical insecticides for the control of soil pests of groundnut.*

Sumário

Produtos naturais das plantas para o controlo das pestes do amendoim na Zambia. *Ensaios do campo foram realizados durante o periodo 1994 na Estação de Investigação Msekera na Zambia, para comparar os insecticidas químicos recomendados com dois botânicos, contra as pestes do solo que atacam o amendoim* (Arachis hypogaea). *Furadan 10G® e Dursban® foram aplicados no solo como granulas, como aplicações únicas (1 kg m.a. ha*$^{-1}$*) durante a sementeira ou como duas doses (0.5 kg m.a. ha*$^{-1}$ *cada) durante a sementcira e oito semanas mais tarde como uma apliçacão nos fulcos aolado. Dursban® foi também testado como um tratamento para a semente antes da sementeira (6 mL m.a. kg*$^{-1}$ *semente). Os botânicos testados foram* Toona ciliata *como folhas em pó (60 kg m.a. ha*$^{-1}$ *). Todos os insecticidas químicos foram efetivos contra termitas e brocadoras das vageus. Com exeção da estação de 1992/93. Entre os botânicos extratos das folhas de* T. ciliata *como uns tratamentos da semente apresentaram potencialidade de substituir os insecticidas químicos para o controlo das pestes do solo que atacam amendoim.*

Introduction

Most of the groundnut (*Arachis hypogaea*) produced in Zambia is grown by resource-poor smallholder farmers. It is therefore important that pest control measures are relatively simple, cheap, effective, and available to these farmers. Most of the synthetic insecticides used to control groundnut pests are expensive and incompatible with integrated pest management programs.

While resistant varieties are the most durable and economical means of minimizing pest-related losses on groundnut, short-term strategies can be a useful supplement. Among a large number of such plants recently studied is *Tephrosia vogelii* Hook f. (Family: Leguminosae), a known source of rotenoids (Gaskins et al. 1972, Kaposhi 1992). Both *T. vogelii* and *Toona ciliata* M.J. Roem. (Family: Meliaceae) were evaluated against the major groundnut pests in Zambia, and the results are discussed in this paper.

1. Msekera Research Station, P 0 Box 510089, Chipata, Zambia.
2. International Centre of Insect Physiology and Ecology (ICIPE), Kwale-Kilifi Project. P 0 Box 83254, Mombasa, Kenya.

Sohati, P.H., and Sithanantham, S. 1994. Natural plant products for control of groundnut pests in Zambia. Pages 69-72 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand, G.L.. and Subrahmanyam. P., eds.). Patancheru 502 324. Andhra Pradesh. India: International Crops Research Institute for the Semi-Arid Tropics.

Materials and methods

The trials were conducted at Msekera Research Station in Eastern Province, Zambia, located at latitude 13°39' S, longitude 32°34' E, 1025 m above sea level; annual rainfall is 1050 mm. A randomized complete block design with four replications was used. Plot size was two rows of 4 m, with a spacing of 75 x 10 cm.

The chemical insecticides (Furadan 10 G® and Dursban®) recommended for the control of soil insect pests were compared under different methods of application, along with leaf extracts and dry leaf powder of *T. ciliata* and *T. vogelii.* Furadan and Dursban were applied to the soil as granules either as single doses (1 kg a.i. ha^{-1}) at sowing or two split doses (0.5 kg a.i. ha^{-1} each) at sowing and 8 weeks later as side-furrow application. Dursban was also tested as a pre-sowing seed treatment (6 mL a.i. kg^{-1} seed).

Dry leaf powder formulation

Mature leaves of *T. vogelii* were selected for the study because earlier observations by Gaskins et al. (1972) indicated that they contain 80-90% rotenoids. The leaves were collected in the evening from 24-month old plants and allowed to dry in the shade. The dry leaves were pounded in a traditional mortar and sieved using a local sieve. The dry leaf powder obtained after sieving was applied in the furrow at sowing @ 60 kg ha^{-1}.

Fresh leaf extract formulation

Fresh leaves were collected as above and 10 kg weighed out. The samples were pounded in a traditional mortar and soaked overnight in an equal weight of water. The mixture was filtered through a 'mutton' cloth, and the filtrate used to treat groundnut seed at 100 mL kg^{-1}. The treated seeds were sown immediately.

Observations on pod scarification by termites and pod damage by borers (false wireworms, wireworms, white grubs, and millipedes) were recorded at harvest on a visual rating scale of 1-9, where 1 = 0% pod damage, 2 = 1-5%, 3 = 6-10%, 4 = 11-20%, 5 = 21-30%, 6 = 31-40%, 7 = 41-60%, 8 = 61-80%, and 9 = >80% pod damage. Kernel yields were also recorded.

Results and disussion

The results are summarized in Table 1. In Makulu Red, pod scarification by termites was controlled most effectively by Dursban seed treatment, followed by Dursban single dose and *T. ciliata* leaf extract seed treatment. All treatments resulted in improvements, to varying degrees, over the untreated plots. Wightman (1989) reported that termites were responsible for 5-9% pod damage in Eastern Province.

In the 1990/91 season, *T. ciliata* leaf extract seed treatment provided the best protection against pod damage by borers in Makulu Red, followed closely by Dursban applied as a single or split dose to soil or as seed treatment. Other treatments were less effective, but still resulted in less pod damage than in unprotected plots. All the treatments resulted in significant increases in kernel yield over the control (931 kg ha^{-1}). The increases ranged from 16 to 26% (182-322 kg ha^{-1}). Dursban seed treatment was superior to the other treatments.

All treatments were relatively less effective against pod borers during the 1992/93 season. This may be due to excessive rainfall that season (Table 2), and consequent leaching of insecticides.

In 1993/94, an improved groundnut variety, MGS 3, was used instead of Makulu Red. The single dose of Dursban applied at sowing gave the best protection against pod borer damage, followed by the split dose of Dursban. Kernel yields were generally low, with the Furadan single dose treatment giving the highest yields (497 kg ha^{-1}), followed by *T. vogelii* leaf powder (404 kg ha^{-1}). The low yields were probably due to a dry spell during the podding and seed-filling stages (Table 2). Under normal rainfall, MGS 3 kernel yields are 1.5-2.5 t ha^{-1}.

These results show the potential of *T. ciliata* leaf extract as seed treatment to protect groundnut pods from damage by termites and pod borers (false wireworms, wireworms, white grubs, and millipedes). This form of seed treatment is normally inexpensive and would be suitable for small-scale farmers, who require cheap and simple means of pest management. *Toona ciliata* is widely grown in Zambia as an ornamental, and can easily be used in integrated pest management programs. Damage to pods, especially scarification by termites, affects seed quality, causing increased contamination by *Aspergillus flavus* and reduced germinability (Kannaiyan et al. 1989). Appropriate treatment, when used in conjunction with recommended cultural practices, can yield excellent results. For example, when harvest was correctly timed in Makulu Red, pod damage by soil pests was

Table 1. Efficacy of chemical and botanical insecticides against soil pests of groundnut, tested on two cultivars, Msekera Research Station, Zambia 1990-94[1].

	Pest damage score (1-9 scale)[2]						
	Pod scarification by termites	Pod damage by borers			Kernel yield (kg ha^{-1})		
	Makulu Red	Makulu Red		MSG 3	Makulu Red		MSG 3
Treatment	1990/91	1990/91	1992/93	1993/94	1990/91	1992/93	1993/94
Furadan (single dose)	2.8	3.8	5.0	3.5	1220	1445	496.6
Furadan (split dose)	3.0	3.5	-	-	1129	-	-
Dursban (split dose)	2.8	2.8	4.5	2.5	1444	1447	364.4
Dursban (seed treatment)	1.8	2.5	4.5	4.0	1253	1248	369.2
Toona ciliata leaf extract (seed treatment)	2.3	2.3	4.0	3.5	1203	1476	390.9
Toona ciliata leaf power (single dose)	2.3	4.0	5.5	3.5	1113	1274	357.0
Tephrosia vogelii leaf powder (soil treatment)	_	_	5.0	4.0	_	1422	403.8
Untreated control	4.5	5.3	4.5	4.0	931	1495	375.0
SE	±0.3	±0.2	±0.7	±0.6	±46.1	±82.2	±39.0
Mean	2.8	3.3	4.9	3.5	1151	1406	386.9
CV (%)	25.0	14.2	28.8	31.5	8.0	11.8	20.2

Sowing dates: 1990/91 - 11 Dec, 1992/93 - 14 Dec. 1993/94 - 23 Dec.

1. Data shown for 3 seasons; drought in 1991/92 caused total crop failure.
2. 1-0% pod damage. 2 = 1-5%. 3 = 6-10%. 4 = 11-20%. 5 = 21-30%. 6 = 31-40%. 7 = 41-60%. 8 = 61-80%, 9 = >80%.pod damage.

Table 2. Rainfall at Msekera Research Station, Chipata, Zambia, 1990-94.

	Total rainfall (mm)			
Month	1990/91	1991/92	1992/93	1993/94
Sep	0.6	-	-	-
Oct	4.6	29.2	-	-
Nov	41.3	121.1	73.0	50.2
Dec	167.8	301.3	336.1	137.9
Jan	267.8	105.4	260.0	235.5
Feb	163.8	39.7	306.9	111.6
Mar	113.2	224.2	243.5	11.2
Apr	19.2	2.8	117.4	13.1
May	-	2.1	-	-
Total	778.3	825.8	1336.9	559.5

Source: Msekera Meteorological Station

only 9%, while a delay in harvest by 3 weeks led to 16-22% pod damage.

Future research will focus on the evaluation of other botanicals—for example, *Swartzia madagascarienst*s (Family: Papilionoideae), which has been reported to be effective against termites. It will also look into the shelf life of promising botanicals, since some of them are unstable in the presence of sunlight, air, and moisture.

References

Gaskins, M.H., White, G.A., Martin, F.W., Delfel, N.E., Ruppel, E.G., and Barnes, D.K. 1972. *Tephrosia vogelii:* a source of rotenoids for insecticida] and piscicidal use. USDA Agricultural Research Service Technical Bulletin no. 1445.

Kannaiyan, J.K., Sandhu, R.S., and Phiri, Y.L. 1989. Status of knowledge on aflatoxin and *Aspergillus flavus* contamination problems of groundnuts in Zambia. Pages 65-70 *in* Aflatoxin contamination of groundnut: proceedings of an International Workshop, 6-9 Oct 1987, ICRISAT Center, India (McDonald, D., and Mehan, V.K., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Kaposhi, C.M.K. 1992. The role of natural products in integrated tick management in Africa. Insect Science Application 13(4): 595-598.

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 (Bock, K.R., Cole, D.L., Hildebrand, G.L., Nigam, S.N., and Wightman, J.A., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Discussion

Zengeni. Is *Toona ciliata* indigenous to Zambia, and is the species easy to grow?

Sohati. The species is exotic and is widely grown in Zambia as an ornamental. It can be easily propagated vegetatively.

Venter. Is *Tephrosia vogelii* a weed, or can the pods be eaten?

Sohati. It is not considered a weed, but neither is it eaten. It is used primarily as a toxin; in addition, being a legume, it will enhance soil fertilization.

Ntare. How did you ensure uniformity of insect infestation in your fields?

Sohati. It is difficult to ensure uniformity of soil pests, but we applied cowdung to attract termites and white grubs.

Ntare. To what extent does cowdung attract termites?

Sohati. Cowdung increases termite activity in the field, and thus improves the uniformity of infestation. We have not quantified the increase in infestation.

van Wyk. Has the active ingredient in *Toona, ciliata* been identified?

Sohati. The component from *Tephrosia vogelii* has been identified, but not the one from *Toona ciliata.*

van Wyk. I would suggest collaboration with groups (e.g., in South Africa) with access to the proper technology for identification of active ingredients of biocontrol agents.

van Eeden. It would be worthwhile to test these natural products under controlled conditions in the laboratory. I appreciate the difficulty involved in working on soil pests, which, being underground, cannot be seen.

Sohati. The point about laboratory studies is valid, but the necessary facilities are not available at our research station.

Subrahmanyam. Did you examine the effects of spraying *Tephrosia* and/or *Toona* leaf extract on control of foliage-sucking pests?

Sohati. Yes; both leaf extracts are very effective against aphids, jassids, and thrips.

Mpanza. How is the 60 kg ha^{-1} of leaf extract prepared—is it mixed with water?

Sohati. With *Tephrosia vogelii* the leaf is picked early in the morning or late in the afternoon, and dried. It is then finely ground using traditional means and applied into the soil.

Evaluation of Foliar Disease Resistant ICRISAT Groundnut Varieties in KaNgwane, South Africa

C Mathews and B D A Beck[1]

Abstract

*Groundnut (*Arachis hypogaea*) is the most important legume crop grown by resource-poor small-holder farmers in the former KaNgwane Lowveld region of the Eastern Transvaal Province of South Africa. Replicates of the fourth International Foliar Disease Resistance Groundnut Variety trial - 1989 (IV-IFDRGVT-89) using the local standard cultivar Sellie as a control, were tested during 1991-93 at two locations in KaNgwane. Nine ICRISAT varieties were selected and compared with Sellie in a further four trials (1992-94). A joint analysis of the seven trials conducted during 1991-94 showed significant pod yield superiority ($P < 0.05$) of 35% in 1CGV 86590 and 31% in ICGV 86594, over Sellie (1.93 t ha^{-1}). Superiority in seed yields was not significant, as a result of poor pod filling in almost all ICRISAT varieties (except ICGV 87123 and ICGV 87240). All ICRISAT varieties had significantly lower ($P<0.001$) disease scores than Sellie. Sellie and ICGV 87123 matured in 132 days, while the other varieties took up to 15 days longer. Significant differences ($P<0.05$) in yield and foliar disease scores were also recorded between seasons.*

Sumario

***Avaliaçăõ de variedades do ICRISAT com resistência a doenças das folhas do amendoim em KaNgwane, Africa do Sul.** O amendoim (*Arachis hypogaea*) é a mais importante leguminosa plantada pelos pequenos agricultores em Kangwane, na regiăõ do Lowveld, a leste da Província do Transvaal, na Africa do Sul. Repetições do Quarto Ensaio Internacional de Variedades de Amendoim com Resistência a Doenças das Folhas – 1989 (IV-IFDRGVT-89), usando, como controlo local, o cultivar Sellie, foi conduzido durante os anos de 1991/93, em dois locais no Kangwane. Nove variedades do ICRISAT foram seleccionadas com base na cor da semente, rendimento de vagem e resistência à mancha precoce da folha e à ferrugen, tendo sido, mais tarde, comparadas com Sellie em quatro ensaios em 1992-94. Uma análise conjunta dos sete ensaios condizidos durante 1991-94, mostraram aumento significativo no rendimento de vagem ($P<0,05$) de 35%, com ICGV 86590, e 31%, com ICGV 86594, acima do rendimento de Sellie (1,93 t ha^{-1}). Contudo, os aumentos no rendimento de grão nãõ foi significativo, devido a pobre enchimento da vagem e 'pops' nas variedades do ICRISAT. A percentagem de descasque foi significativamente mais baixa ($P<0,01$) em todas a variedades do ICRISAT, com excepçăõ no caso de ICGV 87240 (65%) e ICGV 87123 (60%), quando comparadas com Sellie (66%). Sellie e ICGV 87123 atingiram a maturidade em 132 dias, quando as outras variedades atingiram maturidade pelo menos 15 dias mais tarde. Registaram-se também diferenças significativas ($P<0,05$) no rendimento, nos valores de doenças das folhas entre as campanhas.*

1. Department of Agriculture, Eastern Transvaal, Private Bag X 1005, Louws Creek, 1302, Republic of South Africa.

Mathews, C, and Beck, B.D.A. 1994. Evaluation of foliar disease resistant ICRISAT groundnut varieties in KaNgwane, South Africa. Pages 73-78 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand, G.L., and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Introduction

KaNgwane is a former homeland which now is included in the Eastern Transvaal Region of South Africa. Eastern Transvaal accounts for less than 5% of the total area under groundnut (*Arachis hypogaea*) in South Africa (DBSA 1994). However, groundnut is the most important legume crop grown by small-scale farmers in KaNgwane. There are over 12 000 smallholder farmers in KaNgwane, with holdings ranging from 0.25 to 7 ha (DBSA 1989). Almost all the groundnut produced is used locally for home consumption (roasted, boiled, etc.). Local sales are made at substantially higher prices than the price fixed by the National Oilseeds Board, and account for a significant part of farmers' incomes.

The average yield is low due to lack of good quality seed, drought periods at pod filling, foliar diseases, and poor agronomic practices. The majority of farmers use the cultivars Natal Common and Sellie, which are highly susceptible to the leaf disease complex of early leaf spot (*Cercospora arachidicola*), late leaf spot (*Phaeoisariopsis per sonata),* and rust (*Puccinia arachidis*). Groundnut is frequently intercropped with maize.

Research background

Farming communities have requested the Ministry of Agriculture of KaNgwane to assist in the development of sustainable farming systems for continuous cropping to replace their traditional shifting cultivation arable systems. They have particularly requested improved, locally adapted cultivars of maize, groundnut, bambara nut, and cowpea. Groundnut research in KaNgwane was initiated in the late 1980s with a view to improving the groundnut component of the farming systems used by resource-poor farmers in the region. The main objectives of the program were to identify suitable cultivars for rainfed cultivation with yield stability, resistance / tolerance to foliar diseases and to the hemi-parasitic weed *Alectra vogelii,* and also to recommend better management practices.

The first phase of this program is being carried out in formal trials at 2-3 locations in KaNgwane. Since 1986, we have collaborated with the Oil and Protein Seed Centre of the Agricultural Research Council at Potchefstroom, South Africa, in evaluating their groundnut selections. The variety Misga was identified as the highest-yielding variety in studies carried out during 1986-90. Cultivar differences for *Alectra* tolerance were also observed. Infected plants of the variety Natal Common showed a mean yield loss per plant of 38.4%, whereas only 7.8% loss was recorded in the variety 79 HI (Beck et al. 1991). In formal yield trials during 1990-93, the new variety Anel was the most stable yielder across two locations in KaNgwane.

In the second stage, outstanding varieties identified from the formal trials are further tested by farmers themselves on their own farms, in a Farming Systems Research and Extension (FSR/E) Programme, thereby allowing farmers to select varieties of their choice. Anel and Misga were selected by 20 participating farmers across three regions in KaNgwane during 1992/93 (Beck and Mathews 1993). In the 1993/94 season 16 farmers are evaluating four ICRISAT varieties.

With the lifting of sanctions on scientific information/technology exchange, we have established closer links with ICRISAT Asia Center, India. We received one replicate of the fourth International Foliar Disease Resistant Groundnut Variety Trial - 1989 (IV-IFDRGVT-89) in 1991. This paper presents results from seven trials conducted at KaNgwane: three trials of the IV-IFDRGVT-89 material during 1991-93, and four trials of 9 selected ICRISAT varieties during 1992-94.

Materials and methods

In the IV-IFDRGVT-89 trial, 24 ICRISAT groundnut varieties were compared with the local standard cultivar Sellie in a 5 x 5 triple lattice design with three replications, at the Mzinti Demonstration Farm (25°42' S, 31°43' E, 290 m above sea level) in Nkomazi district of KaNgwane during 1991/92. Plot size was four rows of 5 m length spaced 50 cm apart. Seeds were sown 10 cm apart in rows. Soil pH was 6.20 in KC1. Before land preparation, single superphosphate was applied @ 500 kg ha^{-1} and plowed in. Two rounds of manual weeding were done, 25 and 65 days after sowing. Gypsum @ 250 kg ha^{-1} was applied as a top dressing at flowering.

The trial was repeated at Mzinti during the 1992/93 cropping season with another replication at Malekutu (25°12' S, 31°12' E, 350 m above sea level) in Nsikazi district under rainfed conditions. The soil in Nsikazi is predominantly acidic (pH 5.2 in KCl). Both Mzinti and Malekutu are lowland semi-arid areas with a tropical summer and cool winter, and average crop season temperatures of 17.8°C (minimum) and 28.2°C (maximum). The soils in these areas are predominantly sandy loams. Lime was applied @ 1 t ha^{-1} and single superphosphate @ 500 kg ha*[1] during land preparation, at Malekutu. Gypsum was also applied at flowering @ 250 kg ha^{-1}. Plot size and design were the same as for the trials at Mzinti.

Only tan or red seeds are acceptable to the local farmers. After the 1991/92 season, nine of these accessions were selected for extended trials, based on the yield of air-dried pods, foliar disease scores, and testa color. They were compared with Sellie in a randomized block design with three replications in a further four trials, at both locations in the 1992/93 and 1993/94 seasons. Plot sizes and management practices were similar to those in earlier trials. No major insect pest damage was observed. No fungicides were applied to control foliar diseases in any of these trials. Disease scoring was done on a 1-9 scale (1 = no disease, 9 = 50-100% defoliation). Analyses of variance were carried out for percentage full stand at harvest, pod yield, seed yield, shelling percentage, 100-seed mass, and disease scores on early leaf spot, late leaf spot, and rust.

Results and discussions

The results from three replicates of the IV-IFDRGVT-89 trials conducted at Mzinti and Malekutu between 1991 and 1993 are shown in Table 1. Thirteen of the 24 ICRISAT varieties gave higher pod yields than Sellie, although the increase was not large enough to be significant. The highest yield superiority over Sellie was 29% in ICGV 86594. However, most of the ICRISAT varieties recorded low shelling percentages, and only four varieties gave higher seed yields than Sellie. The highest seed yield (26% higher than Sellie) was obtained from ICGV 87123. In general, the Spanish bunch types performed better than the Virginia types.

Disease scores for early and late leaf spots and rust recorded 15 weeks after sowing were very significantly higher for Sellie than for the ICRISAT varieties ($P<0.001$). Significant differences ($P<0.05$) in yield characters were also recorded between seasons. Pod yield, 100-seed mass, and disease scores were significantly higher in 1992/93 than in 1991/92. This was the result of higher, well distributed rainfall during the 1992/93 season (Fig. 1).

Results from all seven trials carried out during 1991-94 are presented in Table 2. Varieties ICGV 86590 and ICGV 86594 gave significantly greater ($P<0.05$) pod yields than Sellie (1.93 t ha^{-1}). The superiority was 35% in ICGV 86590 and 31% in ICGV 86594. Once again, the significantly lower ($P<0.01$) shelling percentages in the ICRISAT varieties reduced the differences in seed yield. Sellie had the highest shelling percentage (66%), followed by ICGV 87240 (65%) and ICGV 87123 (60%). Only two varieties gave higher seed yields than Sellie, and this superiority (4% in ICGV 86594 and 2% in ICGV 87240) was not significant. As in the IV-IFDRGVT-89 trials, foliar disease scores were very significantly higher ($P<0.001$) for Sellie than for the ICRISAT varieties, confirming the disease resistance of these varieties. Among the ICRISAT varieties, ICGV 87123 had significantly highest ($P<0.05$) disease scores. Again, there were significant differences ($P<0.05$) between seasons in pod yield and foliar disease scores. The scores for late and early leaf spots were lower during the 1991/92 and 1993/94 seasons, perhaps because of

Table 1. Performance of 24 ICRISAT foliar disease resistant groundnut varieties and one local variety, mean of 3 trials in KaNgwane, South Africa, 1991-93.

Variety	Pod yield (t ha^{-1})	SHP[1]	Seed yield (t ha^{-1})	FS%[2]	Disease score[3] ELS	LLS	RS	Seed color
ICGV 87123	2.64	66.9	1.79	81.0	3.5	3.4	2.3	Tan
ICGV 87240	2.46	64.4	1.56	82.3	2.5	2.6	1.6	Tan
ICGV 86594	2.76	56.1	1.50	82.8	2.4	1.9	1.5	Tan
ICGV 86659	2.27	60.3	1.48	80.7	3.3	3.1	2.1	Tan
Sellie	2.14	65.8	1.42	72.6	5.8	6.3	6.4	Tan
ICGV 86606	2.50	56.6	1.41	86.0	2.0	2.6	1.9	Tan
ICGV 87280	2.43	56.7	1.40	84.2	2.3	2.9	1.8	Tan

Continued

Table 1. *Continued*

Variety	Pod yield (t ha^{-1})	SHP[1]	Seed yield (t ha^{-1})	FS%[2]	Disease score[3] ELS	LLS	RS	Seed color
ICGV 87281	2.13	64.9	1.37	86.5	2.5	2.4	1.7	Tan
ICGV 87160	2.52	49.7	1.31	85.4	2.4	2.2	1.5	Tan
ICGV 86023	2.07	62.0	1.30	68.3	2.7	2.1	1.6	Red
ICGV 87350	2.27	56.4	1.27	66.3	2.1	2.6	1.3	Variegated
ICGV 87237	2.39	50.5	1.20	90.3	2.0	2.3	1.2	Tan
ICGV 86600	2.14	56.0	1.19	65.6	2.5	3.3	1.6	Tan
ICGV 87254	2.30	50.3	1.17	64.8	2.0	2.1	1.4	Purple
ICGV 86590	2.43	48.1	1.16	81.7	2.3	2.2	1.6	Tan
ICGV 86020	2.16	51.8	1.14	74.9	2.2	2.6	1.3	Tan
ICGV 86707	2.09	54.0	1.13	77.7	2.2	2.1	1.3	Tan
ICGV 86675	1.86	47.6	0.90	68.2	2.0	1.9	1.5	Tan
ICGV 86680	2.04	46.4	0.86	70.5	1.8	2.3	1.3	Tan
ICGV 87264	2.01	42.5	0.84	73.7	1.8	2.4	1.3	Tan
ICGV 86652	1.61	51.3	0.84	83.0	2.5	2.7	1.9	Tan
ICGV 86699	1.54	50.7	0.76	53.9	2.0	2.1	1.2	Red
ICGV 86691	1.44	39.3	0.57	54.4	2.2	2.1	1.3	Tan
ICGV 86687	1.16	47.8	0.56	43.7	2.0	1.7	1.2	Red
ICGV 86694	0.95	35.1	0.33	50.5	2.2	1.9	1.1	Tan
Mean	2.09	53.2	1.14	73.2	2.4	2.6	1.7	
SE	±0.281	±2.507	±0.183	±6.17	±0.27	±0.323	±0.247	

1. Shelling percentage.
2. Percentage stand at harvest.
3. Disease score on a 1-9 scale where 1 = no disease, 9 = 50-100% defoliation. ELS/LLS = early/late leaf spot, RS - rust.

Table 2. Performance of nine selected ICRISAT groundnut varieties and one local variety, mean of 7 trials, KaNgwane, South Africa, 1991-94.

Variety	Pod yield (t ha^{-1})	SHP[1]	Seed yield (t ha^{-1})	PS%[2]	Disease score[3] ELS	LLS	RS
ICGV 86594	2.52	54.6	1.34	73.2	2.3	1.7	1.4
ICGV 87240	2.06	64.7	1.31	77.5	2.7	2.5	1.6
Sellie	1.93	65.6	1.29	72.1	5.1	5.0	5.5
ICGV 86590	2.62	47.8	1.27	83.8	2.3	2.0	1.5
ICGV 87123	2.10	60.4	1.26	72.3	3.3	3.3	3.3
ICGV 86606	2.37	54.2	1.24	76.0	2.1	2.0	1.6
ICGV 87237	2.20	51.5	1.15	83.9	2.0	2.1	1.3
ICGV 87350	2.08	50.3	1.02	70.6	2.2	2.2	1.5
ICGV 86600	1.81	52.1	0.95	65.1	3.1	2.9	2.0
ICGV 86699	1.75	47.8	0.83	55.3	2.3	1.8	1.2
Mean	2.14	54.9	1.17	73.0	2.7	2.5	2.1
SE	±0.173	±2.314	±0.118	±4.18	±0.169	±0.23	±0.235

1. Shelling percentage.
2. Percentage stand at harvest.
3. Disease score on a 1-9 scale where 1 = no disease, 9 = 50-100% defoliation. ELS/LLS = early/late leaf spot, RS - rust.

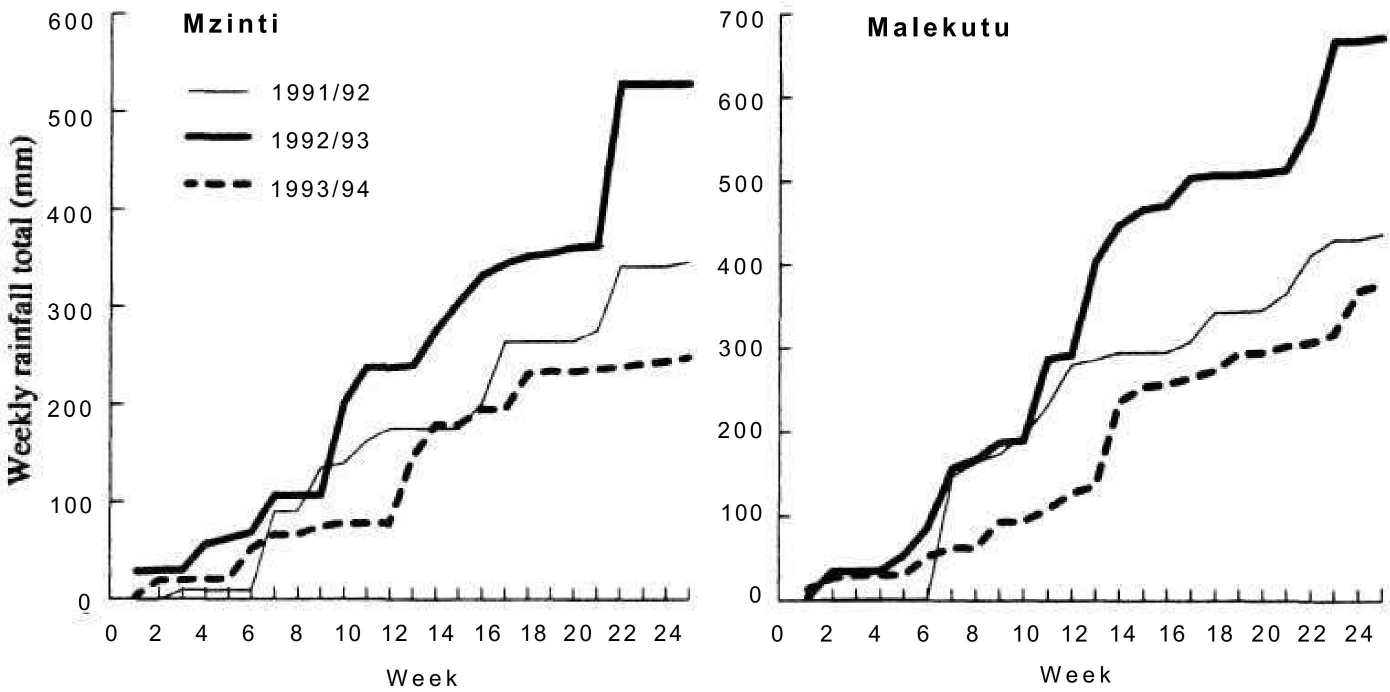

Figure 1. Weekly cumulative rainfall at Mzinti and Malekutufor 3 crop seasons, commencing first week Oct 1991.

the drier weather. Sellie and ICGV 87123 were the earliest-maturing varieties (132 days). The other varieties took 6-15 days longer to mature.

Conclusions and future programs

Based on the studies carried out during 1991-94, ICGVs 86590, 86594, 87123, and 87240 were found to be the most promising in terms of pod yield and resistance to foliar diseases. Final conclusions will be drawn after studying the results of the FSR-E groundnut program for 1993/94. However, it is essential to address the problem of poor pod filling ('pops'). All the ICRISAT varieties, except ICGV 87123, were found to be resistant (scores <3.0) to early and late leaf spots and rust compared to the highly susceptible Sellie (scores >5.0). ICGV 87123 was tolerant (scores >3.0) and had a maturity period similar to that of Sellie (132 days). The Virginia types with longer maturity periods are probably not suited for rainfed production in this area.

Evaluation of groundnut varieties from national and international institutes is in progress and will continue in formal trials and FSR-E programs aimed at identifying varieties with resistance/tolerance to drought and foliar diseases. There is also a need to identify short-duration varieties suitable for intercropping with maize. Emphasis will also be placed on agronomy studies to develop better management practices.

Acknowledgements

We would like to express our profound gratitude to Drs D McDonald and S N Nigam, ICRISAT Asia Center, for the supply of seed materials for these and other ongoing ICRISAT trials in KaNgwane, and also for maintaining close links with us.

References

Development Bank of Southern Africa (DBSA). 1989. Page 6-1-8 *in* Development Information Region F. P O Box 1234, Halfway House, 1685, Johannesburg, South Africa: DBSA.

Development Bank of Southern Africa (DBSA). 1994. Page 103 *in* South Africa's nine provinces: a human development profile. P O Box 1234, Halfway House, 1685, Johannesburg, South Africa: DBSA.

Beck, B.D.A., and Mathews, C. 1993. The FSR-E Programme in KaNgwane: the development of experimental design and evaluation. *In* Abstracts of the Southern African Farming Systems Research and Extension (FSR-E) Conference, 1-3 Jun 1993, Mbabane, Swaziland, P O Box 2716, Mbabane, Swaziland: Society for FSR-E in Southern Africa.

Beck, B.D.A., Mathews, C, and van Rensburg, J. 1991. The effect of *Alectra vogelii* (Benth) on smallholder farming systems in KaNgwane. *In* Abstracts of posters presented at the 29th Annual Plant Pathology Conference, 21-23 Jan 1991, Pietermaritzburg. Pietermaritzburg, South Africa: University of Natal and Society for Plant Pathology.

Discussion

Luhana. 1. You talked of farmer evaluation; what other factors did farmers use in evaluating the varieties? 2. How did you prioritize the evaluation criteria, since some can be more important than others?

Mathews. Farmers evaluate varieties in terms of establishment, resistance/tolerance to diseases, yield, shelling percentage, pod size, seed size, seed taste, seed color, and general acceptability. General acceptability to the farmer is considered to be the most important factor as small-scale farmers grow groundnut mainly for local consumption.

Subrahmanyam. I am very pleased to see the good performance of several FDRVT lines in South Africa. The disease scores are very much in agreement with our results earlier in India and currently in Malawi. What is the next step in advancing these materials?

Mathews. The major problem with the FDRVT lines is low shelling percentages. Recently we obtained a few more lines from ICRISAT Asia Center, and these are being evaluated for their suitability.

Freire. We had similar results on seed color from farmer evaluations in Mozambique. Varieties with other than tan colored seeds are usually rejected; purple seeds are definitely unacceptable.

Groundnut Insect Pests in Swaziland

L M Nsibande[1]

Abstract

Aphids, cutworms, leafhoppers, defoliating caterpillars, grasshoppers, flower thrips, flower beetles, red bugs, leaf- and bud-sucking bugs, red spider mites, termites, and postharvest insect pests are common in the groundnut-producing areas of Swaziland. Two surveys, conducted in 1985/86 and 1992/93 in several parts of the country, showed that the crop was attacked by a number of insect pest complexes. On-station and on-farm trials have also been conducted in the past to identify the major and minor pests of groundnut in Swaziland.

Sumário

Insetos e pestes que atacam o amendoim em Súazilandia. *Afideos, lagartas, saltadores das folhas, lagartas defoliadoras, gafanhotos, tripes das flores, escaravelhos da flor, insetos vermelhos, sugadores das folhas e botoēs, aranhas vermelhas, termitas, e insetos pós colheita são frequetemente encontrados em áreas de Súazilandia onde amendoim e cultivado. Dois inquéritos, conduzidos em 1985/86 e 1992/93 em varias partes do país, esses unquéritos apresentaram que a semente foi atacada por varios insetos e pestes.*

Ensaios tem sido conduzidos nas estações da investigaçâo e nos campos dos cultivadores para a identificaçåo das pestes maiores e menores do amendoim em Súazilandia.

Introduction

Groundnut is a valuable crop in Swaziland, for several reasons. Being rich in protein it is a useful diet supplement; when grown as a cash crop, it gives fair returns from a limited area. The crop has been grown widely by Swazi farmers for some time, but yields are generally low due to production constraints.

The crop is grown in most parts of Swaziland, but concentrated in the Middleveld. Currently about 2% of the total cultivable area is under groundnut production; average yields are less than 500 kg ha^{-1}. Late sowing, low plant population, inadequate inputs, weed competition, diseases, and insect pests are among the main factors contributing to the low yields and the acute shortage of groundnut in the country.

Insect pests

An insect pest survey was conducted throughout the country in the 1985/86 season. Further exploration and problem identification was done during on-station and on-farm trials in the Middleveld, Highveld, and Lowveld regions in 1992/93. Experiments were initiated to estimate insect-related losses. Leaf feeders such as the American bollworm (*Helicoverpa armigera),* various species of grasshoppers, ground weevils (*Protostrophus* spp), and semi-loopers (such as *Cosmophila aurogoides*) were found to cause extensive damage. The 'worst' grasshopper species in terms of damage caused and frequency of occurrence in different regions was the elegant grasshopper (*Zonocerus elegans*). Beetles (*Mylabris* spp, *Coryna*

1. Agricultural Research Division, P O Box 4, Malkcrns, Swaziland.

Nsibande, L.M. 1994. Groundnut insect pests in Swaziland. Pages 79-81 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994. Mbabane, Swaziland (Ndunguru, B.J., Hildebrand, G.L., and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

sp) also caused extensive damage to flowers. Thrips (*Frankliniella schultzei)* were the most serious insect pests in farmers' fields. In the Lowveld and the Lubombo plateau red spider mites were a very serious problem, not only on groundnut, but also on cotton and vegetables (especially tomatoes). Nematodes (especially *Meloidogyne* spp) were observed in one area.

Pest damage at different crop stages

Insect pests in Swaziland occur at different crop growth stages. During the seedling stage mortality may be caused by black cutworms (*Agrotis ipsilon).* Aphid infestation can begin at the seedling stage, with possible build-up even up to late podding, depending on the occurrence of drought spells during the season. Leafhoppers also infest the crop during the seedling stage and may be found till the flowering or podding stages. The elegant grasshoppers, American bollworm, and semi-looper are some of the defoliators that occur from the vegetative stage till the reproductive stage of the crop.

Thrips can be seen active even in the late vegetative stage, and continue their infestation till late flowering and podding. Flower damage by beetles is very common, extending from budding up to late flowering. The giant coreid bug (*Anoplecnemis curuipes),* spiny brown bugs *(Acanthomia* spp), and the green stink bug *(Nezara viridula)* cause extensive damage from the vegetative stage till flowering. At or just before maturity, infestations of red tea bugs and termites are seen. Termite damage to pods is particularly serious when plants are left in the field too long after lifting.

Table 1. Insect pests recorded on groundnut in Swaziland.

Common name	Scientific name	Family	Status
Black cutworm	*Agrotis ipsilon*	Noctuidae	Minor
Groundnut aphid	*Aphis craccivora*	Aphididae	Minor
American bollworm	*Helicoverpa armigera*	Noctuidae	Major
Semi-looper	*Cosmophila aurogoides*	Noctuidae	Major
Spiny brown bug	*Acanthomia* spp	Coreidae	Major
Giant coreid bug	*Anoplecnemis curuipes*	Coreidae	Major
Red spider mite	*Tetranychus cinnabarinus*	Acaridae	Major
Elegant grasshopper	*Zonocerus elegans*	Acrididae	Major
Rower beetles	*Mylabris* spp *Coryna* sp	Meloidae	Major
Leafhopper	*Empoasca* spp	Cicadellidae	Major
Red tea bug	*Hilda patruelis*	Cicadellidae	Minor
Green stink bug	*Nezara viridula*	Pentatomidae	Minor
Termites	*Macrotermes* sp *Microtermes* sp	Termitidae	Minor
Groundnut bruchid	*Caryedon serratus*	Bruchidae	Minor
Red flour beetle	*Tribolium castaneum*	Tenebrionidae	Minor
Rice moth	*Corcyra cephalonica*	Galleriidae	Minor
Ground weevil	*Protostrophus* spp	Curculionidae	Major
Nematodes	*Meloidogyne* spp	Meloidogyniae	Minor
Thrips	*Frankliniella schultzei*	Thripidae	Major

Postharvest insect pests include the groundnut bruchid (*Caryedon serratus*), red flower beetle (*Tribolium castaneum*), and the rice moth (*Corcyra cephalonica*). These insects cause extensive damage to stored groundnut if the produce is left unprotected.

Table 1 lists the major insect pests that occur in the country. Several leaf beetles, grasshoppers, and caterpillars infest groundnut, and we need to make more extensive collections of these, to enable a comprehensive listing of the pest species in the major groundnut areas in Swaziland.

Future research needs

The information gathered so far on the occurrence and importance of different insect pests on groundnut in Swaziland needs to be supplemented. Once additional information becomes available, it will be possible to develop an insect pest management program for groundnut. The objectives would be to:

- Screen the available groundnut germplasm for resistance to aphids, leafhoppers, and bruchids;
- Screen different insecticides (commercial and botanicals) for the control of insect pests;
- Develop cultural control strategies against *H. armigera* based on manipulation of plant population and sowing date.

Discussion

van Eeden. You mentioned the cutworm as an important pest. Cutworms do not only cut the plants off at soil level, but may also partly or totally devour developing pods. This is particularly so in South Africa, where cutworms occur during most of the growing season.

Cole. Do you not think that *Hilda patruelis* invades the crop earlier than you indicated, and that you are noticing incidence only later, when wilting occurs? You also mentioned transmission of a pathogen; what pathogen does *Hilda* transmit?

Nsibande. It is possible that *Hilda* invades plants earlier. I am not sure of the pathogen, but have read about it in the literature.

Kafiriti. We have a lot of *Hilda* damage on groundnut in Tanzania. We understand that the pest exudes certain substances that are toxic to the plants, but does not transmit disease.

Swanevelder. *Hilda* is a problem throughout the groundnut production areas in South Africa, but is particularly important in the northern and western parts. In the eastern coastal regions it occurs on different plant species.

Subrahmanyam. *Fusarium oxysporum* is often associated with *Hilda* damage, but is only a secondary invader of the roots of infested plants.

van Wyk. *Fusarium* species are frequently associated with wilted plants after attack by *Hilda patruelis.* This may result from predisposition of the plant to secondary invasion, but in some cases a more active association of *Fusarium* seems possible.

Agronomy
and
Cropping Systems

Achievements and Future Prospects of Groundnut Production and Research in South Africa

C J Swanevelder[1]

Abstract

Groundnut is produced in South Africa in a variety of systems, from smallholder plots to intensive production under irrigation. Production has fluctuated between 50 000 and 164 000 t over the last 10 years, depending on rainfall. About 32% is taken up by the confectionery market, 8% for seed, 39% utilized for oil, and 21% exported. Groundnut research started in the early 1970s, with work on Spanish types. Research studies over the years have largely focused on practical problems. Several aspects have been covered: disease control (leaf spot), insect pests, the effect on yield of various management variables (e.g., sowing depth, seed size, spacing, sowing/harvest dates), growth regulators, fertilization, etc. Development work on mechanization was another priority area.

*A strong breeding program has provided eight new cultivar releases since its inception; these have led to large production increases in certain areas. Resistance to black hull (*Chalara elegans*) and the pod rot nematode (*Ditylenchus destructor*) has been found. Extensive work has been conducted on the latter problem.*

Sumario

***Sucessos e perspectivas futuras da produção e investigação do amendoim na Africa do Sul.** Na Africa do Sul o amendoim é produzido numa grande variedade de sistemas, desde pequenos agricultores até à produção intensiva em regadio. A produção tem fluctuado entre 50 000 e 164 000 t durante os últimos 10 anos, dependendo das chuvas. Cerca de 32% do amendoim é canalizado para o mercado de doçarias, 8% para sementes, 39% para óleo e 21% é exportado. Investigação do amendoim começou no início dos anos 1970, trabalhando com o tipo Spanish. Estudos feitos nos últimos anos têm-se focado especialmente em problemas práticos. Vários aspectos têm sido cobertos: controlo das doenças (manchas das folhas); pragas dos insectos; o efeito de várias variáveis do maneio na produção (ex., profundidade de sementeira, tamanho da semente, espaçamento, datas da sementeira/colheita); reguladores do crescimento; fertilização, etc. Trabalho do desenvolvimento da mecanização foi outra área prioritária.*

Um forte programa do melhoramento conseguiu, desde a sua fundação, libertar oito novos cultivares; estes levaram a grandes aumentos na produção em certas áreas. Resistência a Chalara elegans *e ao nemátodo da podridão da vagem (*Ditylenchus destructor*) foi encontrada. Muito trabalho sobre o último problema tem sido conduzido.*

Introduction

Groundnut production in South Africa can be divided into three categories— intensive, extensive, and communal. Intensive production is practiced under irrigation, mostly by commercial farmers, while extensive production under rainfed conditions also occurs. Communal production is mostly by smallholders for family consumption. Areas suitable for groundnut production are limited to the Natal, Eastern Lowveld

1. Oil and Protein Seed Centre, Grain Crops Institute, Private Bag X1251, Potchefstroom 2520, Republic of South Africa.

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of Transvaal, Western Transvaal, North Western Free State, and the eastern part of Northern Cape Province. The average production over the last 10 years is about 80 000 t per year. Research over the years has resulted in improved cultivation practices, better cultivars, and successful disease control.

Production and utilization

Since the mid 1980s the area under groundnut has declined, and yields have fluctuated depending on rainfall. Data on area and production are presented in Table 1. The crop is handled by the Oilseeds Marketing Board which, through its agents, prepares the crop for the market (i.e., shelling, grading, and cleaning) and then sells it through a single-channel pool system. This has recently been changed to a floor price system. An indication of how the crop is utilized is given in Table 2.

Table 1. Area and production of groundnut in South Africa by commercial farmers, 1982-92.

Season	Area ('000 ha)	Production ('000 t)
1982/83	227	81
1983/84	238	60
1984/85	230	50
1985/86	221	137
1986/87	162	78
1987/88	207	83
1988/89	153	164
1989/90	86	114
1990/91	78	79
1991/92	189	78
1992/93	170	90

Source: Oilseeds Board

Agronomy

Research on groundnuts at the Oil and Protein Seed Centre began in 1974 with a descriptive study of the Spanish type groundnut plant: flowering, peg, pod and seed set, and vegetative development. The effect of ridging (banking, placing soil on the base of the plant) was also investigated, and it was found that ridging, especially if it occurred in the early growth stages, could reduce yields by over 50% (Swanevelder 1980). The effect of leaf spot diseases caused by *Cercospora arachidicola, Cercosporidiwn personatum,* and *Phoma arachidicola* on groundnut yield was investigated at four localities over four seasons. Yield increases of 9-89% were recorded, depending on locality, season, and harvest date. Sowing-depth and seed size trials were conducted at two localities for 2 years in the early 1980s, to determine the effect on yield. Plant population and yield were reduced by a reduction in the size of seed sown, especially when sowing depth exceeded 75 mm.

Sowing date trials have been conducted over a number of years on the released cultivars, and optimal sowing dates determined for these cultivars. The influence of temperature on yield of the short-duration

Table 2. Utilization of the commercial groundnut crop in South Africa, 1985-93.

Marketing year	Domestic market (t): Confectionery	Domestic market (t): Seed	Domestic market (t): Oil	Exports (t)	Total (t)
1985/86	25 462	8 269	58 315	36 314	128 360
1986/87	28 796	6 425	43 725	9 943	88 889
1987/88	26 714	9 469	37 149	5 435	78 767
1988/89	40 467	5 690	83 222	42 880	172 259
1989/90	27 569	4 028	40 382	26 748	98 727
1990/91	38 957	5 959	9 808	18 617	73 411
1991/92	33 288	10 929	18 608	16 812	79 637
1992/93	31 424	8 833	12 372	7 896	60 525
Total	252 677	59 094	303 588	164 645	780 004
Percentage	32.4	7.6	38.9	21.1	100

Source: Oilseeds Board

cultivar Harts was determined at Vaalharts under field conditions. Plant population trials with different inter- and within-row spacings revealed yield increases with closer spacings (up to 600 mm interrow and 375 mm within-row). The value of the growth retardant daminozide, in combination with nitrogen fertilizer, was investigated for two seasons at Vaalharts and for one season at Potchefstroom. Both nitrogen and daminozide reduced yield (Swanevelder and Loubser 1989). Cultivar evaluation trials were conducted over the years on a national scale and have been extended to Zimbabwe and Namibia for the 1993/94 season. The Southern African Regional Council for Conservation and Utilization of Soil (SARCCUS) Project benefitted all the participating countries.

Attention was also paid to mechanization of the harvesting process. A digger was developed, but although it performed very well it was difficult to adjust to varying plant heights. A very simple hand-operated picker 'and sheller was designed and built at the Centre, and made available to our communal farmers and participating SARCCUS countries.

Lifting (i.e., harvest) and picking (i.e., removal of pods from harvested plants) dates were investigated at a number of locations over 3 years. Mold infections were more frequent in early pickings, regardless of lifting time. During dry years the quality was not affected by lifting or picking time.

Cultivar trials are continuing with Spanish, Valencia, and Virginia types. Trials are being conducted at several locations to investigate a yellowing problem in some of our irrigated groundnut areas. Trials with nitrogen applications, to combat the N-negative period where groundnut is grown after winter wheat, will also be conducted during the coming season.

Soil amendments. Soil fertility/amendment trials were conducted on soils containing P >18 mg kg^{-1} (Bray 2), K >77 mg kg^{-1} (soils with lower levels are not generally cultivated in South Africa). Fertilizer trials with N, P, and K indicated no increase in seed yield, or yield of sound mature kernels. Nitrogen applications also had no effect on yield. Studies to determine the level at which response to applied P levels off, for the soil type on which most South African groundnut is grown, are nearly completed.

Effect of temperature. A 3-year study to determine the effect of temperature on germination under field conditions for six of our cultivars was completed this year. Research on the effect of daily maximum and minimum temperatures on yield, are progressing. From this work the frequency of minimum and maximum temperatures under which yield starts to decline will be determined. With these values determined, production areas for cultivars x sowing dates will be mapped. From this it can be determined which cultivar can be sown in a certain area at a specific sowing date.

Breeding

The groundnut breeding program was started before World War II. The first recognized groundnut cultivar, Natal Common, was selected by J P F Sellschop. More cultivars were later released, but their purity was not maintained became of the lack of a seed scheme. Sellie was released in 1976, and became the only new release for the next 12 years till Harts and Norden were released. Since then Selmani, Jasper, Kwarts, and Robbie have been released.

Resistance to black hull caused by *Chalara elegans* has been found. A breakthrough was made when resistance to the pod rot nematode, *Ditylenchus destructor,* was found (Van der Merwe and Joubert in press). Future objectives will be breeding for yield stability, better grading quality, and higher levels of resistance to *C. elegans, D. destructor, Sclerotinia minor, Botrytis cinerea,* and the *Aspergillus* complex.

Nematology

The major nematode problem on groundnut is D. *destructor.* It was discovered in 1987 and first reported in 1988 (Jones and De Waele 1988). Since then, researchers at the Centre have published 22 scientific papers and 9 popular articles, and made 25 presentations at symposia. It has been established that *D. destructor* is not a nematode on potatoes. It causes brown necrotic lesions at the point of connection with the peg, and a black discoloration appears along the longitudinal veins. Infected seeds were usually shrunken, while the testae and embryos had a yellow to brown or black discoloration. Entry occurs at the base of the pod near the point of connection with the peg. A method for the mass culture of this nematode on groundnut callus tissue was developed. The optimum temperature (28°C) for the development of *D. destructor* was determined. There are more nematodes present in the hulls than in the seed or roots of groundnut.

Ditylenchus destructor can survive in the field in the absence of host plants and in hulls left in the field after harvest, for at least 28-32 weeks. *Zea mays,* *Sorghum bicolor,* and *Nicotiana tabacum* are the best hosts of *D. destructor,* but most other crops also act as hosts. A number of common weed species were identified as hosts of *D. destructor* (De Waele et al. 1990). These are the highlights of the research on *D. destructor.* With genetic resistance having been found recently, this problem might be solved in the near future.

Pathology

The leaf spot complex is a major problem in wet seasons, but can be kept under control by the application of chemicals. Recent work evaluated the registered chemicals for effectiveness. Black hull caused by C. *elegans* was a severe problem in irrigated fields, but was controlled with the release of resistant cultivars. No work has recently been done on this pathogen. *Sclerotium rolfsii, B. cinerea,* and the *Aspergillus* complex have been major problems for many years, and research on these pathogens receives high priority. In certain production areas *S. minor* has also become a problem, causing both yield and quality losses. Research on this pathogen is also given high priority. Viruses also cause problems, but this has not yet been addressed.

Entomology

In a study on pod damage, 23 species of soil insects have been identified to cause damage to groundnut pods (van Eeden et al. 1991). In soil samples Scarabaeidae larvae have the greatest prominence, but false wireworms (Tenebrionidae) seemed to be the most important pest group. The critical time of damage was indicated to be 110 days after sowing. The Labiduridae and Carabidae were the most prominent predators. In view of the dominance of the local pest complex by Coleopterous species, the presence of Therivisae (Diptera) larvae was of special significance, since they are known to be predators of Coleoptera larvae. Predator numbers peaked slightly after the pest complex occurred in maximum numbers.

Five categories of subterranean insect damage were recorded, of which pod scarification was the most important. The effect of scarification alone on quality or yield is generally insufficient to warrant control measures, except in cases of exceptionally high occurrence of scarification. False wireworms *(Somaticus* spp) were the most important in causing pod scarification, whereas termites proved to be less important than in other parts of Africa. Apart from being pod scarifiers, *Somaticus* larvae were also found to be pod borers and to cause pod furrowing, and damage to pegs and immature pods. The damage levels caused by the other members of the pest complex still need to be investigated. The dominant fungi found in relation to insect damage were *Fusarium* spp, followed by *Penicillium* spp and *Aspergillus niger.* Although insects did not act as vectors of the fungi, lesions and holes in the pod shells caused by insect feeding facilitated the invasion of kernels by fungi present in the soil.

References

De Waele, D., Jordaan, E.M., and Basson, S. 1990. Host status of seven weed species and their effects on *Ditylenchus destructor* infestation of peanut. Journal of Nematology 22:292-296.

Jones, B.L., and De Waele, D. 1988. First report of *Ditylenchus destructor* in pods and seeds of peanut. Plant Disease 72:453.

Swanevelder, C J. 1980. Reproduksie by grondbone met spesiale verwysing na die invloed van operd. PhD-verhandeling, UOVS, Bloemfontein.

Swanevelder, C J., and Loubser, H.L. 1989. Die invloed van stikstof en daminozide op die produksie van grondbone. Toegepaste Plantwetenskap 3(1):5-7.

Van der Merwe, P.J.A., and Joubert, H.L.N. In press. Tolerance of groundnut cultivars to the potato rot nematode (*Ditylenchus destructor*). Proceedings of the 10th South African Maize Breeding Symposium, Mar 1992, Potchefstroom.

van Eeden, C.F., van Rensburg, J.BJ., and Van der Linde, T.C. de K. 1991. A checklist of insects occurring in groundnut (*Arachis hypogaea*) fields in the Highveld Region. Phytophylactica 23:255-259.

Discussion

Ndunguru. 1. Why are boron supplements important in South Africa? 2. Can you comment as to why you do not address such other diseases as early and late leaf spots and rosette?

Swanevelder. Boron is deficient in the highly leached, sandy soils found in Northern Transvaal and parts of Natal. 2. We did study the leaf spots. We identified the best chemicals to control the diseases, using two types of spraying programs: preventive spraying at regular intervals, and curative spraying when symptoms appear. Rosette is not a big problem with commercial farmers, but we will have to look at it again, especially where poor germination leads to poor stands.

Zengeni. Are *Sclerotinia-resistant* groundnut lines available?

Subrahmanyam. Yes, there are lines that are moderately resistant to the disease.

van Wyk. We have identified resistance in some cultivars in South Africa, which look promising.

The Role of Cropping Systems in Sustainability of Groundnut Production

E M Kafiriti[1]

Abstract

Groundnut in Tanzania is used both as food and for oil extraction. Most of the groundnut is produced by subsistence farmers with minimal inputs. The crop is grown in a variety of cropping systems, depending on environmental conditions and the objectives the farmer wants to achieve (e.g., primarily as a cash crop, or as a food supplement for home consumption). Intercropping and crop rotation are effective in reducing the incidence of groundnut pests and diseases, and most subsistence farmers in Tanzania use both methods. Unlike chemical control measures, these methods involve no cash expenditure, making groundnut production under such systems economically viable, and in that sense sustainable.

Sumário

O papel dos sistemas de cultivo na sustentabilidade da produçãõ do amendoim. *O amendoim na Tanzania é usado tanto como alimento como para a extraçãõ do óleo. A maior parte do amendoim é produzido por agricultores de subsistência com um mínimo de insumos, sendo cultivado numa grande variedade de sistemas do cultivo, dependendo das condições ambientais e dos objectivos do agricultor (ex., essencialmente como cultura de rendimento ou como suplemento alimentar para consumo caseiro). A consociação e a rotaçãõ das culturas são efectivas na redução da incidência da pragas e doenças do amendoim, a maioria dos agricultores de subsistência na Tanzania usam ambos os métodos. Contrariamente ao controlo químico, estes métodos nãõ envolvem despesas monetárias, tornando a produçaõ do amendoim economicamente viável e, neste sentido, sustentável.*

Introduction

Groundnut (*Arachis hypogaea*) is used in Tanzania mainly as food (MALD 1989). Oil processing is another, but less important, end use—edible oil in the country is produced mainly from cotton seed and sunflower. Most of the groundnut is produced by subsistence farmers with very limited inputs. Chemical fertilizers and pesticides are usually not applied, although it is reported that small quantities of triple superphosphate are often used (MALD 1989).

Groundnut is produced under various cropping systems. The choice of cropping system is determined by the environmental, social, and economic conditions under which the farmer operates, and the objectives (e.g., whether for food or cash sales) for which the crop is grown.

This paper discusses the role of cropping systems, with specific reference to intercropping and crop rotation, in the sustainability of groundnut production.

Intercropping

Groundnut in Tanzania is usually intercropped, often with more than two crops, particularly food crops. Groundnut usually plays a secondary role in the mixture. For example, in southeastern Tanzania, a recent

1. Oilseeds Research Programme, Agricultural Research Institute, Naliendele, P 0 Box 509, Mtwara, Tanzania.

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survey indicated that groundnut was'very commonly grown in mixed stands, usually with two or three other crops, often cassava; 79% of all groundnut fields in the surveyed area contained cassava.

Intercropping is effective in reducing damage due to insect pests and diseases and probably for this reason, it is commonly practiced by farmers in developing countries (Steiner 1982). In many of these countries, most groundnut producers are subsistence farmers. Nearly all conventional measures to control insect pests and diseases involve the use of chemicals, which are often beyond the reach of subsistence farmers. Intercropping is an effective alternative, since it involves minimal cash expenditure.

A number of researchers have documented the importance of intercropping in reducing disease incidence/severity on groundnut. Subrahmanyam (1991) found that the severity of early leaf spot (*Cercospora arachidicola)* and rust (*Puccinia arachidis)* was lower on intercropped groundnut than in sole cropping. Similar findings were reported by Mukiibi (1982) in Uganda when groundnut was intercropped with beans. Other findings indicated a marked reduction in the severity of rosette on groundnut by intercropping with beans in Malawi (Farrell 1979) and Uganda (Mukiibi 1982), and by intercropping with maize in the Central African Republic (Guilleman 1952). Similarly, the incidence of bud necrosis has been found to be reduced by intercropping, particularly with millet (Amin 1983). However, there have been reports of cases where intercropping caused no measurable improvement, or where disease severity was higher in an intercrop than in a sole crop (Lyimo and Kangalawe 1991 in Tanzania, Kannaiyan et al. 1989 in Zambia).

In intercropping systems, the component crops act as physical barriers, limiting the spread of insect pests and diseases when one of the crops is attacked (Karel et al. 1982). In pure stands there is no such barrier to the spreading of a disease. Intercropping also ensures that the microclimate, because it is nonuniform across the field, is less favorable for pathogen proliferation than in a sole-cropped field. The correct choice of component crops, and of spacing, is therefore important in controlling the microclimate, and thus in reducing disease severity.

Crop rotation

Crop rotation is an effective method to reduce the severity of groundnut diseases. By avoiding the cultivation of groundnut in the same field in successive seasons, the possibility of disease carry-over from one season to the next is reduced. This is of particular importance in soilborne diseases and diseases for which the primary source of inoculum is crop debris and volunteer plants. Deep plowing augments the efficacy of rotation by destroying and burying crop debris and volunteer groundnut, and thus reducing the level of inoculum (Schmidt 1992). However, deep plowing is not feasible for the majority of subsistence farmers because the operation requires more sophisticated/expensive tools and more draft power than does conventional plowing.

A number of studies have demonstrated that crop rotation can effectively reduce the severity of several fungal, bacterial, and nematode diseases on groundnut. In Malawi for example, Subrahmanyam (1991) found that the severity of early leaf spot and pod rots caused by *Rhizoctonia solani* and *Sclerotium rolfsii* was reduced by rotating groundnut with another crop. He also reported that rotation could reduce the severity of seedling disorders, invasion of seed by *Aspergillus flavus* and aflatoxin contamination, and web blotch disease.

There have been very few studies in Tanzania on crop rotation in groundnut, but this aspect is an important part of the future research plans of the Oilseeds Research Programme.

References

Amin, P.W. 1983. Studies on arthropod vectors of groundnut viruses: report of work done from 1978-83. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. (Limited distribution.)

Farrell, J.A.K. 1979. Effects of intersowing with beans on the spread of groundnut rosette virus by *Aphis craccivora* Koch (Hemiptera, Aphididae) in Malawi. Bulletin of Entomological Research 66:331-333.

Guilleman, R. 1952. Etudes agronomiques sur l'arachide en A.E.F., Oubangui-Chari, Tschad. Oleagineux 7:699-702.

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 Workshop for Southern Africa, 13-18 Mar 1988, Lilongwe, Malawi (Bock, K.R., Cole, D.L., Hildebrand, G.L., Nigam, S.N., and Wightman, J.A., eds.). Patancheru, A.P. 502 324, India:

International Crops Research Institute for the Semi-Arid Tropics.

Karel, A.K., Lakhani, D.A., and Ndunguru, B.J. 1982. Intercropping maize and cowpea. 1. Effect of plant population and insect pests on seed yield. Pages 102-109 *in* Proceedings of the Second Symposium on Intercropping in Semi-Arid Areas, 4-7 Aug 1980, Morogoro, Tanzania (Keswani, C.L. and Ndunguru, B.J., eds). Ottawa, Canada: International Development Research Centre.

Lyimo, H.J., and Kangalawe, R.Y.M. 1991. The effect of groundnut cultivar mixtures, intercropping, and date of planting on severity of late leaf spot. Pages 91-92 *in* Report of the Second Regional Groundnut Plant Protection Group Tour, Zimbabwe, Mozambique, and Swaziland, 25 Feb to 1 Mar 1991. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. (Limited distribution.)

Ministry of Agriculture and Livestock Development (MALD). 1989. Review of oilseeds. Dar es Salaam, Tanzania: Marketing Development Bureau, MALD.

Mukiibi, J. 1982. The effect of intercropping on some diseases of beans and groundnuts. Page 116 *in* Proceedings of the Second Symposium on Intercropping in Semi-Arid Areas, 4-7 Aug 1980, Morogoro, Tanzania (Keswani, C.L., and Ndunguru, B.J., eds). Ottawa, Canada: International Development Research Centre.

Schmidt, G. 1992. Combined intercropping and crop rotation trials at Chitedze Agricultural Research Station. Pages 125-128 *in* Proceedings of the Fifth Regional Groundnut Workshop for Southern Africa, 9-12 Mar 1992, Lilongwe, Malawi (Nageswara Rao, R.C., and Subrahmanyam, P., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Steiner, K.C. 1982. Intercropping in tropical smallholder agriculture, with special reference to West Africa. Eschborn, Germany: Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ).

Subrahmanyam, P. 1991. Diseases of groundnut in the SADCC region. Pages 14-17 *in* Report of the First Steering Committee Meeting, SADCC / ICRISAT Groundnut Project, 16-17 Apr 1991, Lilongwe, Malawi. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. (Limited distribution.)

Discussion

Chavula. In a groundnut-cassava intercrop the cassava is harvested later than groundnut. Would one not inevitably damage developing cassava roots when the groundnut crop is lifted?

Kafiriti. The groundnut crop normally matures before cassava roots start to develop. In any case cassava is sparsely planted, and the possibility of groundnuts being close enough to the cassava plant to cause damage, is remote.

Freire. In Mozambique, intercropping is more important than rotation.

Ndunguru. The relative emphasis on intercropping and rotation would depend on the nature of agriculture. Intercropping is associated with subsistence farming by smallholders; rotation becomes more important as the scale of operations increases.

Groundnut in the Farming System: Some Results of a Survey in Northern Mozambique

M J Freire[1], L Raffi[2], and P Fernandes[2]

Abstract

A benchmark field survey was conducted from 15 Nov to 10 Dec 1993 in three districts in northern Mozambique: Monapo and Ribaue in Nampula Province, and Montepuez in Cabo Delgado Province. A total of 534 families were selected from 21 villages in a proportional sampling. It was found that total farm size averaged 2.24 ha per family. Very low levels of fallow and crop rotation were recorded, and further research on this subject is recommended. In 1992/93, groundnut was sown on only 7-12% of farms; similar figures are expected for 1993/94. In most cases (63-70% of the groundnut farms) groundnut was intercropped, usually as a secondary crop. Cassava was the most common intercrop, both as a main crop and as a secondary crop. Some seed shortage was reported in Nampula Province. Most of the groundnut seed available at farm level was produced by the farmers themselves.

Sumario

***Amendoim no sistema de produção: alguns resultados dum inquérito no norte de Moçambique.** De 15 de Novembro a 10 de Dezembro de 1993, um inquérito de base foi conduzido nos distritos de Monapo e Ribâuè, na Província de Nampula, e de Montepuez, na Provinciua de Cabo Delgado, no norte de Moçambique. Um total de 534 famílias foram seleccionadas em 21 aldeias, numa amostragem proporcional. Observou-se que o tamanho total médio das machamba é de 2,24 ha por família. Um nível muito baixo de pousio e rotação das culturas foi notado e futuros estudos nesta área foram recomendados. Em 1992/93 apenas 7–12% das machambas foram plantadas com amendoim. Uma imagem semelhante era esperada em 1993/94. Na maioria dos casos (63–70% das machambas de amendoim) o amendoim foi consociado geralmente como cultura secundaria. A mandioca era a mais comum cultura consociada, tanto como cultura principal como secundária. Um certo nível de falta de sementes foi reportado na Província de Nampula. A maior parte de semente de amendoim foi produzida pelo próprio agricultor.*

Introduction

Groundnut was earlier a relatively important crop in the northern part of Mozambique. In Nampula Province it ranked fourth (following cassava, cotton, and sorghum), occupying 7.4% of the total cropped area; yields were 0.38 t ha^{-1}. In Cabo Delgado Province it ranked sixth, following cotton, cassava, sorghum, beans, and maize (2.3% of total cropped area, yield 0.41 t ha^{-1}) (MIAM 1963a,b)

1. Faculty of Agronomy and Forestry Engineering, University Eduardo Mondlane. C P 257, Maputo, Mozambique.
2. Cooptecnital, Vialle dell 'Universita, 2100185 Rome, Italy.

Freire, M.J., Raffi, L., and Fernandes, P. 1994. Groundnut in the farming system: some results of a survey in northern Mozambique. Pages 93-97 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand, G.L., and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

With the gradual onset of peace in Mozambique, after the signing of the Peace Agreement in Oct 1992, many new agriculture-related programs are emerging. For these programs to be successful, they must be based on a knowledge of field conditions, and indicators must be developed to monitor and evaluate progress.

A benchmark field survey was therefore conducted in the districts of Monapo and Ribaue in Nampula Province, and Montepuez in Cabo Delgado Province, with two objectives:

- To describe the farming system(s) in use;
- To develop indicators to be used to monitor and evaluate the Rural Development Program.

Materials and methods

The survey was conducted from 15 Nov to 10 Dec 1993. All three districts lie in the semi-arid to humid climatic zone. Table 1 summarizes the general characteristics of these districts. A total of 534 families were selected through proportional sampling. The sample included 12 villages in Monapo district, 5 villages in Ribaue, and 4 in Montepuez. In each village about 25 families were selected for the survey (Raffi et al. 1994).

Results and discussion

The survey revealed that the average family size was 4.1 persons, ranging from 3.8 in Montepuez to 4.6 in Ribaue. The average family owns about 3-4 *machambas* (farms). Each farm occupied 0.67-0.85 ha, and total cropped area per family averaged 2.24 ha (Table 2). Survey results on fallowing and crop rotation are shown in Table 3. Ribaue district had the highest percentage (8.3%) of families with at least one *machamba* in fallow. However, 23-41% of the families left their land fallow for 2-5 years. Crop rotation was not commonly practiced. In 1993/94, most of the families (65% in Ribaue, 87% in Montepuez) planned to sow groundnut in the same farms used in 1992/93. Among the main crops, only cassava was planned to follow groundnut (Table 3). This lack of rotation could have caused more serious problems had intercropping not been commonly practiced.

The groundnut area (sown in 1992/93, planned for 1993/94) was compared with the area sown the previous year. In both 1992/93 and 1993/94, families in all three districts either maintained or increased their groundnut area. The only exception was Ribaue, where 27% of the families reported a reduction in 1992/93 below 1991/92 levels (Table 4).

Table 2. Number and size of smallholder farms in three districts of Mozambique, 1993.

District	Number of farms per family	Unit farm size (ha)	Total farm size per family (ha)
Monapo	2.9	0.67 ± 0.49	1.93 ± 1.36
Ribaue	3.8	0.85 ± 0.58	3.19 ± 1.73
Montepuez	2.8	0.71 ±0.46	2.01 ± 1.10
Mean	3.1	0.73 ±0.51	2.24 ± 1.50

Table 1. General description of the districts of Ribaue, Monapo, and Montepuez, Mozambique.

Characteristic	District: Ribaue	Monapo	Montepuez
Mean annual rainfall (mm)	1000-1400	800-1200	800-1200
Mean annual evapotranspiration (mm)	1395	1488	1491
Mean monthly temperature (°C)	19.8-26.5	22.3-25.2	21.0-26.6
Mean relative humidity (%)	53.9-74.7	67.7-76.9	51.8-78.0
Altitude (m)	500-1000	<200	200-500
Mean available period of effective rains (weeks)	13-18	8-13	8-18
Sowing period	Dec	Jan-Dec	Dec
Growing period	Nov to Apr	Dec to Mar-Apr	Dec to Mar-Apr

Sources: Reddy (1986), Institute Nacional de Meteorologies

Table 3. Fallow and rotation in smallholder farms in three districts of Mozambique, 1993.

District	Farms in fallow (% of families)	Years of fallow (% of families)		Crop following groundnut (%)	
		0	2-5	Groundnut	Cassava
Monapo	4.0	66.6	27.9	82.8	0.0
Ribaue	8.3	48.4	41.3	65.4	7.7
Montepuez	6.4	68.0	23.0	86.7	6.7
Mean	5.6	62.5	30.3		

Table 4. Trends in groundnut area in three districts of Mozambique, 1992-94.

District	1992/93 compared with 1991/92 (% of families)			1993/94 (planned) compared with 1992/93 (% of families)		
	Increase	Maintain	Reduce	Increase	Maintain	Reduce
Monapo	46.8	48.9	4.3	43.9	47.9	8.8
Ribaue	13.5	59.5	27.0	44.7	51.1	4.3
Montepuez	40.6	59.4	0.0	37.8	59.5	2.7

Table 5. Cropping patterns and extent of groundnut intercropping in three districts of Mozambique, 1992/93 and 1993/94.

District	1992/93				1993/94 (expected)			
	Farms with groundnut (%)	Sole crop (%)	Intercrop		Farms with groundnut (%)	Sole crop (%)	Intercrop	
			Main crop (%)	Secondary crop (%)			Main crop (%)	Secondary crop (%)
Monapo	7	30	21	49	8	21	19	60
Ribaue	10	38	28	35	10	39	27	34
Montepuez	12	36	9	55	12	24	18	58

Cropping patterns involving groundnut (i.e., whether sole-cropped or intercropped, main or secondary) are shown in Table 5. During the 1992/93 season, groundnut was cultivated in 7-12% of the *machambas.* Although these figures are not directly related to the cropped area, they can be a good indicator. A comparison with figures from 1961 and 1962 (MIAM 1963a,b) shows some increase in the two districts in Nampula Province (from 7.4% of the total cropped area in 1961/62), and a larger increase in Cabo Delgado Province (from 2.3% of the total cropped area in 1961/62).

Groundnut is grown mainly as a secondary crop, with cassava being the most popular main crop (Table 6). Where groundnut was grown as a main crop, it was intercropped mostly with cassava and cowpea in 2- or 3-crop combinations. Although groundnut is usually cultivated as a food crop, some farmers do grow it as a cash crop. In Montepuez, 15.4% of the smallholder families grew groundnut for sale. The figures were somewhat lower in Nampula Province (9.2% in Ribaue, 4.5% in Monapo).

One of the constraints identified during the survey was non-availability of seed. Most farmers in Montepuez reported that they had seed, but availability was far lower in Monapo (55.1%) and Ribaue (62.5%) (Table 7). These figures could be misleading, because some of the farmers do not grow groundnut because

Table 6. Groundnut intercropping in three districts of Mozambique, 1993.

Main crop	Secondary crop	Occurrence of secondary crop (as % of total number of farms with main crop) in		
		Monapo	Ribaue	Montepuez
Maize	Groundnut	-	2	3
Cassava	Groundnut	11	13	32
Cotton	Groundnut	7	-	-
Groundnut	Maize	8	9	-
	Cassava	50	27	100
	Sorghum	8	-	-
	Cowpea	42	18	-
	Pigeonpea	17	9	-
	Bambara nut	25	9	-

Table 7. Groundnut seed availability and losses at farm level, as reported by farmers in three districts of Mozambique, 1993.

District	Seed available (% of growers)	Origin of seed (% of growers)			Seed losses during storage (% of growers)	Varieties lost (% of growers)
		Own	Neighbor	Others		
Monapo	55.1	89.5	7.9	2.6	4.6	13.3
Ribaue	62.5	90.0	6.7	3.3	3.5	23.1
Montepuez	93.9	96.8	3.2	0.0	6.7	7.4

Table 8. General calendar followed by smallholder groundnut farmers in three districts of Mozambique, 1993.

District	Clearing		Tillage and cleaning		Sowing		Harvesting	
	From	To	From	To	From	To	From	To
Monapo	Sep	Oct	Oct	Nov	1 Dec	15 Jan	May	Jun
Ribaue	Jun	-	15 Nov	-	1 Dec	-	15 Apr	30 May
Montepuez	-	-	-	-	1 Dec	-	Apr	-

Source: Servicos Distritais de Extenso Rural

they have no seed. Most of the seed available at farm level was produced by the farmers themselves, indicating that the seed supply by government and non-government organizations is probably inadequate.

A very low level of seed losses was reported during storage—only 3.5-6.7% of farmers declared losses (Table 7). However, up to 23% of the farmers have lost at least one variety; no consistency was found in the names given to the lost material by farmers.

Table 8 shows the general calendar followed by smallholders, showing clearly that, although bush clearing, tillage, and cleaning may begin at different times, sowing is usually done in Dec. From the harvesting periods mentioned, it is evident that farmers grow mainly long-duration material.

Observations and recommendations

Based on the results presented the following observations and recommendations can be made:

- There is little concern about fallowing and crop rotation. In view of their importance in the maintenance and enhancement of yields, there is a need for follow-up research to find out why the two practices are not widely used. These practices should also be disseminated by the extension system;
- There is a trend of increased groundnut area;
- Groundnut is normally intercropped (as a secondary crop, cassava being the main crop). It is cultivated as a sole crop in about one-third of the *machambas;*
- Farmers should be encouraged to continue to produce most of their own seed. However, high-quality seed should be made available, and an extension network developed to maintain seed at district level and supply it to farmers when needed;
- Farmers reported the loss of a few varieties. More detailed studies and collection missions should be conducted to collect, evaluate, and maintain the local germplasm.

Acknowledgments

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References

Missao do Inquerito Agricola de Mocambique (MIAM). 1963a. Recenseamento Agrfcola de Mocambique. I. Distrito de Mozambique. Primeira parte. 1961. Governo Geral de Mozambique, Direczao Geral de Economia, Comissao para os Inqueritos Agrfcolas no Ultramar. Lourenzo Marques, Mozambique: MIAM.

Missao do InqueVito Agrfcola de Mozambique (MIAM). 1963b. Recenseamento Agrfcola de Mozambique. II. Distrito de Cabo Delgado. Primeira parte. 1962. Governo Geral de Mozambique, Direccao Geral de Economia, Comissao para os Inqueritos Agrfcolas no Ultramar. Lourenzo Marques, Mozambique: MIAM.

Raffi, L., Freire, M., and Fernandes, P. 1994. Bench mark field survey nos distritos de Monapo e Ribaue, Provfncia de Nampula, e de Montepuez, Provfncia de Cabo Delgado. Cooptecnital, Rome, Italy. Projecto de Reabilitacao dos Servizos Agrfcolas nas Provfncias de Nampula e Cabo Delgado. Maputo, Mozambique: Ministerio da Agricultura.

Reddy, S.J. 1986. Agroclimate of Mozambique as relevant to dryland agriculture. Terra e Agua no. 47. Maputo, Mozambique: Instituto de Nacional de Investigacao Agronomica.

Discussion

Luhana. You mentioned that farmers use their own seed. Is this a traditional practice, or are farmers compelled to do so because the seed distribution system is inadequate?

Freire. Farmers do keep their own seed traditionally, but a distribution system is lacking.

Nxumalo. You have not mentioned fertilizer use in your survey results. Are researchers in Mozambique doing something about generating technology that will help farmers use fertilizer for groundnut production?

Freire. Farmers do not use fertilizer because they have no money; most groundnut farmers in Mozambique operate at subsistence levels.

Cole. Where did the groundnuts the farmers grow originate? Are they long-duration types?

Freire. They are long-duration types that probably originated from Malawi and Zambia a long time ago.

Screening Groundnut for Pops Tolerance/Resistance Under Field Conditions in Malawi

C E Maliro and N E Nyirenda[1]

Abstract

Groundnut is an important crop in Malawi, but area under the crop has declined drastically in recent years. The problem of pops may be a contributing factor. Results from a pops screening experiment conducted at Mbawa Experiment Station, Malawi, from 1987/88 to 1992/93 are reported here. The objectives were to identify and evaluate pops-tolerant varieties for possible release or use in breeding programs. Although pops-tolerant genotypes (MB 662, Florunner, TG 9) may exist, no correlation was found between pops incidence and seed yield. However, farmers' perceptions of the pops problem may be an important factor, irrespective of the magnitude of pops-related losses. The influence of sowing date on pops was only marginal at best. Contrary to the commonly held view that large-seeded genotypes are more susceptible, we found seed size to be very poorly correlated with pops incidence.

Physiological studies and sustained surveys should be conducted in the pops problem areas of Malawi, with a view to eventually breeding for high yields in these areas. Meanwhile, agronomy work (e.g., on spacing) needs to be done on pops-tolerant genotypes.

Sumario

Avaliação do amendoim para a tolerancia a pops/resistencia nas condições nos campos em Malawi. *Amendoim e uma cultura importante em Malawi, mais recentemente a área sob o cultivo do amendoim tem declinado drásticamente. É possivel que o problema do 'pops' seja um dos fatores que contribui a esse declinio. Os resultados de uma avaliação conduzida por a Estação da investigação de Mbawa em Malawi de 1987/88 a 1992/93 são relatados. Os objetivos erão a identifiação e avaliação das variedades resistentes a 'pops' (vagens chochas), para as libertar, ou para as utilizar nos programas do melhoramento. Embora os genotipos con tolerância a 'pops' (MB 662, Florunner, TG 9) podem existir, não se consegui uma correlação entre a incidencia do 'pops' e o rendimento da semente. Porem as percepções dos agricultores em relação ao problema do 'pops', podem ser un fator importante independente da magnitude dos danos causados por 'pops'. A influência da data da sementeira sobre o 'pops' foi marginal. Um ponto da vista é que os genótipos com vagens grandes são mais suscetível ao 'pops', mas nós achamos que o tamanho da semente e pobremente correlacionado com a incidencia do 'pops'.*

Estudos fisiológicos e inquéritos precisam ser conduzidos em áreas de Malawi onde o 'pops' é um problema, com a vista de eventualmente conseguir nessas áreas linhas do melhoramento com altos rendimentos. No entanto trabalho de agronomia (como os cmpassos) presica ser feito sobre os genotipos resistentes a pops.

1. Chitedze Agricultural Research Station, P 0 Box 158, Lilongwe, Malawi.

Maliro, C.E., and Nyirenda, N.E. 1994. Screening groundnut for pops tolerance/resistance under field conditions in Malawi. Pages 98-105 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand, G.L., and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Introduction

Groundnut (*Arachis hypogaea)* is a very important crop in Malawi. It provides export earnings from confectionery groundnut, and helps reduce imports by satisfying part of the country's demand for edible-oil raw materials. Groundnut is also widely traded within Malawi, and is thus a source of income for farmers and traders. Groundnut (pure or blended with other foods) is also very important nutritionally, as it is rich in protein and energy compounds. Being a legume, it also enhances soil fertility when used as a rotation crop, thus helping smallholder farmers save on fertilizer costs.

However, production problems are fairly severe. Groundnut area in Malawi has declined by about 56% between 1989 and 1993, and yields are consistently low: 450 kg seed ha^{-1} with Chalimbana and Chitembana (Ministry of Agriculture 1992, 1993). Pops (pods without seeds or improper filling of seeds) is one reason for the decline in groundnut area, particularly in areas where the pops problem is severe. Pops incidence is associated with poor yield and quality, and could thus be an important factor in the confectionery trade.

Pops results from low calcium levels in the immediate vicinity of developing pods. Sandy soils constitute a substantial part of the main groundnut production areas of Malawi. In these areas, dominated by acid (pH 4.8-6.6), sandy-ferralitic soils (Maliro unpublished), pops has been reported to be a problem.

No work has been done in Malawi to directly measure the effect of pops on groundnut yield (Maliro unpublished). However, data from other studies (on crop responses to lime and gypsum application) indicate that pops apparently reduces seed yield by 16-55% (Maliro unpublished), and could also cause serious quality losses. Calcium deficiency in the upper 8 cm of topsoil can lead to yield and quality losses; the problem of inherently Ca-deficient soils is often compounded by leaching of Ca from the upper layers of sandy soils (Gascho et al. 1993).

In sandy soils in the USA, Ca deficiency causes pod rot, which also contributes to low yield and poor quality (Walker and Csinos 1980). Large-seeded Virginia genotypes require more Ca in the pegging/fruiting zone than do smaller-seeded runner types (Walker et al. 1979, Cox et al. 1982, Sumner et al. 1988). In Georgia, depending on the genotype and/or topsoil Ca, gypsum is recommended for groundnut (Plank 1989). Both gypsum and lime (depending on soil pH, Ca, and lime application methods) increase pod yield and the proportion of sound mature kernels (SMK), and reduce the incidence of pod rot (Gascho et al. 1993, Sullivan et al. 1974).

A review of groundnut research in Malawi (1960/61 to 1981/82) indicated that responses to lime or gypsum occurred in <50% of seasons; only in a few areas (e.g., Bulala, Wenya, Chinteche, and Lunyangwa in northern Malawi) were responses observed every season. Soil analysis for the experiment sites revealed that, except in Chinteche and Lunyangwa areas, pH was sufficiently high for groundnut (Maliro unpublished). Also, most of the pops-prone soils apparently have adequate Ca, and a few soils have marginally low soil Ca. Within an experimental site there were considerable differences over seasons/years in soil Ca; this may partly account for the erratic yield responses to gypsum application. The erratic responses to gypsum, huge amounts of lime/gypsum needed, and the low groundnut yields (84-1600 kg seed ha^{1}), together make lime/gypsum technology unfeasible in Malawi. In the USA, where yields are higher (600-4400 kg ha^{-1}), lime/gypsum application is viable (Gaines et al. 1989, Gascho et al. 1993).

To solve the pops problem in Malawi, therefore, resistant/tolerant genotypes may be required. The objectives of this study were to:

- Identify pops-tolerant genotypes, regardless of other characteristics, for use in breeding programs;
- Identify high-yielding, pops-tolerant genotypes for immediate release in pops areas in Malawi.

Materials and methods

The pops screening experiment was conducted at Mbawa Experiment Station from 1987/88 to 1992/93 (no data was collected in 1989/90). The station is situated in the Mzimba plain, the major pops problem area in Malawi. Sites were located in fields where pops has been a consistent problem. In the 1987/88 season, 40 genotypes from the Malawi national program and the SADC/1CRISAT breeding program were screened. These genotypes included two controls: one pops-tolerant/resistant (MB 662) and one susceptible (Chalimbana in 1987/88 and 1988/89, B 624/1 from 1990/91 onwards).

In the first season, the genotypes were grown in a randomized complete block design without replication. Since seed was limited, only one 6-m ridge was sown to each genotype. In later years, three replications were used in a split-plot design. Treatments were a factorial combination of genotype (G) and sowing date (T). Two or three sowing dates were used: the earliest with the first sowing rains, and the two later dates following at 3-week intervals. Good management practices were used. The data collected included pops incidence, yield, seed size, and number of seeds per pod. Genotypes with low pops incidence in the first season were advanced to the replicated experiment the following season. Depending on seed availability, some genotypes were included at later-stages of the trial. Data were analyzed using the General Linear Models procedure in the Statistical Analysis System (SAS) computer program. Both treatment factors and the replication factor were considered fixed.

Results and discussion

1987 / 88 season. Forty genotypes, including two controls, were evaluated. The experiment was not replicated, and the results are therefore only indicative. Pops severity appeared to depend on genotype but not on time of sowing. Overall, pops incidence was low (Table 1). Except for 3 early-sown and 7 late-sown genotypes, pops incidence was <12%. Interestingly, the susceptible control, Chalimbana, suffered <10% pops incidence. Seed yields were low: 267-1000 kg ha^{-1} for early sowing, and 89-556 kg ha^{-1} for late sowing. Seed yields were not related to pops incidence in the various genotypes.

1988 / 89 season. Ten genotypes, including two controls, were evaluated. Pops incidence (mean of two sowing dates) ranged from 2.5% (in Robut 33-1, lower than the tolerant control) to 57% in the susceptible control (Table 2). Four of the eight test genotypes showed mean pops incidence < 12%. Seed yields were low: 209-742 kg ha^{-1} for early sowing, 71-676 kg ha^{-1} for late sowing. All the test genotypes gave higher yields than the pops-susceptible control, but there was no relationship between yield and pops incidence. Neither did sowing date appear to influence pops incidence.

1990/91 to 1992/93. Fifteen genotypes, including two controls, were evaluated over these three seasons. In 1990/91, seed yields were variable and pops incidence relatively uniformly low, with several genotypes showing incidence similar to that in the pops-tolerant control (Table 3). In the 1991/92 season, pops incidence was relatively severe (Table 4). In both 1990/91 and 1991/92, as in previous years, there was no clear relationship between pops incidence and sowing date. A G x T interaction was observed in 1991/92 and 1992/93; but in neither season did yield correlate with pops incidence (Tables 4 and 5).

Parameter relationships

There appeared to be no clear relationship between seed yield and pops incidence. Linear regression gave coefficients of regression (R^2) ranging from 0.003 to 0.56 in various years; the best association (R^2 = 0.36 to 0.56) was for the 1991/92 data. However, this best fit accounted for only 36-56% of the total yield variation. Nonlinear regression too did not indicate any clear relationship between yield and pops incidence.

As expected, pops incidence was strongly associated (linearly) with shelling percentage (R^2 = 0.72) and number of seeds per pod (R^2 = 0.90). However, contrary to the commonly held view that larger seed size is linked to higher pops incidence, we found that seed size was very poorly correlated with pops incidence (R^2 = 0.22 in 1988/89 and 1992/93).

Conclusions

Pops-tolerant genotypes, e.g., MB 662, Florunner, and TG 9, may exist. However, high pops tolerance may not necessarily mean high seed yields. Conversely, high-yielding genotypes may be susceptible. The 'psychological' factor can be important in farmers' attitudes to the pops problem. At the time of shelling, a variety that produces a large number of empty shells is likely to be discarded; farmers often will not consider the fact that the variety may have in fact given a higher seed yield than a pops-tolerant but smaller-seeded variety.

For groundnut in Malawi, the growth-related parameter most variable among seasons is rainfall; perhaps pops incidence may be partly influenced by rainfall. The influence of sowing date on pops was only marginal at best.

It is necessary to determine whether pops is a problem by itself or merely an impact symptom associated with the real cause(s) of low yields. This would involve sustained surveys (over a block of seasons) in the pops problem areas, and also physiological studies. Breeding for high yields in these problem areas may have to wait for the causes to be established, using the surveys and physiology studies proposed above. As for now, agronomy work needs to be done on the genotypes showing pops tolerance, with the hope that some yield increases may result. Studies

Table 1. Growth habit, seed yield, shelling percentage, pops incidence, and seed number per pod in 40 genotypes, Mbawa Experiment Station, northern Malawi, 1987/88.

Genotype	Growth habit[1]	Yield (kg ha^{-1})			Shelling percentage		Pops incidence (%)			Seeds $pods^{-1}$	
		T1	T2	Mean[2]	T1	T2	T1	T2	Mean	T1	T2
MB 662	B	511	356	433.5	70	73	3	1	2.0	1.69	1.74
Chalimbana	R	622	244	433.0	67	50	0	8	4.0	1.78	1.55
Robut 33-1	SB	400	178	289.0	62	73	1	2	1.5	1.51	1.40
85 hyq(vb)t	SB	800	533	666.5	69	67	6	9	7.5	1.55	1.50
B 910/1/2	SB	644	311	477.5	60	45	0	3	1.5	1.78	1.73
C 851/7	SB	689	-	-	59	-	7	-	-	1.63	-
E 910/1/2	SB	778	378	578.0	61	41	3	6	4.5	1.79	1.64
B 434/1	SB	556	244	400.0	54	39	6	36	24.0	1.57	0.96
D 58/1	SB	800	378	589.0	67	61	1	7	4.0	1.78	1.64
C 763	SB	400	222	311.0	33	42	25	24	24.5	1.12	1.25
D 27/3	SB	1000	268	634.0	68	57	0	3	1.5	1.65	1.52
TG 9	SB	311	222	266.5	61	63	3	0	1.5	1.82	1.60
C 863/2	SB	600	333	466.5	60	60	9	3	6.0	1.63	1.72
B 19/2	B	956	556	756.0	64	63	5	5	5.0	1.73	1.75
D 196/3/1	SB	667	356	511.5	62	53	5	8	6.6	1.44	1.59
C 763/1/1	SB	467	200	333.5	44	47	25	14	19.5	1.12	1.32
E 685/1	SB	511	289	400.0	52	54	7	6	6.6	1.46	1.4
D 636/2	SB	667	267	467.0	65	60	0	6	3.0	1.48	1.27
B 624/1	SB	311	89	200.0	44	29	21	48	34.5	1.11	0.54
B 80/3/2	SB	711	400	555.5	63	53	0	6	3.0	1.79	1.57
D 341/1	SB	711	222	466.5	56	56	4	11	7.5	1.52	1.26
F-16-3-40-a	R	400	311	355.5	56	58	1	6	3.5	1.54	1.54
C 212/2	SB	511	356	433.5	68	67	2	4	3.0	1.62	1.44
B 80/3	SB	867	378	622.5	67	55	0	-	-	1.79	-
E 685/2	SB	800	179	489.5	64	47	3	6	4.5	1.30	1.34
C 863/1/2	SB	556	378	467.0	60	65	5	3	4.0	1.52	1.55
E 685/3/1	SB	667	422	544.5	61	56	7	5	6.0	1.42	1.57
C 212/1/1	SB	267	156	211.5	60	50	4	7	5.5	1.46	1.58
C 763/3	SB	533	289	411.0	48	47	3	16	9.5	1.40	1.35
B 80/2	SB	689	333	511.0	56	46	2	10	6.0	1.81	1.50
D716	SB	489	-	-	65	-	5	7	6.0	1.46	1.45
D 261/2	SB	667	222	444.5	53	40	1	9	5.0	1.58	1.35
E 267/2	SB	644	289	466.5	64	59	0	1	0.5	1.20	1.30
B 201/3	SB	711	356	533.5	55	59	11	5	8.0	1.42	1.72
B 80/1	SB	533	489	511.0	60	49	7	16	11.5	1.40	1.60
B 201/1	B	422	422	422.0	54	54	1	0	0.5	1.36	1.75
C 100/1/1	SB	533	400	466.5	60	51	4	7	5.5	1.53	1.44
B 434/2/1	B	578	311	444.5	58	50	7	15	11.0	1.40	1.22
D 657/2/2	SB	400	244	322.0	64	44	2	7	4.5	1.67	1.43
E 685/1/2	SB	511	356	433.5	50	62	4	3	3.5	1.50	1.70

1. T1 = early sowing (with first sowing rains), T2 = late sowing, T1 + 3 weeks.
2. B = bunch/erect, SB = semi-bunch, R = runner/prostrate growth habit.

Table 2. Seed yield, shelling percentage, pops incidence, and seed number per pod in 10 genotypes, Mbawa Experiment Station, northern Malawi, 1988/89.

	Yield (kg ha^{-1})			Shelling percentage		Pops incidence (%)			Seeds pod^{-1}	
Genotype	T1	T2	Mean	T1	T2	T1	T2	Mean	T1	T2
MB 662	684	524	604.0ab	66	52	4	1	3.0e	1.61	1.69
Chalimbana	209	71	140.0c	23	16	51	63	57.0a	0.65	0.45
Robut 33-1	520	218	369.0b	62	65	2	3	2.5e	1.35	1.35
B 910/1/2	640	413	526.5ab	42	37	22	22	22.0bc	1.29	1.42
D 27/3	742	676	709.0a	41	48	19	5	12cde	1.05	1.42
TG9	440	396	418.0b	58	62	4	3	3.5de	1.36	1.39
C 212/2	827	316	571.5ab	50	43	9	32	20.5bcd	1.15	0.76
E 267/2	547	356	451.5b	48	39	15	24	19.5bcde	1.22	1.19
B 201/1	480	400	440.0b	44	42	14	9	11.5cde	1.27	1.23
E 685/1/2	733	271	502.0ab	41	29	35	36	35.5b	0.98	0.93
Mean	582.2	364.0		47.4	43.3	19.8	17.5		1.190	1.183
SE	±107.45			±4.61		±7.40			±0.208	
CV(%)	39			18		69			30	

T1 = early sowing (with first sowing rains), T2 = late sowing, T1 + 3 weeks.
Means within a column, followed by the same letter, are not different by Duncan's Test.

Table 3. Seed yield, shelling percentage, pops incidence, and seed number per pod in 15 genotypes, Mbawa Experiment Station, northern Malawi, 1990/91.

	Seed yield (kg ha^{1})			Shelling percentage			Pops incidence (%)		
Genotype	T1	T2	T3	T1	T2	T3	T1	T2	T3
MB 662	1373	982	387	75	75	73	24	3	6
B 624/1*	853	409	98	46	38	41	53	62	35
Florunner*	764	835	244	77	77	69	2	3	9
B 910/1/2	2027	942	529	68	58	59	6	11	8
D 27/3	1436	804	333	76	57	61	12	7	20
TG9	947	689	378	67	72	62	3	3	5
E 267/3*	1356	933	320	65	56	45	5	13	13
E 267/2	1258	840	249	65	55	36	22	24	26
ACG 1*	1653	867	347	59	48	42	17	31	18
E 685/1/2	1636	680	484	64	53	57	10	11	12
C 851/7	1609	1236	484	65	62	53	8	6	10
C 264/1/2*	1613	533	360	63	40	45	6	28	25
B 80/3	1316	764	324	58	54	43	15	19	23
E 267/11*	1338	867	404	59	47	44	19	39	27
ICGMS 42*	1511	1049	653	76	71	70	5	10	12
Mean	1379.3a	828.7b	373.0b	65.5a	57.7b	53.4b	13.8	18.0	16.6
SE		±152.52			±4.54			±8.05	
CV(%)		31			13			86	

T1 = early sowing, T2 = T1 + 3 weeks, T3 = T1 + 6 weeks.
* First season for the genotype.
Means for the same parameter, followed by the same letter, are not different by Duncan's Test.

Table 4. Seed yield, shelling percentage, pops incidence, and seed number per pod in 15 genotypes, Mbawa Experiment Station, northern Malawi, 1991/92.

	Yield (kg ha^{-1})				Shelling percentage			Pops incidence (%)			Seeds pod^{-1}		
Genotype	T1	T2	T3	Mean	T1	T2	T3	T1	T2	T3	T1	T2	T3
MB 662	484	818	258	520.0	54	69	63	9	13	7	1.28	1.32	1.53
B 624/1	129	218	133	160.0	15	28	36	82	78	60	0.14	0.31	0.40
Florunner	453	827	333	537.7	61	64	53	21	17	27	1.14	1.12	0.92
B 910/1/2	373	391	222	328.7	30	34	36	25	39	24	0.69	0.68	0.99
D 27/3	355	240	351	315.3	30	29	45	54	33	16	0.93	0.62	1.09
TG9	204	200	337	247.0	54	44	56	32	29	27	0.77	0.72	1.04
E 267/3	151	262	253	222.0	32	38	48	30	35	19	0.67	0.81	1.06
E 267/2	288	151	168	202.3	28	27	43	58	34	31	0.64	0.45	0.82
ACG 1	160	160	102	140.7	18	21	30	72	63	60	0.34	0.49	0.61
E 685/1/2	284	382	200	288.9	30	36	38	48	50	44	0.74	0.58	0.80
C 851/7	311	342	182	278.5	30	33	36	47	50	33	0.50	0.69	0.77
C 264/1/2	306	288	106	250.0	28	24	33	54	47	48	0.42	0.51	0.60
B 80/3	200	217	111	176.3	25	33	37	56	50	44	0.38	0.73	0.70
E 267/11	244	217	124	195.6	22	25	24	60	63	40	0.41	0.51	0.66
ICGMS 42	551	351	240	380.7	43	37	41	43	57	21	0.45	0.38	1.03
Mean	582.2	364.0	208.0		47.4	36.1	43.3	19.8	17.5	33.4	1.190	1.183	0.868
SE		±107.45				±4.61			±7.40			±0.208	
CV (%)		39				18			69			30	

T1 = early sowing, T2 = T1 + 3 weeks, T3 = TI + 6 weeks.

Table 5. Seed yield, shelling percentage, pops incidence, and seed number per pod in 15 genotypes, Mbawa Experiment Station, northern Malawi, 1992/93.

	Yield (kg ha^{-1})			Shelling percentage			Pops incidence (%)			Seeds pod^{-1}		
Genotype	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
MB 662	395	231	128	71	65	68	3	8	12	1.77	1.58	1.45
B 624/1	480	88	48	53	45	53	16	20	22	1.27	1.34	1.30
Florunner	248	182	133	73	61	63	11	15	9	1.36	1.35	1.53
B 910/1/2	600	146	97	59	50	54	7	17	17	1.55	1.32	1.35
D 27/3	444	93	48	49	35	55	12	29	30	1.45	1.00	1.13
TG9	142	111	106	64	68	53	10	17	16	1.53	1.32	1.27
E 267/3	471	164	88	58	53	55	5	25	22	1.59	1.18	1.16
E 267/2	342	168	115	55	39	42	13	13	22	1.28	1.24	1.16
ACG 1	435	137	62	51	37	48	16	22	21	1.20	1.08	1.18
E 685/1/2	422	151	88	59	58	53	16	11	22	1.32	1.60	1.27
C 851/7	586	208	115	54	52	54	12	14	11	1.47	1.42	1.49
C 264/1/2	328	186	88	34	44	43	36	34	25	0.88	0.99	1.10
B 80/3	324	142	62	53	48	42	6	22	24	1.28	1.03	1.19
E 267/11	435	115	120	56	45	44	9	26	21	1.37	1.04	1.09
ICGMS 42	426	217	88	60	56	59	8	17	14	1.23	1.33	1.19
Mean	582.2	364.0	92.4	47.4	43.3	52.4	19.8	17.5	19.2	1.190	1.183	1.257
SE		±107.45			±4.61			±7.40			±0.208	
CV (%)		39			18			69			30	

T1 = early sowing, T2 = T1 + 3 weeks, T3 = T1 + 6 weeks.

on plant population may be potentially fruitful, since some of the genotypes (e.g., MB 662) are non-spreading, and may therefore respond better to close spacing.

Acknowledgments

We thank the Malawi Government and SADC / ICRISAT breeding programs for providing us with the genotypes/lines evaluated in the work reported here. The technical input by our research technicians (C A M Phangaphanga (deceased), L K Gondwe, and B Z Judge) was indispensable. The input by the technical staff at Mbawa Experiment Station is also greatly appreciated. Finally, we thank Mrs Chintsanya for typing part of this paper.

References

Cox, F.R., Adams, F., and Tucker, B.B. 1982. Liming, fertilization, and mineral nutrition. Pages 139-163 *in* Peanut science and technology (Pattee, H.E., and Young, C.Y., eds.). Yoakum, Texas, USA: American Peanut Research and Education Society.

Gaines, T.P., Parker, M.B., and Walker, M.E. 1989. Runner and Virginia type peanut response to gypsum in relation to soil calcium level. Peanut Science 16:116 - 118.

Gascho, GJ., Hodges, S.C., Alva, A.K., Csinos, A.S., and Mullinix, B.G., Jr. 1993. Calcium source and time of application for Florunner and Virginia peanuts. Peanut Science 20:31-35.

Ministry of Agriculture. 1992. Pages 65-68 *in* Guide to agricultural production in Malawi, 1992-93. Lilongwe, Malawi: Ministry of Agriculture.

Ministry of Agriculture. 1993. Pages 74 - 77 *in* Guide to agricultural production in Malawi, 1993-94. Lilongwe, Malawi: Ministry of Agriculture.

Plank, C.O. 1989. Soil test handbook for Georgia. Athens, Georgia, USA: Cooperative Extension Services, University of Georgia. 316 pp.

Sullivan, G.A., Jones, G.L., and Moore, R.P. 1974. Effects of dolomitic limestone, gypsum and potassium on yield and seed quality of peanuts. Peanut Science 1:73-74.

Sumner, M.E., Kvien, C.S., Smal, H., and Csinos, A.S. 1988. On the Ca nutrition of peanuts. I. Conceptual model. Journal of Fertilizer Issues 5:97-102.

Walker, M.E., Flowers, R.A., Henning, R.J., Keisling, T.C., and Mullinix, B.G., Jr. 1979. Response of early bunch peanuts to calcium and potassium fertilization. Peanut Science 6:119-123.

Walker, M.E., and Csinos, A.S. 1980. Effect of gypsum on yield, grade and incidence of pod rot in five peanut cultivars. Peanut Science 7:109-113.

Discussion

Maphanyane. Determination of pops severity in terms of percentage of occurrence may be misleading. Low shelling percentage is probably more important than pops, as a reason for low pod yield; data on percentage by weight of 'pops' may therefore be more meaningful.

Maliro. I agree. We will follow this method in future.

Swanevelder. It may be useful to study the relationship between pops incidence and the number of rain showers for, say, a 60-day period after the onset of flowering. I also suggest exploring the possibility of using ashes from the home fire (collected for use at sowing) and burning all available bones, feathers, etc., which are rich in calcium. Another approach could be to change the nature of the seed bed so that it does not dry out quickly.

Ntare. In western Africa we have a problem of low Ca levels. Calcium nutrition is influenced by pod size; larger pods have higher Ca requirements, and large-podded varieties therefore suffer higher pops incidence. Our studies suggest that runner types are more efficient in pod filling in low-Ca soils. It would be useful to classify your material into small- and large-podded types.

Maliro. In our trial we had a wide range of pod sizes, but we did not get the impression that pops was more of a problem with large-podded varieties.

Ntare. That may be because you were using soils that were not deficient in calcium.

Venter. Are the empty pods a result of a fertilization problem with the flowers, or a seed development and fill problem?

Maliro. Fertilization takes place normally; the problem lies in seed development. Ca taken up by the plant before seed development cannot be transported down to the pods (it is not transported through the phloem); it must be taken up by the pod directly from the soil to enable seed development. If the soil is poor in Ca, or very dry (low rainfall), Ca cannot be taken up directly by the pod, and pops is a result.

Freire. During the 5th Regional Groundnut Workshop in 1992, Bruce Syamasonta concluded that it was not useful to work with pops tolerance. Could you comment?

Maliro. Our conclusion is somewhat similar. However, we feel that more work is required, to find the real cause(s) of pops.

Optimal Sowing Dates for Groundnut in Southern Mozambique

M J Freire[1] and K V Ramanaiah[2]

Abstract

Optimal sowing dates and sowing period for groundnut in southern Mozambique were calculated using data from four trials conducted at Marracuene and Umbeluzi (Maputo Province) from 1981 to 1984, and by fitting a non-linear equation. Maximum yields were obtained when the crop was sown between 31 Aug and 6 Sep. By sowing in Aug and Sep, yields can be achieved that are at least (approximately) 85% of the optimum. Both early and late sowing reduced groundnut yields. Due to the erratic rainfall pattern in Maputo Province, it is reiterated that, as earlier recommended, groundnut should be sown with the first rains.

Sumário

Datas de sementeira óptimas para o amendoim no sul de Moçambique. *Usando dados de quatro ensaios conduzidos na região de Marracuene e Umbelúzi (Província de Maputo, sul de Moçambique) de 1981 a 1984 e ajustando uma equaçãõ nãõ-linear, datas e épocas de sementeira óptimas foram determinadas. A mais alta Razão de Perfomance (relacionada com o rendimento óptimo) foi obtida para o periodo de sementeira de 31 Agosto a 6 de Setembro. Semear durante os meses de Agosto e Setembro é recomendado, assegurando pelo menos 85% do rendimento óptimo. Devido ao padrão errático das chuvas na Província de Maputo, é recomendado semear o amendoim com as primeiras chuvas.*

Introduction

Groundnut is widely grown and consumed in southern Mozambique, mainly by smallholder farmers engaged in rainfed, low-input, subsistence agriculture. However, yields are normally low (200-500 kg ha^{-1}). Delayed sowing is one important factor contributing to low yields. Groundnut sowing is usually delayed because other crops (e.g., maize) are given higher priority when labor is in short supply, because seed only becomes available late, or because the rainy season begins late.

It is well known that delayed sowing reduces groundnut yield mainly because of insufficient rainfall (Malithano et al. 1983, Freire 1987, Sibuga et al. 1990), which may increase defoliation (Maieux 1992), shorten the pod-filling period (Choudhary et al. 1986), and increase the incidence of pests (leaf-eating caterpillars, aphids) and diseases (rust, rosette) (Malithano et al. 1982, 1983). On the other hand, very early sowing (which is possible when irrigation is available) can also reduce yield, mainly due to low temperatures that may delay seedling emergence and early-stage growth (Choudhary et al. 1986, Maieux 1992).

With the objective of determining optimal sowing dates for Spanish type groundnut in Maputo Province (southern Mozambique), four trials were conducted between 1981 and 1984 in Marracuene and Umbeluzi (Malithano et al. 1982, 1983). However, no attempt was made to analyze the data together. This paper presents an overall analysis of results from the four

1. Faculty of Agronomy and Forestry Engineering, University Eduardo Mondlane, C P 257, Maputo, Mozambique.
2. Ministry of Agriculture, Pre-program, Maputo, Mozambique.

Freire, M.J. and Ramanalah, K.V. 1994. Optimal sowing dates for groundnut in southern Mozambique. Pages 106-109 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand. G.L., and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

trials, and recommendations on optimal sowing dates/periods for Spanish type groundnut, particularly the cultivar Bebiano Branco.

Materials and methods

From 1981 to 1984 four sowing date trials were conducted, two at Marracuene (on a sandy soil, under rainfed conditions, using the groundnut genotypes Bebiano Branco and Bebiano Encarnado) and two at Umbeluzi (on a sandy-loam soil, irrigated, using Bebiano Branco and Starr) (Malithano et al. 1982, 1983). The sowing dates and yields are presented in Table 1.

As growing conditions and sowing dates varied from trial to trial, ANOVA analysis 'across years and locations' was found inappropriate. Instead, non-linear regression analysis was used. However, it was necessary to standardize the data from the various trials. To do so, a ratio of performance was computed in two different ways:

- Ratio of Performance (mean) = $\frac{\text{Yield at sowing date}}{\text{Mean yield of all trials}}$
- Ratio of Performance (maximum) = $\frac{\text{Yield at sowing date}}{\text{Maximum yield at any sowing date}}$

This procedure was repeated both with the sowing date mean yield of all cultivars and the sowing date yield of Bebiano Branco. With the computed ratios and the related calendar day, a non-linear regression was done using the following equation:

$$r = \frac{1}{a+bD+cD^2}$$

where r is the Ratio of Performance, a, b, and c are regression constants, and D is the sowing date (quantified as 1 = 1 Jan, 365 = 31 Dec).

Results and discussion

From Table 1 it is evident that a delay in sowing reduced mean yield significantly (P <0.001) at all sites, with the highest reduction (78%) at Umbeluzi during the 1982/83 season. In the same trial, the reduction in Bebiano Branco yield was also highest (82%). According to Malithano et al. (1982, 1983), these yield reductions were caused by low rainfall after the (delayed) sowing, and higher levels of pests (leaf-eating caterpillars, aphids) and diseases (rust, rosette).

Table 1. Yield and ratios of performance in four groundnut trials, southern Mozambique, 1981-84.

		Basis for ratio calculation						
		Mean values			Bebiano Branco			
Location, season	Sowing date	Mean yield (kg ha^{-1})	Ratio of Perform-ance (mean)	Ratio of Perform-ance (max)	Yield of Bebiano Branco (kg ha^{-1})	Ratio of Perform-ance (mean)	Ratio of Perform-ance (max)	Level of signifi-cance/CV
Umbeluzi 1981/82	31 Aug	1723	1.54	1.00	1743	1.46	1.00	0.1%
	1 Oct	1287	1.15	0.75	1508	1.27	0.87	
	3 Nov	348	0.31	0.20	321	0.27	0.18	18%
Umbeluzi 1982/83	24 Aug	2003	1.33	1.00	1833	1.28	1.00	0.1%
	22 Sep	1829	1.21	0.91	1734	1.21	0.95	
	1 Nov	704	0.47	0.35	720	0.50	0.39	21%
Marracuene 1982/83	10 Aug	926	1.11	0.92	1020	1.09	0.90	0.1%
	22 Oct	1009	1.21	1.00	1135	1.22	1.00	
	1 Dec	569	0.68	0.56	643	0.69	0.57	6%
Marracuene 1983/84	16 Sep	775	1.10	1.00	835	1.17	1.00	5%
	20 Oct	640	0.90	0.83	590	0.83	0.71	20%

Table 2. Characteristics of the multiple regression equations r =1 / (a+bD+cD^2) (D = sowing date, BB = Bebiano Branco) obtained on analysis of data from four groundnut trials, southern Mozambique, 1981-84.

					Critical dates		
					Optimum	Limits for 15% yield loss	
Factors	a	b	c	R^2	yield	From	To
Mean vs Ratio of Performance (Mean)	12.7571	0.0975	0.0002	0.66	2-3 Sep	8 Aug	28 Sep
Mean vs Ratio of Performance (max)	13.2150	0.0998	0.0002	0.55	31 Aug-1 Sep	3 Aug	30 Sep
BB vs Ratio of Performance (mean)	14.4764	0.1100	0.0002	0.65	4-5 Sep	12 Aug	30 Sep
BB vs Ratio of Performance (max)	15.8723	0.1200	0.0002	0.59	5-6 Sep	9 Aug	1 Oct

From the values of R^2 (Table 2), it is evident that 55-66% of the variations in yield can be accounted for by the effect of sowing date (Fig. 1). From the equations (Table 2) the optimum sowing period appears to be 31 Aug to 6 Sep. However, it must be pointed out that during this period the rains are just beginning and groundnut sowing is often postponed for several reasons. These include inadequate land preparation, unavailability of seed, low priority for groundnut as a component in the cropping system, or delay in the onset of rains.

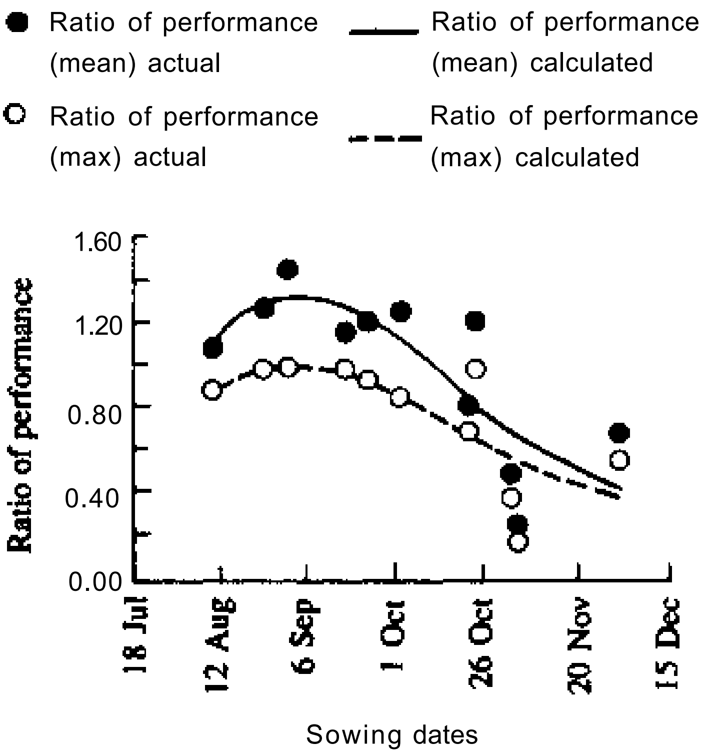

Figure 1. Ratios of performance computed from sowing date mean yields of groundnut cultivar Bebiano Branco,

Assuming that the best period to sow groundnut is such that no more than 15% of the optimal yield is lost, only the period from Aug to Sep fulfills the requirements.

Conclusions and recommendations

Based on the results, the following conclusions and recommendations can be made:

- For maximum yield, Spanish type groundnut in general, and Bebiano Branco in particular, must be sown between 31 Aug and 6 Sep;
- Sowing Spanish type groundnut (Bebiano Branco) in Aug or Sep is highly advisable for both subsistence farmers and farmers with access to irrigation;
- Due to the erratic rains in southern Mozambique, it is recommended that rainfed groundnut be sown with the first rains. It is important to note that this is not different from the practice followed by successful subsistence farmers;
- Efforts should be made to use data from sources other than sowing date trials, to obtain specific recommendations on optimal sowing dates for other cultivars, using a methodology similar to the one described here.

References

Choudhary, G.A., Bukhtiar, B.A., Sarwar, G.M., and Masood, T. 1986. Pod yield and other characteristics of groundnut as influenced by various planting times under rainfed conditions. Pages 125-133 *in* Proceedings of the National Groundnut Workshop, 17-19 Feb 1986, Islamabad, Pakistan. Islamabad, Pakistan: National Agricultural Research Centre.

Freire, M.J. 1987. Effect of staggered sowing dates and plant proportions in intercropping groundnut/ maize. M.Sc. Thesis, Andhra Pradesh Agricultural University, College of Agriculture, Hyderabad, India. 130 pp.

Maieux, A. 1992. Effect of sowing time on groundnut yield in Botswana. Pages 75-79 *in* Proceedings of the Fifth Regional Groundnut Workshop for Southern Africa, 9-12 Mar 1992, Lilongwe, Malawi (Nageswara Rao, R.C., and Subrahmanyam, P., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-arid Tropics.

Malithano, A.D., Ramanaiah, K.V., Chilengue, B.S., and Panguene, G.A. 1982. Annual Report of the Groundnut Improvement Project 1981/82. Maputo, Mozambique: Faculty of Agronomy and Forestry Engineering, Eduardo Mondlane University.

Malithano, A.D., Ramanaiah, K.V., Chilengue, B.S., and Panguene, G.A. 1983. Annual Report of the Groundnut Improvement Project 1982/83. Maputo, Mozambique: Faculty of Agronomy and Forestry Engineering, Eduardo Mondlane University.

Sibuga, K.P., Songambele, S.S., and Kakema, T.P.N. 1990. Influence of sowing dates on growth and yield of groundnuts in Tanzania. Pages 183-188 *in* Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania (Hildebrand, G.L., Schmidt, G., Laxman Singh, Subrahmanyam, P., and Wightman, J.A., eds.). Patancheru, A.P. 502324, India: International Crops Research Institute for the Semi-Arid Tropics.

Discussion

Mpanza. You have suggested optimal sowing dates for groundnut in southern Mozambique. What climatic conditions are encountered in that region?

Freire. Average rainfall is around 250 mm per year. Average temperature data for the rainy season is not available, but the maximum is around 40°C.

Performance of Two Groundnut Cultivars at Two Populations Intercropped with Sunflower

K Kanenga[1]

Abstract

This paper describes agronomy work conducted over three seasons (1988/89 to 1990/91) at the Msekera Research Station, Zambia, on a groundnut-sunflower intercropping system. The objectives were to compare the performances of two groundnut varieties, Chalimbana and the recently released MGS 2, and study the effect of plant density on crop yields and cropping system efficiency. There were no significant yield differences between the cultivars when they were intercropped with sunflower. An increase in groundnut density had an overall effect on the system: for Chalimbana there was a marginal yield increase (in all seasons) with increasing plant density. MGS 2 showed a yield reduction at higher density for two seasons out of three, and a marginal (non-significant) yield increase in one season. In a dry year, the yield difference between sole cropping and intercropping was large. This difference was reduced in years of good rainfall. In these years the land equivalent ratio was as high as 2, suggesting that when rainfall is sufficient, total intercrop yields are higher than sole crop yields.

Sumário

Comportamento dos dois cultivars do amendoim em duas populações consociados com girassol. *Esse artigo descreve o trabalho agronomico conduzido por três estações (1988/89 a 1990/91) na Estação de Investigação em Msekara, Zambia sobre o sistema de consociação amendoim/girassol. Os objetivos erão a comparação do comportamento das duas variedades do amendoim Chalimbana e a variedade recentemente libertada MGS 2 também o estudo do efeito da densidade das plantas sobre o rendimento e sobre a eficiência do sistema do cultivo.*

Os cultivares não apresentarão significativas diferenças no rendiments quando forão consociados com girassol. Com aumento na densidade houve um efeits total sobre o sistema: Chalimbana apresenton um aumento marginal no rendimento com aumenis na densidade em todas as estações. Para duas das três estações MGS 2 apresenton uma redução no rendimento com aumento na densidade e um aumento marginalmente insignificante numa das estações.

Em un ano de seca a diferença no rendimento entre a cultura simples e consociação foi grande. Em anos de boa chuva esta diferença foi reduzida. Em' esses anos sugerindo que, quando a precipitação e suficiente o rendimento da consociação e mais alto que a rendimento da cultura simples.

Introduction

A considerable number of small-scale farmers in Zambia traditionally practice intercropping, and groundnut is extensively intercropped with other crops. For the farmer to fully realize the yield potential of intercrops, it is imperative that researchers go beyond establishing crop compatibility, to studying

1. Food Legumes Research Team, Msekera Research Station. P 0 Box 510089, Chipata, Zambia.

Kanenga, K. 1994. Performance of two groundnut cultivars at two populations intercropped with sunflower. Pages 110-113 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand, G.L., and Subrahmanyam, P., eds.). Patancheru 502 324. Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

agronomic and management factors that will improve the efficiency of these crop mixtures. Such studies would focus on identifying suitable crop cultivars and determining optimum spacing and nutrient levels.

Early research on intercropping concentrated on identifying suitable intercrop combinations. Thus, the botanist's (rather than the agronomist's) interpretation of competition between different plant species has resulted. A number of published studies are available on these and related aspects of plant competition (e.g., Willey 1979). Several national and international research institutes have regular programs on intercropping work. This paper describes recent agronomy work conducted at the Msekera Research Station, Zambia, on a groundnut-sunflower intercropping system. The study was conducted with two objectives:

- To compare the performance of two groundnut cultivars: Chalimbana, a popular traditional variety that has been cultivated for a number of years, and MGS 2, which was recently released;
- To determine whether high or low plant densities were appropriate for these cultivars when intercropped with sunflower.

Materials and methods

The study was conducted over three seasons, 1988/89 to 1990/91. The study site was located at Msekera Research Station, Chipata, in Zambia's Eastern Province. The elevation at the site is 1024 m, and the mean annual rainfall 887-1014 mm. The soils are moderately deep, dark reddish brown, moderately to strongly leached, moderately permeable, well drained, and clayey, with sandy-loam top soil, low nutrient-holding capacity, and pH ($CaCl_2$) ranging from 4.5 to 5.6.

Rainfall patterns during the three seasons of the study were not similar (Table 1). In 1988/89, there was very little rain at sowing and during the germination phase. In 1989/90 rainfall was satisfactory during both the germination and flowering phases. In 1990/91, the rainfall was barely adequate at sowing, but satisfactory thereafter.

The experiment consisted of nine treatments. Two groundnut varieties, Chalimbana (control) and MGS 2, were sown, each at two plant densities (low, 22 222 plants ha^{-1} and high, 44 444 plants ha^{-1}) in a sunflower intercrop. The other five treatments were sole crops for each variety and population density, and sole sunflower. The nine treatments are referred to here as: SV_1P_1 SV_1P_2, SV_2 P_1 SV_2 P_2, sole V_1 P_1, sole V_1P_2, sole V_2P_1, sole V_2P_2, and sole S; where S is the sunflower variety (CH 336), V_1 and V_2 are the groundnut varieties Chalimbana and MGS 2, and P_1 and P_2 are low and high groundnut plant population densities.

For *intercrops,* sunflower and groundnut were sown on alternate rows (on ridges) 75 cm apart. For groundnut at low density, within-row spacing was 30 cm; for high-density, 15 cm. Sunflower within-row spacing was 30 cm. For sole crops, interrow spacing was 75 cm in all treatments. Sunflower within-row spacing was 30 cm, and groundnut within-row spacing was either 30 cm or 15 cm.

Table 1. Rainfall data at Msekera Research Station, Chipata, Zambia, 1988/89 to 1990/91.

Month	Normal rainfall (mm)	Actual rainfall (mm) during		
		1988/89	1989/90	1990/91
Oct	16	46	0	5
Nov	85	20	172	41
Dec	213	153	190	168
Jan	267	429	233	268
Feb	229	286	235	164
Mar	157	201	151	113
Apr	47	26	88	20
May	0	19	39	0
Seasonal total	1014	1180	1108	779

Source: Msekera Agromet Station

Treatments were arranged in a randomized complete block design with four replications. Each replication consisted of nine plots. The sole-crop plots of both crops consisted of four rows 5 m long, while the intercrop treatments consisted of six alternating rows of the same length. Plot size was therefore different for sole and intercrops. The gross plot area for sole crop treatments was 15 m^2 (3 m x 5 m) and the corresponding net plot size 6 m^2 (1.5 m x 4 m) (the two middle rows, with 50 cm at each end of the row discarded). Gross plot area for intercrops was 22.5 m^2 (4.5 m x 5 m) and net plot area 12 m^2 (3 m x 4 m) (four middle rows, with 50 cm from each end of the ridge discarded).

Land preparation was by plowing and later discing (20-30 cm deep), using a tractor. Ridging and sowing were done by hand. 'D' compound fertilizer (150 kg ha^{-1} @ N:P:K:S 1:2:1:1) was broadcast evenly over each plot as basal fertilizer; 150 kg ha^{-1} of urea (46% N) was applied to sunflower 2 weeks before flowering. The fungicide Captasam M® was used as a seed dressing @ 125 g per 50 kg of groundnut seed. No seed dressing was applied to sunflower.

Sowing depth was 3 cm for both crops. Groundnut was sown with the first effective rains (mid Nov to early Dec), and sunflower almost a month later (end Dec or beginning of Jan). Hand hoe weeding was done twice, 2 weeks and 3 weeks after groundnut was sown. Data were collected on germination percentage, time to 50% flowering, stand count at harvest, disease score (leaf spot), yield, and yield components. The data were subjected to ANOVA analysis using Mstat; yield data were also subjected to bivalate analysis.

Results and Discussion

1988/89 season. Yields were generally low in both groundnut varieties, possibly due to lack of moisture. There were no significant differences in kernel yield between Chalimbana and MGS 2 when intercropped. In sole cropping, however, MGS 2 outyielded Chalimbana by about 15%. The effect of component plant population density on yield was also studied. Increasing the plant population increased kernel yield for Chalimbana from 70% to 100% of the corresponding sole crop yield. In contrast, MGS 2 yields were reduced from 47% of sole crop yield at low population to 44% at the higher population. Mutsaers (1978), in mixed cropping experiments with maize and groundnut, found that groundnut yield decreased with increasing plant populations. In our study, MGS 2 gave results similar to those of Mutsaers (1978), but Chalimbana did not. The overall results (Table 2) show that Land Equivalent Ratios (LERs) were highest for Chalimbana at low population, followed by MGS 2 at low population, and MGS 2 at high population; Chalimbana at high population gave the lowest LER.

Table 2. Groundnut yields and Land Equivalent Ratios (LERs) for two groundnut varieties in a groundnut-sunflower intercrop, Msekera Research Station, Chipata, Zambia, 1988/89 to 1990/91.

	1988/89		1989/90		1990/91	
Density[1]	Chalimbana	MGS 2	Chalimbana	MGS 2	Chalimbana	MGS 2
Low	230[2]	239	472	505	607	602
	(0.70)[3]	(0.47)	(0.93)	(0.89)	(0.67)	(0.75)
	(1.48)[4]	(1.25)	(1.48)	(1.66)	(1.95)	(2.18)
High	335	231	512	575	917	788
	(-0.01)	(0.44)	(0.95)	(1.04)	(0.85)	(0.56)
	(0.76)	(1.18)	(1.71)	(1.64)	(1.98)	(1.86)
Mean	288	235	492	540	762	695
CV(%)	32.00		6.30		26.00	
SE	±38.00		±16.00		± 114.00	

1. Density: low population - 22 222, high population - 44 444 plants ha^{-1}.
2. Kernel yield (kg ha^{-1}).
3. Groundnut LER.
4. Total LER.

1989/90 season. Groundnut yields were higher (due to good rainfall) than in the previous season. Again, there were no significant yield differences between the two varieties. As in the previous season, Chalimbana yields were higher at higher plant population. At low density Chalimbana produced 93% of the sole crop yield; and at high density, 95% of sole crop yield. For MGS 2 at low density, yields were 89% of sole crop yield; at high density they were 104% of sole crop yield. These results differ from the density vs yield relationship observed in 1988/89, but the increase in yield at higher densities (from 89% to 104%) in 1989/90 was not significant.

LERs were used as a measure of the overall efficiency of the system. The LER for Chalimbana increased with an increase in density (1.48 at low density, 1.71 at high density). In contrast, LER for MGS 2 decreased (from 1.66 to 1.64) when population density increased, indicating that density may have exceeded the optimum competition threshold.

1990/91 season. Groundnut yields were better than in the two previous seasons, probably due to better rainfall. There were no significant yield differences between the two varieties. The two varieties responded differently to an increase in population. Chalimbana produced 67% of sole crop yield at low density and 85% of sole crop yield at high density. MGS 2 yields were reduced from 75% of sole crop yield at low density to 56% at high density. The population vs yield relationship for both varieties was thus similar to the trend observed in 1988/89.

The overall intercropping efficiency (i.e., LER) was highest for MGS 2 at low density, followed by Chalimbana at high density, and Chalimbana at low density. MGS 2 at high density gave the lowest LER (Table 2).

Conclusions

Yield response patterns in the two varieties to changes in plant population were discernible across seasons. There were no significant differences for yield between Chalimbana and MGS 2 when they were intercropped with sunflower. An increase in plant density had an overall effect on the whole system: for Chalimbana there was a marginal, non-significant yield increase (in all seasons) with increase in density. For MGS 2 there was a yield reduction at higher density for two seasons out of three and a marginal (non-significant) yield increase in one season.

In a dry year, the yield difference between sole cropping and intercropping was large. This difference was reduced in years of good rainfall. In these years the LER was as high as 2, suggesting that when rainfall is sufficient, total intercrop yields are higher than sole crop yields.

References

Mutsaers, H.J.W. 1978. Mixed cropping experiments with maize and groundnut. Netherlands Journal of Agricultural Science 26(1978):345.

Willey, R.W. 1979. Intercropping—its importance and research needs. Part 2. Agronomy and research approaches. Field Crop Abstracts 32(2):75.

Discussion

Kafiriti. Your sunflower-groundnut intercropping trials were sown in rows. Do farmers in Zambia sow both crops in rows? If they do not, recommendations made on the basis of your trials may not benefit farmers.

Kanenga. Farmers sow groundnut in rows, but not sunflower. However, I feel that recommendations resulting from these trials will be useful to farmers even if sunflower is not sown in rows.

Freire. What populations did you use for sunflower? Your groundnut populations (in intercropping) were very low. What sole crop population did you use to compute the LER?

Kanenga. Sunflower is the main crop and was sown at the full recommended population. For groundnut, we used the standard sole crop recommendation to compute the LER.

Zengeni. Is groundnut-sunflower intercropping commonly practiced in Zambia?

Kanenga. No proper survey was carried out before the trial. However, there are reports of this practice in some parts of the country.

Luhana. Is there any danger of transferring foliar diseases from sunflower to groundnut or vice versa, since both crops can sometimes be heavily attacked by foliar diseases?

Subrahmanyam. I don't see any major problems with foliar diseases such as leaf spots and rust. However, in Malawi, high incidence of groundnut streak necrosis disease (GSND, which is caused by a sunflower virus) has been reported on groundnut intercropped with, or even grown in proximity to, sunflower.

Technology Transfer

Partnership in Technology Transfer: A Case Study in Nkhata Bay District in Malawi

A J Chiyembekeza[1], B J Ndunguru[2], E A Chisala[3], and C Mtalo[3]

Abstract

Malnutrition is endemic in Malawi, particularly among preschool children. Realizing the importance of groundnut in children's diets, the United Nations Children's Fund (UNICEF), in collaboration with the SADCI1CR1SAT Groundnut Project and the Malawi national agricultural research system, introduced seed of two groundnut cultivars, CG 7 and JL 24, in the Child Survival and Development Project (CSDP) areas of Maula and Sanga, in Nkhata Bay district of Malawi. The seed was provided on credit, at low prices, on a cost-recovery basis. By increasing production of groundnut and soybean (which was the main legume crop in these areas during the initial years of the Project) by households with young children (< 5 years old), we hope to improve child nutrition and thereby reduce mortality. In addition, the crop would provide some cash for farmers.

In 1992/93 and 1993 / 94, a total of 400 farmers grew CG 7 and JL 24 alongside their local cultivar, Kasawaya. JL 24 and CG 7 outyielded Kasawaya in both years, and were preferred by farmers. By pooling resources from various sources and organizations, as has been demonstrated in this case, we hope to make faster progress in the transfer of new technologies developed at research stations.

Sumario

Sócios na transferência de tecnologia: Um caso no Distrito de Nkhata Bay no Malawi. *A malnutriçäõ é epidémica na Malawl, particularmente em crianças em idade pré-escolar. Tomando em consideraçäõ a importância do amendoim na dieta da criança, a UNICEF (Fundo das Naçöes Unidas para a Criança) em colaboraçäõ com o Projecto do Amendoim do SADC/ICRISAT e do NARS (Sistema de Investigaçäo Agrícola Nacional), introduziu semente de dois cultivares do amendoim, CG 7 e JL 24, no CSDP (Projecto de Desenvolvimento e Sobrevivência da Criança) nas áreas de Maula e Sanga, no Distrito de Nkhata Bay, no Malawi. A semente foi fornecida a crédito, mas com um baixo juro. Durante os primeiros anos do projecto, estas áreas tinham a soja como principal leguminosa. Aumentando a produçäõ destas leguminosas em família com crianças com menos de 5 anos de idade, esperamos poder melhorar o 'status' nutricional das crianças e, assim, reduzir a mortalidade causada por uma nutriçäõ pobre. Em adiçäõ a cultura pode providenciar algum dinheiro para os agricultores. Durante duas campanhas agrícölas de 1992/93 e 1993/94, um total de 400 agricultores semearam o CG 7 e JL 24 ao lado do seu cultivare 'Kasawaya'. Em ambos os anos, JL 24 e o CG 7 produziu mais o cultivar dos agricultores, 'Kasawaya', embora os rendimentos tenham sido inferiores aos obtidos nas estaçöes de investigaçäo. Os agricultores preferiram ambos os cultivares. Juntando recursos das várias fontes e organigaçöes, como temos vindo a demonstrar neste caso, esperamos fazer um progresso rápido na transferência das novas tecnologias desenvolvidas nas estaçöes de pesquisa.*

1. Chitedze Agricultural Research Station, P O Box 158, Lilongwe, Malawi.
2. SADC/ICR1SAT Groundnut Project, P 0 Box 1096, Lilongwe, Malawi.
3. UNICEF Malawi, P 0 Box 30375, Capital City, Lilongwe, Malawi.

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Introduction

Agriculture plays a very important role in the economy of Malawi. Over 80% of Malawians live in rural areas and derive their livelihood from agriculture, directly or indirectly. The farming practice is mainly subsistence and these farmers face many constraints. Malnutrition is endemic, particularly among preschool children. Recent national-level data indicate that 35% of all children are malnourished and 56% are physically stunted (Government of Malawi 1993). The high incidence of stunting indicates chronic malnutrition, as opposed to occasional severe episodes of malnutrition that lead to wasting.

It is against this background that the United Nations Children's Fund (UNICEF) implemented, on a pilot basis, three Child Survival and Development Projects (CSDPs), one of which operates in Nkhata Bay district in northern Malawi. Many parts of the district receive adequate rainfall, and a number of crops are grown. Cassava *(Manihot esculenta)* is the main staple food in the district. Other staple foods are rice *(Oryza sativa)* and maize *(Zea mays).* The main legumes include drybean *(Phaseolus vulgaris),* pigeonpea (*Cajanus cajan),* groundbean *(Vigna subterranea),* and cowpea *(Vigna unguiculata).*

Until the inception of the CSDP, the area under soybean *(Glycine max)* and groundnut *(Arachis hypogaea)* was very small. These areas have now increased, partly because of a CSDP credit package introduced for farmers. By increasing production of these legumes, we hope to improve child nutrition and thereby reduce mortality. In addition, the crops could be sold for cash.

Collaboration between the SADC/ICRISAT Groundnut Project and the Malawi national agricultural research system (NARS) has resulted in the release of a number of groundnut cultivars that could potentially boost production. However, these improved cultivars have not reached farmers for a number of reasons (ICRISAT 1994), and farmers continue to grow their local cultivars. Insufficient participation by farmers in the process of cultivar development is one reason for such non-adoption. The introduction of new cultivars with more desirable yield attributes than the cultivars presently grown, would boost groundnut production in the area.

Farmers would be asked to evaluate some of the recently developed (both released and pre-release) cultivars. Feedback from farmers would enable the groundnut research program to more effectively address farmers' preferences and needs. Our aim was also to ensure the successful introduction of the new groundnut cultivars in this CSDP area.

Methodology

Initiation of the CSDP. The Nkhata Bay CSDP was initiated in 1990 in the areas of Maula and Sanga. These areas were chosen for the CSDP because of high rates of child mortality, female illiteracy, and malnutrition. Each CSDP effected interventions in several areas, including household food security. Part of the household food security component was the agricultural credit sub-project, which provides inputs to targeted groups, primarily women farmers. These inputs (typically fertilizers and hybrid maize, soybean, and groundnut seed) were issued to farmers on credit, on a cost-recovery basis. In addition, 100 kg of maize flour was provided to ensure a staple food supply for a 6-8 week period in Dec and Jan, during which operations such as weeding are undertaken.

Sources of seed. The SADC/ICRISAT Groundnut Project, in collaboration with the Malawi NARS and UNICEF, provided seed of two groundnut cultivars, JL 24 (short-duration Spanish) and CG 7 (medium- to long-duration Virginia). JL 24 was proposed for release in 1989 on the basis of its yield potential and seed quality. However, because of poor oil chemistry (oleic/linoleic acid ratio, which determines the shelf life of the processed product) this cultivar was not officially approved for release. CG 7 was approved for release in 1989, but had not yet reached Nkhata Bay district.

Seed distribution and selection of farmers. Groundnut seed was distributed to 100 farmers during the 1992/93 growing season for sowing in areas of Maula, Sanga, Lisale, and Msane. Twenty farmers received CG 7 seed and 80 received JL 24 seed. The farmers selected in these areas were those who had grown soybean under the CSDP the previous year. The 1993/94 scheme included farmers who had not participated in the soybean scheme the previous seasons. Three hundred farmers were given seed in areas of Maula, Sanga, Msane, Lisale, Nkhwali, and Usisya; 223 farmers received CG 7, while 77 farmers received JL 24.

The farmers were also requested to grow the local cultivars adjacent to CG 7 or JL 24, for comparison. Farmers were advised to plant the seed the way they preferred, but were also given information on management of the improved cultivars.

Demonstration plots. In addition to the farmers' fields, five cultivars (JL 24, CG 7, and three controls—Malimba, Mawanga, and Chalimbana) were sown on demonstration plots. All demonstration plots in the various Extension Planning Areas (EPAs) were sown by extension staff. Each cultivar was sown on two ridges, 6 m long and 90 cm apart. One demonstration plot was sown at each of the following sites: Sanga North, Sanga South, Maula, Lisale, Msane, and Usisya, in the areas where the participating farmers lived. This was done to compare the consistency in JL 24/CG 7 performance under variable farmer management and under the standard practices recommended for EPA plots (Ministry of Agriculture 1993).

Sowing. Sowing patterns varied from field to field. In some fields, the seed was sown on ridges spaced 90-120 cm apart, with 1-2 rows per ridge, depending on the size of the ridge. In other fields, the seed was sown on the flat. Sowing dates also varied from field to field. During the 1992/93 cropping season, sowing began during the last week of Dec 1992, while the last crop was sown during the first week of Feb 1993. In 1993/94 the onset of sowing rains was late, but all fields were sown by mid Jan 1994.

Monitoring and harvesting. Fields were visited regularly during the growing season (Jan-Apr) and during harvest, to assess the performance of the cultivars. In general, crop establishment and development was good, although crop stands were poor in some fields, especially where CG 7 was sown late. This was because of a dry spell experienced soon after sowing.

Yield measurements. At the end of the season, yields were estimated in farmers' fields from 100 m^2 plots. Data were also collected from two 6-m long rows on the demonstration plots. Data were sampled and analyzed from 12 fields and four demonstration plots in 1993, and from one demonstration plot (not reported here) and 56 farmers' fields in 1994. The latter included 12 fields each from the EPAs of Maula, Sanga North, and Sanga South, and 20 fields from Lisale.

Results and discussion

Crop management. In general, management of the crop was good. Most fields were kept weed-free throughout the growing season. In most cases, farmers followed the recommended cultural practices. In both 1992/93 and 1993/94, the demonstration plots were also well managed.

Diseases and insect pests. Early and late leaf spots and rust were present in all fields. However, only late leaf spot and rust were predominant. Seedling diseases (e.g., collar rot, *Aspergillus niger*) were noticed in some fields, particularly those sown to CG 7, but the problem was not serious. Groundnut rosette was also noticed in some fields; this too was not serious. We noticed some termite damage in certain fields, but the occurrence was sporadic. In other fields, we saw wilted plants. The suspected cause of the wilt was *Hilda patruelis,* but the insect could not be found. Overall, insect pest damage was insignificant.

Pod yields. Yield data for the 1992/93 cropping season are presented in Table 1 (farmers' fields) and Table 2 (demonstration plots). Yield data for 1993/94 are presented in Table 3. The performance of both

Table 1. Performance of JL 24 and CG 7 in 12 farmers' fields, Nkhata Bay district, Malawi, 1992/93 season.

Field	Cultivar	Yield ($t\ ha^{-1}$) Pod	Seed	Shelling percentage
1	JL 24	3.22	2.14	67
2	JL 24	1.56	1.24	80
3	JL 24	1.89	1.51	80
4	JL 24	0.93	0.75	80
5	JL 24	1.33	1.07	80
6	JL 24	1.13	0.87	77
7	JL 24	1.11	0.83	75
8	JL 24	0.89	0.67	75
9	JL 24	1.69	1.30	77
10	JL 24	0.44	0.32	73
11	CG 7	1.44	1.01	70
12	CG 7	1.78	1.28	72
SE		±0.201	±0.134	±2.5
Overall means	JL 24	1.42	1.07	76
	CG 7	1.61	1.15	71
CV (%)		48	44	11

Table 2. Performance of five cultivars sown in demonstration plots at Maula, Sanga, and Lisale in Nkhata Bay district, Malawi, 1992/93 season.

Cultivar	Yield ($t\ ha^{-1}$) Pod	Seed	Shelling percentage
CG 7	1.89	1.20	61
JL 24	1.67	1.22	72
Chalimbana	1.74	1.13	62
Mawanga	1.33	0.97	71
Malimba	1.07	0.66	63
SE	±0.28	±0.19	±4.4
CV (%)	36	35	13

JL 24 and CG 7 was encouraging. Both cultivars out-yielded Malimba, the local control. In the 1992/93 season, overall mean yields from farmers' fields were 1.42 t ha^{-1} for JL 24 and 1.61 t ha^{-1} for CG 7 (Table 1). From demonstration plots, overall mean yields were 1.67 t ha^{-1} for JL 24, 1.89 t ha^{-1} for CG 7, and 1.07 t ha^{-1} for Malimba (Table 2). The differences in yield between farmers' fields and demonstration plots were mainly due to differences in management.

Table 3. Performance of JL 24 and CG 7 in 56 formers' fields, Nkhata Bay district, Malawi, 1993/94 season.

Location	Cultivar	Yield (t ha^{-1}) Pod	Seed	Shelling percentage
Lisalc	CG7 (12)[1]	0.69	0.52	75
	JL 24 (8)	0.89	0.75	86
Maula	CG 7 (7)	0.73	0.50	68
	JL 24 (5)	0.81	0.57	70
Sanga North	CG 7 (9)	0.47	0.33	70
	JL 24 (3)	0.71	0.64	90
Sanga South	CG 7 (9)	0.71	0.54	76
	JL 24 (3)	0.68	0.47	69
SE		±0.240	±0.228	±3.6
Overall means	JL 24 (19)	0.80	0.64	79
	CG 7 (37)	0.65	0.48	71
CV(%)		34	42	14

1. Figures in parentheses show number of farmers who grew the respective cultivar.

Yields in 1993/94 were in general lower that those in 1992/93 (Table 3), largely due to poor rainfall. The onset of the sowing rains was late and although farmers sowed their crop, there was drought during the pod-filling phase. Overall, JL 24 significantly out-yielded CG 7 ($P<0.05$) at all sites and also gave the highest shelling percentage across sites.

Landholdings. The majority of farmers in all areas had very limited land. Consequently, they sowed groundnut on land that was unsuitable for the crop (i.e., following a cassava crop that was usually not fertilized), and obtained low yields. Some of the areas were inaccessible to vehicles, and this sometimes made it very difficult for extension staff to visit and advise farmers.

Farmers' impressions about JL 24 and CG 7

All the farmers we visited were very impressed with the performances of both JL 24 and CG 7. Although JL 24 resembled their local cultivar Kasawaya, farmers indicated a preference for JL 24 because of its large seed and high yield. They were unfamiliar with CG 7, but were very impressed with its performance. This was evident in Usisya, where the cultivar was being introduced for the first time.

Credit recovery

Credit recovery was carried out by the CSDP, with assistance from extension staff of the Mzuzu Agricultural Development Division. At the beginning of the 1992/93 season, a total of MK 560 (1 US$ = 7.3 MK) worth of seed was issued to the 100 farmers, with each farmer receiving an average of MK 5.60 worth. By the end of Oct 1993, all farmers had repaid their loans in full. Farmers who grew soybean were unable to repay their loans fully, mainly because the soybean crop did not do very well that season. Credit repayment for the 1993/94 season will be in kind, i.e., farmers will pay back 5 kg of unshelled seed.

Conclusions

It was evident from interactions with farmers that they were keen on groundnut production. Both CG 7 and JL 24 performed much better than the local cultivars, and were preferred by the farmers. On-farm yields were much lower than those recorded at research stations. There is a need to continue evaluating these cultivars and the related management aspects in the area to ascertain their yield potential. We envisage continued cooperation with all parties concerned as we continue to expand our activities in the district. By pooling resources from various sources and organizations, as has been demonstrated in this case, we hope to make faster progress in the transfer of new technologies developed at research stations.

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References

Ministry of Agriculture. 1993. Guide to agricultural production in Malawi. Lilongwe, Malawi: Agricultural Communications Branch, Ministry of Agriculture.

ICRISAT Southern and Eastern Africa Regional Program. 1994. Annual Report 1993. P O Box 776, Bulawayo, Zimbabwe: SADC/ICRISAT Sorghum and Millet Improvement Program. (Semiformal publication.)

Government of Malawi. 1993. Situation analysis of poverty in Malawi. Lilongwe, Malawi: Government of Malawi and United Nations (Malawi). 209 pp.

Discussion

Ntare. Were the data you presented all for on-station trials?

Chiyembekeza. Data for other SADC countries were from on-station trials, but the Malawi data used in the stability analysis included some data from on-farm trials.

Freire. 1. Why were women farmers selected for the on-farm evaluation? 2. What was the level of retention of technology (comparing 1993/94 with 1992/93)?

Chiyembekeza. 1. Women were selected because they form the majority of groundnut farmers; the men are mostly fishermen. 2. Farmers who were given seed in 1992/93 were not given it in 1993/94. However, most of the 100 farmers who received seed the first season retained seed from the harvest for sowing in 1993/94.

Subrahmanyam. What was the yield advantage of CG 7 and JL 24 over the control?

Chiyembekeza. Both varieties were superior by about 50% over seasons.

On-farm Groundnut Varietal Evaluation in Swaziland

Zodwa Mamba[1]

Abstract

Seven improved groundnut lines and varieties (ICG 221, ICGV 86016, ICGV 867004, ICGV-SM 86720, Sellie, Natal Common, and Selection 5) and the local variety were evaluated by 16 farmer cooperators in on-farm trials conducted in two agroecological zones (Middleveld and Lowveld) in Swaziland during the 1993/94 season. Significant differences were observed in grain and pod yields and seed size. The most promising improved line was ICG 221, which was both well adapted and highly productive. The local variety and Natal Common (a recommended variety) also performed well.

The genotypes differed in their performance across environments. The best performers were ICG 221, the local variety, and Natal Common. Other improved varieties did not perform well under farmers' field conditions, although some had better on-station performances than Natal Common. It is therefore necessary to screen improved varieties under low-management conditions on-station in the future, to simulate farmers' field conditions.

Sumário

Avaliação varietal dos ensaios dos campos do amendoim conduzidos em Súazilandia. *Sete linhas melhoradas e variedades do amendoim (ICG 221, ICGV 86016, ICGV-SM 86720, ICGV 867004, Natal Commun, e Seleção 5) e a variadade local foram avaliadas por 16 agricultores cooperadores em ensaios nos campos dos agricultores. os ensaios foram conduzdos em duas zonas agro-ecologicas (Middleveld e Lowveld) em Suázilandia durante a estação de 1993/94. Foram observadas diferenças significativas nos rendimentos das vagens e grão e também no tamanho da semente. A linha melhorada mais prometedora e a ICG 221, que é bem adaptada e altamente produtiva. A variedade local e Natal comum também tiveram um bom comportamento.*

Os genótipos tiveram diferenças do rendiments nos ambientes diferentes. Os melhores rendimentos foram obtidos com a variedade ICG 221, variedade local, e Natal comum. Outras variedades do amendoim não tiveram um bom comportamento nas condições nos campos dos agricultores, embora algumas linhas melhoradas produziram melhor que o Natal comum nas estações experimentais É por isso necessário no futuro avaliar as variedades melhoradas em condições do nível baixo em estação experimental de forma a simular as condições dos campos dos agricultores.

Introduction

Groundnut (*Arachis hypogaea*) is one of the most important legumes in Swaziland, where it has been grown for several decades. Groundnut is grown both for home consumption (it is an important source of protein) and for sale as fresh boiled pods and/or dry seed. The crop is grown in all four agroecological zones in Swaziland—Highveld, Middleveld, Lowveld, and Lubombo Plateau. The major production area is the Middleveld (CSO 1986). Area and production figures are shown in Table 1.

1. Malkerns Research Station, P O Box 4, Malkerns, Swaziland.

Mamba, Z. 1994. On-farm groundnut varietal evaluation in Swaziland. Pages 122-125 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand, G.L., and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Table 1. Area and production of groundnut in Swaziland, 1971/72 to 1989/90.

	1971/72	1981/82	1989/90
Area (ha)	4945	1655	3041
Production (t)	2898	481	220

Source: Central Statistical Office. Swaziland

In 1991, an informal survey was conducted of grain legume farmers from representative areas in all four zones. The major production constraints identified during the survey were lack of suitable varieties, low plant populations, limited use of fertilizers, poor seed-bed preparation, diseases, and insect problems (Mamba and Willis 1992). Farmers nevertheless continue to grow the crop irrespective of these constraints.

Groundnut is normally sown between mid Oct and Nov, and harvested between Feb and Mar. A large percentage of farmers grow it as a sole crop; a few intercrop groundnut with maize, especially when there is a shortage of labor or land. Some farmers intercrop groundnut to minimize crop failure due to drought. Research, however, has not been done in Swaziland to determine the advantages and disadvantages of intercropping groundnut.

Farmers use their own seed from the previous harvest. If there is a shortage, they buy seed from neighbors or relatives. The commonly grown types are Spanish (Natal Common) and Valencia (unknown variety) (Subrahmanyam and Mamba 1993).

The main objective of the study reported here was to evaluate the performance of promising groundnut varieties (earlier identified in on-station trials) under farmers' field conditions.

Materials and methods

The on-farm groundnut research program began in 1993/94. Four target areas, two each in the ecological zones of Middleveld and Lowveld, were selected on the basis of the food grain legumes informal survey (Mamba and Willis 1992). Three trials were sown at sites located in the Rural Development Areas (RDAs) of Bhekinkosi/Mliba (dry Middleveld), Sithobela (Lowveld), and Southern RDA (SRDA, moist Middleveld). Sowing at the fourth planned site (Mandlangempisi, in the Lowveld), was not possible due to drought—the first rains came only in Jan.

Climatic conditions differ between the two zones. SRDA has a more reliable rainfall distribution than does Sithobela. Soil texture and acidity levels also differ; loamy soils with low soil pH (<4.8) are common in SRDA; in Sithobela there are mainly sandy-loamy soils with patches of Vertisols in some areas, and soil pH is generally higher than 4.8.

Sixteen farmers sowed the trials at SRDA and Sithobela. The trials were arranged in a randomized block design with two replicates at each farm. Entries consisted of seven experimental varieties provided by the Malkerns Research Station; farmers provided the local variety as the control. Each plot consisted of two rows 10 m long. Within-row spacing was 10 cm; spacing between rows was not controlled.

The trials were researcher-implemented and farmer-managed, with farmers using their normal crop management practices. Harvesting was done jointly by the farmer and the research team. Each trial was harvested and left at the site for drying. Later the research team returned for pod stripping and weighing. A 1-kg sample of pods was taken from each plot to determine shelling percentage and 100-seed mass.

The research team consisted of two people: the resident research assistant or extension worker for the area, and the research on-farm coordinator. Crop management practices, other field background information, and yield were recorded. Data were available from 15 farmers; assessments are yet to be conducted.

The data were analyzed using two statistical tools, analysis of variance (ANOVA) and regression modified stability analysis (MSA). The results will be used to formulate recommendations for the two domains. The eventual objective is to develop a set of recommendations for each zone, which can then be applied in the different environments (differing in land quality and farmers' resources) within each zone.

We sought to characterize the environments (each replication was considered as one environment) on the basis of the data collected. Results from trial monitoring reveal that farmers used similar management practices; differences were only observed as to when a particular practice or operation was carried out. Thus, environments were classified as good or poor, on the basis of the environmental index, computed from the average yield from all plots/cultivars (see Hildebrand 1993). 'Good' environments were those with an index higher than 4.0 for grain yield or 9.0 for pod yield.

Results

Characterization of environments. Good environments were characterized by large field sizes, use of crop rotation (usually with maize and beans), use of tractors (>75% of total draft power used coming from tractors), minimal interrow cultivation, and early sowing. About 75% of the environments in the moist Middleveld were classified as good, but only 25% of those in the Lowveld.

The Lowveld environments had erratic rainfall and sandy soils. Fields were small and rotations involved maize, cowpea, or fallow. Tractors and oxen provided roughly equal shares of the total draft power for seedbed preparation; interrow cultivation was seen on 82% of the fields, and sowing was often late (Table 2). It must be noted that this does not constitute a proper characterization of environments, which would require long-term data and further analysis.

Yield in good and poor environments. In poor environments, ICG 221 gave relatively high, stable yields, followed by Natal Common. The farmers' local variety and (especially) ICGV-SM 86720 showed considerable variation at different locations. In good environments, the local variety and ICG 221 were the best performers. The relative performance of varieties was probably affected to a considerable degree by differences in crop management practices, which varied from farmer to farmer. However, ICG 221, the local variety, and Natal Common generally performed better than the others in all environments, suggesting that they are better adapted.

Combined results for all sites. Performance across sites showed significant genotypic differences in pod yield (P<0.05). ICG 221, an Indian accession, performed very well across diverse environments; the local variety and Natal Common also performed well (Table 3).

Shelling percentage was the lowest in the local variety (roughly on par with ICGV 867004) and highest in Sellie. Grain yield differences were highly significant (P<0.01). ICG 221 gave significantly higher grain yield than ICGV 86016 and ICGV-SM 86720, but was on par with the other varieties (Table 3).

The 100-seed mass varied between 34.4 and 48.2 g. ICGV-SM 86720 had the highest seed mass, but four other varieties had seed mass values nearly as high.

Table 2. Environmental characterization of on-farm groundnut trials in Southern Rural Development Area and Sithobela, Swaziland, 1993/94.

Management practice	Good environment	Poor environment
Previous crop grown	Beans, groundnut, maize	Maize, cowpea, fallow
Source of draft power for seedbed preparation	Tractor 75%, oxen 25%	Tractor 50%, oxen 50%
Sowing date	25 Nov to 8 Dec	25 Nov to 8 Dec 40%, 9-21 Dec 60%
Field size	1612-5564 m^2	477-1500 m^2
Interrow cultivation (recorded 30 DAS[1])	37%	85%
First hand hoc weeding Second hoe weeding	30 DAS With ridging	30 DAS With ridging
Ridging	45 DAS	60 DAS
Basal fertilizer, nitrogen top dressing	Not applied	Not applied
Disease/pest control	Not done	Not done

1. DAS = Days after sowing

Table 3. Performance of eight groundnut lines/varieties in on-farm trials at Southern Rural Development Area and Sithobela, Swaziland, 1993/94 season.

Variety	Pod yield (kg ha^{-1})	Shelling percentage	Grain yield (kg ha^{-1})	100-seed mass (g)
ICG 221	924.8	65.20	606.6	40.70
Local variety	850.1	60.90	547.8	34.40
Natal Common	835.7	65.50	549.6	37.30
ICGV 867004	807.2	63.10	510.7	41.00
Selection 5	798.5	65.20	521.4	39.90
Sellie	759.2	65.60	502.2	40.40
ICGV 86016	726.2	65.40	479.4	43.10
ICGV 86720	715.6	61.90	466.2	48.20
Mean	805.23	64.38	522.88	40.78
SE	±42.03	±1.15	±25.31	±1.95
CV (%)	25.28	8.53	23.76	17.34

Discussion

In these trials crop management was a major performance determinant. The previous crop grown in the field had a critical effect (Table 2), probably because of residual soil fertility. The normal sowing period is mid Oct to Nov. Due to late rains, these trials were sown between 25 Nov and 8 Dec in the good environments, and even later in the poor environments (Table 2). While the delay in sowing would have contributed to low yields, yields were still acceptable in the good environments. The best environments were found mainly in the Middleveld, where there was adequate soil moisture and ideal soil (textured loamy soils). Farmers in this region had relatively large areas (0.16-0.56 ha) under groundnut, and grew the crop for sale.

Farmers practiced interrow cultivation as a means of weed control. Most farmers (85%) in the poor environment followed this practice, as against 37% in the best environment. It is speculated that interrow cultivation could have reduced yields by disturbing the formation and/or development of pegs and root systems.

Overall, the best performer in the trial was ICG 221, which is both well adapted and highly productive. The local variety and Natal Common (a recommended variety) were the second and third best yielders overall. Both are small-seeded; it is suspected that the local variety could be a selection from Natal Common, which has been grown since the 1970s. The medium- to large-seeded lines (except ICG 221) gave relatively low yields, and ICGV-SM 86720, a large-seeded, long-duration variety, gave the lowest yields.

Some of the improved varieties did not perform well in the trials, although they had better on-station performances than Natal Common, suggesting that they are best adapted to good management conditions. There is thus a need to screen improved varieties under low-management conditions on-station in the future to simulate conditions in farmers' fields.

References

Central Statistical Office (CSO). 1986. Annual Statistical Bulletin 1985/86. Mbabane, Swaziland: Swaziland Government.

Mamba, Z., and Willis, S. 1992. Informal survey on grain food legume crops grown in four agroecological zones of Swaziland. Research study series no. 14. Mbabane, Swaziland: Ministry of Agriculture and Cooperatives.

Subrahmanyam, P., and Mamba, Z.I. 1993. Diseases of groundnut in Swaziland. International Arachis Newsletter 13:7-8.

Discussion

Luhana. Production figures have dropped from about 2900 t in the 1970s to very low levels in 1990. It is important to correctly identify the causes for the decline. Is poor seed really the main constraint—are the local varieties currently used different from the ones used in the 1970s?

Seed as a Constraint to Sustainable Groundnut Production in Malawi

S C Luhana[1], B J Ndunguru[2], N E Nyirenda[1], A J Chiyembekeza[1], F Nyondo[1], K M Chavula[3], and V N Kamvazina[4]

Abstract

Production of groundnut in Malawi has declined in the past few years. Seed shortages in both the formal and informal markets have led to a reduction in groundnut area and consequently to lowered production. Other causes of low production are late sowing, late weeding, and low plant population. Early leaf spot is the major disease, while leaf eaters and termites are the major pests. One kilogram of CG 7 seed given to each of 300 women farmers during the 1993/94 growing season was successful in partly addressing the problem of seed shortages.

Sumario

A semente como limitante para a sustentabilidade da produção do amendoim no Malawi. *A produçãõ do amendoim no Maláwi baixou nos últimos anos. A falta da semente tanto no mercado formal como no informal levou à redução da área cultivada com amendoim, o que, por seu lado, levou à redução da produçãõ. Outras causas da baixa produçãõ podem ser a sementeira tardia, controlo dos infestantes tardio e baixa população das plantas. A mancha precoce das folhas tem sido a doença mais importante, enquanto que mastigadores das folhas e termites têm sido as principais pragas. A distribuição de um kilograma da semente de CG 7, a cada uma das 300 agricultoras durante 1993/94, foi bem sucedida na resolução parcial deste problema.*

Introduction

Malawi's economy is dependent on agriculture. For extension purposes, the country is divided into eight Agricultural Development Divisions (ADDs), which form the focus of major agricultural activities. The major crops grown in Lilongwe ADD are maize, tobacco, groundnut, and dry bean.

In Malawi, groundnut is used to extract edible oil and as a snack food by smallholder farmers; groundnut flour and butter are used to season relish. Although groundnut is the most important food legume crop, its production has been decreasing for the past few years. The highest groundnut production was obtained in the 1985/86 season, and the lowest in 1991/92, when the crop was devastated by drought. The overall downward trend has been due to a progressive reduction in groundnut area (Table 1). Nevertheless, productivity was highest in 1992/93. A survey was conducted in Lilongwe ADD (a major production area) to gather more information about the causes for this decline.

1. Chitedze Agricultural Research Station, P O Box 158, Lilongwe, Malawi.
2. SADC / ICRISAT Groundnut Project, P O Box 1096, Lilongwe, Malawi.
3. Department of Agricultural Extension and Training, P O Box 30145, Lilongwe, Malawi.
4. Salima Agricultural Development Division, Private Bag 1, Salima, Malawi.

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Luhana, S.C., Ndunguru, B.J., Nyirenda, N.E., Chiyembekeza, AJ., Nyondo, F., Chavula, K.M.. and Kamvazina, V.N. 1994. Seed as a constraint to sustainable groundnut production in Malawi. Pages 126-130 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand, G.L., and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Table 1. Groundnut area and production in Malawi, 1982-93.

Season	Production (t)	Area (ha)	Yield (kg ha^{-1})
1982/83	53 991	146314	369
1983/84	54 766	144 935	378
1984/85	62 240	135 955	458
1985/86	88 297	176 293	501
1986/87	88 073	209 938	420
1987/88	76 754	175 819	437
1988/89	34 752	139 691	249
1989/90	18 574	48 185	359
1990/91	31 051	69 978	444
1991/92	12 060	64 386	187
1992/93	31 936	61 059	523

Source: Economic Planning Unit, Ministry of Agriculture

Survey methodology

The survey was conducted in Namitete, Kasiya, and Nsaru areas of Lilongwe ADD. A structured questionnaire was used, and sampling was random but targeted (only groundnut farmers were sampled). The survey team comprised an agronomist, a breeder, two economists, and five field assistants. The survey was done in two parts. Part one was done in two phases, when the groundnut crop was at peak vegetative growth (22-26 Feb and 10-12 Mar 1993). During this period, 94 farmers were interviewed. These included 30 farmers who had been given seed of the cultivar CG 7.

In the second part of the survey, 86 farmers (all of whom had been interviewed in the first phase) were interviewed during the harvest period, between 19 May and 12 Jun 1993. This part of the survey aimed at studying the timing and method of harvesting, measuring production, and identifying preservation and seed selection methods and end uses.

Both qualitative and quantitative data were recorded on the crop being grown; groundnut seed sources and seed rates; the 'calendar' for each groundnut variety; the variety that farmers liked most (and the reasons why); the frequency at which farmers grew groundnut in the previous season; the rotational system; the sowing sequence (priority) for different crops (and the reasons why a particular sequence was used); crop management practices and the methods used; cropping systems; and pests, diseases, and control measures. Data were analyzed for 83 farmers, using the Statistical Package for Social Scientists (SPSS).

Results and discussion

The results are discussed in terms of non-researchable and researchable areas. A summary is given below.

Non-researchable areas

Institutional constraints. Seed shortage is a major constraint to groundnut production in Malawi as a whole, and Lilongwe ADD in particular. Due to seed shortages most of the farmers interviewed had very small groundnut plots—72% had plots of less than 0.25 ha, and only 10% had 0.50 ha and above (Table 2).

Table 2. Groundnut holding sizes in Lilongwe ADD, Malawi, 1993.

Area (ha)	% of farmers interviewed
0.25	72
0.25-0.50	18
>0.50	10

Production of groundnut seed by commercial seed companies has not been successful in Malawi because of the high prices farmers have to pay for seed. In the mid- to late 1980s, the Ministry of Agriculture recognized the need to produce adequate high-quality seed at lower than commercial prices. Accordingly, smallholder seed multiplication schemes were introduced. However, these schemes failed because, at about the same time, the government decontrolled sales of farm produce. As a result, groundnut that was intended for seed was bought by private traders for other uses.

Groundnut seed shortages are also a result of defective pricing policies. The Agricultural Development and Marketing Corporation (ADMARC), the parastatal responsible for seed distribution, operates under a government-controlled price structure. Farmers are offered very low prices for their produce, and consequently most of the groundnut is sold through informal markets and immediately consumed or processed; seed shortages are a result. Major seed companies such as National Seed Company and Lever

Brothers have not been willing to take up seed production because of the farmers' practice of seed recycling.

Because of the attractive prices offered on the informal markets, most farmers do not sell to ADMARC. Of the farmers interviewed, 50.6% expressed their willingness to sell groundnut, but less than half of this number said they would sell to ADMARC.

Sources of seed. Many of the farmers interviewed (48%) indicated that they retain their own seed for sowing the next season. Other seed sources included purchases from local markets (16%), ADMARC (13.2%), friends (9.6%), credit (2.4%), and research stations (22.8%). However, farmers often do not keep aside enough seed for sowing because of the attractive prices offered by local merchants and the inhibitive prices of cooking oil. As a result, groundnut flour and butter is used as a substitute for seasoning vegetables.

Most of the farmers (82%) grew the Chalimbana variety because it has been available for a much longer time than other varieties. The majority (79%) said they grew this variety because it gave high yields and produced large seeds, which the local traders preferred. The new varieties such as CG 7 are not familiar to most farmers, and seed for these varieties is not available. Other varieties reported as being used, but on a much smaller scale than Chalimbana, were Kalisele, Buyaya, Mani Pintar, RG 1, and Chitembana.

Uses of groundnut. The end uses of groundnut were the same for different varieties. Of the farmers interviewed, 50.6% planned to sell most of their produce, 89% to keep some for seed, and all planned to consume some.

Researchable areas

Plant density. The recommended plant density for groundnut in Malawi is 74 000 to 111 000 plants ha^{-1} depending on the variety used. This density is achieved when plants are spaced at 15 cm between planting stations and 60-90 cm between ridges. Of the farmers interviewed, only 19% used a plant population above 60 000 plants ha^{-1}. The average spacing was 94.23 cm between ridges, and 23.49 cm between plants.

Numerous studies have recommended dense spacing, with optimum densities of 90 000 to 130 000 plants ha^{-1} for Virginia runner types and 130 000 to 180 000 plants ha^{-1} for Spanish bunch types. Ngwira (1985) and Maliro (1989) suggested 60 cm spacing between rows instead of the 90 cm recommended in Malawi.

Time of sowing. The recommendation states that groundnut should be sown with the first effective rains. Of the farmers interviewed, 71.2% sowed 3 weeks after the onset of rains. Research has shown that late sowing (3 weeks after the onset of rains) can reduce yield by 20-50% (Nyirenda et al. 1992). Farmers are aware that late sowing reduces yield, but because they place a higher priority on the major food (maize) and cash (tobacco) crops, these are sown first, and groundnut sowing is delayed. All the farmers interviewed sowed groundnut last. Some farmers (38%) sowed groundnut in the first half of Dec, and 32% sowed in the second half of Dec. Only 29% sowed groundnut in Nov, and only 12% of this number in the first half of the month.

Time of weeding. Research has shown that yield losses of up to 40% can be incurred with Chalimbana if weeding is done later than 35 days after crop emergence. Weed competition is very intense 30-50 days after emergence, and can affect both yield and quality (Chiyembekeza and Sibale 1986).

Almost all (97%) the farmers interviewed weeded their groundnut fields, although the majority weeded late (later than 30 days after sowing) because their limited labor resources were used for other crops. More than half the farmers interviewed weeded only once.

Pests and diseases. High incidence of diseases and pests can cause substantial yield losses. In Lilongwe ADD, early leaf spot was identified as the major disease, and leaf eaters as the major pests (Table 3). Most farmers felt that leaf spots were a sign of physiological maturity. Only 12% of the fields surveyed

Table 3. Disease and pest incidence in groundnut fields, Lilongwe ADD, Malawi, 1993.

Disease/pest	Incidence (%)
Early leaf spot	50.4
Late leaf spot	2.4
Rosette	10.8
Aphids	12.0
Leaf eaters	23.2
Termites	10.8
Hilda	1.2

were attacked by aphids, 11% by termites, and 23.2% by leaf eaters.

The CG 7 seed multiplication approach

Groundnut research has resulted in the release of several varieties, one of them being CG 7. As a preliminary step to more intensified extension efforts, a group of women farmers from three ADDs (Lilongwe, Kasungu, and Salima), led by extension personnel, were invited for a field day at Chitedze Agricultural Research Station in Mar 1993. This was done to allow the women farmers and extension personnel to evaluate the performance of this variety before further dissemination.

Farmers expressed interest in CG 7. As a result, 100 kg of seed were given to each of the three ADDs for distribution to women farmers. Each farmer was given 1 kg of seed to sow. All cultural practices were followed under the direction of researchers and extension workers. Some extension planning areas (EPAs) were also given seed for demonstration. Details and preliminary results of this exercise are presented elsewhere in these Proceedings.

Farmers were expected to return 1 kg of seed after harvest and retain the rest of their produce. Whatever seed is obtained from the farmers will be distributed to other farmers the following season.

Advantages of the approach

The approach is inexpensive because farmers are not required to purchase seed. This allows more farmers to participate in the technology evaluation process. Even the least endowed can afford to allocate a small portion of land to a new cultivar.

Farmers who would have either used poor quality seed or not sown groundnut due to lack of seed, were able to experiment with this variety. Researchers also had a chance to learn from farmers and extension workers their impressions about CG 7. The few kilograms of seed initially distributed could have significant multiplier effects. The initial recipients would harvest enough seed for subsequent sowings; other farmers would buy seed; and new recipients would be inducted into the scheme. With time, the problem of seed shortages may be alleviated.

Conclusions

The survey results indicated that the major constraints to groundnut production were lack of seed, low plant population, late sowing, late and/or insufficient weeding, and pests and diseases.

To alleviate seed shortages, a sound seed multiplication and distribution mechanism should be instituted. This calls for closer liaison between the Department of Agricultural Research and the Department of Extension and Training. The government of Malawi should encourage ADMARC to offer higher prices for groundnut, so that more farmers will sell their produce to ADMARC. This will ensure the availability of seed during sowing time.

Late sowing and weeding is mainly due to labor shortages. Mechanization could be introduced for faster sowing and weeding of maize, so that groundnut could be sown earlier than is presently done. Early leaf spot is the major disease, but the Malawi national program and the SADC / ICRISAT Groundnut Project are breeding varieties that are tolerant of the disease.

Groundnut requires fewer inputs than do other crops. Apart from seed, few other purchased inputs are needed. It is hoped that the efforts currently under way to multiply and distribute groundnut seed will continue.

Acknowledgments

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References

Chiyembekeza, A.J., and Sibale, P.K. 1986. Groundnut research work in Malawi: achievements, problems and future strategies. Pages 86-87 *in* Research highlights and constraints to crop production: proceedings of the 1986 Research and Extension Workshop, Blantyre, Malawi (Maida, J.H.A., ed.). Blantyre, Malawi: Ministry of Agriculture.

Maliro, C.E. 1989. Effect of ridge spacing and plant population on groundnut yield in Malawi. Pages 205-209 *in* Proceedings of the Third Regional Groundnut Workshop for Southern Africa, 13-18 Mar 1988, Lilongwe, Malawi (Bock, K.R., Cole, D.L., Hildebrand, G.L., Nigam, S.N., and Wightman, J.A., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Ngwira, P. 1985. Groundnut improvement in Malawi. Pages 49-53 *in* Proceedings of the Regional Groundnut Workshop for Southern Africa, 26-29 Mar 1984, Lilongwe, Malawi (McDonald, D., ed.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Nyirenda, N.E., Cusack, TJ., and Saka, V.W. 1992. Groundnut agronomy research in Malawi: past achievements and future priorities. Pages 29-33 *in* Proceedings of the Fifth Regional Groundnut Workshop for Southern Africa, 9-12 Mar 1992, Lilongwe, Malawi (Nageswara Rao, R:C., and Subrahmanyam, P., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Discussion

Freire. You have suggested recommendations on times of sowing and weeding. Are these recommendations really appropriate? Labor is diverted to whichever crop (e.g., tobacco) farmers find most remunerative. It would be necessary to consider economic factors (the cost-effectiveness of labor spent on groundnut, as compared to other crops).

Luhana. Research should look for ways to release labor from the major crops (maize and tobacco) by mechanizing ridging, sowing, or weeding. The farmer will then have sufficient labor to plant even the minor crops on time.

Ndunguru. In Malawi, early groundnut sowing is currently not practicable—maize is the staple crop, and is always sown first. We need to find ways to increase the speed of sowing operations for the main crops, so that minor crop sowing dates can be advanced.

Cole. What aspects of maize production could you mechanize and how?

Luhana. Mechanization would depend on economic factors. A first step would be to promote the use of ox-drawn equipment, rather than hand hoes, for land preparation.

The Role of Groundnut Technology Transfer to Communal Farmers for Sustainable Groundnut Production

D J M Marais and K Morrow[1]

Abstract

Socioeconomic and other factors play a major role in the dissemination and adoption of groundnut technology. To obtain information on these aspects, nine villages in the Kavango region of Namibia were surveyed in 1993. Farming in these areas was largely at subsistence level; literacy levels and awareness of technological opportunities were low, and infrastructure (e.g., transportation) was lacking. Seed shortages were common. Groundnut areas were invariably too small (because of shortages of seed, cash, and labor) to ensure household food security. Land preparation was done manually or with oxen. No ripping or deep cultivation was practiced to reduce soil compaction, and this could have severe consequences on productivity and sustainability.

Considerable potential exists to improve productivity by improving agronomic practices (sowing in straight lines at optimal densities, using kraal manure and artificial fertilizers, timely and adequate weeding).

Sumario

***A importância da transferença da tecnologia aos agricultores para uma sustentavel produção do amendoim.** Fatores socio econommicos e outros fatores representam uma parte principal na disseminaçãq e adopção da tecnologia do amendoim. Para obter informação sobre esses aspectos inquéritos foram conduzidos em move alderas na regrão de Kavango em Namibia no ano de 1993. Agricultura nessas áreas é, em maior parte ao nível de subsistência; nívers da alfabetização e conhecimento das oportunidades da tecnologiâ são baixas, e há falta da infrastructura (como transporte). Há escassez de semente. Invâriavelmente as áreas onde amendoim é cultivado são pequenas (porque há escassez da semente, finanças, e labor) para assegurar alimentação para a familia. Preparação do solo é feita manualmente ou com juntas dos bois. Semear profundamente, que reduz a compactação do solo não foi praticado, e isto pode ter severas conseqüências sobre a produtividade e sustentabilidade.*

Considerável potencial existe para o melhoramento da produtividade com melhoramento das praticas agronomicas (semeação em linhas direitas e retas com adequada densidade das plantas, uso dos fertilizantes artificiais e adequada capina).

Introduction

The total cropped area in the communal areas of Namibia is approximately 60 000 ha. Groundnut is produced mainly in the Kavango and Caprivi areas. Reliable figures on groundnut area are not available, but we estimate that 1% of the crop land in Kavango and 10% in Caprivi is occupied by groundnut.

The influence of technology transfer on groundnut production depends not only on the technology itself, but also on socioeconomic and other factors, which play a major role in production and technology dis-

1. Ministry of Agriculture, Water and Rural Development, P O Box 788, Grootfontein, Namibia.

Marais, D J.M., and Morrow, K. 1994. The role of groundnut technology transfer to communal farmers for sustainable groundnut production. Pages 131-134 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand, G.L., and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

semination and adoption. To obtain information on these aspects, nine villages in the Kavango region were surveyed in 1993.

The majority of people in the villages surveyed existed at subsistence level, with periodic bouts of hunger, usually before the new crop was ready for harvest. Literacy levels were low, as was the level of awareness of technological opportunities. Technical know-how on fertilizers was sometimes completely absent. Not surprisingly, cash availability in the villages was extremely limited, with corresponding repercussions on productivity. Lack of infrastructure is another major problem: the transportation of agricultural products to the market from most of the villages surveyed is virtually impossible.

Millet is the most important food crop in the region. Estimates of area under other crops in each village were made in comparison with millet area (Table 1). Groundnut is one of the four most important crops in Namibia's communal areas. Large nuts are eaten as a separate dish, while smaller nuts (usually rejects) are used to prepare a sauce that is consumed along with millet porridge.

The survey results indicate that three cultivars are grown in the region:

- An upright bushy type;
- A short-statured spreading type;
- A type intermediate between the two.

Seed supplies

In only a minority of cases did farmers have adequate seed supplies. In some communities 25% of the villagers had to buy seed from elsewhere. However, the majority of farmers did not have enough cash to buy seed to augment their own-grown stocks, or to transport seed from the purchasing centers to their farms, and suffered food shortages as a result. One community stated that they had no idea where they could buy seed; this indicates a serious lack of communication.

Cropped area

There was no recorded instance where a communal farmer stated that he had planted groundnut over a sufficiently large area to ensure adequate food supplies. The main reasons were difficulties in land preparation and non-availability of seed. The majority of farmers had to rely on manual labor for land preparation; some had to sell their oxen, for example to pay school fees. Some farmers were able to hire oxen, but had to wait till the owners had completed their own work. This caused serious delays in land preparation.

Table 1. Relative importance of the major food crops grown in nine villages (1-9) surveyed in the Kavango region, Namibia, 1993[1].

	Village								
Crop	1	2	3	4	5	6	7	8	9
Millet	100	100	100	100	100	100	100	100	100
Maize	50	30	20	50	10	10	10	25	10
Sorghum	100	100	25	100/25[2]	25	100	100	-	-
Beans	I[3]	I	I	I	1	I	I	I	I
Groundnut	20	10	10	U	U	V	U	U	u
Bambaranut	20	10	10	U	u	V	U	u	u
Pumpkin	V	V	V	V	V	V	V	V	V
Sweet potato	10	5	-	-	-	-	P	-	-
Watermelon	I	-	I	I	-	-	-	I	I
Sweet sorghum	-	I	25	-	u	-	-	-	-

1. All areas shown relative to millet area in the respective village, taken as 100.
2. Data showed two distinct clusters; both values shown.
3. I = intercropping. U = uncertain, V = very variable within community. P = previously grown, but has died out due to eelworm and pests.

Land preparation

Land preparation was done manually or with oxen, with an ox plow, up to a depth of 15-20 cm. No ripping or deep cultivation was done to break up the compact layers in the soil, and this can have severe consequences in a high-risk, low-potential region like Namibia.

A commercial farmer in the Grootfontein region (bordering Kavango, and with similar soils) used a penetrometer to determine the extent of compaction in his soils. The tests were conducted on fields that had been cropped for 1 year, 2 years, and several years. Cultivation had been done using a disk plow and moldboard plow. The results showed that compaction was already present after 1 year of cultivation, and increased rapidly in subsequent years to the point where it prevented root penetration and water uptake, resulting in drought stress. A cultivation method like ripping, using suitable implements, will reduce compaction and thus reduce the risk involved in growing groundnut (or any other crop). This will help to create a more secure food supply for communal farm families.

Sowing practices

Sowing in straight lines. The idea of sowing in straight lines is something new to many communal farmers. Some farmers are aware of this practice, but believe that it would be excessively laborious. A few farmers did make an attempt to sow in straight lines. This was done by sowing large grains (maize, groundnut, etc.) in every third furrow, sowing one seed at every step taken while walking along the furrow. However, these lines were not straight enough for ox-cultivation.

Plant population. Similar spacings (approximately 60 x 50 cm) were used for groundnut and maize. This gave a plant population of 30 000 plants ha^{-1}, which is too high for maize and too low for groundnut. The recommended groundnut plant population for the Kavango and Caprivi regions is 100 000-150 000 plants ha^{-1}. Some farmers intercrop groundnut with millet or maize, using the same spacing throughout the field.

Fertilizers

Kraal manure. Very few farmers used kraal manure as a fertilizer, except on fields adjacent to the cattle kraal. The reasons were difficulty in the transport of manure, and a general reluctance (because it is not a traditional practice) to use kraal manure.

Artificial fertilizers. Most of the soils in Namibia, and especially the sandy soils, have a very low general fertility, with deficiencies in phosphorus and zinc. Therefore, fertilizer use can substantially increase yield. However, less than 1% of farmers interviewed used artificial fertilizers on a regular basis. The sole limitation, apparently, is the availability of cash—knowledge of the value of fertilizers was fairly widespread, although there were a number of farmers who were unaware of the advantages to be gained.

Weeding

Weeding is carried out manually. Fields were severely under-weeded, as the farmers themselves admitted. There appeared to be little prospects of persuading farmers to weed their fields more frequently. No one disputed that crop plants in poorly weeded fields had to compete with weeds for sunlight, moisture, and nutrients; but the traditional cultivars with their low yield potentials offer no incentive for providing the additional labor for weeding.

Another problem was the timing of weeding. When groundnut is hand-weeded the plants are ridged, which means that the first internodes (where the first flowers and branches are formed) are buried. Thus, weeding at the wrong time (e.g, at the flowering stage) can cause yield losses of up to 20%. An additional obstacle to more frequent weeding could conceivably be the poor nutritional level prevailing in many communities at this time of the year.

As a result of these factors, weeding is usually neglected by farmers. It is clear that clean-weeding of fields, with consequent benefits, can only be brought about by a change in technology away from manual labor.

Harvesting and storage

Only two crops—millet and sorghum—were usually stored for any length of time. All other crops were produced in quantities too small to require long-term storage. Groundnut sowing normally begins in Dec, and the crop is harvested 120 days later. Late-sown fields may be harvested as late as May. The crop is consumed by the farmer or sold on the market for 0.50 N$ per cup or 2-3 N$ per kg (3.6 N$ = 1 US$).

Improved cultivars

There is a widespread willingness among farmers throughout the region to test new and improved cultivars, but adoption is constrained by cash and/or seed availability.

Conclusion

The development of new and better-adapted technology, and successful technology transfer to communal farmers, will have an enormous impact on groundnut production (and thus on incomes and food security), because almost no technology currently exists. Other related factors like markets and transport must also be examined. Eventually, these changes will make farming a more attractive occupation, improve community health and welfare, and benefit the country as a whole.

Packages for Sustainable Groundnut Production in Lesotho

S S Moima[1]

Abstract

Groundnut is a newly introduced crop in Lesotho. Several approaches are used to transfer production technology to smallholder farmers in the country. These include on-station (yield!adaptability screening and agronomy) trials, on-farm trials planned and conducted jointly by researchers, extension agents, and farmers, in-service training, field days, demonstrations, and agricultural shows. Information is also disseminated through village meetings, the media, and printed pamphlets. Groundnut production in Lesotho suffers from several constraints, which are briefly discussed.

Sumário

Programas compactos para produção do amendoim em Lesoto. *Amendoim foi recentemente introduzido em Lesoto. Vários métodos foram utilizados para a transfêrencia da tecnologia aos agricultores pequenos desse país. Esses incluêm ensaios nos campos da investigação (rendimento testes da adaptação e agronomia) ensaios nos campos dos agricultores, planeados e conduzidos juntamente pelos investigadores, extensionistas e agricultores, treino nos campos, demonstrações e exibições agronomicas. Informação é também disseminada atravéz de reuniões aldeianas a média, e pamfletos. A produção do amendoim em Lesoto sofre várias restrições que são discutidas brevemente nesse artigo.*

Introduction

Lesotho has a temperate climate with well marked seasons—warm summers with short growing seasons, and cold winters with frost and long periods of drought. Most of the rain (80%) falls between Oct and Apr. Maize, sorghum, wheat, and *Phaseolus* beans are the major field crops while peas, sunflower, and lentil are minor crops. Groundnut is a newly introduced crop in the country, and is grown mainly in the lowlands and the Orange River valley, where environmental conditions are favorable (better soil types, warm temperatures, and good rainfall distribution).

Approaches to technology transfer

The following approaches were initiated by the Agricultural Research Division for groundnut technology transfer to communal farmers, as a means of ensuring the sustainability of groundnut production.

On-station trials. These are conducted for research purposes, at research farms and under good management. They are planned and conducted by researchers, and involve:

- Screening trials to evaluate newly-introduced genetic material for adaptability and yield;
- Agronomy trials to determine optimum sowing date, fertilizer rates, plant population and spacing, and cropping systems; and to ameliorate soil acidity.

Field days are organized at the flowering, podding, and maturity stages, to permit extension workers and farmers to examine and evaluate germplasm and breeding lines. Promising materials are

1. Agricultural Research Division, Ministry of Agriculture and Marketing, P OBox 829, Maseru 100, Kingdom of Lesotho.

Moima, S.S. 1994. Packages for sustainable groundnut production in Lesotho. Pages 135-136 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand, G.L., and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

further tested for a 3-year period for yield stability. Finally, selected materials are tested again under farmers' conditions.

On-farm research. Researchers, extension workers, and farmers work together to plan and conduct these trials, on farmers' fields and under farmer management. In this process farmers participate actively in research and technology development, and collaboration between farmers and extension/development agencies is strengthened.

Demonstrations. These usually serve as teaching aids to the farming community, and may be conducted by a researcher or an extension worker in conjunction with farmers. 'Method' demonstrations show how to perform various operations, e.g., seedbed establishment, calibration of planters, etc. 'Result' demonstrations are held after the on-farm verification stage of research. Here, farmers evaluate different varieties at both on-station and on-farm demonstration plots.

Information. Recommendations on production practices are made as simple and clear as possible. Extension staff monitor the field conditions during the season, and issue reminders for various operations at appropriate times. The main communication channels used are; village committees, general meetings, radio broadcasts, and printed pamphlets.

Training. One effective method of technology transfer is in-service training of extension staff and farmers. The training is conducted by researchers, and covers various aspects of groundnut production including improved management practices, implementation of recommendations, etc.

Agricultural shows. Agricultural shows are usually held each year in all districts, in order to make farmers aware of new groundnut production technology. They are also useful to extension staff and the farming community as a whole.

Constraints to groundnut production

- Lack of seed of improved cultivars: the seed multiplication unit of the Ministry of Agriculture is disorganized and (at present) inefficient because of inadequate staffing;
- High input costs: imported groundnut seed (seed is not available within Lesotho) and fertilizer are too expensive for resource-poor farmers;
- Lack of farm machinery: most farmers use ox-drawn planters (brand name Safim) for sowing maize, sorghum, and beans. These have a special seed plate to provide adequate seed rates for these crops, but are unsuitable for groundnut because they cause high seed damage and deliver low seed rates;
- Lack of economic policies conducive to groundnut production.

Possible solutions

The government should modify agricultural policies to improve conditions for groundnut production, and ensure financial support for the national groundnut research program. The SADC / ICRISAT Groundnut Project should supply breeders' seed of promising materials. This seed can then be used by NARS in different countries for on-farm research and seed multiplication. The SADC/ICRISAT Groundnut Project provides financial support to NARS for collaborative research activities. This support should also be extended to conducting training courses and field days for both extension workers and farmers. Continued informal advice from the SADC/ICRISAT Project staff from time to time will support NARS research in different fields.

Discussion

Swanevelder. I personally believe that we have to take our technology to the farmer the way Mr Moima does, with on-farm demonstrations. There is no better way to get farmers to accept and use research results.

Chavula. On the question of pricing incentives, one of the problems we face in Malawi is that the parastatal responsible for providing incentives to groundnut producers is overstretched, in that it deals with many other crops. As a result it cannot concentrate on groundnut.

Moima. In Lesotho too, and in several other countries in the region, there is no special agency dealing with groundnut, but rather a government-controlled board that buys produce of all crops.

Simultaneous Seed Multiplication and Further Evaluation of CG 7 Groundnut on Farmers' Fields in Malawi

N E Nyirenda[1], C E Maliro[1], and B J Ndunguru[2]

Abstract

*Groundnut (*Arachis hypogaea*) is grown throughout Malawi, mostly by smallholder farmers. However, production has severely declined in the past few years, partly due to low official producer prices. Male farmers have abandoned groundnut for more profitable cash crops; it is now cultivated largely by women farmers for food. The variety CG 7 was released in Malawi in 1989. Although it is higher-yielding, stores better, and is more suitable than all other Malawi genotypes, its adoption by farmers has been almost non-existent, apparently due to lack of seed and slow production technology transfer to women. The objectives of this work were seed multiplication and further evaluation of CG 7, and demonstration of this variety to farmers.*

Generally, CG 7 convincingly outyielded Chalimbana and Chitembana in diverse environments. The initial phase of the seed multiplication exercise, involving mainly women farmers, was largely successful. The farmers were pleased with the performance of CG 7, and most extension staff are now aware of this cultivar. The seed multiplication exercise will be extended to all major groundnut production areas in Malawi, and the impact/adoption of CG 7 will be monitored through surveys.

Sumario

Simultanea multiplicação da semente e avaliação adicional do amendoim CG 7 nos campos dos agricultores em Malawi. *Amendoim e semeado em todo o Malawi, por a maioria dos pequenos agricultores. Porem, nos anos passados a produção tem dechnado severamente, parcialmente devido aos baixos preços oficiais. Os cultivadores, homens, tem abandonado o amendoim para umas culturas mais lucrativas, agora o amendoim e cultivado pelas mulheres para a alimentação. O genótipo CG 7, que tem um alto rendimento pode ser bem arnazenado, e é muito mais conveniente que os outros genótipos de Malawi, porem a adopção desse genótipo pelos cultivadores tem sido praticamente inexistente, aparentemente devido a falta da semente e um atraso em transfêrencia da technologia da produção para as mulheres. As objectivos desse trabalho foram a multiplicação da semente CG 7 uma avaliação adicional e a demonstração de CG 7 aos cultivadores.*

Geralmente o CG 7 teve un rendimento muitisimo mais alto que as variedades Chalimbana e Chitembana em ambientes diversos. A fase inicial, à de multiplicação da semente envolvendo uma maioria das mulheres cultivadoras foi un grande sucesso. Os cultivadores estão contentes com o comportamento do CG 7 e a maioria dos extensionistas agora tem conhicemento do CG 7. Esse exercisio da multiplicação da semente pode ser extendido a todas as áreas de importantes em Malawi, onde amendoim é cultivado, e o impacto/adoptação do CG 7 pode ser monitorado através dos inquéritos.

1. Chitedze Agricultural Research Station, P O Box 158, Lilongwe, Malawi.
2. SADC/ICRISAT Groundnut Project. Chitedze Agricultural Research Station, P 0 Box 1096, Lilongwe, Malawi.

ICRISAT Conference Paper no. CP 962.

Nyirenda, N.E., Maliro, C.E., and Ndunguru, BJ. 1994. Simultaneous seed multiplication and further evaluation of CG 7 groundnut on farmers' fields in Malawi. Pages 137-142 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand, G.L.. and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Introduction

Groundnut (*Arachis hypogaea)* is a major source of vegetable protein and oil for most people in Malawi. Until recently, it provided more than 25% of all smallholder cash income and about 50% of Malawi's supply of edible oils. The haulms are used as livestock feed in some parts of the country. Groundnut is a suitable crop for rotation with maize *(Zea mays),* a staple food for most Malawians.

Groundnut is grown throughout Malawi, mostly by smallholder farmers. The main production areas are at medium altitudes (about 600 m above sea level) in the Lilongwe, Mchinji, Kasungu, Mzimba, and Rumphi plains. Other production areas lie in the Lake Shore (about 200 m above sea level), mainly in the Karonga and Salima flood-plains. Production has severely declined in recent years—1991/92 production was only 15% of the mid 1980s levels (Donovan 1993). A major reason for this decline is low official producer prices. Agriculture Planning Division economists estimate that real producer prices of groundnut fell by 27% between 1981 and 1993 (Ministry of Agriculture 1992). Groundnut has now become basically a smallholder food crop; male farmers have therefore abandoned it for more profitable cash crops, and increasingly, women farmers are responsible for groundnut production.

The genotype CG 7, a product of the ICRISAT groundnut breeding program, was released in Malawi in 1989. Although it offers several advantages (including higher yields) over other released varieties, the adoption of CG 7 by farmers has been almost non-existent. Apparently, the major reasons are non-availability of quality seed, and slow transfer of groundnut production technology to the target farmer (women)—extension workers have traditionally targeted farm-production technology transfer at male farmers. Earlier studies (Hirchmann and Vangham 1984) have also found that women are often not targeted in agricultural development programs.

The main objectives of the work reported here were to:

- Multiply CG 7 seed with the hope of accelerating its adoption by women farmers;
- Further evaluate CG 7, since it was released before detailed agronomic evaluation;
- Set up evaluation/demonstration plots to increase farmer awareness of the variety.

Methodology

The project, initiated in the 1993/94 cropping season, involved two sub-projects—seed multiplication (SM, targeted at women farmers), and on-farm evaluation/ demonstration (ED). The SM component involved 300 women farmers from Lilongwe, Kasungu, and Salima Agricultural Development Divisions (ADDs). These women had previously attended a special groundnut field day for women, organized by SADC/ICRISAT at Chitedze Research Station, Malawi. Their demand for CG 7 at the field day prompted this seed multiplication scheme. Each woman farmer was supplied with 1 kg of seed, and asked to return 1 kg after harvest; this seed would then be distributed to other farmers. The seed was to be grown in her farm alongside other groundnut genotypes. Farm-home Instructoresses supervised the SM farmers.

The ED sub-project involved 12 farmers (both male and female) from four areas: Mzimba South West Rural Development Project (MZW), and Lilongwe, Kasungu, and Salima ADDs. These farmers evaluated CG 7 in comparison with two earlier-released genotypes, Chalimbana and Chitembana.

Statistical analysis, testing for genotype and farmer effects, was performed on data from both subprojects. Results from 4 ED and 18 SM farmers were analyzed for seed yield and yield-related parameters.

Results and discussion

At first the data was pooled for analysis. However, it was suspected that pooling would be inappropriate because data from different ecological zones may have different variances. The SM data was therefore analyzed separately for each ecological zone (differing in rainfall amount and distribution), while ED data was analyzed for each Extension Planning Area (EPA).

Seed multiplication

The pooled results (Table 1) showed that CG 7 gave higher kernel yield than Chalimbana; however, zone-based data (Tables 2, 3) indicated that this was not true for Salima ADD, where there was considerable variation in yield data.

Table 1. Groundnut yield, shelling percentage (SH %), seed size, sound mature kernels (SMK), and harvest population (H-POPN) (pooled data) of two groundnut genotypes grown by smallholder formers, Lilongwe West, Lilongwe East, Bwanje Valley, and Mzimba South West Rural Development Projects, Malawi, 1993/94.

	Seed yield ($kg\ ha^{-1}$)		SH %		100-seed mass (g)		SMK (%)		H-POPN ($plants\ m^{-2}$)	
	CH[1]	CG 7	CH	CG 7	CH	CG 7	CH	CG 7	CH	CG 7
Mean	456.3b	741.8a	56.7b	63.3a	46.2	47.3	37.0b	68.7a	5.12	5.57
SE	±46.85		±0.855		±1.07		±2.76		±0.701	
CV (%)	32		6		10		22		54	

1. CH = Chalimbana.

Means for a given parameter, followed by the same letter, are not different by LSD.

Table 2. Groundnut yield, shelling percentage (SH%), seed size, sound mature kernels (SMK), and harvest population (H-POPN) in two genotypes grown in seven farmers' fields, Lilongwe West Rural Development Project, Malawi, 1993/94.

	Seed yield ($kg\ ha^{-1}$)		SH %		100-seed mass (g)		SMK (%)		H-POPN ($plants\ m^{-2}$)	
Farmer	CH[1]	CG 7	CH	CG 7	CH	CG 7	CH	CG 7	CH	CG 7
1	317	800	56	65	39	46	16	57	6.1	5.8
2	539	750	64	69	53	54	45	76	4.4	5.9
3	317	694	61	70	50	52	42	70	4.2	4.1
4	361	450	58	68	45	4)	38	71	4.3	4.3
5	256	1056	54	62	37	44	26	29	4.0	5.8
6	489	661	60	74	53	53	55	75	5.1	6.3
7	267	589	53	56	55	52	55	75	5.1	6.3
Mean	363.5b	714.3a	58.0b	66.4a	47.6	48.6	40.1b	64.3a	4.58	5.37
SE	±63.70		±0.930		±1.21		±3.40		±0.240	
CV (%)	31		4		7		17		13	

1. CH = Chalimbana.

Means followed by the same letter are not different by LSD.

Table 3. Groundnut yield, shelling percentage (SH%), seed size, sound mature kernels (SMK), and harvest population (H-POPN) in two genotypes grown in six farmers' fields, Lilongwe East Rural Development Project, Malawi, 1993/94.

	Seed yield ($kg\ ha^{-1}$)		SH %		100-seed mass (g)		SMK (%)		H-POPN ($plants\ m^{-2}$)	
Farmer	CH[1]	CG 7	CH	CG 7	CH	CG 7	CH	CG 7	CH	CG 7
8	739	1356	55	69	43	56	38	81	5.7	6.2
9	711	761	55	64	44	47	38	76	5.4	5.8
10	-	-	53	59	54	43	40	45	-	-
11	672	950	56	64	43	48	26	66	3.3	3.3
12	955	1117	63	68	45	48	62	74	3.1	4.1
13	1106	1772	64	65	65	55	59	72	2.5	3.4
Mean	836.6b	1191.1a	57.7b	64.8a	49.1	49.3	38.4b	68.9a	4.00	4.57
SE	±86.89		±1.29		±2.66		±4.81		±0.132	
CV (%)	19		5		13		22		7	

1. CH = Chalimbana.

Means followed by the same letter are not different by Duncan's Test.

Lilongwe North West ecological zone. Kernel yield and related yield parameters are presented in Table 2. Plant stands at harvest were similar for both genotypes. Chalimbana yields were very low. CG 7 yields were 350 kg ha^{-1} (96%) higher, but still ranged only from very low to just fair. Better pod filling (higher shelling percentage) and a higher proportion of mature nuts (more sound mature kernels, SMK) contributed to the yield advantage of CG 7. There were differences between farmers in shelling percentage, seed size, and SMK, but these did not translate into significant yield differences. Low plant population (33% less than the expected population of 7.4 plants nr^2) was one reason for the low yields. The low shelling percentage and seed size, especially in Chalimbana (for which the normal is about 70% and 90 g), indicate problems during pod filling. Moisture deficiency is the most likely cause, as the rainy season was much shorter than normal.

Lilongwe East ecological zone. Kernel yield and related yield parameters are presented in Table 3. Yields of CG 7 were generally better than those of Chalimbana in most farmers' fields. Thus, CG 7 appears to be better adapted to the Lilongwe East environment than to Lilongwe North West. Unlike in Lilongwe North West, in the East zone there were yield differences among farmers. Shelling percentage and SMK were higher in CG 7, but these do not fully explain its yield advantage over Chalimbana (superiority of 342 kg ha^{-1}, or 45%).

Salima ecological zone. Kernel yield and related yield parameters are presented in Table 4. Kernel yields were similar, and very low, for both genotypes. Shelling percentages were also very low for both genotypes. The seed size for Chalimbana indicates that most seeds were shrivelled. The low yields in Salima were due to severe drought stress during the 1993/94 crop season.

Demonstration/Evaluation

Yield, shelling percentage, and seed size were very low for Chalimbana and Chitembana in all areas (Table 5). Seed size and SMK values indicate that the seeds were largely unfilled. Both genotypes gave similar yields at the various sites. CG 7 yields were generally low, and lowest in EPA 9. However, *CG* 7 outyielded the two controls by 130, 578, 444, and 317 kg ha^{-1}, in EPAs 9, 10, 13, and Mbawa respectively. The yield advantage (in percentage terms) was most pronounced in the most unfavorable environment (EPA 9).

Conclusions

These are preliminary results for the 1993/94 cropping season, which was generally dry. Although the results represent only one season's data, the varieties were tested in a diverse range of environments, with

Table 4. Groundnut yield, shelling percentage (SH%), seed size, sound mature kernels (SMK), and harvest population (H-POPN) in two genotypes grown in five farmers' fields, Bwanje Valley Rural Development Project, Malawi, 1993/94.

	Seed yield (kg ha^{-1})		SH %		100-seed mass (g)		SMK (%)		H-POPN (plants m^{-2})	
Farmer	CH[1]	CG 7	CH	CG 7	CH	CG 7	CH	CG 7	CH	CG 7
14	143	106	56	59	37	43	35	83	24.9	8.8
15	227	500	55	62	41	45	18	85	4.5	4.9
16	200	728	50	59	45	44	38	61	2.8	2.8
17	433	161	58	51	51	45	32	82	5.8	5.2
18	28	161	50	54	30	38	30	62	4.7	5.0
Mean	206.1	331.1	56.7b	63.3a	46.2	47.3	37.0b	68.7a	5.12	5.57
SE	±95.9		±0.855		±1.07		±2.76		±0.701	
CV (%)	80		6		10		22		54	

1. CH = Chalimbana.

Means followed by the same letter are not different by LSD.

Table 5. Groundnut yield, shelling percentage (SH %), seed size, sound mature kernels (SMK), and harvest plant population (H-POPN) in three genotypes grown on farmers' fields in EPAs 9, 10, and 13 in Lilongwe West Rural Development Project, and at Mbawa EPA in Mzimba West Rural Development Project, Malawi, 1993/94.

	Seed yield (kg ha^{-1})				SH %			100-seed mass (g)			SMK (%)			H-POPN (plants m^{-2})		
Farmer	CH[1]	CHT	CG 7	Mean	CH	CHT	CG 7	CH	CHT	CG 7	CH	CHT	CG 7	CH	CHT	CG 7
EPA 9																
1	17	28	128	57.4	9	31	38	36	32	43	25	19	78	3.2	4.1	3.1
2	6	6	100	37.0	20	20	49	22	12	35	1	15	57	3.2	3.7	3.2
3	6	28	206	79.6	25	42	56	36	33	43	19	18	69	3.7	4.2	4.2
Mean	9.3b	20.4b	144.4a		17.9b	31.0b	47.7a	31.5b	25.6b	40.0a	24.9b	17.5b	68.2a	3.35	4.00	3.50
SE		±17.50				±3.80			±2.03			±4.44			±0.162	
CV (%)		52				20			11			21			8	
EPA 10																
4	183	89	861	377.8	32	34	62	41	44	48	34	15	46	6.3	7.1	7.2
5	167	161	656	327.8	48	45	61	48	41	45	33	36	58	6.1	6.3	6.8
6	161	50	622	277.8	60	47	64	41	44	43	44	44	50	5.9	5.9	6.5
Mean	170.4b	100.0b	713.0a		46.7b	42.0b	62.5a	43.3	42.8	45.5	36.8ab	31.4b	51.2a	6.09b	6.43ab	6.83a
SE		±45.74				±3.98			±2.03			±4.63			±0.112	
CV (%)		24				14			8			20			3	
EPA 13																
7	129	228	794	387.0	45	40	67	50	47	55	36	25	81	6.2	6.4	6.2
8	461	356	533	450.0	46	49	61	55	55	42	40	42	68	6.6	6.3	5.8
9	188	200	789	392.6	50	44	63	47	51	55	35	31	50	4.6	5.8	5.1
Mean	263.0b	261.1b	705.6a		46.7b	44.3b	63.7a	50.9	50.8	50.3	36.6b	32.6b	66.6a	5.78	6.15	5.67
SE		±96.23				±2.42			±3.80			±6.02			±0.259	
CV (%)		41				8			13			23			8	
Mbawa EPA																
10	78	167	561	268.5	33	37	60	37	49	49	38	30	66	6.3	5.1	6.6
11	506	506	856	622.2	56	57	68	57	68	48	45	64	56	6.1	5.7	6.1
12	500	533	678	570.4	45	47	62	37	60	45	21	36	56	5.2	6.1	6.0
Mean	361.1b	401.9	698.2a		44.8b	47.0b	63.5a	43.8	58.9	47.4	34.6	43.5	59.4	5.89	5.59	6.24
SE		±49.03				±2.39			±4.00			±6.93			±0.331	
CV (%)		17				8			14			26			10	

1. CH = Chalimbana, CHT = Chitembana.

Means followed by the same letter are not different by Duncan's Test. Means along a row and for a given parameter, followed by the same letter, are not different by LSD.

high variability of rainfall, even within an EPA. With a few exceptions, CG 7 convincingly outyielded Chalimbana and Chitembana, and produced higher quality seeds (higher SMK values). In all areas there were differences in yield among farmers, even within an EPA, caused by differences in management practices.

The initial phase of the seed multiplication exercise was highly successful, with women farmers successfully growing CG 7. However, it remains to be seen whether they will continue to grow the cultivar on their own initiative. In casual interviews, they indicated that they liked CG 7 for its high yield (the groundnut had not yet been processed, and taste was thus not a factor). Most extension staff (Field Assistants) were not aware of the existence of CG 7. Thus, both the seed multiplication and evaluation/demonstration exercises created some awareness among the people charged with facilitation of technology transfer.

This seed multiplication exercise will be extended to all the main groundnut production areas in Malawi. Frequent surveys to measure the impact/adoption of CG 7 will be carried out in the areas covered by this seed multiplication exercise.

In zones where CG 7 did not outperform the local variety, a larger number of genotypes may have to be tested, to identify and promote superior genotypes adapted to local conditions.

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References

Ministry of Agriculture. 1992. Annual review of producer prices for smallholder agricultural commodities and input, and proposals for the 1992/93 cropping season. Lilongwe, Malawi: Agricultural Planning Division, Ministry of Agriculture.

Donovan, G. 1993. Structural adjustment and agriculture. Washington DC, USA: World Bank.

Hirchmann, D., and Vangham, M. 1984. Women farmers of Malawi—food production in the Zomba district. Berkeley, USA: University of California.

Discussion

Nxumalo. CG 7 and the local variety performed similarly in Salima ADD, but CG 7 was clearly superior elsewhere. What is the soil condition in Salima?

Nyirenda. The main reason for the Salima results was not inherently poor soil, but moisture deficiency during the growing season, which caused both varieties to perform poorly.

Hildebrand. I disagree that the data given for Salima shows no difference between CG 7 and Chalimbana. There is a 50% difference in CG 7 over Chalimbana. Regardless of CVs and LSDs, that difference must mean something.

Ndunguru. The methods of analyzing agronomic data from on-farm trials need to be examined. Socioeconomists and breeders probably use more sophisticated methodologies than do agronomists, and could contribute to the development of unconventional but more suitable methods to analyze and interpret on-farm data.

Groundnut Technology Transfer to Smallholder Farmers in Zimbabwe for Sustainable Production

S Alibaba[1]

Abstract

*Groundnut (*Arachis hypogaea*) is widely grown by smallholder farmers in Zimbabwe; but yields on such farms are only about 0.4 t ha^{-1} (unshelled), as against 2.5 t ha^{-1} at research stations. The low yields may be due partly to the pre-1980 method of technology development and transfer, in which technologies developed primarily for the large-scale sector were transferred, relatively unchanged, to smallholder farmers. This led to the formulation of recommendations not fully suited to the majority of smallholder farmers. In the new approach farmers play a more active role, working together with researchers and extension agents to identify and solve specific problems of local importance. Considerable emphasis is placed on the diagnosis of problems through on-farm surveys using the informal survey procedure developed by the Centro Internacional Mejoramiento de Maizy Trigo (CIMMYT). This has led to a better understanding of farmers' needs, development and testing of appropriate technology, and higher adoption rates. The overall aim in this new approach is to improve the researcher/extension agent's understanding of the smallholder farmer, and to improve relationships between researchers, extension agents, and farmers.*

On-farm demonstration, with small plot sizes and a limited number of treatments, have been found to be useful in technology transfer. Demonstration plots are managed by farmers, who can thus evaluate new technologies under farm conditions before making a decision to accept or reject a technology.

Sumario

Transfêrencia de tecnologia do amendoim para o pequeno agricultor para a sustentabilidade da produgao. *O amendoim (*Arachis hypogaea*) é gerahmente cultivado por os pequenos agricultores em Zimbabwe; mas os rendimentos nesses campos são em redor de 0,4 t ha^{-1} (em casca) em comparação aos rendimentos da investigação que são em redor de 2,5 t ha^{-1}. Os baixos rendimentos podem ser parcialmente causados pelo método do desenvolvimento e transfêrencia da tecnologia pré-1980, em que as tecnologias desenvolvida primáriamente para as cultivações em escalas largas, foram transferidas cultores. Isto levou a recomendações que não cram completamente apropriadas para a maioria dos pequenos agricultores. Os agricultores tomão uma parte mais ativa nesse novo método, trabalhando em conjunto com os investigadores e os extensionistas num trabalho conjunto em vista de identificar e resolver os problemas dum grupo específico dos agricultores. A maior ênfase é agora posta no diagnóstico do problema atráves de inguéritos do campo usando os informais procedimentos de inquéritos do CIMMYT. Isto levou a uma melhor compreensão das necessidades dos agricultores, desenvolvimento e investigação da tecnologia apropriada e adopção dessa tecnologia. O propósito dessa nova abordagem é uma compreensão melhor entre todas as partes envolvidas, resultando em tecnologias mais apropriadas e facilmente adotadas pelos agricultores pequenos, e também o melhoramento das relações entre os agricultores.*

Foi descoberto que os ensaios nos campos com talhões pequenos são úteis para a transfêrencia da tecnologia. Os talhões são maneiados por os cultivadores que assim podem avaliar da nova tecnologia antes de tomar a decisão de aceitar ou rejeitar essa nova tecnologia.

1. Department of Agricultural Research and Extension Services (AGRITEX), P 0 Box 326, Gwanda, Zimbabwe.

Alibaba, S. 1994. Groundnut technology transfer to smallholder farmers in Zimbabwe for sustainable production. Pages 143-146 *in* Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5-7 Jul 1994, Mbabane, Swaziland (Ndunguru, B.J., Hildebrand, G.L., and Subrahmanyam, P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Introduction

Groundnut (*Arachis hypogaea)* has been widely grown in Zimbabwe for several decades. Research began at the Harare Research Station (formerly Salisbury Research Station) in 1912. On-station trials over the years have given fairly high pod yields: 1.4 t ha^{-1} (average, 1912-1950s; Mettlekemp 1987), and 2.5 t ha^{-1} currently. In contrast, yields on smallholder farms have remained extremely low, and in some cases are below 30% of research station yields, with little improvement over the years.

Annual sales to controlled markets by the large-scale sector averaged around 19 000 t of shelled nuts during the period 1955-76 (Table 1), but by 1992 the figure had dropped to 1500 t. Under the previous regulations, large-scale commercial farmers had to sell all their produce to the Grain Marketing Board (at low prices), while small-scale farmers were free to dispose of their produce through any channels. Low yields, increase in labor costs, high cost or non-availability of machinery, and relatively poor prices, especially for large-scale farmers, have made groundnut production in Zimbabwe now an exclusively smallholder enterprise.

Table 1. Shelled groundnut deliveries to the Grain Marketing Board, Zimbabwe, 1971/72 to 1986/87.

Season	Large-scale commercial sector (t)	Small-scale sector (t)	Total (t)
1971/72	1 500	54 500	56 000
1975/76	600	26 600	27 200
1979/80	100	4 900	5000
1983/84	2600	800	3400
1986/87	14000	3 300	17 300

Source: Grain Marketing Board

Technology generation—the earlier approach

Groundnut research in Zimbabwe covers the following aspects:

- Breeding: development of cultivars for confectionery use and oil;
- Agronomy: studies to determine optimum fertilizer rates and timing of application, optimum population and spacing;
- Pathology/entomology: control of diseases and pests;
- Harvest timing and postharvest techniques.

Although the research effort has been considerable, the gap between research results and farmers' yields continues to widen (Table 2). This may be due in part to the pre-1980 method of technology development and transfer to the small-scale farmer. During this period the research emphasis in general was on the large-scale commercial farmer, who has sufficient resources and is likely to adopt new technology (Shumba 1990). Research was mainly station-based, and recommendations were formulated with little interaction with smallholder farmers. Agricultural Research and Extension Services (AGRITEX) extension staff were responsible for demonstrating complete production packages to farmers.

One major flaw was that no effort was made to look at farmers' circumstances, understand their real problems, or to include farmers in the process of problem identification and solution. The only small-scale farmers to benefit were those with the technical and financial resources to make use of high-input technology. The recommendations were too risky for most small-scale farmers since they involved higher inputs/costs (although they promised higher yields). This method required farmers to move too quickly from one level to a higher level.

Table 2. Groundnut production in the small-scale sector in Zimbabwe, 1989-93.

Season	Estimated area[1] (ha)	Estimated production (t)	Estimated pod yield (t ha^{-1})
1989/90	307 900	108 690	0.35
1990/91	214 800	99 688	0.46
1991/92	167 600	31 032	0.19[2]
1992/93	113 000	53 350	0.47

1. Harvested area; excludes areas where crop failure occurred.
2. Low yields and production due to drought.

Source: AGRITEX Crop Forecasting Committee

The new approach to technology generation

After analysis of the smallholder groundnut sector in the mid 1980s, and the formation of the Farming System Unit within the Department of Research and Specialist Services, it was decided that a more integrated approach was required to address specific production constraints. The new approach is based on the principle that the farmer is the person, in most circumstances, with the best knowledge about his environment, and with specific skills related to the enterprise. Therefore, any innovation introduced with his (or her) active involvement would most likely be successful.

In this approach a great deal of emphasis is placed on the diagnosis of problems jointly by the farmer and the extension agent, using diagnostic surveys as described in the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) informal survey procedures. A systems approach is undertaken to identify the real issues involved and to understand the interlinkages between different farm activities. This process requires considerable involvement of extension staff, who must be fully trained to identify problem areas and determine their effects on the system.

Once problems have been identified, information on those requiring further research is passed on to the relevant institution(s). Problems for which solutions already exist are tackled by the farmers and the extension agent, who select those technologies which are applicable to their situation; usually, technologies that combine low cost, high response, flexibility, and minimized risk.

The farming systems approach has been instrumental in highlighting the problems faced by the smallholder farmer. To date, numerous trials and demonstrations have been undertaken on farmers' fields (COFRE 1990), with farmers playing a major role in identifying their production constraints and also participating in some aspects of problem solving.

This approach has led to a better understanding between the researcher and the farmer, with the result that current technology recommendations are becoming more relevant and hence easily adopted by the smallholder farmer. It has also resulted in a better flow of information to other parties involved in the groundnut industry. For example, results from a survey (Shumba 1983) indicated that the availability of seed of new varieties was almost non-existent at farm level; responsibility for seed supply has recently been transferred from the state-controlled Grain Marketing Board to a very successful seed cooperative. It is expected that this will improve seed supplies to smallholder farmers.

The role of demonstrations

In Zimbabwe it has been found that new technologies and concepts are best promoted through simple demonstrations on farmers' fields. Plot sizes are extremely small and in most cases very few treatments are included. Farmers are responsible for all field management practices; the extension agent provides only the technology input (e.g., improved seed or information on improved management practices). The farmer is expected to grow the crop using his/her own inputs.

This demonstration will continue for 2-3 seasons, allowing farmers to evaluate the new technology against their normal practice on a small scale. After evaluation, they will be able to decide whether or not to adopt the new technology. During the 1993/94 season, national programs from various countries and the SADC/ICRISAT Groundnut Project jointly undertook a number of demonstrations to introduce new, improved groundnut varieties to farmers. Each demonstration consisted of three varieties sown on a single nonreplicated plot of 0.03 ha, using traditional cultural practices. Farmers could thus clearly perceive that the yield increases were due to varietal superiority alone.

During the three seasons from 1987/88 to 1989/90, COFRE has conducted 54 on-farm trials and 262 demonstrations at various sites in the major groundnut areas in Zimbabwe (Shumba 1990). These were designed to demonstrate new varieties, fertilizer responses, and the effects of sowing date and population on groundnut yield (COFRE 1990).

Field days are held at each demonstration site during the growing season, with farmers continuously assessing the technology under study. Suggestions and comments are gathered from all visitors to further refine the demonstration for the next season. At the end of the season farmers harvest the different plots, and compare yields. If the demonstration was correctly undertaken and the real problems identified at the early stages, the new technology should, in most cases, prove to be a viable option.

The future role of technology transfer

Surveys have shown that yield could be significantly improved by improving crop management practices' (Shumba 1983). These improvements require little or no cash investment and simply involve adjustments to existing practices. For example, early sowing with correct plant populations would increase yield without requiring much cash input.

For appropriate technology to be developed and transferred an increased effort should be made to involve all the actors—researchers, extension agents, and farmers—in all stages of technology development and transfer. Extension staff will continue to require training in the diagnostic approach to problem identification and solution formulation, to ensure that the needs of the smallholder farmer are identified and met.

References

Committee for On-farm Research and Extension (COFRE). 1990. Groundnuts. Pages 29-35 *in* Annual directory of proposals for on-farm research and demonstrations for 1989/90. Harare, Zimbabwe: COFRE.

Mettlekemp, H. 1987. Review of crop research relevant to the semi-arid areas of Zimbabwe. Pages 190-316 *in* Cropping in the semi-arid areas of Zimbabwe. Proceedings of a Workshop, 24-28 Aug 1987, Harare, Zimbabwe. Bonn, Germany: Deutsche Gesellschaft fUr Technische Zusammenarbeit.

Shumba, E.M. 1983. Factors contributing to a decline in groundnut production in Mangwende-Murewa district, and the need for a technical research input. Zimbabwe Agricultural Journal 80(6):42-46.

Shumba, E.M. 1990. The performance of COFRE during the last 4 years and suggestions for improvement. Pages 20-24 *in* Research and extension linkages for smallholder agriculture in Zimbabwe: proceedings of a workshop on assessing the performance of the Committee for On-farm Research and Extension (COFRE), 7-9 May 1990, Kadona, Zimbabwe. Harare, Zimbabwe: COFRE.

Plenary Session

Discussion and Recommendations

The participants formed four working groups: on genetic enhancement, crop protection, agronomy/cropping systems, and technology transfer. Each group identified the major problems in their research area, defined research priorities, reviewed research progress made in the member countries, and outlined a medium-term approach to constraint alleviation throughout the region. The groups met separately, and subsequently presented their recommendations at the plenary session for further discussion and formal adoption by the Workshop participants.

The final Workshop recommendations are summarized below. These form a fairly comprehensive research and policy agenda for southern and eastern Africa. It is hoped that these recommendations will form the basis of future collaborative research programs, and contribute to the alleviation of constraints to groundnut production throughout the region.

Genetic Enhancement

Three broad areas were considered:

- Drought tolerance
- Resistance to diseases
- Priority setting and selection criteria.

Drought tolerance

Approaches to this very complex problem could be improved in two ways:

- Drought nurseries should be sown every season in identified 'core' areas. The data could be used as benchmarks, also applicable to other areas in the region;
- Efforts should be directed at characterization of environments, since the number of variables (rainfall, temperature, sowing date, etc.) is large.

Resistance to diseases

- Access of cooperators to disease nurseries should be streamlined. NARS should be allowed to choose nurseries that relate to either specific local needs or regional problems, as appropriate.

Priority setting and selection criteria

The need was felt to review and prioritize selection criteria in order to narrow the yield gap between research stations and farmers' fields. No consensus emerged on the stage at which selection should take place, for eventual use of the cultivar under low-input conditions. However, it was noted that:

- The overall objective would be to provide a range of cultivars for each environment, from which farmers could choose, depending on the availability of resources and infrastructure;
- Evaluation should involve farmers as much as possible. However, it was not practical to involve farmers in early-stage evaluation;
- The logistic problems involved in multilocational testing should be addressed;
- Exchange of material amongst NARS is not sufficiently widespread; this crucial activity should be intensified;
- Standard cultivars from each country should be included in regional trials wherever possible, taking into consideration the associated administrative and property-rights problems.

Crop Protection

Two categories of smallholders were recognized:

- Subsistence farmers who grow crops almost exclusively for their own consumption. This group is not expected to consider crop protection a priority;
- Relatively commercial smallholders, who will sell a part of their produce and can afford limited inputs. These farmers are more likely to accept and apply the recommended technologies.

Four broad areas relating to crop protection were discussed:

- Surveys
- Disease control strategies
- Technology transfer
- Immediate research and extension goals.

Surveys

Surveys should be conducted in important areas, where information is lacking:

- Disease incidence/severity, damage assessment, incidence and relative importance of insect pests and diseases, especially in Lesotho, Mozambique, and parts of South Africa;
- Surveys throughout the region, and especially in Tanzania and Swaziland, on aflatoxin contamination. Such data is available for marketed groudnut, but not for groundnut that is consumed by the growers themselves. These families are suspected to be prone to liver cancer arising from aflatoxin contamination.

Control strategies

- The use of disease-resistant cultivars should be given the highest priority, because it is the easiest method for farmers to adopt. Such cultivars should provide stable yields and be resistant to adverse conditions including a wide range of major insect pests and diseases;
- Cultural practices should be developed and disseminated. These may relate to the timing of sowing and/or harvest to reduce disease/pest attack, and sanitary measures (e.g., removal of weeds and alternative hosts) to avoid the build up of pest and pathogen complexes. These methods are more likely to be adopted by the more progressive smallholders;
- Efforts should be made to reduce pesticide use, by developing suitable cultivars and management practices;
- Research efforts on botanical pesticides should be intensified. This approach can be made more attractive to the smallholder by demonstrating the multiple uses (e.g., soil fertilization + pest control) of botanical pesticides.

Technology transfer

- Research should focus on the development of flexible integrated packages; farmers may then adopt the entire package or some components. Packages must be developed for each community or region within a country, since local needs will differ;
- The use of printed material, especially color pamphlets, should be explored for technology dissemination. It is important to budget for such extension material at the research planning stage.

Immediate research and extension goals

- Stronger and more extensive training programs are required in all aspects of crop protection: research, extension, diagnosis of pests and diseases, and crop management;
- Emphasis should be placed on aflatoxin research. It was noted that preliminary studies in northern Botswana had reported that children were given a small, inexpensive clay pill as a traditional prophylactic measure against aflatoxin hazards. This technology should be studied further for possible wide dissemination throughout the region;
- The control strategies discussed above should be developed for use by the small-scale farmer, and the technology effectively transferred to the farm.

Agronomy

The discussions focused on six broad areas:

- Agronomy extension
- Seed production
- Technology development
- Technology transfer
- Agronomy and breeding
- Regional coordination.

Agronomy extension

- The existing links between researchers and extension staff are weak, and should be improved;
- There is often an overlapping of interests and goals, which can be exploited by closer collaboration;
- Research findings have not so far demonstrated significant impact in farmers' fields;
- A more participatory approach to research is called for, involving both extension staff and farmers;
- Agronomy recommendations should be such that they can be conveniently implemented, using technology available at farm level;
- The participation of nongovernmental organizations, churches, and other grassroots organizations would strengthen research and extension efforts.

Seed production

- Seed shortages at farm level are a major constraint throughout the region;
- Research stations should explore the possibilities of producing seed on a limited scale, e.g., for distribution during on-farm trials;
- Farmer and community involvement should be strengthened.

Technology development

- Research must focus on low-input technologies;
- Labor-saving technologies are required; these should be effective but low-cost;
- Farmers should be closely involved in defining criteria for on-farm evaluation of technologies;
- Farmers' constraints must be identified and factored into technology evaluation;
- Research should focus on developing sustainable systems (e.g., in terms of soil fertility);
- More attention must be paid to nutrition and dietary aspects;
- Storage methods in current use are often unsuitable; this should be another priority area for research.

Technology transfer

Several factors have contributed to the lack of progress in this key area. The following aspects should be specifically addressed.

- Traditional land use practices have continued, with respect to haphazard or sub-optimal spacing; the practice of sowing in rows should be encouraged;
- Information is lacking on certain aspects of intercropping systems, e.g., suitable crop combinations and the relative proportions of the component crops.

Agronomy and breeding

- Breeders and agronomists play critical (and complementary) roles in varietal development. Breeders should produce materials adapted to a wide range of environmental conditions. Agronomists should be responsible for final evaluation for specific environments.

Regional coordination

- The SADC/ICRISAT Project should strengthen links with research programs in the Republic of South Africa;
- Although research and training funds were available through SACCAR, funding for regional travel by national scientists continued to be a constraint;
- SACCAR was urged to look into the problem of lack of communications, which is serious throughout the region.

Technology Transfer

The objective of research is to develop new technologies and transfer them to the farmer. This transfer has been less successful than anticipated. The discussions covered several aspects that were felt to be crucial for successful technology transfer.

Farmer-researcher-extension linkages

- The only effective approach, as has been clearly demonstrated, is one of participatory research, involving farmers, extension staff, and researchers working together;
- Collaborative meetings among farmers, researchers, and extension staff should be budgeted for in the research planning stage;
- Extension efforts must be made to ensure that farmers clearly understand how they will benefit from research, and specifically from on-farm trials.

The role of research

- Research should be conducted by multidisciplinary teams; different problems may require different emphasis on the various disciplines;
- Researchers should do some extension work; this would give them a clearer understanding of field situations and problems;
- Research institutions and the national programs should provide refresher courses at least once a year to continuously update the skills of staff involved in technology transfer;
- Research recommendations should not merely specify what to do, but also how to do it;
- Technology should be sufficiently flexible to allow farmers several options; recommendations should not be dogmatic;
- Proper identification (through discussions, questionnaires, etc.) must be the first step in problem solving. Staff should be provided training on the identification of problems at farm level.

Demonstrations and other extension issues

- Demonstrations are an important component of technology transfer, and should be considered at the research planning stage. Each demonstration should convey a specific message, e.g., about a specific management recommendation; routine or general demonstrations are usually ineffective;

- Farm-to-farm technology transfer can be very effective: the farmer can be the best extension agent if given the opportunity to discuss with other farmers his/her experiences with a technology;
- Continuity is an important factor in extension; it is also essentia] that communication is made with farmers by somebody they trust.

Socioeconomic perspectives

- Technologies should be evaluated in a socio-economic perspective (including compatibility with traditional end uses of the crop), rather than only in terms of yield or productivity;
- Socioeconomists should be closely involved in demonstrations and on-farm trials, starting at the planning stage.

Seed shortages

- Seed shortages could be alleviated by encouraging farmer-to-farmer exchange of seed, strengthening seed distribution channels, and modifying pricing structures and agricultural policies.

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Sitting (left to right): P D Mkhatshwa (Chief Agricultural Research Officer, Ministry of Food, Agriculture and Cooperatives, Swaziland), L K Mughogho, N M Nkambune, C T Nkwanyana, Zodwa Mamba.
Standing (first row, shoulder to shoulder): C L Malima, K M Chavula, L K Sibandze, C M Busolo-Bulafu, K Kanenga, P Subrahmanyam, C J Swanevelder (in cap), A J Chiyembekeza, A Varadachary, G S Maphanyane, G M Ndlangamandla, S S Moima, Cheryl Venter.
Standing (back row, staggered): S Zengeni, P S van Wyk, G L Hildebrand, T V Mpanza, L M Nsibande, B R Ntare (behind Busolo-Bulafu), N E Nyirenda, S Alibaba, P H Sohati (immediately behind Kanenga, face obscured), D J M Marais (at back, face obscured), V N Kamvazina (immediately behind Subrahmanyam), C F van Eeden (behind Chiyembekeza), M Mukonde, S C Luhana, E M Kafiriti, C E Maliro, M J Freire, B J Ndunguru, C Mathews, Desiree L Cole.

Participants

Botswana

G Seja Maphanyane
Acting Chief Agricultural Research Officer
Department of Agricultural Research
Private Bag 0033
Gaborone

Lesotho

S S Moima
Agronomist (Research Officer)
Agricultural Research Division
P O Box 829
Maseru 100

Malawi

K M Chavula
Assistant Chief Agricultural Extension Officer
Ministry of Agriculture
Department of Agricultural Extension and Training
P O Box 30145
Lilongwe

A J Chiyembekeza
Groundnut Breeder and Commodity Team Leader
Chitedze Agricultural Research Station
P O Box 158
Lilongwe

V N Kamvazina
Women's Programmes Officer
Salima Agricultural Development Division
Private Bag 1
Salima

Sekererani C Luhana
Socio-Economist
Chitedze Agricultural Research Station
P O Box 158
Lilongwe

Charles E Maliro
Groundnut Agronomist
Chitedze Agricultural Research Station
P O Box 158
Lilongwe

Noah E Nyirenda
Chitedze Agricultural Research Station
P O Box 158
Lilongwe

Mozambique

Afonso De Oliveira
AV Lenine-B Coop
PHB 8-91
Maputo

M J Freire
Agronomist
Faculty of Agronomy and Forestry Engineering
University Eduardo Mondlane
CP 257
Maputo

Marcela P F Libombo
Research Assistant
National Institute for Agricultural Research (INIA)
CP 3658
Maputo

Namibia

Daniel J M Marais
Agronomic Researcher
Ministry of Agriculture, Rural and
Water Development
P O Box 788
Grootfontein 9000

SACCAR

C T Nkwanyana
Principal Programmes Officer
Private Bag 00108
Gaborone
Botswana

Republic of South Africa

Cherian Mathews
Principal Agricultural Adviser
Department of Agriculture
Eastern Transvaal Province
Private Bag X 1005
Louws Creek 1302

C J Swanevelder
Programme Manager, Groundnuts
Oil and Protein Seeds Centre
Private Bag X 1251
Potchefstroom 2520

C F van Eeden
First Regional Entomologist
Highveld Agricultural Development Institute
Private Bag X 804
Potchefstroom 2520

Pieter Schalk van Wyk
Programme Manager
Oil and Protein Seeds Centre
Private Bag X 1251
Potchefstroom 2520

Cheryl Venter
Agricultural Researcher
Oil and Protein Seeds Centre
Grain Crops Institute
Private Bag X 1251
Potchefstroom 2520

Swaziland

Carol L Malima
Agricultural Officer
Ministry of Agriculture and Cooperatives
P O Box 501
Manzini

Zodwa Mamba
Agronomist
Malkerns Research Station
P O Box 4
Malkerns

T V Mpanza
Agricultural Officer
Crop Storage Section
P O Box 4
Malkerns

George M Ndlangamandla
Agricultural Officer
Ministry of Agriculture and Cooperatives
P O Box 501
Manzini

Leonard M Nsibande
General Entomologist
Agricultural Research Division
P O Box 4
Malkerns

Tanzania

E M Kafiriti
Research Officer and National Research Coordinator
Oilseeds Research Programme
Agricultural Research Institute
Naliendele
P O Box 509
Mtwara

Uganda

C M Busolo-Bulafu
Senior Research Officer
Serere Agricultural and Animal Research Institute
P O Soroti

Zambia

Kennedy Kanenga
Agronomist and Team Leader, Food Legumes
Msekera Research Station
Ministry of Agriculture, Food and Fisheries
P O Box 510089
Chipata

P H Sohati
Senior Agricultural Research Officer
Msekera Research Station
P O Box 510089
Chipata

Zimbabwe

Shack Alibaba
Senior Agricultural Extension Officer (Crops)
AGRITEX (Matabeleland South)
P O Box 214
Gwanda

Desiree L Cole
Senior Lecturer
Crop Science Department, Faculty of Agriculture
University of Zimbabwe
P O Box MP 167
Mount Pleasant
Harare

Simba Zengeni
Research Manager
National Tested Seeds Pvt Ltd
P O Box 2705
Harare

ICRISAT

G L Hildebrand
Principal Scientist (Breeding)
SADC/ICRISAT Project
P O Box 1096
Lilongwe
Malawi

L K Mughogho
Executive Director, Southern and Eastern Africa Region
Matopos Research Station
P O Box 776
Bulawayo
Zimbabwe

Morgan Mukonde
Administrative Officer
SADC/ICRISAT Groundnut Project
P O Box 1096
Lilongwe
Malawi

Bruno J Ndunguru
Principal Scientist (Agronomy) and Team Leader
SADC/ICRISAT Groundnut Project
P O Box 1096
Lilongwe
Malawi

B R Ntare
Principal Scientist (Breeding)
ICRISAT Sahelian Centre
Western and Central Africa Region
BP 12404
Niamey
Niger

Pala Subrahmanyam
Principal Scientist (Pathology)
SADC/ICRISAT Groundnut Project
P O Box 1096
Lilongwe
Malawi

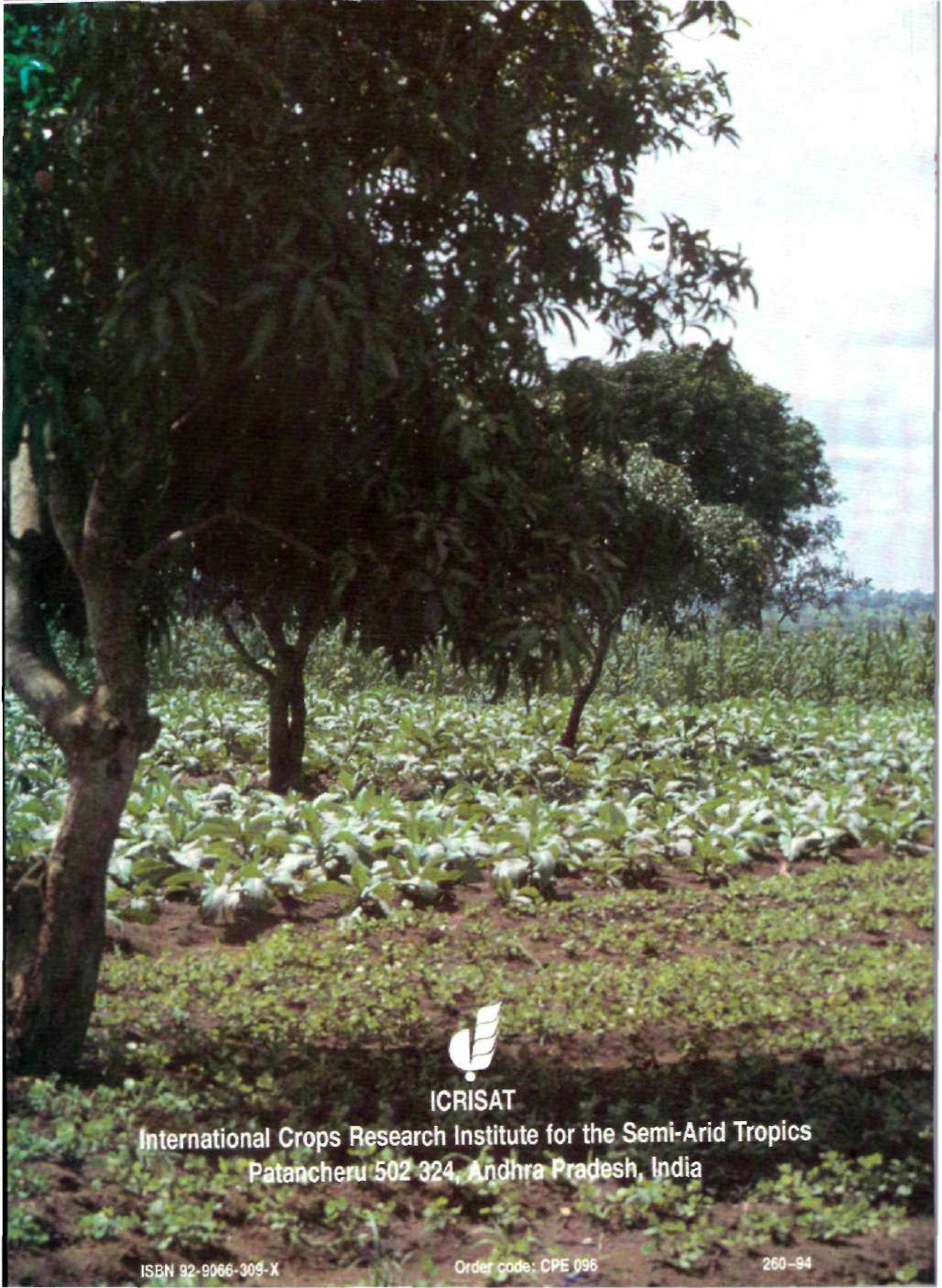
Ajay Varadachary
Editor, Information Management and Exchange Program
ICRISAT Asia Center
Patancheru 502 324
Andhra Pradesh
India

About ICRISAT

The semi-arid tropics (SAT) encompasses parts of 48 developing countries including most of India, parts of southeast Asia, a swathe across sub-Saharan Africa, much of southern and eastern Africa, and parts of Latin America. Many of these countries are among the poorest in the world. Approximately one-sixth of the world's population lives in the SAT, which is typified by unpredictable weather, limited and erratic rainfall, and nutrient-poor soils.

ICRISAT's mandate crops are sorghum, pearl millet, finger millet, chickpea, pigeonpea, and groundnut; these six crops are vital to life for the ever-increasing populations of the semi-arid tropics. ICRISAT's mission is to conduct research which can lead to enhanced sustainable production of these crops and to improved management of the limited natural resources of the SAT. ICRISAT communicates information on technologies as they are developed through workshops, networks, training, library services, and publishing.

ICRISAT was established in 1972. It is one of 17 nonprofit, research and training centers funded through the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is an informal association of approximately 50 public and private sector donors; it is co-sponsored by the Food and Agriculture Organization of the United Nations (FAO), the World Bank, and the United Nations Development Programme (UNDP).



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International Crops Research Institute for the Semi-Arid Tropics
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