Proceedings of the

Second Regional Groundnut Workshop for Southern Africa

International Crops Research Institute for the Semi-Arid Tropics

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

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Opening Address

S.T. Mombeshora*

Mr Chairman, Distinguished Participants and Guests, Comrades, Ladies and Gentlemen.

1 feel greatly privileged to officiate at this inaugural session of the Second Regional Groundnut Workshop. I understand that 45 participants are expected to attend representing the national programs of Botswana, Malawi, Mozambique, Swaziland, Tanzania, Zambia, and Zimbabwe. In addition, we have eminent scientists from Ethiopia and Uganda, and representatives from IDRC and ICRISAT Center.

On behalf of the Government and people of Zimbabwe I would like to welcome you all to Zimbabwe. Furthermore, I would like to extend our thanks to ICRISAT and IDRC for their financial support, without which this Second Regional Groundnut Workshop could not have taken place. On a broader front, it is our hope that such assistance will continue because through it our groundnut research program, and those of our neighbours, will be strengthened not only by the provision of training but through the dissemination of ideas and the free exchange of germplasm. In Zimbabwe, the Government considers groundnut to be a major crop grown both as a food crop and a cash crop. It is an important source of protein to a large sector of our population, particularly children, who need proteins the most and find groundnuts palatable, and can take them in both their natural and various prepared forms.

It is an important source of cooking oil, and as a confectionery nut it can be an important earner of foreign currency. It is predominantly grown by small-scale farmers. In our country over 95% of the crop is produced by the communal or peasant farmers and small-scale commercial farmers. However, I am told that groundnut production, not only in Zimbabwe but also in the entire southern African region, is declining rapidly in favour of other crops. Among the reasons quoted for this decline are low, uneconomic producer prices, shortage of seed, high cost of seed, lack of suitable varieties, and low yields that are further reduced by pests and diseases. It is the policy of my Government to encourage the increase in groundnut production to meet both domestic and export requirements. To this end we have markedly increased the producer price. We sponsored a seed multiplication scheme and we will continue to support an active research program and advisory service.

To advise on how production can be increased one must have the advice to give, and this must be based on sound agronomic practices. But where do we start? I believe that there is an urgent need for the development of a substantial reservoir of adapted varieties for each farming sector that yield well and contain resistance, or at least tolerance, to the major diseases of the region.

The communal or peasant farmer requires varieties that are specifically adapted to very low-input situations whereas the small-scale commercial farmer requires varieties that respond optimally to low or moderate inputs of fertilizer and crop protection "packages". Finally, the large-scale commercial farmer requires varieties that respond optimally to high inputs.

Any research program should be a sensible compromise between the requirements of these three sectors, and this will largely be dependent on Government policy. In Zimbabwe our stated aim is to improve the living standards of the communal-area farmers. We should, therefore, concentrate initially on selection for the very low-input conditions and then possibly reselect lines that respond to moderate inputs.

It is here that the ICRISAT Regional Program can play an important role. It must rapidly and effectively broaden the genetic resources of the region. This will involve the evaluation, throughout the southern African region, of a very large number of groundnut lines developed by and introduced into the region from ICRISAT Center (International Crops Research Institute for the Semi-Arid Tropics) in India that has the responsibility for the world collection of genetic material. From this wealth of genetic material the program must identify outstanding material, which should then be tested by the national programs, and where appropriate, incorporated into the national programs.

A further problem we have in the developing world is that scientists often find themselves working in rather isolated places with little opportunity for discussion with other scientists in the same field, and with limited library facilities. Already the ICRISAT Regional Program has tackled this problem by fostering the dissemi-

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nation and sharing of information by means of workshops such as the one that starts today, by specialist group tours, by newsletters, and perhaps most important of all, by cooperative regional experimentation.

After talking to my colleagues on these matters it is evident that the ICRISAT Regional Program is a flourishing one. It is respected by the national programs of our region and its endeavors are pertinent to our problems.

On this note, Mr Chairman, I have the great honour to declare the proceedings of the Second Regional Groundnut Workshop open and I hope that our distinguished participants will learn much about groundnut production that is relevant to their conditions.

Thank you.

Response to Opening Address

R.A. Kirkby*

The Honourable S. Mombeshora, Deputy Minister of Lands, Agriculture and Rural Settlement, Mr Chairman, Mr Gibbons, Professor Schweppenhauser, Distinguished Participants, Ladies and Gentlemen.

I feel it is entirely fitting that Zimbabwe is hosting this Second Workshop on Groundnut Improvement in southern Africa, in view of its record of effective, applied research on this crop. On behalf of the outside sponsors of the workshop, i.e., ICRISAT and IDRC, I should like to take this opportunity to thank you for taking time from your busy schedule to open the workshop. I feel sure that ail participants appreciate the commitment of the Government of Zimbabwe to regional cooperation for the improvement of groundnut production, which your presence confirms.

The Regional Groundnut Improvement Program for Southern Africa started in 1982. A regional program of this kind, however, does not exist by and of itself, but rather, to work with national programs and to contribute to the strengthening of the national programs' abilities to benefit their farmer and consumer clients. Whether a regional program effectively complements and assists national program activities, or tends to compete with them for funds and to overshadow the research conducted by national program scientists, depends both upon how the relationships among national and regional programs are defined and upon the manner in which individual scientists put these relationships into practice. These aspects of regional program effectiveness should be reviewed periodically, and a biennial workshop provides a useful opportunity for doing so.

While other participants are more appropriately placed than I to evaluate the effectiveness of regional activities, allow me to outline a few developments that have occurred in the two years since we met at the First Regional Groundnut Workshop in Lilongwe.

You will recall that at Lilongwe in March 1984, national groundnut improvement programs drew up a list of guidelines for research and research support activities at the regional level. At that time I told you that ICRISAT and IDRC would listen carefully to your comments and recommendations. Later in 1984, those discussions formed the basis of ICRISATs proposal to IDRC for a second phase of funding for the regional program, securing its support to the end of 1986, and this proposal was accepted by IDRC. You have already seen a number of results from the evolution of the regional program that have resulted in two issues of an annual newsletter, a monitoring tour for groundnut breeders, specific collaborative research, and the establishment of biennial workshops with rotational selection of venue.

What of the future? So far as financial support is concerned, let me say only that, at the time of agreeing to this second phase, IDRC advised ICRISAT as well as SADCC that it would not be able to continue its present support beyond 1986. IDRC is a relatively small donor organisation, whose primary mandate is to provide direct support to national research programs. Regional programs are expensive, this activity is already large in comparison with most of IDRCs activities, and we would be quite unable to cover the expansion in the program that is foreseen by SADCC.

We sincerely hope that these two years of notice will prove sufficient for satisfactory alternative arrangements to be made that will ensure the continuity of the regional activities. IDRC also hopes that these four and a half years of support will have enabled national programs and ICRISAT to develop together a useful regional strategy that will not only continue, but will also continue to evolve in response to the needs of national programs.

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Welcome from ICRISAT

R.W. Gibbons*

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

It is with great pleasure that I respond to the request of Dr K.R. Bock to make a few remarks on behalf of the ICRISAT Center Groundnut Program in India at this Second Regional Groundnut Workshop for Southern Africa.

First of all it is a great personal pleasure to be back in this region where I worked on groundnut for 12 years, firstly for the Agricultural Research Council of Central Africa, and then for the Agricultural Research Council of Malawi. I have very pleasant memories of this delightful area of Africa. It is very gratifying to note the active collaboration that has developed between the groundnut researchers of the SADCC countries in such a short time, and the excellent research progress that has been made. This is the second such regional workshop, and there has also been a breeders* tour. All this has been achieved since the ICRISAT program became operational in 1982. However none of this could have taken place without the generous financial backing the program has received from IDRC, the encouragement of SADCC governments, and the facilities provided by the Government of Malawi at the Chitedze Agricultural Research Station, near Lilongwe. I must also place on record the help and encouragement we have received from all the officials and scientists of the SADCC-member States. Today our meeting takes place in Zimbabwe, and on behalf of ICRISAT I thank the Government and the officials who have made this possible. Holding such meetings in different countries of the region broadens our knowledge and demonstrates the type of regional cooperation we all want.

ICRISAT is now placing much more emphasis on the semi-arid regions of Africa with the encouragement of the Consultative Group for International Agricultural Research (CGIAR) and the approval of the ICRISAT Governing Board. In March the ICRISAT Governing Board will meet in Harare for the first time, and prior to that the Program Committee of the Board will review the groundnut work in Malawi and the sorghum and millet work in Zambia and Zimbabwe. In 1986 a groundnut team will be set up in West Africa and will conduct research on a regional basis. We will ensure that this regional research in West Africa will link up effectively with the program in southern Africa and the ICRISAT Center program.

The reports of the first regional workshop were most encouraging, and we hope that the deliberations and conclusions of the second meeting will lead to more cooperation and success, to help the groundnut farmers of the SADCC countries.

Thank you all.

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Rosette and Early Leaf Spot Diseases: A Review of Research Progress, 1984/85

K. R. Bock*

Abstract

Observations made over 2 years on the patterns of spread of groundnut rosette virus (GRV) within fields suggested that primary infections originated from a migration of infective vectors that occurred within days of plant emergence, and that significant radial spread was from these point sources of infection only. Such conditions were simulated in the establishment of a GRV resistance screening nursery in which a disease incidence of about 90% was induced.

Preliminary studies of the inheritance of resistance to GRV confirmed that it is governed by recessive genes. They confirmed an approximate ratio of 15 susceptible plants to J resistant plant in progenies of resistant x susceptible crosses.

Grafting experiments indicated that the GRV-resistant cultivar RG 1 is immune to vector inoculation of GRV and also demonstrated symptomless systemic infection. This underlines the necessity for the critical examination of the methods of resistance in those lines that are used as resistant parents in breeding programs.

Aphis craccivora Koch vector of GRV was trapped in low numbers throughout the dry season, suggesting the presence of local resident populations. Dry-season aphid activity was greater in central than in southern Malawi. At one site in October, GRV occurred before the onset of the rains.

In preliminary studies of early leaf spot (Cercospora arachidicola), the number of leaflets retained were counted at 70 and 88 days after sowing on a range of genotypes. In all ICRISAT trials the highest-yielding line of sequentially branched types retained more leaflets than control varieties, but so did a small number of poorer-yielding entries. Leaf retention among alternately branched types was apparently more uniform.

Sumario

Roseta e mancha foliar tempora: Uma revisao ao progresso da investigacao, 1984/85. Observacdes feitas durante dois anos, sobre os padrbes de dispersao do virus da roseta do amendoim (GRV) nos campos de cultivo, sugerem que as infeccoes primarias originadas da migracao de vectores infecciosos, que ocorreu poucos dias depois da emergencia da plant a, e que uma significativa dispersao radialfoi a unicafonte de infeccao. Estas condicoes foram simuladas no estabelecimento de viveiros de seleccao para a resistencia ao GRV, nos quaisfoi induzida uma incidencia da doenca de cercade 90%.

Estudos preliminares sobre heranca da resistencia ao GRV confirmaram que ela e regulada por genes recessivos. Eles confirmaram uma razao aproximada de 15 (quinze) plantas susceptive is para I (uma) resistente, em descendencias do cruzamento de plantas resistentes com susceptiveis.

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Ensaios de enxertia indicaram que o cultivar RG I resistente ao GVRe imune a inoculacao do virus por vectores e tambem mostrou carencia de sintomas de infecgao sistemica. Isto realca a necessidade de exame critico dos metodos de resistencia das linhas que sao usadas como progenitores resistentes nos programas de melhoramento.

Aphis craccivora Koch, vector do GR V, foi capturado em pequeno numero durante a estacao seca, sugerindo a presenca de populacoes residentes no local. A actividade dos afideos durante a estacao seca foi maior na zona central do Malawi do que na zona sul. Num dos locais, o virus da roseta do amendoim apareceu em Outubro antes do inicio das chuvas.

Em estudos preliminares sobre a mancha foliar tempora (Cercospora arachidicola), o numero de foliolos retidos pela planta foram contados aos 70 e 88 dias depots da sementeira num grupo de gendtipos. Em todos os ensaios do ICRISA T, com tipos de ramificacao sequencial, a linha com maior rendimento reteve mais foliolos que as variedades de controlo. Contudo, o mesmo ocorreu com algumas das linhas de mais baixo rendimento. A retencao foliar nos tipos de ramificacao alternada foi aparentemente mais uniforme.

The regional pathology program is concerned almost exclusively with research on groundnut rosette virus (GRV) and early leaf spot (ELS), Cercospora arachidicola. An endorsement of this priority is contained in recommendations arising out of the first regional workshop (ICRISAT 1985). One of the regional program's broad objectives is to develop high-yielding cultivars containing resistance to these two diseases.

Sources of resistance to GRV in the cultivated groundnut are well known. It has also been established that this resistance is most probably governed by recessive genes. It has already been successfully exploited, notably in Malawi and in West Africa. In spite of these advances, few commercially acceptable varieties exist, and resistance has not yet been transferred into short-maturing, spanish-type varieties, which are of great importance over extensive areas of southern Africa. The challenge in this regard lies not with the generation of resistant * susceptible crosses but in the screening of the large number of hybrids that this program demands. GRV is a disease which, though devastating, is sporadic in occurrence, often with intervals of several years between pandemics. Reliance cannot, therefore, be placed on natural incidence, and an alternative strategy must be devised. The development of GRV-screening nurseries is one such means, and our progress in this direction is reported briefly here.

We remain ignorant of the seasonal origins of GRV, the resolution of which must involve studies on the ecology of the vector, Aphis craccivora. We also report on progress in this direction.

Identification of resistance to ELS in Africa has thus far proved elusive. The disease is very severe every season in our experimental fields at Chitedze Research Station. Our strategy has been one of selection for high yield under conditions of high disease pressure, and in this we have been eminently successful. If the ICRISAT 9-point field scale for assessing ELS resistance is used, all cultivars, including the highest yielding entries, score 7, 8, or 9, and must thus be classified as susceptible. It seemed possible that visual scoring systems were too coarse to detect small but perhaps important differences in at least one parameter, leaf retention. We consequently adopted a more laborious assessment of leaf retention by counting leaves lost and leaves retained. Results of these preliminary studies are also given in this presentation.

Groundnut Rosette Virus

Pattern of Spread within Fields and Disease Nurseries

We studied the occurrence and patterns of spread of GRV in fields at Chitedze in 1983/84 and 1984/85. Primary foci were marked with stakes, and subsequent spread from these first infections of the season was recorded on a 6 * 6 m grid. In 1983/84, average incidence in 6 x 6 m plots containing the primary source was 38.3%; for the 8 adjacent similar plots, 6.3%; and for the 16 plots adjacent to the latter, 0.4%. Incidence in the remainder of the field was 0.3%. Disease gradients associated with primary sources were thus exceptionally steep, and secondary infections, whatever their origins (from primary foci within the field or from an external source), did not give rise to patches of high incidence. Similar observations were made in 1984/85. We deduced from these observations that primary infections apparently originated from one period of migration of infective vectors, which occurred within days of emergence, and that significant radial spread from point sources of infection occurred only in these circumstances.

We attempted to simulate this natural sequence of events in the establishment of a GRV-screening nursery in 1984/85. Prior to the onset of the rains, 1000 groundnut seedlings were raised in the greenhouse and inoculated by means of viruliferous aphids. We planted one infector row of the susceptible Malimba cultivar between every two contiguous rows of test lines. Two weeks after the emergence of plants in the field we transplanted, at 2 m spacing in each infector row, the diseased seedlings that were, by this time, heavily infested with vectors. We harvested several thousand viruliferous aphids from a second batch of greenhouse-grown seedlings and seeded the nursery with them on two further occasions. We induced an overall level of 89% incidence (Table 1). Of the 5912 F_2 plants exposed, 5234 became infected with GRV and were eliminated in the field. Of the remaining 678 plants, 272 were discarded by the breeder as being poor agronomically, thus leaving 406 plants.

Three seeds from each of these were sown in the greenhouse and inoculated twice using viruliferous aphids. Individual plant tests were considered valid only where all three seedlings grew, were inoculated, and survived until final unequivocal records were taken 6 weeks later. On this basis, 379 of the 406 greenhouse tests were valid, from which 134 plants emerged as having resistance. These will be included in the 1985/86 disease nursery.

Whether such disease nursery management is successful every year, and whether it will be possible to improve upon the overall incidence of about 90% obtained in 1985, remains to be seen.

Table 1. Field and greenhouse screening of progenies of susceptible * resistant crosses for resistance to groundnut rosette virus, Chitedze, Malawi, 1985.

	Field screening (F_2)		Greenhouse screening (F_3)		
Cross	No. plants rosetted	No. plants symptomless	Tested	Susceptible	Resistant
RG 1 as male parent					
Robut 33-1 x RG 1	220	24	24	14	10
Spancross x RG 1	22	2	2	2	0
SAC 58 x RG 1	52	10	5	2	3
Malimba	90	6	3	1	2
L.No. 95A x RG 1	95	8	8	4	4
Chalimbana x RG 1	53	10	8	0	8
RG 1 as female parent					
RG 1 * RR1/24	87	107	3	3	0
RG 1 x Ah 114	57	5	4	0	4
RG 1 x EPT 14	42	1	-	-	-
RG 1 x E879/6/4	35	5	5	4	1
RRI/24 as male parent					
E879/6/4 * RRI/24	17	1	1	0	I
Chalimbana * RRI/24	142	22	9	6	3
Robut 33-1 x RRI/24	610	78	73	53	20
Malimba * RRI/24	144	25	25	20	5
Spancross * RRI/24	55	10	10	10	0
JL 24 * RRI/24	118	8	8	6	2
SAC 58 * RRI/24	193	24	13	10	0
L.No. 95A * RRI/24	127	5	3	2	1
Shulamith x RRI/24	139	7	7	2	5
SPI x RRI/24	247	29	15	4	11
Egret x RRI/24	124	15	4	4	0
Makulu Red x RRI/24	20	4	4	3	1

Continued.

Table 1. continued.

Cross	Field screening (F_2) No. plants rosetted	No. plants symptomless	Greenhouse screening$_g$(F_3) Tested	Susceptible	Resistant
RRI/24 as female parent					
RRI/24 x A 1176	73	9	3	3	0
RRI/24 x EPT 14	30	0			
RRI/6 as male parent					
Chalimbana x RRI/6	36	9	2	2	0
Robut 33-1 x RRI/6	73	10	5	3	2
JL 24 x RRI/6	271	21	21	14	7
SAC 58 x RRI/6	19	1	1	l	0
L.No. 95A x RRI/6	83	5	3	1	2
SPI x RRI/6	135	11	7	1	6
Malimba x RRI/6	30	2	1	0	1
Egret x RRI/6	34	6	3	2	1
RMP 91 as male parent					
E879/6/4 x RMP 91	69	8			
Egret x RMP 91	216	64	37	32	5
Spancross x RMP 91	86	9	7	6	1
JL24 x RMP 91	260	13	13	11	2
SAC 58 x RMP 91	136	6	4	3	1
SPIx RMP 91	238	45	17	7	10
Mani Pintar x RMP 91	111	6	2	0	2
Chalimbana x RMP 91	138	11	11	9	2
SAC 58 x RMP 93	70	7	5	0	5
Malimba x RMP 93	45	6	3	0	3
Malimba (infector rows)	1906	261			
Totals (for crosses)	5234	678	379	245	134

Studies on Inheritance of Resistance

We set out to confirm the recessive nature of resistance to rosette with preliminary studies on the proportion of resistant to susceptible progeny derived from four sets of crosses involving the resistant cultivar RG 1 and the susceptible cultivars JL 24, Mani Pintar, Chitembana, and Chalimbana. Each set was grown under greenhouse conditions and was inoculated twice using viruliferous aphids in batches of eight.

Ratios of resistant to susceptible plants for the crosses studied were 1:21, 1:11, 1:8, 1:12, and 1:15 (Table 2). The data were subjected to statistical analysis by the breeder. With one possible exception, the ratios fall within probability limits of the predicted ratio of 1:15 previously reported in the literature. The reason why 100% infection was not obtained in all susceptible control plants is not known.

Further Aspects of Resistance: Grafting Experiments

All apparently resistant plants that remained symptomless in the inheritance study experiment, together with 32 RG 1 plants, and 5 or more selected control plants from each set, were used as stocks into which a healthy scion of the susceptible Spancross was grafted.

By means of this technique we hoped to find out whether resistance to GR V was apparently absolute (no rosette symptoms developing in the susceptible scion) or whether tolerance mechanisms were operating (rosette symptoms developing in the scion, stock remaining symptomless). In the latter case, we hoped, by means of vector tests, to determine whether the symptomless plants also contained groundnut rosette assistor virus (GRAV).

None of the susceptible scions grafted to the inoc-

Table 2. Rosette resistance inheritance studies on groundnut, Chitedze greenhouse, Malawi, 1985.

Set No.	Identity	No. plants inoculated	No. plants susceptible	No. plants resistant	Ratio resistant: susceptible plants
I	RG 1	9	0	9	
	JL24	10	9	0	
	(RG 1 x JL 24) F_1	8	8	0	
	(JL 24 x RG 1) F,	8	8	0	
	(JL 24 x RG I) F_2	217	207(16)[1]	10	1:21
	Spancross control	43	40		
II	RG 1	9	0	9	
	Mani Pintar	10	10	0	
	(Mani Pintar x RG 1) F_1	5	5	0	
	(Mani Pintar x RG 1) F_2	199	182(39)	17	1:11
	Spancross control	53	52		
III	RG 1	10	0	10	
	E879/6/4	10	10	0	
	(RG 1 x E879/6/4) F_2	273	241(49)	32	1:8
	(E879/6/4 x RG 1) F_2	308	284(10)	24	1:12
	Spancross control	51	51		
IV	RG 1	7	0	7	
	Chalimbana	10	10	0	
	(RG 1 x Chalimbana) F_2	129	121 (0)	8	1:15
	Spancross control	69	68		

1. Numbers in parentheses refer to numbers of susceptilble plants with suppressed or atypical symptoms.

ulated symptomless RG 1 plants developed GRV, whereas all of those grafted to various rosetted control plants developed typical symptoms of GRV in about 17 days, from which GRV was readily transmitted to healthy seedlings by aphids. These results show that RG 1 is immune to inoculation of GRV by the vector. We cannot comment on its resistance to GR AV at this stage. As with RG 1, apparently resistant hybrids of all four sets of crosses did not contain GRV because susceptible scions grafted into them grew vigorously and remained symptomless.

During 1985 we also tested the resistance of 45 introduced West African rosette-resistant lines, and selected 10 apparently resistant symptomless plants from among them for grafting. Eight grafted scions remained symptomless and we assume the plants contained resistance similar to that of RG 1. In one plant, GRV developed in only two of the eight stems after 16 weeks, and subsequently the scion also developed it. The tenth plant remained symptomless throughout the course of the experiment but the susceptible scion developed severe GRV, which was readily transmitted by the vector: an indication of symptomless systemic infection and, presumably, tolerance. This illustrates clearly the importance of a critical examination of the type of resistance contained in any line or cultivar that might be used as a resistant parent in the generation of resistant hybrids. We are at present re-examining RMP 91, RMP 93, and other cultivars in this regard.

Vector Ecology

We continued with studies on the seasonal origins of GRV by means of aphid trapping and by establishing small dry-season bait plots in the southern and central areas of Malawi.

We have abandoned the use of sticky traps in favour of yellow water traps because of great difficulties in identification of aphid species after impaction on sticky traps. Table 3 summarizes the weekly totals of numbers of A. craccivora caught between April and November 1985, and compares these with data given by Adams and Farrell (1967) for 1966. A. craccivora was trapped in low numbers consistently

Table 3. Numbers of Aphis croccivora trapped in Moericke yellow water traps at Chitedze, Malawi, during the 1985 dry season, compared with the 1966 records of Adams and Farrell (1967).

	1985			
Month	Week	Weekly total	Monthly total	1966
Jun	1	62		
	2	78		
	3	249		
	4	207	596	22
Jul	1	76		
	2	17		
	3	16		
	4	4	113	20
Aug	1	1		
	2	2		
	3	7		
	4	3	13	10
Sep	1	1		
	2	0		
	3	4		
	4	5	10	3
Oct	1	10		
	2	2		
	3	4		
	4	I	17	3
Nov	1	2		
	2	12		
	3	2		
	4	1	17	1

throughout the dry-season in both these years, suggesting the continuous presence of a local resident population.

In addition to water traps, we also used bait plants to monitor populations of the vector. Twenty 21 -day old greenhouse-grown groundnuts (Spancross seedlings) were exposed in the field every 3.5 days between November 1984 and November 1985, and the number of A. croccivora (alates, apterae, and nymphs) were recorded at the end of each exposure period. These bait plants indicated two periods of intense flight and breeding activity, i.e., the first during January and February, and the second from May to July. We continued to trap low numbers of A. craccivora throughout the dry-season, in August, September, and October.

In early August, when the dry-season was advanced and when there was no chance of any groundnut plants remaining in farmers' fields, we selected eight bait plot sites on the Lilongwe Plain in the Central Region and eight sites in southern Malawi. At each site a 15 x 15 m area was cleared and a 10 * 10 m plot of the Mani Pintar cultivar was established at wide (30 cm) spacing. Our choice of site was restricted to areas where water supplies could be assured, either piped or drawn from perennial streams or pools. All plots were visited on three occasions, each plant being examined for the presence of A. craccivora (Table 4).

A. craccivora was recorded in four out of seven plots in the south and in all plots in the Central Region by late September (about 6 weeks after emergence). There was thus ample time between the arrival of the aphids and termination of the experiment in early November for GRV to manifest itself had any migrant aphid been infective. GRV was not recorded at any site in the south, and on the Lilongwe Plain only four plants were infected at one(Chileka) of the eight sites.

Dry-season aphid activity, as measured by the number of sites infested, the number of plants infested per site, and population increase within sites, was greater on the Lilongwe Plain than in the south, where infestation was apparently confined to low-lying areas near rivers (Kasinthula), or lakes (Namiasi and Domasi), or in the single "dambo" plot (Kasongo).

In the Central Region, dambos (shallow grassland valleys with impeded drainage, which support green vegetation throughout the dry season), are both numerous and extensive. Whether this difference in land form and its associated ecology is significant or not remains to be seen, but it seems certain from water trap, bait plant, and bait plot data that A. craccivora is able to maintain itself locally and successfully throughout the dry season in both central and southern areas of Malawi.

The presence of GRV at the Chileka plot before the onset of the rains suggests the presence of a local source but does not indicate its extent nor significance.

Early Leaf Spot (Cercospora arachidicola)

Screening for Resistance

There are several likely components of tolerance or resistance to ELS which, presumably, may act independently or in various combinations. The more

Table 4. Incidence of Aphis craccivora and GRV on dry season groundnut plots in central and southern Malawi, Aug-Nov 19S5.

Site	Aphis craccivora	No. plants infested/ no. exposed	No. plants with GRV
Southern Region			
Lower Shire (Rift)			
Kasinthula	+	6/591	0
Southern Highlands			
Thyolo	-	0/227	0
Phalombe Plain			
Thuchila	+1	0/250	0
Phalombe	-	0/299	0
Kasongo Dambo	+	6/338	0
Domasi	+	46/101	0
Lake Shore			
Namiasi	+	23/123	0
Central Region			
Lilongwe Plain			
Chitedze	+	48/343	0
Chileka	+	4/311	4
Kamanzi	+	6/210	0
Likuni River	+	247/368	0
Malingunde	+	4/298	0
Chafumbwa	+	3/296	0
Nathenje	+	130/304	0
Nkhoma	+	8/285	0

1. Alatae observed but no subsequent colonization.

obvious of these may be apparent as a higher degree of leaf retention, few lesions, small lesions, and depressed sporulation. These components have all been used to assess resistance in the past.

Field assessment has generally involved visual scoring systems, such as the ICRISAT 9-point field scale: these often seek to assess at least two components simultaneously, and are inherently subjective. Few studies seem to have involved the more tedious physical measurement of one or more components, or to have sought a possible relationship between any one component of resistance and yield.

In the preliminary studies of the 1984/85 season, we measured leaf retention by counting the number of leaflets lost and retained at different sampling dates. We also examined the data in relation to yield.

In all the 1984/85 field trials, one stem of each of four plants, taken at random from an inner row of each plot of each replicate, was sampled by counting the number of leaflets absent and the number of mature leaflets present. All trials were sampled twice and most three times: 10-11, 12-14, and 16 weeks after emergence. Replicated data for each groundnut entry were pooled, and the average percentage of leaves retained for each successive sampling date was calculated. Subsequently entries were ranked for yield, and leaf data were examined in relation to ranked yield.

Tables 5, 6, and 7 summarize the results of leaf retention data. The total number of leaves produced per stem at any given sampling time was similar in high- and low-yielding lines. The higher number of leaflets retained by the former therefore did not seem attributable to a compensatory or faster rate of production of new leaves.

The data contained in Table 5 illustrate leaf retention at 88 days after emergence for varieties in the sequentially branched (S-type) and alternately branched (A-type) sections, which were widely used as controls in the various trials. It can be seen that S-types retained on average about 25% of their leaves, whereas A-types retained about 32%. For the purpose of this report these figures may be assumed to represent normal values for the two botanical sections for the given period of sampling and for the particular season at Chitedze.

Table 5. **Mean percent leaf retention following early leaf spot infection in groundnut for control varieties 88 days after emergence, all trials, Chitedze, Malawi, 1984/85.**

Genotype	Infection (%)	Mean
Sequentially branched section		
J 11	25, 34, 30, 23, 22	27
JL 24	28, 29, 25, 24, 23	26
Sellie	27, 27, 26, 21	25
Spancross	29, 26, 26, 24, 28, 19, 22	25
Malimba	26, 24, 23, 21, 28, 22, 27	24
Mean		25
Alternately branched section		
Mani Pintar	35, 38, 35, 30, 29, 39, 37, 28	34
SAC 58	34, 32, 34, 35, 32	33
Egret	34, 29, 36, 33, 28	32
RG 1	31, 31,34, 31,30,28, 30	31
Chalimbana	32, 32,31, 28	31
E 879/6/4	31,28,27,29	29
Mean		32
Robut 33-1	23, 20, 27	25

A-types have often been described as showing some degree of field resistance to leaf spots. Under the conditions of severe epidemics that occur on the Lilongwe Plain, it is perhaps to be expected that the difference might not be wide, but a comparison of the overall mean is possibly suggestive and seems to reflect this inherent difference.

The data also suggest possible variations in susceptibility within each group, Robut 33-1 being an example of extreme susceptibility among the A-types and Malimba perhaps the most susceptible of the S-types tested.

Data presented in Table 6 for S-types show great differences in leaf retention at 70 and 88 days between lines. Some high-yielding lines not only retained more leaves at both 70 and 88 days after emergence, but lost proportionately fewer leaves during the 3-week period between samplings: attrition proceeded at a lower rate. It seems possible that tolerance is involved, and that it will be necessary to adopt an appropriate method in order to identify

Table 6. Percent leaf retention following early leaf spot infection in groundnut at 70 and 88 days after emergence in relation to yield in certain sequentially branched selections and varieties, Chitedze, Malawi, 1984/85.

Trial[1]	Entry	Percent leaf retention at day 70	Percent leaf retention at day 88	Pod yield (kg ha-')	Yield rank	Percent leaf retention at 88 days
1 (35)[2]	ICGMS 30	54	43	2354	1	1
	ICGMS 29	62	40	1733	14	2
	Spancross	43	29	1957	7	9
	Malimba	46	26	1660	19	12
2 (28)	1CGM 285	63	45	3 297	2	1
	ICGM 281	59	45	3050	5	1
	ICGM 189	57	43	2776	6	2
	ICGM 286	56	42	3 366	1	3
	Sellie	46	26	1594	23	15
	Spancross	35	28	1533	25	14
	Malimba	46	28	1458	26	14
3 (22)	ICGM 550	43	37	2312	1	2
	ICGM 473	46	39	1430	10	1
	Spancross	45	24	1319	15	11
	JL24	42	29	1270	17	6
	Sellie	43	27	1097	20	8
	Malimba	46	21	1048	20	14
4 (22)	ICGM 525	51	47	2611	1	1
	Sellie	45	27	1708	8	10
	Spancross	49	26	1537	14	11
	JL24	47	28	1505	17	9
	Malimba	45	23	1407	22	14

1. Trial 1 - Regional Yield Trial; 2 = Elite Germplasm Trial; 3 = Advanced Germplasm Trial; 4 = Preliminary Germplasm Trial.
2. Figures; in parentheses denote number of entries

Table 7. Percent leaf retention following early leaf spot infection in groundnut at 70 and 88 days after emergence in relation to yield in certain alternately branched sections and varieties, Chitedze, Malawi, 1984/85.

Trial[1]		Entry	Percent leaf retention at day 70	Percent leaf retention at day 88	Pod yield (kg ha-')	Yield rank	Percent leaf retention at 88 days
1	(16)'	ICGMS 36	50	37	2116	7	1
		ICGMS	48	35	2438	4	3
		ICGMS 42	45	32	3211	1	5
		Mani Pintar	49	35	2911	2	3
2	(18)	ICGMS 336	51	34	3109	1	2
		Egret	48	36	3042	2	1
3	(12)	ICGM515	45	32	2138	6	1
		Mani Pintar	49	30	2555	3	2
		SAC 58	45	32	2569	2	I
		Egret	35	29	2618	1	4
4	(41)	ICGM 623	47	37	3046	1	1
		ICGM 484	51	35	2792	2	3
		ICGM 614	46	36	2745	3	2
		SAC 58	50	34	2727	4	4
		Egret	45	34	2639		
		Mani Pintar	50	35	2421	12	3
		Chalimbana	45	32	2245	18	6
5	(15)	ICGM 42	49	35	2966	1	2
		Mani Pintar	53	39	2861	2	1
		Egret	53	33	2783	4	3

1. Trial 1 = Regional Yield Trial; 2 = Elite Germplasm Trial; 3 = Advanced Germplasm Trial; 4 = Preliminary Germplasm Trial; 5 = High Yield and Quality Trial.
2. Figures in parentheses denote number of entries.

and to assess it quantitatively. At 88 days, all entries score 7,8, or 9 on the ICRISAT 1-9 scale, and would therefore be rated as susceptible. In this particular instance the 9-point field scale appears to be too coarse a method to detect possible differences between various entries.

We have had the opportunity of analysing the data from only one experiment, that of the breeder's Regional Yield Trial (Spanish Bunch) (Table 6). Analysis of variance of arc sine transformed data showed that there was a significant difference in leaf retention between ICGMS 30 and ICGMS 29 on the one hand and Spancross and Malimba on the other. The standard error was ±1.4 and the coefficient of variation 8.3%. There was no significant correlation between leaf retention and yield. At this stage it would not be profitable to speculate further on our observations, but they seem to provide a possible lead worthy of further investigation for at least one more season.

Leaf retention in A-types (Table 7) appeared to be more uniform and, in contrast to S-types, no exceptional differences were apparent among the cultivars, or between the higher-yielding ICRISAT breeding lines and the controls.

In the next season we hope to examine this aspect more critically by sampling for leaf retention in a number of selected trials at 10-day intervals throughout the growing season. We also hope to attempt to examine other components of resistance (possible differences in lesions and sporulation) in relation to leaf retention in a number of carefully selected S-type lines.

Disease Monitoring at Chitedze

Late leaf spot (Phaeoisariopsis personata) and rust (Puccinia arachidis) appeared in trace amounts late in the season, an established and apparently normal pattern for the Lilongwe Plain. Incidence of peanut mottle virus was appreciably lower than that of the 1983/84 season. Tomato spotted wilt virus (TSWV), apparently of wide occurrence but very low incidence throughout the region, was again present in traces. We marked with stakes all TSWV-affected plants in the ICRISAT fields early in the season, in order to monitor possible spread from source plants. We recorded 108 affected plants in our 7-ha experimental area, an overall incidence of about 0.02%.

All infections apparently occurred over one comparatively brief period, within 2 or 3 weeks of emergence, presumably a result of a migration of the vector.

There was no evidence of subsequent plant-to-plant spread nor for increase in incidence with time. We harvested 21 affected plants together with 1 healthy plant on either side of each diseased plant and measured seed yield in healthy and diseased individuals. The yield of diseased plants was about 30% of the yield of the controls.

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A Review of the Present Status of the Genetic Resources of the ICRISAT Regional Groundnut Improvement Program, of the Southern African Cooperative Regional Yield Trials, and of Rosette Virus Resistance Breeding

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Abstract

The status of the groundnut genetic resource collections of the national programs in the southern African region and of the ICRISAT Regional Groundnut Improvement Program for Southern Africa is reviewed. The role of 'introductions' in the improvement of groundnut is discussed with particular emphasis on the Valencia types in the region.

Two years' results from the ICRISAT Southern African Cooperative Regional Yield Trials are presented. While reviewing progress made in breeding for groundnut rosette virus (GRV) resistance, it is suggested that resistance to this disease is governed by two recessive genes. Transfer of this resistance into early maturing groundnut varieties will require large F_2 populations.

Sumario

Uma revisao do presente estado dos recursos geneticos no Programa Regional de Melhoramento do Amendoim do ICRISAT, dos ensaios regionais cooperatives para o rendimento na Africa Austral e do melhoramento para a resistencia ao virus de roseta. E revisto o estado das coleccoes de recursos geneticos de amendoim dos programas nacionais da Africa Austral e do Programa Regional de Melhoramento do Amendoim do ICRISAT para a Africa Austral. A importancia das 'introducoes' no melhoramento do amendoim nesta regiao e discutida com particular realce nos amendoins do tipo Valencia.

Sao apresentados dois anos de resultados dos ensaios regionais cooperativos para o rendimento na Africa Austral do ICRISAT. Durante a revisao do progresso feito no melhoramento para a resistencia ao virus da roseta do amendoim, e sugerido que a resistencia a esta doenca e governadapor genes recessivos. A transferencia desta resistencia para variedades de maturacao precoce vai requerer grandes populacoes F_2.

Since the inception of the ICRISAT Regional Groundnut Program for Southern Africa in July 1982, significant progress has been made in various aspects of groundnut improvement in the region. The research requirements for groundnut improvement in the region (Nigam 1984) and the progress up to 1984, were reviewed at the previous Regional Workshop in 1984 (Nigam and Bock 1985).

This paper deals mainly with two specific aspects, i.e., genetic resources and regional yield trials, which were discussed at length in the concluding session of the ICRISAT-IDRC Regional Groundnut Breeders*

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Group Tour (Zimbabwe-Zambia-Malawi), 25 Feb-1 Mar 1985. A brief review is also given of the breeding for the Groundnut Rosette Virus (GRV) resistance program, which has expanded greatly in the last two years.

Genetic Resources

Germplasm is an important raw material for any crop-breeding program. The extent of genetic diversity for characters of economic importance in an available germplasm collection plays a significant role in the success of a breeding program.

A collection of groundnut germplasm consisting of 11 548 accessions of Arachis hypogaea L. is currently available with the Genetic Resources Unit of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India. This material has been evaluated for various morpho-agronomic characters, including resistance to diseases and insect pests (Rao 1985).

The most complete catalogued collection of approximately 4000 accessions, is maintained in the USA by the Southern Regional Plant Introduction Station, Georgia. Several other countries and programs maintain their own collections.

ICRISAT Center has a special interest in wild species of Arachis. This genus includes 50 or more species from seven clearly differentiated taxonomic sections. Wild species collections are also maintained in some U.S. universities.

A review of the genetic resources available within national programs in the region indicates that some of them not only maintain sizeable collections of germplasm but have also exploited them successfully. The largest collection of over 2000 lines is maintained by the Zimbabwe national program at Harare. The collection includes introductions from various countries in Africa; Brazil, Bolivia, and the USA in the Americas; and from ICRISAT Centers in India and Malawi (Chiteka 1985).

The Oilseeds Research Project at Mtwara, Tanzania has more than 1000 lines in its collection. The majority of these lines have been obtained from ICRISAT Center, India. In a recent joint collection mission with ICRISAT, the national program has collected more than 80 diverse groundnut samples from the central region of Tanzania (Mwenda 1985). The Groundnut Project at the Msekera Regional Research Station, Chipata, Zambia maintains a collection of 850 lines (440 local landraces and 410 exotic lines). These lines have been evaluated and catalogued for important agro-morphological characters including disease resistance (Sandhu 1985). The Malawi national groundnut program maintains a collection of 317 lines that have been evaluated for seed color, seed size, and resistance to rosette disease.

The Mozambique collection consists of 216 local landraces and 157 exotic lines from ICRISAT, USA, Burkina Faso, Malawi, and Tanzania. Botswana has recently acquired cultivars from Burkina Faso, Senegal, the Republic of South Africa, Zimbabwe, and ICRISAT, and plans to develop this collection further and maintain it annually (Mayeux 1985). Although ICRISAT has recently supplied groundnut germplasm lines, cultivars, and breeding lines to programs in Angola, Lesotho, and Swaziland, nothing is known about the status of their germplasm collections.

Genetic resources available with the national programs have been successfully exploited as direct "introductions" or in hybridization programs. Introductions from South America, especially those from Bolivia in the long-season group, and from Brazil in the short-season group, have shown particular promise in Zimbabwe (Chiteka 1985). Similarly, the cultivars from West Africa and the USA showed promise in the preliminary trials in northern Mozambique (Malithano et al. 1985).

Of the nine cultivars released in Zimbabwe (Valencia R1, Valencia R2, Jacana, Natal Common, Swallow, Plover, Makulu Red, Egret, and Flamingo), all except Swallow and Flamingo are'introductions' or re-selections from introductions. Similarly, of the six currently-recommended cultivars in Malawi (RG1, Chitembana, Chalimbana, Mani Pintar, Mawanga, and Malimba), only the first two are the product of hybridization. All four cultivars in Zambia (Chalimbana, Makulu Red, Natal Common, and Comet) and the two recent releases in Tanzania (Spancross and Robut 33-1) are 'introductions'. Selections from the local landraces (Bebiano Branco, Bebiano Encarnado, Jonca, Napalala) and an introduction, RMP 12 from Senegal, have been recommended for production in Mozambique.

Germplasm Collection at the ICRISAT Regional Program

The selected introduction of germplasm lines from various sources, their evaluation under Chitedze conditions, and their proper documentation occupy a significant place in the activities of the breeding program.

By the end of the 1984/85 crop season, the regional program had acquired 765 Arachis hypogaea germplasm lines, mainly from ICRISAT Center, India. These lines have been critically evaluated for various agronomic and morphological characters, assigned ICGM (ICRISAT Groundnut Malawi) numbers, and are properly documented in the Germplasm Accession Register. Five hundred and four of these lines belong to A. hypogaea ssp fastigiata and 249 to A. hypogaea ssp hypogaea. The remaining 12 are yet to be classified. Three hundred and ninety-two of the lines originated in North and South America, 260 in Africa, 80 in Asia, 5 in the Middle East, 1 in Australia, and the remaining 27 are of unknown origin.

In response to the recommendations of the Regional Groundnut Breeders' Tour, the regional program has acquired this year 345 lines from the Zambian collection and 60 lines from the recent Tanzanian collection for evaluation and documentation. Forty-five promising lines of the Mozambican collection have already been evaluated in the 1984/85 season.

The regional program also holds a collection of 32 Arachis wild species accessions received from ICRISAT Center in India. They are being screened for early leaf spot (Cercospora arachidicola) resistance under field conditions at Chitedze.

Field Evaluation of the Germplasm

Four hundred and eighty-eight germplasm lines and 111 elite parents and sources of resistance to diseases and insect pests were evaluated in 1982/83, together with 9 important regional varieties as controls, in single 6-m row plots. Pod yield in control varieties ranged from 0.62 to 1.09 kg plot^{-1} and seed yield from 0.38 to 0.65 kg plot^{-1}. Fifty-one promising lines, having a pod yield equal to or greater than 1 kg plot^{-1}, or a seed yield equal to or greater than 0.60 kg plot^{-1}, were selected for further evaluation in a replicated yield trial in 1983/84. A further 162 lines were retained for re-evaluation due to their poor plant stand in the trial.

The top 10 lines on the basis of seed yield were ICGM 336 (0.83 kg), 471 (0.80 kg), 437 (0.80 kg), 48 (0.79 kg), 197 (0.78 kg), 479 (0.78 kg), 177 (0.78 kg), 189 (0.73 kg), 449 (0.73 kg), and456 (0.72 kg). ICGM 336 belongs to the Nambyquarae group, 437 and 456 to the Spanish group and the rest either to the Valencia or the Manyema group. From the preliminary evaluation it appears that some of the Valencia types, particularly those from the South American region, perform well under Chitedze conditions. These observations, in general, are in agreement with results from Zimbabwe on the performance of long-season varieties from Bolivia and short-season varieties from Brazil under Zimbabwe conditions. The top ranking line ICGM 336 originated in Bolivia and the second and third ranking lines ICGM 471 (Spanish) and 437 (Valencia) originated in Brazil.

None of the lines showed any appreciable level of resistance to early leaf spot. Some lines (NC 3033, PI 259747, and PI 270608), earlier reported as resistant to early leaf spot in the U.S. (Sowell et al. 1976, Hassan and Beute 1977) had no resistance under Chitedze conditions.

Preliminary Germplasm Trial

One hundred and sixty-two ICGM lines and 108 new germplasm introductions were evaluated in a non-replicated trial in the 1983/84 season. Nine standard cultivars from the region and India (Mani Pintar, Egret, Chalimbana, Mawanga, RG1, Robut 33-1, Spancross, J 11, and JL 24) were used as repeated controls. The performance of single 6-m row test entries was judged against the results of the controls after making an appropriate statistical adjustment of the data to eliminate the influence of a soil-fertility gradient in the field.

Of the 270 test entries, 70 yielded more than the highest control yield of 0.63 kg plot^{-1}. Of these, 38 had an alternate-branching habit (ssp hypogaea) and 32, sequential branching habit (ssp fastigiata). The top 10 lines, with their adjusted pod yield/ plot values, were ICGM 623 (1.04 kg), 627 (0.98 kg), 93 (0.96 kg), 526 (0.96 kg), 617 (0.94 kg), 484 (0.94 kg), 652 (0.93 kg), 631 (0.91 kg), 499 (0.90 kg), and 528 (0.89 kg).

Advanced Germplasm Yield Trial

Fifty-one ICGM lines, selected on the basis of their performance in the 1982/83 evaluation, together with 13 control cultivars from the region and India were evaluated in an 8 * 8 lattice with two replications. ICGM 285, belonging to the sequential-branching group, yielded the highest (Table 1). It was followed by ICGM 336,286,281,284,177, and

Table 1. Advanced Germplasm Yield Trial (groundnut), Chitedze, Malawi, 1983/84.						
ICGM Number	Origin	Branching habit	Days to maturity	Pod yield (kg ha-')	Shelling %	100-seed mass (g)
285	Brazil	S[1]	133	2650	71	37
336	Bolivia	A[2]	144	2640	75	50
286	Brazil	S	137	2550	73	37
281	Bolivia	S	130	2400	72	36
284	Brazil	S	135	2390	73	32
177	Brazil	S	134	2370	72	35
197	Bolivia	S	136	2330	79	37
189	Brazil	s	134	2080	72	36
292	Brazil	s	136	2060	76	34
23	Brazil	s	119	2040	77	36
282	Bolivia	s	130	2010	74	37
288	Brazil	s	106	1980	72	32
Control						
Sellie	S. Africa	s	106	1750	73	29
Egret	Zimbabwe	A	147	2280	72	44
Mani Pintar	Malawi	A	148	2140	73	42
SE (Mean)				±188.7		
CV (%)				11		

1. S = Sequential branching (ssp fastigiata).
2. A = Alternate branching (ssp hypogaea).

197. Except for ICGM 336, all belonged to the sequential-branching group. All these lines yielded significantly more than the highest-yielding, sequential-branching control, Sellie. When compared with Egret, the highest-yielding alternate branching control, yield differences were not significant. However, both ICGM 285 and 336 had significantly higher yields than Mani Pintar, the second highest-yielding, alternate-branching control from Malawi. ICGM 336, 177, and 197 ranked first, seventh and fifth respectively in the 1982/83 germplasm evaluation.

Promising germplasm introductions from the 1983/84 trials were regrouped into three replicated yield trials in 1984/85 with larger plot sizes.

Preliminary Germplasm Trial

The trial consisted of 53 lines selected from the 1983/84 Preliminary Germplasm Trial and 11 cultivars of the region included as controls. It was planted in an 8 * 8 lattice design with three replications.

Twenty-one of these lines have been retained for further evaluation. Of these, 6 belong to the sequential-branching and 15 to the alternate-branching group.

Of the six sequentially-branched Valencia germplasm lines only two, ICGM 525 and 559, yielded significantly more than the control cultivar Sellie (Table 2).

The highest yield in the alternate-branching group was produced by ICGM 623. It was followed by ICGM 484. However, both these lines did not differ significantly from the control cultivar Mawanga (Table 2).

Advanced Germplasm Trial

Twenty-four lines from the 1983/84 Advanced Germplasm Trial and 13 control varieties were evaluated in a 6 * 6 lattice design with four replications.

Of the 11 lines retained for further evaluation, ICGM 550, 554, and 522 yielded significantly more than the highest-yielding control JL 24 (Table 3).

Elite Germplasm Trial

Twenty-four germplasm lines that performed well in the 1983/84 Advanced Germplasm Trial were pro-

Table 2. Preliminary Germplasm Yield Trial (groundnut), Chitedze, Malawi, 1984/85.

Identity	Cultivar[1] group	Origin	Days to maturity	Pod yield (kg ha-')	Shelling (%)	100-seed mass (g)	Seed color	Mean ELS score (1-9 scale)[2]
ICGM 525	Valencia	Argentina	126	2510	65	47.6	Purple	8.0
ICGM 559	Valencia	Israel	118	2350	68	34.0	Purple	8.0
Sellie Control	Spanish	S. Africa	107	1700	75	30.2	Tan	9.0
ICGM 623	Virginia	USA	147	3090	74	57.0	Tan	7.0
ICGM 484	Georgia	Bolivia	145	2820	71	44.6	Red	7.0
Mawanga Control	Virginia	Malawi	148	2750	72	56.1	Variegated	6.5
SE (Mean)				±136.6				
CV (%)				12.6				

1. Source: Gibbons et al. 1972.
2. Early leaf spot score at 90 days after emergence.

moted to this trial. They were evaluated with 12 controls in a 6 * 6 lattice design with four replications.

The highest yield was produced by ICGM 286 (Table 4). Fifteen other Valencia lines yielded signficantly more than the highest-yielding sequential control J11. The yield of ICGM 336, an alternate-branching line, was significantly more than J 11, but was not different to that of Mani Pintar, the highest-yielding, alternate-branching control. However, ICGM 336 had a better shelling percentage and a larger seed size than Mani Pintar, and ranked first in 1982/83, second in 1983/84, and fourth in the 1984/85 evaluation. It stood first in all the three seasons in the alternate-branching group.

The top 8 Valencia lines in Table 4 also appeared in the top 8 in the 1983/84 Advanced Germplasm Trial, with slight differences in ranking.

All the germplasm lines that were retained for further evaluation in the 1984/85 season have been re-grouped into trials during 1985/86 as per their botanical types, i.e., Elite Germplasm Trial (Valencia), Elite Germplasm Trial (spanish), and Elite Germplasm Trial (Virginia). This will be the final evaluation before outstanding lines are included in the Cooperative Regional Yield Trials.

Many of the Valencia types have performed well in the last three seasons' evaluation at Chitedze. Valencias have not received enough attention in the region, with the exception of Zimbabwe, where the cultivar Valencia R2 is still recommended. It is expected that some of these lines will find suitable recognition in the region, provided they maintain their performance at other locations.

Table 3. Advanced Germplasm Yield Trial (groundnut), Chitedze, Malawi, 1984/85.

Identity	Cultivar[1] group	Origin	Days to maturity	Pod yield (kg ha-')	Shelling	100-seed mass (g)	Seed color	Mean ELS score (1-9 scale)[2]
ICGM 550	Valencia	Sudan	121	2360	64	43.3	Purple	8.0
ICGM 554	Valencia	Zimbabwe	121	1980	69	35.7	Purple	8.0
ICGM 522	Spanish	India	118	1770	75	30.0	Tan	8.5
JL 24 (Control)	Spanish	India	108	1390	77	27.5	Tan	9.0
SE (Mean)				±88.1				
CV (%)				10				

1. Source: Gibbons et al. 1972.
2. Early leaf spot score at 90 days after emergence.

Table 4. Performance of the groundnut lines retained for further evaluation in the Elite Germplasm Trial, Chltedze, Malawi, 1984/85.

Identity	Cultivar[1] group	Origin	Days to maturity	Pod yield (kg ha-')	Shelling (%)	100-seed mass (g)	Seed color	Mean ELS score (1-9 scale)[2]
ICGM 286	Valencia	Brazil	123	3330 (3)[3]	75	37.3	Red	7.0
ICGM 285	Valencia	Brazil	124	3200(1)	69	35.3	Red	7.0
ICGM 284	Valencia	Brazil	119	3190 (5)	75	35.3	Red	7.5
ICGM 336	Nambyquarae	Bolivia	145	3060(2)	78	53.0	Variegated	7.0
ICGM 197	Valencia	Bolivia	124	3030 (7)	74	35.5	Red	7.0
ICGM 281	Valencia	Bolivia	123	2970 (4)	73	38.2	Red	7.0
ICGM 189	Valencia	Brazil	119	2770 (8)	75	40.7	Red	7.0
ICGM 292	Valencia	Brazil	124	2650 (9)	75	29.5	Red	7.0
ICGM 177	Valencia	Brazil	124	2620 (6)	73	38.8	Red	7.5
ICGM 282	Valencia	Bolivia	123	2520(11)	74	33.0	Red	7.5
ICGM 48	Valencia	Brazil	120	2480 (19)	74	38.2	Red	9.0
ICGM 23	Valencia	Brazil	110	2420 (10)	74	39.5	Red	8.0
ICGM 288	Valencia	Brazil	no	2380(12)	72	36.3	Red	7.5
ICGM 300	Valencia	Brazil	105	2250 (18)	71	29.3	Red	9.0
ICGM 119	Valencia	India	106	2210 (20)	74	27.2	Red	8.5
ICGM 472	Valencia	-	107	2120(13)	74	40.4	Red	9.0
ICGM 504	Valencia	Argentina	108	2100(17)	74	37.5	Red	9.0
Mani Pintar (Control)	Nambyquarae	Malawi	141	3010	76	47.9	Variegated	7.0
J II	Spanish	India	108	1650	76	24.8	Tan	9.0
SE (Mean)				±141.0				
CV (%)				12				

1. Source: Gibbons et al. 1972.
2. Early leaf spot score at 90 days after emergence.
3. Ranking for pod yield in the 1983/84 Yield Trial.

ICRISAT Southern African Cooperative Regional Yield Trials

The two cooperative regional yield trials, started in 1983/84, were conducted in Malawi (2 locations), Mozambique (2 locations), Zambia (3 locations), and Zimbabwe (1 location) in the first year. In 1984/85 these trials were repeated at the same locations. Botswana (1 location) and Tanzania (2 locations) were supplied seeds for these trials for the fust time. In 1985/86 these trials were extended to Angola. Swaziland also indicated interest to participate in these trials, but in the absence of an import permit, seed could not be supplied.

ICRISAT Southern African Cooperative Regional Yield Trial (Sequential Branching)

Thirty-four ICGMS (ICRISAT Groundnut Malawi Selection) lines and two local control varieties were recommended for evaluation in a 6 * 6 lattice design with four replications. The results received from various locations are discussed by country. Tables 5 and 6 present performance of lines that merit further testing.

No data for the 1984/85 season were received from either location in Tanzania.

Table 5. ICRISAT Southern African Cooperative Regional Groundnut Yield Trial, Sequential Branching, 1983/84.

ICGMS lines	Malawi				Mozambique	Zambia			Zimbabwe		Overall mean	
	Chitedze		Lupembe		Sabie	Msekera		Magoye	Gwebi			
	(a)[1]	(b)[2]	(a)	(b)	(a)	(a)	(b)	(a)	(a)	(b)	(a)	(b)
1	1630[3,4]	1250	1790[3,4]	1340[4,5,6]	1210	1800	1330[4]	1420	1830	1380	1690	1320
2	1850[4,5,6]	1440[6]	1500	1100	1450	1970[4]	1500[4]	1950[4]	820	600	1620	1160
5	1660[3,4]	1160	1540[4]	1090	1180	2240[4,5,6]	1490[4]	1710[4]	3290[3]	2200	2090	1490
9	1500	1170	1580[4]	1120	1240	2000[4]	1430[4]	1740[4]	1520	1110	1670	1210
11	1380	980	1850[3,4,6]	1270[4,5]	1310	2100[4]	1370[4]	1920[4]	3510[3]	2390	2150[6]	1500
12	1440	1020	1660[4]	1130	1180	1880	1240	1500	2960	1980	1890	1340
14	1280	890	1800[3,4]	1200[3,4]	1340	1690	1070	1830[4]	2860	1940	1890	1280
18	1340	1040	1270	980	1260	2000[4]	1440[4]	930	1510	1140	1410	1150
21	1560	1180	1410	1050	1170	1860	1330[4]	2110[3,4,6]	2360	1740	1860	1330
22	1780[4,5]	1320	1400	1070	1330	1870	1390[4]	1810[4]	1890	1420	1750	1300
23	1760[4,5]	1370	1190	810	1220	2010[4]	1350[4]	1210	2820	2090	1800	1410
28	1550	1160	1230	870	1280	1960[4]	1420	1350	3270[3]	2420	1870	1470
30	1230	890	970	610	1840	2180[4,3]	1250	1420	2160	1400	1590	1040
31	1800[4,5]	1330	1420	950	1740	1670	1100	1070	4110[3,6]	3120[6]	2010	1630[6]
33	1730[4,5]	1330	1610	1260[4,5]	1180	1840	1350[4]	1860[4]	3130	2310	2030	1560
Control 1	1460	1090	1540	1010	1050	1830	1320	1830	2690	1940	-	-
Control 2	1380	1080	1440	980	750	1880	1350	1420	4010	2930	-	-
SE	±87.6	-	±113.2	±74.4	-	±114.2	±75.9	±222.6	±159.2	-	-	-
Trial mean (n=36)	1500	-	1330	930	-	1850	1280	1560	2580	-	-	-
CV (%)	12	-	17	16	-	12	12	29	12	-	-	-

1. a = Pod yield kg ha^{-1}.
2. b = Seed yield kg ha^{-1}.
3. Significant over lower control only.
4. Non-significant with the higher ICGMS line.
5. Significant over higher control.
6. Highest yield among the ICGMS lines.
(Sabie not included in the overall mean.)

Table 6. ICRISAT Southern African Cooperative Regional Groundnut Yield Trial, Sequential Branching, 1984/85.

	Botswana	Malawi			Mozambique	Zambia				Zimbabwe			
ICGMS	Sebele	Chitedze		Lupembe	Boane	Msekera		Magoye		Gwebi		Overall mean	
lines	(a)[1]	(a)	(b)[2]	(a)	(a)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
1	1180	2040[3]	1510	710[3,4,6]	670	2040	1270	1180	680	600	370	1470	1050
2	1040	2220[3,4]	1640[6]	710[3,4,6]	550	2810[4,5]	1620	1390[4]	650	1070	700	1870	1320
5	-	2040[3]	1470	240	1050[4]	2880[4,5]	1860[4,5]	1430[4,6]	410	1430[4]	960[4]	1950	1430[6]
9	1170	1970	1460	770[3,4]	670	2330	1430	1140	580	940	700	1600	1200
11	-	2010[4]	1410	450[4]	1160[4]	2980[4,5,6]	1860[4,5,6]	1770[3,4,6]	590	1530[4,6]	1020[4]	2070[6]	1430[6]
12	1080	1620	1120	350	880[4]	2650[5]	1540	1630[4]	400	1080	720	1750	1130
14	-	1290	790	700[3,4]	1210[4,5,6]	2000	1110	1260	640	1060	730	1400	880
18	-	1540	1170	530[4]	630	2620[3]	1750[3,4]	1370[4]	570	830	630	1590	1180
21	1140	1620	1220	760[3,4]	600	2070	1310	1520[4]	720	880	660	1520	1060
22	1110	1560	1170	710[3,4]	640	2380	1520	1500[4]	710	780	570	1560	1360
23	-	1760	1302	760[3,4]	920[4]	2320	1380	1320	620	1180	890	1380	1190
28	-	1640	1180	470[4]	930[4]	2100	1360	1310	550	1030	770	1520	1100
30	-	2340[4,5,6]	1590	100	470	2640[3]	1660	1120	480	1310[4]	840	1850	1360
31	-	1900	1410	250	630	2240	1340	1630[4]	1020[5,6]	1490[4]	1120[3,4,6]	1820	1290
33	-	1450	1090	250	600	1860	1140	1070	680	1020	770	1350	1000
Control 1	650	1690	1270	590	780	2250	1490	1330	690	1310	940	1650	1230
Control 2	-	1950	1480	350	790	2350	1590	1370	560	2570	1850	2060	1640
SE	-	±104.7	-	±97.3	±145.1	±107.6	±63.6	±147.3	±90.4	±86.4	±61.1	-	-
Trial Mean (n=36)	-	1730	-	430	690	2290	1410	1330	610	1080	760	-	-
CV (%)	-	12	-	39	42	9	9	22	30	16	16	-	-

1. a = Pod yield kg ha^{-1}.
2. b = Seed yield kg ha^{-1}.
3. Significant over lower control only.
4. Non-significant with the highest ICGMS line.
5. Significant over higher control.
6. Highest yield among the ICGMS lines.
   (Sebele, Lupembe, Boane, and Magoye (b) excluded from the overall mean.)

Botswana

1984/85. Unfortunately the trial at Sebele Research Station was located in part of a recently extended field, where two full replications and a part of the third were planted on reclaimed land that was previously a road. This resulted in suppressed plant growth in those plots, which were rejected for yield observations. Based on pod-yield data from the remaining plots, six lines, ICGMS 1 (1180 kg ha^{-1}), ICGMS 9 (1170 kg ha^{-1}), ICGMS 21 (1140 kg ha^{-1}), ICGMS 22 (1110 kg ha"^{1}), ICGMS 13 (1080 kg ha"^{1}), and ICGMS 2 (1040 kg ha^{-1}), which yielded well above the control Sellie (650 kg ha^{-1}), have been selected by the national program for further testing. Seed has been sent to Botswana so that the trial can be repeated in the 1985/86 season.

Malawi

1983/84. At Chitedze, pod yields of ICGMS 2, 6, 22, 23, 31, and 33 were significantly more than that of the higher-yielding control variety Malimba; ICGMS 2 yielded the highest. Other lines, which did not differ significantly from ICGMS 2, included ICGMS 1 and 5. The top 5 lines for seed yield were ICGMS 2, 23, 31, 33 and 22.

At Lupembe, 8 ICRISAT lines yielded more than the higher-yielding control Malimba, but yield differences were not significant. When compared with the lower-yielding control Spancross, ICGMS 11, 14, and 1 had significantly more pod yield. ICGMS 11 yielded the highest; other lines that did not differ significantly from it included ICGMS 14,1,32,12,9, 7, and 5. For seed yield, ICGMS I yielded the highest, followed by ICGMS 11 and 33. All three lines were significantly superior to the higher-yielding control Malimba. Two other lines that did not differ significantly from ICGMS 1 were ICGMS 14 and 32.

On a country mean basis, ICGMS 1 was highest for both pod and seed yield, but only ICGMS 33 was common among the top five for seed yield at both the locations.

1984/85. At Chitedze, ICGMS 30 gave the highest pod yield and was significantly superior to the higher-yielding control Spancross; ICGMS 2, 1,5, and 11 yielded more than Spancross, but the yield differences were not significant. However, these lines were significantly superior to the other control, Malimba. The yield difference between ICGMS 30 and 2 was not significant. The top 5 lines for seed yield were ICGMS 2, 30, 1, 5, and 9.

At 60 days after emergence, ICGMS 30, a selection from the rust-resistant population (NC Ac 2190 x NC Ac 17090), had a lower early leaf spot score of 4 on a 1-9 scale compared to other lines in the trial. Disease development on this line was slower by about 2 weeks. It retained foliage when other lines were defoliated.

The trial at Lupembe was sown in a randomized-block design. It was poorly managed and suffered from drought from flowering through to harvest. Pod yield varied from 101 to 770 kg ha^{-1} with a mean of 430 kg ha^{1}. The coefficient of variation was high (39%). The top 5 lines this year included ICGMS 1 and 14, which had yielded significantly more than the higher-yielding control in the 1983/84 season.

Mozambique

1983/84. The emergence of test entries at Sabi was highly variable and of local controls, very poor. Data from this location were neither analyzed (replicated data not provided) nor included in the overall mean. However, among the ICGMS lines, 29,30,31, 3, and 20 occupied the first 5 ranks.

1984/85. The trial was carried out at Boane in a randomized-block design. Pod yield ranged from 270 to 1210 kg ha^{-1} with a mean of 690 kg ha"^{1}. Data were again of poor quality, as indicated by the high coefficient of variation (42%), so a meaningful interpretation of results was precluded. However, 9 ICGMS lines yielded more than the higher-yielding control Starr. The top 6 ICGMS lines included ICGMS 14, 11,5, 10, 13, and 28.

Zambia

1983/84. The trial at Msekera Regional Research Station suffered Treflan® (a weedicide) damage, which resulted in an unsatisfactory plant stand. It was also planted relatively late.

Only ICGMS 5 yielded significantly more pods than the higher yielding control variety Natal Common. The lines which did not differ significantly from ICGMS 5 included ICGMS 30,11,32,27,2,9, 10, 18, 19, 23, 28, and 34. Although ICGMS 2 gave the highest seed yield, the yield did not differ significantly from that of Natal Common. ICGMS 5,9,10, 11,22,23,32, and 34 did not differ significantly from ICGMS.

Lines ICGMS 29 and 30, both rust-resistant populations, had lower rust scores in comparison with other ICGMS lines. All the lines were equally susceptible to early leaf spot.

At Magoye, the plant stand was satisfactory, but the trial was harvested late, which resulted in heavy pod loss in the soil. Seed yield was not determined at this location. Only ICGMS 21 yielded significantly more than one of the control varieties, Natal Common. The yield difference between ICGMS 21 and the other control, Comet, was not significant. Lines which did not differ significantly from ICGMS 21 were ICGMS 3, 2, 11, 29, 15, 26, 27, and 33.

ICGMS 29 and 30 scored lowest (4.3) on a 1-9 scale for leaf spots. This observation was made rather early, at a time when disease levels were moderate (highest score 6.8).

ICGMS 11 and 2 were the common lines in the top 5 entries at both locations in Zambia.

1984/85. On the basis of pod yield, ICGMS 11 ranked first at Msekera. It was followed by ICGSM 5, 2, and 12. All these lines had significantly higher pod yield than Comet, the higher-yielding control. In addition to these lines, ICGMS 30 and 18 had significant yield differences with the other control, Natal Common. Only ICGMS 11 and 5 maintained a significant superiority for seed yield over control Comet. The third place was occupied by ICGMS 18. In the 1983/84 trial at Msekera, ICGMS 5, 30, and 11 had occupied the first three places for pod yield and ICGMS 2, 5, and 34, for seed yield.

At Magoye the trial started with good emergence but subsequent poor and erratic precipitation during Feb-Mar resulted in lower pod and seed yields. Fifteen ICGMS lines produced higher pod yields than the higher-yielding control Comet. However, yield differences were not significant. In comparison with the lower-yielding control Natal Common, only ICGMS 11 had significantly higher yield. Other lines included in the top 5 were ICGMS 12,31,10, and 19. In the previous year the top 5 ICGMS lines at this location were 21,3,2,11, and 29. Seed yields, besides being poor, also had a higher coefficient of variation (31%) in this year's trial.

Zimbabwe

1983/84. ICGMS 31 gave the highest pod yield, followed by the higher-yielding control Valencia R2. The yield difference between these two was not significant. ICGMS 31, 11, 13,6, 5, 28, and 24 yielded significantly more than Plover, the second control variety. The top 5 ICGMS lines for pod yield were ICGMS 31, 11, 13, 6, and 5, and for seed yield, ICGMS 31, 6, 28,24, and 11.

1984/85. The local control Valencia R2 gave the highest pod yield. This variety tends to give higher yields at Gwebi Centre due to its location in the cooler climate of the high veld area. Among the ICRISAT lines, ICGMS 11, 31, 5, and 15 occupied the first four places for pod yield. Although they yielded more than the Spanish control Plover, the yield differences were not significant. ICGMS 31 ranked first in seed yield and also had a significantly higher yield than Plover. Next in rank were ICGMS 11,5, and 8.

In the 1983/84 trial ICGMS 31 had given the highest pod yield and seed yield. ICGMS 11 and 5 were included in the top 5 ICGMS lines.

ICRISAT Southern African Cooperative Regional Yield Trial (Alternate Branching)

Fourteen ICGMS lines and 2 local control varieties were recommended for evaluation in a 4 * 4 lattice design with four replications. Results received from various locations are discussed by country. Tables 7 and 8 present performance data for the years 1983/84 and 1984/85 for those lines that merit further regional testing. Data for the 1984/85 trial were not received from one location in Malawi and one in Mozambique, and from neither of the locations in Tanzania.

Malawi

1983/84. At Chitedze, the highest pod yield was produced by ICGMS 42. It was significantly superior to all other entries in the trial. No other line yielded more than the higher-yielding control Mani Pintar.

At Meru, the pod yield of ICGMS 45 was highest and differed significantly from that of the local cultivar Mani Pintar, which was the second in order of performance. For seed yield, ICGMS 45 was ranked first followed by ICGMS 42 and Mani Pintar. Seed yield difference between ICGMS 45 and Mani Pintar was significant, but there was no difference

Table 7. ICRISAT Southern African Cooperative Regional Groundnut Yield Trial, Alternate Branching, 1983/84.

ICGMS	Malawi				Mozambique	Zambia				Zimbabwe			
	Chitedze		Meru		Namialo	Msekera		Golden Valley		Gwebi		Overall mean	
lines	(a)[1]	(b)[2]	(a)	(b)	(a)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
35	1660	1210	1690	1020	560	2110	1520	1370[3,4]	840[5,6]	2070	1400	1780	1200
36	1740	1290	1920	1250	1000[6]	2450[4]	1800[4,6]	1120[3]	690[5]	760	520	1600	1110
38	1370	1030	2250	1560	880	1700	1230	1160[3]	690[5]	2340	1640	1770	1230
39	1690	1270	2040	1310	520	2020	1470	1230[3]	740[5]	1860	1290	1770	1210
42	2650[5,6]	1990[6]	2490	1810	630	2530[4,6]	1800[4,6]	1380[3,4]	810[4,5]	3560[4,5,6]	2630[6]	2520[6]	1810[6]
43	1790	1360	2340	1660	590	1800	1260	1660[4,5,6]	1000[4,5,6]	3270[4,5]	2390	2170	1530
45	1620	1120	3330[5,6]	2350[5,6]	590	2250[4]	1440	840	470	3320[3,4]	2290	2270	1530
47	1730	1350	2350	1630	410	2300[4]	1710[4]	1040[3]	660[5]	2850	2050	2050	1480
48	1460	1100	2420	1510	670	2240[4]	1550[4]	1450[4,5]	590[3]	1390	910	1790	1130
Control 1	2380	1760	2490	1670	610	2560	1730	1030	450	3090	2100	2310	1540
Control 2	1720	1290	2170	1520	570	2300	1550	530	330	2790	1930	1900	3220
SE	±89.9	-	±197.2	±138.0	-	±130.8	±96.0	±131.6	±70.5	±103.6	-	-	-
Trial Mean (n = 16)	1630	-	2190	1460	630	1930	1340	1140	660	2420	-	-	-
CV (%)	11	-	18	19	-	14	14	23	22	9	-	-	-

1. a = Pod yield kg ha^{-1}.
2. b = Seed yield kg ha^{-1}.
3. Significant over lower control only.
4. Non-significant with the highest ICGMS line.
5. Significant over higher control.
6. Highest yield among the ICGMS lines.
   (Namialo not included in the overall mean.)

Table 8. ICRISAT Southern African Cooperative Regional Groundnut Yield Trial, Alternate Branching, 1984/85.

ICGMS	Malawi		Zambia				Zimbabwe			
	Chitedze		Msekera		Golden Valley		Gwebi		Overall mean	
lines	(a)[1]	(b)[2]	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
35	2400	1680	2030	1220	2150[3]	1400	1790	1290	2090	1400
36	2130	1580	2530[3,4]	1830[3,4,5]	2490[3,4]	1860[3,4,5]	980	650	2030	1480
38	1930	1390	2100[3]	1300	2290[3,4]	1530[3,4]	1380	1000	1930	1310
39	2360	1700	2240[3]	1280	2400[3,4]	1360	1780	1260	2200	1400
42	3200[3,5]	2400[5]	2430[3,4]	1750[3,4]	2630[3,4,5]	1680[3,4]	2630[3,5]	1900[3,5]	2720[5]	1930[5]
43	2100	1530	2030	1380[3]	2220[3]	1390	1920	1410	2070	1430
45	2070	1390	2600[3,4,5]	1560[3]	2010	1350	2020	1430	2180	1430
47	1600	1100	1920	1400[3]	2250[3,4]	1470[3]	1480	1110	1810	1270
48	1710	1210	1740	1140	2610[3,4]	1660[3,4]	1390	930	1860	1240
Control 1	2490	1710	1770	1150	1700	1050	2520	1740	2120	1410
Control 2	2930	2170	2890	2070	2680	1660	2690	1880	2800	1950
SE	±109.1	-	±112.1	±73.9	±135.4	±130.9	±104.5	±80.4	-	-
Trial Mean (n = 16)	2070	-	1980	1310	2130	1370	1620	1150	-	-
CV (%)	11	-	11	11	12	19	13	14	-	-

1. a = Pod yield kg ha^{-1}.
2. b = Seed yield kg ha^{-1}.
3. Significant over lower control only.
4. Non-significant with the highest ICGMS line.
5. Highest yield among the ICGMS lines.

between those of ICGMS 42 and Mani Pintar.

On an overall basis for Malawi, ICGMS 42, 45, 43, 47, and 48 obtained the first five ranks for both pod and seed yield.

1984/85. At Chitedze, ICGMS 42 again gave the highest pod yield. It was followed by controls Mani Pintar and Chitembana. The yield difference between ICGMS 42 and Chitembana was significant.

Mozambique

1983/84. The plant stand density for the trial at Namialo was low across all treatments, (21-36% of the normal stand). Data from the trial were neither analyzed (in the absence of replicated data) nor included in the overall mean. However, the top 5 lines at Namialo were ICGMS 36,38,40,37, and 48.

Zambia

1983/84. At Msekera, the pod yield of the local control variety Makulu Red was highest, followed by ICGMS 42, 36, 47, 45, and 48, none of which, however, differed significantly from Makulu Red. The highest seed yield was attained by 2 lines, ICGMS 42 and 36. They were followed by Makulu Red, ICGMS 47, Chalimbana, and ICGMS 48. Both ICGMS 42 and 36 were larger seeded than Makulu Red. ICGMS 45 had the lowest score (2.0) for rust and ICGMS 47 had the lowest score(5.8) for leaf spot (1-9 scale).

General pod and seed yield levels at Golden Valley were low due to late planting. The pod yields of ICGMS 43 and ICGMS 48 were significantly greater than the control (Makulu Red) yield. All other lines except ICGMS 41 and 45 yielded significantly more than the lower-yielding control, Chalimbana. However, the lines that did not differ significantly from ICGMS 43 included ICGMS 48, 42, and 35.

Similarly, for seed yield ICGMS 43 was ranked first, followed by ICGMS 35,42, 37, and 39. All had significantly greater seed yields than Makulu Red. On an overall basis in Zambia, ICGMS 42,48, 36, 35, and 43 held the first ranks for pod yield, and ICGMS 42,36,47,35, and 43, the first five ranks for seed yield.

1984/85. The trial at Msekera planted in mid-November suffered from initial soil-moisture stress, causing unsatisfactory seedling emergence.

Control Makulu Red gave the highest pod yield, followed by ICGMS 45, but the yield difference between these 2 lines was not significant. Other lines that yielded significantly more than the lower-yielding control Chalimbana included ICGMS 36, 42,39, and 38. Control Makulu Red had the highest seed yield and was significantly superior to all the ICGMS lines. The lines that yielded significantly more than the other control Chalimbana included ICGMS 36, 42, 45, 47, and 43.

At Golden Valley also, Makulu Red gave the highest pod yield, followed by ICGMS 42, 48, 36, and 39; again, these lines did not differ significantly from Makulu Red. ICGMS 36 gave the highest seed yield which did not differ significantly from those of Makulu Red, ICGMS 42,48,38, and 47. In addition to these lines, ICGMS 43 also had a significantly higher yield compared to the other control, Chalimbana.

Zimbabwe

1983/84. At Gwebi, pod yield of ICGMS 42 was highest, followed by ICGMS 45, both being significantly higher than the higher-yielding control Egret. ICGMS 43 yielded more than Egret, but the difference was not significant. For seed yield, ICGMS 42 maintained its first rank but the positions of ICGMS 45 and 43 were reversed.

1984/85. Yields at Gwebi were affected by wet weather conditions. The highest pod yield was produced by the control Makulu Red. It was followed by ICGMS 42 and another control, Egret. These lines did not differ significantly between each other. The next 2 lines in rank were ICGMS 45 and 43; however, these had significantly lower pod yields. A similar trend was followed for seed yield, except that ICGMS 42 ranked first.

The Regional Breeders' Group discussed regional yield trials at their meeting in Feb 1985. National program breeders considered that "regional yield trials should run for 2 seasons only: entries which perform poorly should be discarded and replaced on a 2-year basis at maximum." Responding to this consensus of opinion, I have summarized the data for the last 2 years and have selected tentatively those lines that merit further regional testing (Tables 5, 6, 7, and 8). These results will be compared with the 1985/86 results before making final decisions.

From the results obtained from the various regional locations, it is evident that only some of them can be used for drawing valid conclusions. Unless good quality data are received from all participating locations it will remain difficult to reorganise regional yield trials in 2 years. National programs are encouraged to identify promising lines for their locations in these trials and include them in their own multi-location trials. Malawi and Zimbabwe have already taken a lead in this matter.

Rosette Resistance Breeding

Development of high-yielding, GRV-resistant varieties of varying maturity lengths constitutes an important breeding objective of the program.

Since 1956, groundnut research programs in West Africa have directed their efforts towards developing GRV-resistant varieties suitable to their agroclimatic conditions. Significant progress has been made by the programs in Senegal, Burkina Faso, and Nigeria. Utilizing the resistant sources, which were semierect and late maturing, varieties such as KH-149A, KH-241D, 69-101, RMP 12, and RMP 91 have been developed and released by the programs in Senegal and Burkina Faso (Bockelee-Morvan 1983). The first two of these varieties belong to the Spanish and the remaining to the Virginia group.

In southern Africa, the pioneering breeding efforts of Gibbons and his team in Malawi culminated successfully in the release of the GRV-resistant variety RG1. Several other GRV-resistant breeding lines with better kernel size are in an advanced stage of testing in Malawi (Sibale and Kisyombe 1980). Other national programs in the region have shown little interest in GRV-resistance breeding.

The regional program has assigned a very high priority to the development of high-yielding, short-season GRV-resistant varieties as the area under short-season varieties in the region is extensive.

Breeding Material

1984/85. After confirming their hybridity, 26 F, crosses involving sources of GRV resistance (RG 1, RMP 93, and RRI/6) and promising exotic germplasm and breeding lines were advanced to the F_2 generation.

Twenty-eight populations consisting of a total of 5912 F_2 plants were screened for the first time under an infector-row system in the field (for details of technique see Bock, these Proceedings). At the conclusion of the experiment only 678 symptomless F_2 plants remained. Two hundred and seventy-two of these plants had either very few or no pods and were rejected. The remaining 406 plants were harvested individually. A few seeds from each of these symptomless F_2 plants was grown in the glasshouse for testing resistance in F_3 generation. The F_3 plants from 245 symptomless individual F_2 plants were found to be susceptible to rosette, indicating that these either carried susceptible dominant genes in the homozygous condition or that they were heterozygotic. The remaining F_2 seed of these plants was bulked in each cross and has now been grown as F_3 bulks under the infector-row system. It is expected that the seeds from the hyterozygote-susceptible plants in these bulks will segregate into resistant and susceptible plants.

The remaining 161 individual F_2 plants have been progeny-rowed under the infector-row system for further selection. These plants either carry double recessive genes in the homozygous condition or are heterozygotes. The majority of these plants had poor pod yield. One hundred and fifty-three belonged to the Virginia bunch, 6 to the Virginia runner, and 2 to the Spanish group. As expected, the recovery of spanish-type, resistant plants was very low, as both these characters are recessive. In future much larger F_2 populations will be required to isolate such plants in the Spanish * Virginia combination.

1985/86. The rosette disease nursery, in addition to a full set of rosette inheritance study material, consists of 26 F_2s, 161 F_2 plant progenies, and 35 F_3 bulks.

It is planned to confirm the resistance of two Spanish varieties, KH-149A and KH-241D, as they have been referred to as tolerant and resistant in the same publication. If these varieties are found resistant under Malawi conditions, they will be used extensively in the hybridization program.

Preliminary GRV Inheritance Study

In 1958 French workers had reported that the "rosette resistant trait" was determined by two recessive genes (Annual Report IRHO 1958). Later Berchoux (1960) confirmed this observation. Harkness (1977), while discussing the breeding and selection of groundnut varieties for resistance to rosette virus disease in Nigeria, observed that "it has been common to find some rosette appearing in resistant lines." He ascribed the low recovery of resistant plants in some F_2 crosses to the appearance of rosette symptoms in some of the double recessives following early and heavy inoculation. In support of his observations he cited Dhery and Gillier (1971), who observed that the resistance to rosette was a physiological character under genetic control, and that under conditions of heavy infestation with viruliferous aphids early in the life of the plant, reputedly resistant lines may show disease symptoms that could be temporary or permanent. He further suggested that the double recessive genotype did not confer resistance in all nuclear environments and loss of resistance from generation to generation in individuals in crossbred material could be expected.

Four crosses were selected for preliminary studies on inheritance of rosette resistance. These included two crosses where F_1 and F_2 generations were available, and two with F_2 reciprocals. Each cross was organized into a set of parents and available generations. These sets were screened for rosette resistance under glasshouse conditions (for details see Bock, these Proceedings). In each set a susceptible control, Spancross, was also included. The data obtained from each set together with Chi-square values for the F_2 ratio of 15 susceptible plants to 1 resistant are presented in Table 9.

Except in Set 1, check inoculations of the susceptible control Spancross resulted in 98-100% successful infection: in Set 1 it was only 93%. Repeated inoculations of the remaining plants proved unsuccessful. However, all susceptible parents inoculated (JL 24, Mani Pintar, Chitembana, and Chalimbana) became infected with rosette.

All the F_1 plants in crosses, RG 1 x JL 24, JL 24 x RG1, and Mani Pintar x RG 1 were susceptible. This confirms the earlier reported recessive nature of the resistance to rosette disease and also shows that at least in the case of RG 1 * JL 24 cross, reciprocal differences are not present.

In the F_2 generation there were several plants, which though susceptible to rosette, did not express

Table 9. Preliminary inheritance studies on resistance of groundnut to GRV, Chi-square tests for the 15:1 F_2 ratio of plants segregating for susceptibility vs resistance to GRV, Chitedze, Malawi, 1984/85.

Set number	Identity	Number of plants			Chi-square value	P-value
		Inoculated	Susceptible	Resistant		
I	RG I>	9	0	9	-	-
(Virginia * Spanish)	JL 24[2]	9	9	0	-	-
	(RG 1 x JL 24)F_1	8	8	0	-	-
	(JL 24 x RG 1)F_1	8	8	0	-	-
	(JL 24 x RG 1)F_2	217	207 (16)[4]	10	0.7365	0.5-0.3
	Spancross[3]	43	40	-	-	
II	RG l«	9	0	9	-	-
(Virginia * Virginia)	Mani Pintar[2]	10	10	0	-	-
	(Mani Pintar x RG I)F_1	5	5	0	-	-
	(Mani Pintar x RG 1)F_2	199	182 (39)[4]	17	1.4134	03-0.2
	Spancross[3]	53	52	-	-	-
III	RG 1[1]	10	0	10	-	-
(Virginia * Virginia)	Chitembana[2]	10	10	0	-	-
	(RG 1 x Chitembana)F_2	273	241 (49)[4]	32	13.0369	<.001
	(Chitembana x RG 1)F_2	308	284 (10)[4]	24	1.0008	0.5-0.3
	Spancross[3]	51	51	-	-	-
IV	RG V	7	0	7	-	-
(Virginia x Virginia)	Chalimbana[2]	10	10	0	-	-
	(RG 1 x Chalimbana)F_2	129	121	8	0.0256	0.9-0.8
	Spancross[3]	69	68	-	-	-

1. Resistant parent.
2. Susceptible parent.
3. Susceptible control in each set.
4. Number of susceptible plants with suppressed or atypical symptoms.

typical symptoms. Such plants were pooled with the normal susceptible plant category. All the apparently resistant plants that remained symptomless in the F_2 generation were further checked for symptomless systemic infection by grafting. All these plants were found to be free of rosette virus.

The F_2 data were subjected to Chi-square analysis for testing the genetic hypothesis of segregation of the 15 susceptible to 1 resistant plant, after making Yate's correction for continuity (Yates 1934). The Chi-square fit for a 15:1 F_2 ratio was good in all cases except for the cross RG1 x Chitembana, where there was an excess of resistant plants. Even after pooling the two reciprocals, the Chi-square value was too high, 10.818 ($P < 0.001$). The heterogeneity Chi-square was high, 3.219, but not significant ($0.10 > P > 0.05$).

From the preliminary studies it is evident that the resistance to rosette disease is recessive in nature and is governed by two recessive genes. Even in the Spanish * Virginia combination (JL 24 x RG 1) this hypothesis holds true.

A detailed investigation is being carried out this year involving F, and F_2 reciprocals and their backcross generations to confirm these results in different botanical backgrounds.

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Discussion on Regional Program Papers

Doto: The research done by the ICRISAT Regional Program is indeed commendable and must, therefore, be encouraged. Do Bock and Nigam feel that rosette (GRV) screening methodology (primary infection simulation) is now ready for general use by breeders?

Nigam: As indicated by Bock in his presentation, we achieved 90% incidence in our rosette disease nursery last season. So far this season, incidence is up to 60%, but should we encounter a couple of dry weeks it is likely to increase further. Success of field screening may be dependent on weather conditions: heavy rain may affect rate of spread adversely. We will be in a better position to comment after one or more seasons. Meanwhile the important thing is to reduce as much as possible the number of plants in the F_2 crosses so that subsequent screening is that much less of a task.

Reuben: We note in the rosette-resistance inheritance study that the trait is double recessive. In the reciprocal cross you report differences in the significance of the Chi-square test. How is this explained?

Nigam: Table 9 indicates that all F,s were susceptible, including reciprocals. This suggests that resistance is recessive. The Chi-square fit for the 15:1 F_2 ratio of susceptible to resistant plants was good in all cases except one, where there was an excess of resistant plants. The material we used was not meant specifically for inheritance studies: therefore the individual F_1 plant identity was not checked in the F_2s and it is possible that one of the plants could have been a self. The results give general support to the hypothesis that rosette resistance is governed by a double recessive. We have a detailed inheritance study in progress this season and we hope to reconfirm our observations.

Sandhu: Could the high yield potential of the Valencia lines mentioned in Table 4 in fact be exploited in some areas of southern Africa because of their shorter maturity, red testa color, and smaller seed size?

Nigam: Some of these Valencia types take 120-125 days to mature. At Chitedze we have not had any problems with them during harvesting, and even sprouting has not been encountered. They could be highly suitable for areas where the growing season is shorter. In the light of the chronic shortage of oil in many countries in our region, seed color and size should not matter. There already is the beginning of change in the thinking of some of the national programs along these lines.

Kannaiyan: Have there been any serious outbreaks of rosette disease in eastern and southern Africa recently? In view of the great losses caused by the leaf spots in our region, foliar disease should perhaps be afforded a higher priority for research than rosette.

Bock: Rosette epidemics occur sporadically and at present we are experiencing low levels of disease. It is certain that major epidemics will occur periodically and it is also certain that their effect will be devastating. The 1975 Nigerian epidemic destroyed 0.8 million ha and resulted in great hardship; recovery is not yet complete and this year they are experiencing another rosette crisis. Rosette was one of the main contributory factors in the abandonment of the Tanzanian groundnut scheme in the early 1950s, and in our region losses were substantial in 1982/83. I do not think it would be responsible of us to minimize a major potential threat, and rosette remains one of our two priority areas. The other is early leaf spot. We direct a great deal of effort into our search for tolerance or resistance but, as is well known, the world has yet to identify ELS resistance that can be exploited and that will withstand the very high infection pressures encountered in southern Africa.

Rao: Do you have any information on the percentage of viruliferous aphids at the beginning, middle, and end of the season? Why does rosette occur erratically? Are there any areas in Malawi where rosette is endemic and severe?

Bock: We have no information on the percentage of viruliferous aphids because rosette virus detection techniques have not yet been developed. We do not know why rosette occurs sporadically, but are at present directing research towards this problem. There are no areas in Malawi where rosette is endemic but there is one area, the Phalombe Plain, where in epidemic years incidence is particularly high. For this reason, the rosette-resistant variety RG 1 is officially recommended for the area. The seasonal origins of rosette and factors determining incidence are not known.

The Role of Wild Species in the Improvement of the Cultivated Groundnut (Arachis hypogaea L.)

R. W. Gibbons*

Abstract

The genus Arachis is native to South America, and consists of 22 described and possibly more than 40 undescribed species. Collections are maintained in Brazil, the USA, and India. Many of the species accessions have been screened for useful characters. Immunity, or high levels of resistance, exist in the genus to rust, leaf spots, viruses, and some insect pests. To utilize these species in breeding programs to improve the cultivated groundnut, has necessitated much basic study on the cytogenetic relationships of the species and the cultivated groundnut. ICRISAT is currently using diploid species of section Arachis, which are cross compatible with the tetraploid cultivated groundnut, to transfer useful genes through interspecific hybridization by various routes. Currently stable, tetraploid, interspecific hybrids with resistance to rust and the late leaf spot are showing high yield potential. Species in other sections of the genus that will not normally cross with the cultivated groundnut are being exploited through hormone treatments and embryo-rescue techniques.

Sumario

A importancia de especies selvagens no melhoramento do amendoim cultivado (Arachis hypogaea L.). O genero Arachis e nativo da America do Sul, consistindo em 22 especies descritas e possivelmente mais de 40 especies nao descritas. Coleccoes sao mantidas no Brasil, EUA e India. Muitas das especies obtidas foram avaliadas quanto a possiveis caracteres uteis. Neste genero existe imunidade ou altos niveis de resistencia a ferrugem, manchasfoliares, viroses e alguns insectos. Para a utilizacao destas especies nos programas de melhoramento do amendoim cultivado, foi necessario muito estudo basico sobre as relacoes citogeneticas das especies selvagens e do amendoim cultivado. Currentemente, o ICRISAT esta a usar especies diploides da seccao Arachis, cujo cruzamento com o tetraploide amendoim cultivado e compativel, para transferir genes uteis atraves de hibridacao interespecifica por diversos meios. Hibridos interespecificos tetraploides, currentemente estaveis e com resistencia a ferrugem e mancha tardia estao a mostrar alto rendimento potencial. Especies de outras seccoes deste genero e que nao cruzam normalmente com o amendoim cultivado, estao sendo exploradas atraves de tecnicas de tratamentos hormonais e de salvamento de embrioes.

The cultivated groundnut, Arachis hypogaea L., is grown throughout the tropical and warm temperate regions of the world. Commercial production is largely within the limits 40°N and 40°S, and 67% of the world's total tonnage is grown in the semi-arid tropics (SAT) by small-scale farmers of limited means (Gibbons 1980). Average yields in the SAT are low, around 800 kg ha^{-1}, and do not compare well with the average yields of 2900 kg ha^{-1} from developed countries. Constraints to groundnut production in the SAT include pests and diseases, unreliable rainfall patterns, and limited agronomic inputs. Many of the SAT constraints also apply to the developed world, but there farmers are able to

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overcome them by utilizing modern farming practices and high-level inputs.

Over the last decade there has been much interest in trying to use genetic means to overcome constraints, particularly those caused by pests and diseases (Gibbons 1980). In some cases the cultivated groundnut has been found to be resistant to biotic constraints, and so can be directly utilized by conventional breeding procedures. One example is resistance to groundnut rosette virus (GRV), found in cultivated landraces occurring in the northern Ivory Coast area of West Africa (Gillier 1978). Commercially acceptable rosette-resistant cultivars have now been released in Senegal, Nigeria, and Malawi by crossing the resistant germplasm with high-yielding, but susceptible, cultivars. In other cases, only moderate levels of resistance have been located in the A. hypogaea genepool to such diseases as late leaf spot, caused by Phaeoisariopsis personata(Berk. & Curt.) v Arx. Sometimes, despite intensive searches, resistance cannot be found in the cultivated groundnut to some pests and diseases, and this has prompted researchers to screen the available wild species as alternative sources of useful genes.

The Genus Arachis

The genus Arachis (2n = 2x = 20,4n = 40) is native to South America. There are presently 22 described species, including A. hypogaea, and possibly 40 or more undescribed species (Gregory et al. 1980). Species are either annual or perennial, 3-4 foliolate, and diploid or tetraploid. Gregory et al.(1980) described the limits of distribution of the genus as east of the Andes, south of the Amazon, and north of La Plata. Further explorations are still needed to precisely delimit the exact distribution limits of individual species (Valls et al. 1985).

Gregory et al. (1980) assigned the species to seven sections based on their morphological characteristics and cross compatibility. Species within a section will generally hybridize, but hybrids between species of different sections are difficult to obtain and are sterile (Stalker 1980).

Useful Characters of the Wild Species

Several large collections of Arachis are now maintained in India, Brazil, and the USA. In India, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) maintains a collection of wild species as part of its world mandate to conserve groundnut germplasm. Collections in Brazil are maintained by the Centro Nacional de Recursos Geneticos (CENARGEN) and in the USA collections are conserved by Texas A & M University, North Carolina State University, and by United States Department of Agriculture (USDA) scientists at Oklahoma State University (Valls et al. 1985). Besides maintaining the species and conducting basic research studies, scientists at all these institutions are involved in evaluating their usefulness for genetic improvement programs.

Fungal Disease Resistance in Arachis Species

Rust

Groundnut rust, caused by Puccinia arachidis Speg., is an important disease of groundnuts in many parts of the world. Yield losses of up to 50% have been recorded and haulm yields are even more reduced (Subrahmanyam and McDonald 1983). Resistance has been recorded in A. hypogaea, mainly from Peruvian landraces, by various workers (Bromfield and Cevario 1970, Cook 1972, Subrahmanyam et al. 1980a, 1982).

The resistance in A. hypogaea is of the 'slow rusting' type where resistant genotypes have increased incubation periods, decreased infection frequency, reduced pustule size and spore production, and reduced spore viability (Subrahmanyam et al. 1983a). Resistance is governed by two or more recessive genes (Nigam et al. 1980).

Subrahmanyam et al. (1983b) screened 61 accessions of wild species, representing five sections of the genus, at ICRISAT under both field and laboratory conditions for their reaction to rust. Most were immune, six were highly resistant, and two were susceptible. Some of these results are shown in Table 1, and it is interesting to note that several species from section Arachis, which are cross-compatible with the cultivated groundnut, are immune to rust. More recent work by Singh et al. (1984) indicated that rust resistance in the wild species is governed by dominant or partially dominant genes. Thus there appears to be a possibility of combining different genes from resistant cultivated and wild species into one background, to give more effective and stable resistance.

Section, series, and species	USDA plant introduction number (PI)	1CRISAT groundnut accession number (ICG)	Rust reaction
Section: Arachis			
Series: Annuae			
A. batizocoi	298639	8124	Immune
A. duranensis	219823	8123	Immune
A. spegazzinii	262133	8138	Immune
Series: Perennes			
A. correntina	331194	4984	Immune
A. stenosperma	338280	8126	Highly resistant
A. cardenasii	262141	8216	Immune
A. chacoense	276235	4983	Immune
A. villosa	210554	8144	Immune
Section: Erectoides			
Series: Tetrafoliatae			
A. apressipila[1]		8129	Immune
A. paraguariensis[1]		8130	Immune
Section: Triseminale			
A. pusilla	338449	8131	Immune
Section: Extranervosae			
A. villosulicarpa[1]		8142	Immune
Section: Rhizomatosae			
Series: Eurhizomatosae			
A. hagenbeckii	338305	8922	Immune
A. glabrata	338261	8149	Immune

Table 1. Reaction of some wild Arachis species to Puccinia arachidis.

1. No PI number allocated because the source was not the USDA.
Source: Subrahmanyam et al. 1983.

Leaf Spots

Leaf spots, caused by Cercospora arachidicola Hori and P. personata (Berk. & Curt.) v Arx (formerly Cercosporidium personatum [Berk & Curt.] Deighton), are probably the most important fungal diseases of groundnuts on a worldwide basis (Subrahmanyam et al. 1980).

A number of A. hypogaea germplasm accessions have been found to have resistance to either C. arachidicola or P. personata in the USA. These were reviewed by McDonald et al. (1985), and are summarized in Table 2. At ICRISAT, further sources of resistance to P. personata in the cultivated groundnut have been identified (McDonald et al. 1985) and are listed in Table 3. These germplasm lines are also resistant to rust. Resistance to the leaf spots is recessive and independently inherited. Kornegay et al. (1980) stated that resistance to leaf spots was quantitatively inherited. Nevill (1982) showed that late leaf spot resistance was governed by recessive alleles at five loci. There is some evidence of variation in pathogenicity in the leaf spot fungi, but races have not been clearly characterized. Some A. hypogaea lines, for example, reported to be resistant to early leaf spot in the USA, are susceptible in Malawi (McDonald 1985, Nigam and Bock 1985).

There have been a number of reports of very high levels of resistance, or even immunity, to the leaf spot fungi in the wild species. Gibbons and Bailey (1967) reported that A. hagenbeckii and A. glabrata (section Rhizomatosae), and A. repens(section Caulorhizae) did not develop any C. arachidicola symptoms under conditions of natural infection in Malawi. Abdou et al. (1974) screened 94 accessions for resistance to both leaf spots, and reported immunity in sections Arachis, Erectoides, Rhizomatosae, and Extranervosae. In section Arachis Abdou et al. (1974) found A. chacoense was highly resistant to C. arachidicola but susceptible to P. personata,

Table 2. Some genotypes resistant to groundnut leaf spot pathogens Cercospora arachidicola and Phaeoisariopsis personata in the USA.

Resistance to C. arachidicola	Resistance to P. personata
PI 109839	PI 259747
PI 162857	PI 261893
PI 259639	PI 262090
PI 259679	PI 341879
PI 259747	PI 371521
PI 261893	
PI 270806	NC Ac 3139
PI 306230	
PI 350680	
PI 468251	
PI 468253	
PI 468293	
PI 368295	
PI 475871	
PI 476029	
PI 476034	
NC5	
NC 3033	
NC Ac 3139	
NC 3139	
Kanyoma	

Source: McDonald et al. 1985.

but in India Subrahmanyam et al. (1980b) found small, non-sporulating lesions of both fungi on A. chacoense. Foster et al. (1981) found two species of section Arachis (A. chacoense and A. stenosperma) were highly resistant to C. arachidicola. Melouk and Banks (1978) and Shariefet al. (1978) reported no lesion development when A. chacoense was inoculated with spores of C. arachidicola. Abdou et al. (1974), Sharief et al. (1978), and Subrahmanyam et al. (1985a, b) all reported A. cardenasii was immune to P. personata. Nevill (1979), in Nigeria, found no lesions of P. personata on A. stenosperma or A. cardenasii (section Arachis). More recently Subrahmanyam et al. (1985) evaluated 96 accessions of Arachis species under laboratory conditions for their reactions to P. personata. Small, non-sporulating lesions formed on all accessions of sections Erect oides, Triseminalae, Extranervosae, Rhizomatosae, and Caulorhizae. Species in section Arachis formed lesions 0.16 to 1 mm in diameter, and non-sporulating lesions were found on 15 accessions. Defoliation due to P. personata varied greatly in section Arachis. Generally, defoliation was high in this section except for a recently collected perennial accession GKSSc 30093 (0% defoliation) and A. correntina (5% defoliation). In section Rhizomatosae over 60% of the accessions tested showed no defoliation at all.

Although the wild species appear to be valuable sources of resistance to the leaf spots there appear to be some differences in disease reaction of the various species. Subrahmanyam et al. (1985b) discussed a number of possible reasons for these discrepancies, including possible variation in the pathogen; host, pathogen, and environment interaction; preinoculation environment; incorrect identification of, or variation within the host species; and variation in methods of evaluation and interpretation of results.

Table 3. Groundnut genotypes resistant to Phaeoisariopsis personata available from ICRISAT in 1985.[1]

Groundnut genotypes	ICG no.[2]	Botanical type/ variety	Country of origin
EC 76446 (292)	2716	fastigiata	Uganda
USA 63	3527	fastigiata	USA
PI 259747	4747	fastigiata	Peru
PI 350680	6340	fastigiata	Honduras
NC Ac 17133-RF	7013	fastigiata	Peru
PI 215696	7881	fastigiata	Peru
PI 351879	7884	fastigiata	Peru
PI 381622	7885	fastigiata	Peru
PI 390595	7887	fastigiata	Peru
PI 405132	7897	fastigiata	Peru

1. Also resistant to Puccinia arachidis at ICRISAT.
2. ICRISAT Groundnut Accession number.
Source: McDonald et al. 1985.

Virus Resistance in Arachis Species

Peanut Mottle Virus

Peanut mottle virus (PMV) is a seedborne virus of worldwide distribution, often overlooked because of the wild symptoms produced. At ICR1SAT screening of the A. hypogaea germplasm collection has located accessions with tolerance to PMV, and others that do not transmit the virus through the seed (ICR1SAT 1985).

The wild species appear to be better sources of resistance to PMV. Demski and Sowell (1981) reported that six wild rhizomatous species, probably all accessions of A. glabrata, were not infected by mechanical or aphid inoculation, or in the field under natural high disease pressure. Fifty wild species accessions were screened at ICRISAT under greenhouse conditions using mechanical inoculation techniques (Subrahmanyam et al. 1985a). All were infected except three species in section Arachis (A. cardenasii, A. chacoense, and A. correntina), and one species in section Triseminale (A. pusilla).

After repeated grafting of PMV infected scions onto the wild species, accessions A. chacoense and A. pusilla still remained free from infection. They did not act as symptomless carriers of the virus as this was checked by assays on a known host, Phaseolus vulgaris (cv Topcrop), and by a serological technique known as the enzyme-linked immunosorbent assay (ELISA).

Tomato Spotted Wilt Virus

Bud necrosis disease (BND) is a serious problem in India; it is caused by tomato spotted wilt virus (TSWV) and the vectors are species of thrips (Ghanekar 1980). The main vector is Frankliniella schultzei and the minor vector is Scirtothrips dorsalis (Amin and Mohammad 1980). No known sources of genetic resistance to the virus occur in the cultivated groundnut, although some A. hypogaea cultivars are less affected in the field than others, and others have resistance to the vector (ICRISAT 1985).

Forty-two wild species accessions were screened at ICRISAT for resistance to TS WV by mechanical and Frankliniella schultzei inoculation. Only A. chacoense remained free from infection by TSWV after indexing on P. vulgaris and by ELISA tests. When a massive dose of the virus was introduced during grafting tests the virus could be detected in A. chacoense. However A. chacoense always remained free from the disease under field conditions where the disease incidence was high. Two other accessions of the species, A. correntina and A. cardenasii, although infected by mechanical and thrips inoculation, also showed no infection under field conditions over several seasons. Useful resistance genes may therefore be present in the wild species, particularly in A. chacoense, to combine with less susceptible and thrips-resistant accessions of A. hypogaea.

Peanut Stunt Virus

Peanut stunt virus (PSV) has been reported from the US A and Herbert and Stalker (1981) tested 90 accessions of Arachis species for resistance by mechanical and graft inoculations. Forty-eight accessions representing four sections of the genus were rated as highly resistant, and this was also confirmed by field tests.

Insect Resistance in Arachis Species

Thrips

Several species of thrips are pests of groundnuts, but they are most important when they act as vectors of TSWV (see previous section). At ICRISAT, Amin (1985) studied the fecundity and survival of S. dorsalis and F. schultzei on Arachis species and concluded that most wild species were more resistant than cultivars of A. hypogaea. Stalker and Campbell (1983) screened wild species against F.fusca and found 17 accessions were completely free from injury symptoms. They included A. batizocoi and A. villosa (section Arachis), A. pusilla (section Triseminale), A. paraguariensis (section Erectoides), and A. repens (section Caulorhizae).

Aphids

Amin (1985) reported low levels of fecundity and survival of Aphis craccivora on wild species accessions, in comparison to accessions of A. hypogaea where the pest survived and multiplied rapidly. Two species in section Arachis {A. chacoense and A. villosa) and one in section Rhizomatosae exhibited high levels of resistance to A. craccivora.

Jassids

In view of the large number of A. hypogaea accessions that exhibit resistance to Empoasca sp there is little need to exploit the wild species unless it is shown that different resistance mechanisms apply, according to Amin (1985). Stalker and Campbell (1983) did report, however, that 21 accessions were free from jassid injury when they screened a collection of Arachis species accessions. Four accessions were from section Arachis (A. cardenasii, A. duranensis, A. correntina, and A. villosa).

Lepidopterous Larvae

Lynch et al. (1981) evaluated 14 Arachis species in the USA for resistance to the armyworm, Spodoptera frugiperda, by using a 'host suitability index (HAI)'. A. villosa (section Arachis) and A. burkartii (section Rhiomatosae) were shown to be totally unsuitable as hosts to S. frugiperda because the larvae did not show any development on them at all. Other species had low host-suitability indices.

Stalker and Campbell (1983) also exposed Arachis collections to feeding tests by Heliothis zea in the USA. Most of the 53 accessions showed less damage than the A. hypogaea check cultivar, Florigiant. On A. villosa, A. correntina, A. chacoense, and A. stenosperma (all section Arachis) leaf damage ranged from 0.5 to 1.6% compared to 37% in A. hypogaea.

Other Traits

Smartt and Stalker (1982), in a review article, considered that wild species may also be useful in improving the protein and oil composition of the cultivated groundnut. This was based on preliminary studies by Cherry (1977) and Amaya et al. (1977).

Stalker (1985) reported that preliminary investigations at North Carolina State University, USA, indicate that high levels of resistance to Cylindrocladium crotalariae and Sclerotium rolfsii may be present in Arachis species. Banks (1969) and Castillo et al. (1973) have also screened wild species for resistance to nematodes with some success. Indications are that accessions of the Rhizomatosae are possible sources of resistance to Meloidogyne hapla.

Very little research has been conducted so far on the potential utilization of wild Arachis species for yield improvement in the cultivated groundnut, but recently Soumano (1986) has shown very high levels of heterosis in F,s of crosses between tetraploid interspecific derivatives and A. hypogaea cultivars. Much more research on these aspects is required.

Breeding Strategies for the Utilization of Wild Species at ICRISAT

A large number of wild species accessions have been established in collections and evaluated for their desirable traits. The pioneering work of Gregory and Gregory (1979) on crossability made the utilization of wild species a distinct possibility. In 1978, ICRISAT started an extensive program of interspecific hybridization with the objective of transferring disease and pest resistance to cultivated groundnut (Singh et al. 1980). Two strategies were adopted: one to utilize resistant compatible diploid species from section Arachis, and the other to try and utilize species from the other sections of the genus not compatible with A. hypogaea.

Compatible Species

Studies on genome relationships in section Arachis have led to the identification of two genomes, A and B, in the diploid species, and there is evidence that the cultivated groundnut is an amphiploid (AABB) involving these two genomes (Singh and Moss 1982). These studies have led to the identification of appropriate routes for the introgression of useful genes from section Arachis diploids (Singh 1985). Eight diploid species from section Arachis have been used in the ICRISAT program, along with a range of cultivars representing the botanical groups of A. hypogaea (Singh and Moss 1982, 1984). Many of these species have resistance to leaf spots or rust.

1. Introgression through Amphiploids (Hexaploids)

This has been the most common method used by many workers (Singh 1985). Wild diploids are crossed with cultivated tetraploids, and the triploid hybrid, which is usually sterile, is colchicine treated to produce fertile hexaploids. These hexaploids are backcrossed several times to cultivated groundnuts and selection pressure is applied for the desired characters. At ICRISAT the characters selected are disease resistance and agronomically desirable traits such as high yield and commercially acceptable pod and seed characters. Many stable tetraploid lines have now been developed with late leaf spot or rust resistance, or with resistance to both pathogens. Several of these interspecific derivatives are now in the varietal testing system of the All India Coordinated Research Project on Oilseeds (AICORPO). At ICRIS AT Center pod yields of these derivatives often exceed 3500 kg ha^{-1}, and because of their resistance to foliar diseases haulm yields can exceed 6500 kg ha-' (Moss 1985).

2. Introgression through Triploids

Normally triploids, resulting from crosses between diploid species and cultivated tetraploid, have been sterile. At ICRISAT some fertility in these triploids was found across all combinations produced. Cytological analyses of triploids revealed interspecific and intergenomic pairing between chromosomes of wild and cultivated species. Singh (1985) suspects that environmental conditions play a major role in determining fertility in triploids by the production of restitution nuclei and unreduced gametes, which occur due to the production of haploid to hyperdiploid gametes following spindle breakdown. Triploids produced and maintained at Reading University were sterile, but cuttings from these plants established at ICRISAT consistently produced viable seed. Singh (1985) observed that many triploid progenies have fewer chromosomes than hexaploids, and some are tetraploid, which has reduced the number of backcrosses needed for the production of tetraploid derivatives at ICRISAT.

3. Introgression through Amphiploids (Tetraploids)

Singh and Moss (1984) suggested that the maximum genetic exchange between chromosomes of wild and cultivated species can be achieved when two wild diploid species, with AA and BB genomes, are crossed, the chromosomme number doubled, and the resultant AABB amphiploid crossed with the cultivated groundnut to produce a fertile hybrid. Singh (1985) reports that this method has been effective for transferring rust resistance from wild diploids to A. hypogaea.

4. Introgression through Autotetraploids

Another system is to double the chromosomes of wild diploids and cross the resulting autotetraploids with A. hypogaea. Singh (1985) found differences in pollen and pod fertility between the autotetraploids of section Arachis. Crossabilities between A. hypogaea and the autotetraploids of section Arachis do not differ, but the fertility of the resulting first generation hybrids does differ. Autotetraploids have been backcrossed to A. hypogaea and some have produced A. hypogaea-like tetraploids within two backcross generations.

Incompatible Species

Most of the wild species outside section Arachis are not cross-compatible with the cultivated groundnut, and many of the sections of the genus are isolated from each other. However, many of the species have desirable traits unavailable in section Arachis. Section Rhizomatosae is known to have resistance or immunity to viruses, nematodes, and other pests (Subrahmanyam et al. 1985a, Amin 1985). Mallikarjuna and Sastri (1985a, 1985b) have reviewed and investigated the reasons for incompatibility and have devised methods to try and overcome them, including hormone treatments and culturing of ovules and embryos. Very promising initial results have been obtained from crosses of section Rhizomatosae and cultivated groundnuts using these techniques. This indicates the possibility of utilizing genes from other species in the improvement of A. hypogaea in the not too distant future.

Future Research

In India ICRISAT will intensify research on constraints other than rust or late leaf spot. The screening for other constraints is well underway and the techniques already being applied for the foliar diseases will be utilized or adapted as required. Breeding for insect pest and virus resistance are high-priority research areas. There will be more emphasis on the utilization of wide crosses and embryo rescue techniques in order to tap useful genes from other sections of the genus.

In Africa more research is planned on finding and utilizing resistance to the early leaf spot (C. arachidicola). Wild species from section Arachis will be initially screened in Malawi, as variation in the pathogen may prevent the research being done in India. Also, because the predominant leaf spot pathogen in India is P. per sonata, field screening for C. arachidicola resistance becomes difficult. Therefore the ICRISAT cytogeneticists will cooperate with the ICRISAT Malawi staff and screen species for resistance in Africa. Using the appropriate cytogenetic techniques and routes, selection pressure for C. arachidicola resistance will be applied in Africa on progenies developed there.

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Discussion on the Role of Wild Species in Groundnut Improvement

Nigam: My comment refers to tolerance to early leaf spot referred to by Cole. We have lines in the lCRISAT Cooperative Regional Yield Trial (ICGMS 30 is a good example) that retain more foliage for a longer time than control varieties. Onset of disease and subsequent development is slower by 2 weeks, and, in some lines, this character seems to be associated with high yield. My question to Gibbons is, do we have any information on length of hypocotyl of catenate types as this character might be an important survival mechanism.

Gibbons: No definite information is available, but in view of the length of peg in some of the wild species, I think it is.

Hildebrand: I have recorded hypocotyls as long as 35 cm in some cultivated types after deep burial of the seed.

Rao: How far have we gone with breeding to develop cultivars with multiple resistance to major pests and diseases?

Gibbons: We have gone some way towards this objective. We have breeding lines with combined resistance to rust, late leaf spot, mid-season drought, and some insect pests. Cultivated germplasm and wild species have been found with multiple resistance but often they are in a low-yield potential background. How many of these resistances can be transferred simultaneously into a high-yielding background is not yet known. In future I think that at least we can incorporate a few resistances to major constraints into one cultivar suitable for specific environments.

Syamasonta: When wild species are crossed with cultivated groundnut there is a high possibility of getting sterile seeds in the F,. How do you overcome this problem?

Gibbons: At present with 'incompatible' crosses we use hormone treatments at hybridization and then use embryo rescue techniques and grow them in vitro on suitable media.

Syamasonta: Are induced mutations used on wild species at ICRISAT Center? What are the results?

Gibbons: We have not used induced mutations in our wild species work. In future we will have a radiation source and will use irradiated pollen. In general, mutation breeding in cultivated groundnuts has not been very successful. I think we can generate enough variability from wide crosses by conventional means.

Reuben: Are you employing the embryo-culture technique to rescue the embryo where there are problems of abortion due to incompatibility?

Gibbons: Yes, we are doing a great deal on that and anyone interested in further details should ask the Regional Program, Malawi, for the recent ICRISAT publication, "Cytogenetics of Arachis ".

Cole: Why do you think Cercospora arachidicola resistant lines have variable performance in different growing regions of the world?

Gibbons: Possibly strains, or mixtures of strains, are coupled with environmental effects.

Recent Developments in Groundnut Improvement in Zambia

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Abstract

Groundnuts in Zambia are grown traditionally by small-scale farmers. Total groundnut production in the country has increased from 9372 t in 1982 to 14517 t in 1985, while the officially marketed production declined from 2739 t in 1979 to 1156 t in 1984, indicating demand outstripping supply.

The broad goals and specific objectives of the groundnut program are stated and zonal needs identified. A short-season Spanish type has been released and another is ready for release. A few long-season introductions/selections are under advanced testing and a line suitable for valley conditions identified.

Sumario

Recentes avancos no melhoramento do amendoim na Zambia. Na Zambia o amendoim e tradicionalmente cultivado por pequenos agricultores. A producao total de amendoim no pais aumentou de 9.372 t em 1982 para 14.517 tern 1985, enquanto que a producao oficialmente comercializada reduziu de 2.739 t em 1979para 1.156 t em 1984 indicando que a procura excede a oferta.

Os objectivos gerais e especificos do programa do amendoim sao apresentados e as necessidades de cada zona identificadas. Uma variedade de ciclo cur to, do tipo Spanish, foi autorizada para distribuicao e outra esta pronta para ser distribuida. Algumas introducoes/seleccoes de ciclo longo estao sendo submetidas a testes avancados e uma linha adaptada para condicoes de vale foi identificada.

Groundnuts are traditionally grown by small-scale farmers in Zambia. Both long- and short-season groundnut types contribute to production. The long-season Virginia types, which mature in 140 to 170 days, are grown in medium and high rainfall areas (900-1525 mm), mainly in the Eastern and Central Provinces, accounting for about 90% of the total groundnut crop. The short-season Spanish types, maturing in 110 to 120 days are restricted to the low-rainfall regions (below 900 mm) of the south and west, producing about 10% of the crop.

The total national groundnut production recorded a significant increase from 9372 t in 1982 to 14517 t in 1985. The marketed production through official channels during the same period declined, as most of the groundnut crop is sold through the more lucrative informal market.

Although information on the number of farmers engaged in groundnut production at the national level is not available, in the Eastern Province the number increased from 20 187 in 1981 to 39840 in 1984. Since 1983 the area under groundnuts has stabilized at over 30000 ha. Yields have averaged 480 kg ha^{-1}, though this was lower during the 1983/84 season, due to drought.

Confectionery nuts make up the bulk of produc-

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tion and consumption in the country. The Eastern Province alone produces and markets 75-90% of officially marketed groundnuts, which are all of the confectionery type. Of late, however, domestic consumption has taken an increasing share of production, leaving little or none for export.

Pricing policy has varied over the years, reflecting concern for encouraging production of confectionery nuts on one hand and for stimulating production to meet domestic oil needs on the other. More recently, price support has been maintained at a level to sustain producer confidence. Since 1981, there has been more than a three-fold increase in prices.

A review of research work carried out in Zambia prior to 1981 was presented at the First Regional Workshop on Groundnut Research and Improvement in Southern Africa (Sandhu et al. 1984). Work done subsequently is briefly discussed in this paper.

Varietal Improvement Program

The broad goal of the groundnut improvement program is to produce high-yielding stable groundnut varieties that are adapted to the needs of small-scale farmers across the various agroclimatic zones of Zambia. The specific zonal conditions identified are:

1. The major groundnut producing areas of the Eastern and Central Plateau receiving medium rainfall (Virginia types);
2. Light textured soils of the southern and western regions receiving scanty rains within a short-growing period (Spanish types);
3. Acid leached soils in the high rainfall areas of the north and north-west ("pops"-tolerant Virginia types); and
4. Valley areas having typically high temperatures and a comparatively shorter season (early-maturing Virginia types).

The specific objectives of the breeding program are:

1. To develop high-yielding groundnut varieties with acceptable kernel qualities;
2. To develop early-maturing varieties to suit specific agroecological conditions;
3. To develop varieties that are resistant/ tolerant to major diseases (leaf spots, rust, and rosette), drought, and "pops";
4. To undertake germplasm collection and evaluation; and
5. To assist the seed agency in the production and multiplication of approved groundnut varieties.

Variety Testing

In view of the importance of long-season confectionery nuts in the country, high-priority has been given to finding a suitable improvement on the presently grown large-seeded variety, Chalimbana. This variety lacks high-yield potential, has non-uniform pods, and is susceptible to leaf spots, rust, and "pops" condition. A few selected lines from traditionally-grown local landraces and some promising introductions were tested in advanced groundnut variety trials across three environments during the past two seasons. The results are presented in Table 1.

Although most of the selected lines recorded marginal increases over the yield of Chalimbana (J 196 kg ha^{-1}), only one entry, M 13, excelled by significant margins of 24% at Masumba and 43% at Msekera. Significant location * year interaction was indicated at the third site at Mufulira. Entry M 13 is characterized by being,a week earlier in maturity than the control variety and gives better shelling (70-74%), but has smaller kernel size (124-142 kernels 100 g^{-1}). The predominantly three-seeded local selection MGS 1 gave inferior yields. The entry M 13 needs a year or more of testing before it could be considered for release. The trial has been repeated at four sites during the 1985/86 season.

The oil-yielding, long-season variety Makulu Red, although potentially a high-yielder, has never been popular as a source of food protein in Zambian diet due to an unattractive kernel flavor, testa color, and seed appearance. It is also highly susceptible to "pops" condition on acid-leached soils in high rainfall areas. To replace this variety, a few releases and fixed lines from Zimbabwe along with some promising accessions, were evaluated in advanced variety trials across four environments for the past two seasons. The results are summarized in Table 2.

Three entries, 4a/8/2, Apollo, and Egret, recorded nonsignificant mean yield increases of 2 to 5% over that produced by variety Makulu Red (1485 kg/ ha^{-1}). All of them have superior kernel characteristics. Both Copperbelt Runner ("pops" tolerant) and Robut 33-1 (early-maturing) yielded poorly and were highly susceptible to leaf spots. A significant variety x location interaction was obtained. The larger-seeded entry, 4a/8/2, was first in yield at both Msekera and Chisamba. Early-maturing Sigaro

Table 1. Yield data, Advanced Groundnut Variety Trial (lons-season confectionery), Zambia, 1983/84 and 1984/85.

Variety	Kernel yield (kg ha^{-1}) Variety x location			Variety x Year		Variety mean
	Msekera	Masumba	Mufulira	1983/84	1984/85	
M 13	1622	1991	712	1374	1509	1442
Ch 82/178	1309	1730	860	1211	1388	1300
Ch 148/80	1 119	1737	1005	1 180	1393	1287
Ch 147/80	1220	1628	938	1 194	1330	1262
Ch 21/80	1261	1545	816	1 152	1263	1207
Ch82/174	1170	1628	822	1 138	1276	1207
Chalimbana (C)	1 134	1606	850	1 169	1223	1 196
MGS 1	I 115	1471	705	1032	1 161	1097
Grand Mean	1244	1667	838	1 181	1318	1251
SE		±89.16		±72.80		±51.47
c v %		-		-		10.23

Table 2. Yield data, Advanced Groundnut Variety Trial (long-season), Zambia, 1983/84 and 1984/85.

Variety	Kernel yield (kg ha^{-1}) Variety * location				Variety * Year		Variety mean
	Msekera	Masumba	Chisamba	Mufulira	1983/84	1984/85	
Egret	2092	2051	1270	802	1293	1815	1554
Apollo	2062	1939	1245	806	1290	1735	1513
4a/8/2	2175	1781	1304	774	1 199	1818	1508
Makulu Red (C)	2159	1875	1150	755	1 166	1803	1485
Sigaro Pink (35)	1942	2170	1 126	642	1247	1693	1470
Makulu Pink	2070	1892	1220	693	1296	1642	1469
Copperbelt Runner	1215	1693	963	640	994	1262	1 128
Robut 33-1	1265	1634	896	491	1 127	1016	1071
Grand mean	1872	1879	1 146	700	1201	1598	1400
SE		±89.16			±67.10		±47.45
c v %					-		9.59

Pink (35) excelled in the Luangwa Valley at Masumba recording 16% higher yield (significant at 0.05) than the control variety. The variety * year interaction was also significant. During 1983/84 (a drought year) yields were generally depressed except in the entry Robut 33-1 due to its very early maturity. Since varieties Egret and Apollo (Zimbabwe) are both protected by Breeders Rights, the case for release of the other two entries, 4a/8/2 and Sigaro Pink (35), will be considered after a year or more of further testing.

The short-season Spanish bunch variety, Natal Common, is grown in the light-textured soils of the Southern and Western Provinces where the growing period is short. It matures in about 110 days but is highly susceptible to leaf spots and has nondormant, flat-ended small kernels. To identify a suitable replacement, a series of advanced variety trials were conducted at four sites for the past three seasons. The trial entries included some introductions with larger kernels. The results are given in Table 3.

Two entries, Comet and Tifspan, both from USA, recorded significant mean yield increases of 9 and 10% respectively over that of the variety Natal Common (849 kg ha^{-1}). All entries with larger seed size were inferior in yield. Based on results obtained from trials conducted earlier, the highest-yielding entry, Comet, which had round-ended seeds, was

Table 3. Yield data, Advanced Groundnut Variety Trial (short-season), Zambia, 1982/83-1984/85

	Kernel yield (kg ha^{-1})							
	Variety x location				Variety x year			Variety
Variety	Magoye	Maochipapa	Siatwinda	Kaoma	1982/83	1983/84	1984/85	Mean
Tifspan	1297	834	699	920	846	1075	893	938
Comet	1253	891	708	863	834	1094	858	929
Natal Common (C)	1227	698	670	798	699	1046	801	849
Sellie	1237	740	595	815	664	1083	793	847
Jacana	1118	732	584	803	645	963	819	809
Plover	1 122	706	576	785	614	1018	761	797
636/73	1213	703	582	684	689	953	744	795
Grand mean	1213	767	634	821	725	1043	807	858
SE		±54.15				±46.90		±27.08
c v %		-				-		10.92

released in October, 1984, while Tifspan is also under consideration for release. The trial with some additions and deletions is being grown at five sites this season (1985/86).

Two years of testing at two sites (Msekera and Chisamba) of 14 long-season entries from the ICRISAT Regional Groundnut Program for Southern Africa, Lilongwe (Table 4), has indicated that two entries, ICGMS 36 and ICGMS 42, gave only marginal increases (up to 2%) over the yield of Makulu Red control, even though significant increases of 52% and 50%, respectively, were recorded against the yield of the Chalimbana control. Both entries recorded higher-shelling percentage and larger ker-

Table 4. Yield data, ICRISAT Southern Africa Regional Groundnut Variety Trial (long-season), Zambia, 1983/84 and 1984/85.

	Kernel yield (kg ha')				
	Variety x location		Variety x year		Variety
Variety	Msekera	Chisamba	1983/84	1984/85	mean
ICGMS 36	1827	1268	1248	1847	1547
ICGMS 42	1773	1274	1307	1740	1523
Makulu Red (C)	1898	1 139	1091	1946	1518
ICGMS 47	1554	1036	1 188	1403	1295
ICGMS 43	1313	1 187	1126	1374	1250
ICGMS 35	1368	1 111	1 179	1299	1239
ICGMS 48	1350	1097	1071	1376	1223
ICGMS 45	1501	925	958	1468	1213
ICGMS 38	1272	1 136	964	1444	1204
ICGMS 39	1367	1035	1 104	1298	1201
Chalimbana (C)	1351	682	939	1098	1018
ICGMS 37	950	914	817	1046	932
ICGMS 44	977	843	823	996	910
ICGMS 46	910	886	778	1018	898
ICGMS 41	1039	741	715	1066	890
ICGMS 40	770	894	674	990	832
Grand mean	1326	1010	999	1338	1168
SE	±133.35		±133.25		±94.29
CV (%)			-		16.14

nel size than Makulu Red. The trial has been repeated at the two locations during the current season.

In a second series of trials comprising 34 short-season entries from the ICRISAT Regional Groundnut Program for Southern Africa conducted at two sites for the past two seasons (Table 5), one entry, ICGMS 11, exceeded the yield of control varieties Natal Common and Comet by significant margins of 24.7 and 18.1%, respectively. Two more

Table 5. Yield data, ICRISAT Southern Africa Regional Groundnut Variety Trial (short-season), Zambia, 1983/84 and 1984/85.

	Kernel yield (kg ha^{-1})				
	Variety x location		Variety x year		Variety
Variety	Msekera	Magoye	1983/84	1984/85	mean
ICGMS 11	2548	1801	2009	2340	2175
1CGMS 5	2562	1541	1974	2129	2051
ICGMS 2	2413	1669	1959	2123	2041
ICGMS 15	2206	1692	1867	2031	1949
ICGMS 12	2298	1552	1692	2157	1925
ICGMS 21	1954	1832	1986	1800	1893
ICGMS 22	2083	1683	1840	1926	1883
ICGMS 27	2148	1609	1952	1805	1878
ICGMS 10	2138	1566	1759	1945	1852
ICGMS 17	2197	1504	1814	1887	1850
Comet (C)	2087	1598	1830	1855	1842
ICGMS 30	2425	1256	1799	1882	1841
ICGMS 20	2181	1498	1747	1932	1839
ICGMS 9	2 184	1420	1870	1733	1802
ICGMS 32	2109	1457	1731	1835	1783
ICGMS 7	2131	1401	1654	1878	1766
ICGMS 19	1979	1509	1682	1806	1744
Natal Common (C)	2089	1399	1649	1839	1744
ICGMS 18	2329	1 151	1466	2014	1740
ICGMS 26	1937	1480	1768	1650	1709
ICGMS 34	2030	1387	1639	1778	1708
ICGMS 14	1851	1550	1760	1642	1701
ICGMS 23	2 145	1254	1610	1788	1699
ICGMS 13	1893	1489	1742	1640	1691
ICGMS 3	1853	1511	1794	1570	1682
ICGMS 33	1858	1483	1850	1491	1670
ICGMS 31	1957	1372	1371	1958	1664
ICGMS 28	1997	1327	1654	1671	1662
ICGMS 4	2030	1 191	1416	1814	1615
ICGMS 1	1923	1294	1606	1611	1608
ICGMS 16	1753	1447	1475	1725	1600
ICGMS 24	1722	1365	1312	1775	1544
ICGMS 25	1800	1274	1435	1639	1537
ICGMS 29	1731	1318	1775	1274	1524
ICGMS 6	1866	1 177	1494	1549	1521
ICGMS 8	1966	922	1264	1824	1444
Grand Mean	2066	1444	1701	1809	1755
SE	±156.25		±156.25		±110.48
CV%			-		12.58

entries, ICG MS 21 gave the best yield at Magoye. Seed size in both ICGMS 11 and ICGMS 5 is larger than that of the control varieties. The trial has been repeated during the current season at Magoye although Msekera has been replaced by Masumba, which is a more representative site.

Hybridization and Selection

As a long-term measure, planned crosses have been made since 1982 to develop groundnut genotypes with high yield potential, acceptable pod and kernel characteristics, and resistance to important diseases. About 150 combinations have been attempted so far. From among the 21 cross bulks received from ICRISAT Center, India, and ICRISAT Regional Groundnut Program, Malawi, 61 promising selected lines have been entered in preliminary yield evaluation trials during the 1985/86 season. Single-seed descent methods of selection (Brim 1966) have been followed. Seeds of 66 F_2 to F_4 population bulks have also been grown for advancement of generation prior to selection.

Germplasm

More than 1000 accessions collected from local and exotic sources have been maintained in observation rows at Msekera and evaluated across seasons in respect of important plant and seed characteristics, and reaction to diseases. The germplasm has been serving as a useful source of donor genes for the breeding program. A few high-yielding genotypes have been found to be of direct use. It is intended to broaden the genetic base through further acquisition of elite materials from pertinent regions of the world.

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Recent Developments in Groundnut Pathology Research in Zambia

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Abstract

Leaf spots, a major constraint limiting groundnut production, are given top priority in resistance screening and chemical control. A leaf-spot tolerant and rust-resistant accession, ICG 7888, was identified and is being used in the breeding program. As a short-term control measure for leaf-spot and rust, an economically suitable fungicide, Labilite® (thiophanatemethyl 20% + maneb 50%), is being recommended. Results of research on rust, rosette, aflaroot and aflatoxin are also discussed.

Groundnut is an important cash and food crop grown traditionally by small-scale farmers in Zambia. Diseases are a major constraint to production. Fortunately, most of the diseases are of minor importance and occur sporadically. Leaf spots, rust, rosette, aflaroot, and aflatoxin are of some economic value in Zambia. The groundnut pathology work carried out during the 1983/84-1984/85 seasons on leaf spots and rust resistance screening and their chemical control are briefly discussed in this paper, with some aspects of other potentially important diseases.

Sumario

Recentes avancos na investigacao) da patologia do amendoim na Zambia. Nos testes para a deteccao de resistencia e controlo quimico, primeira prioridadefoi dada as manchas foliares, uma das maiores limitantes na producao de amendoim. Uma aquisicao tolerante as manchas foliares e resistente a ferrugem, ICG 7888, foi identificada e esta a ser utilizada no programa de melhoramento. A curto prazo e como medida de controlo das manchas foliares e da ferrugem, umfungicida economicamente adaptado, Labilite@ (thiophanatemethyl 20% + maneb 50%), est a a ser recomendado. Osresultados da investigacao sobre ferrugem, roseta, aflaroot e aflatoxina sao tambem discutidos.

O amendoim e uma importante cultura comercial e alimentar tradicionalmente cultivada na Zambia por pequenos agricultores. Doencas sao a maior limitante para a sua producao. Afortunadamente, grande parte das doencas sao de menor importancia, ocorrendo esporadicamente. Manchas foliares, ferrugem, roseta, aflaroot e aflatoxina tern algum valor economico na Zambia. As actividades sobre a patologia do amendoim realizadas durante os anos de 1983/84 e 1984/85, no respeitante a testes de identificacao de resistencia as manchas foliares e a ferrugem, bem como o seu controlo quimico, sao brevemente discutidos neste artigo, incluindo-se alguns aspectos de outras doencas potencialmente importantes.

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Table 1. Reaction of groundnut entries in different trials to leaf-spot infection, Msekera, Zambia, 1983/84 and 1984/85.[1]

	1983/84						1984/85					
Groundnut trial	No. of entries screened	Highly resistant (1)	Resistant (2-3)	Tolerant (4-5)	Low susceptibility (6-7)	High susceptibility (8-9)	No. of entries screened	Highly resistant (1)	Resistant (2-3)	Tolerant (4-5)	Low susceptibility (6-7)	High susceptibility (8-9)
Advanced Variety Trial	8	0	0	0	6	2	11	0	0	0	0	11
Advanced Variety Trial	9	0	0	0	0	9	11	0	0	0	1	10
Advanced Variety Trial	8	0	0	0	0	8	11	0	0	0	2	9
ICRISAT Regional Variety Trial 1	16	0	0	0	8	8	16	0	0	0	1	15
ICRISAT Regional Variety Trial 2	36	0	0	0	0	36	36	0	0	0	0	36
Prelim. Yield Eval. Trial 1	18	0	0	0	10	8	49	0	0	0	13	36
Prelim. Yield Eval. Trial 2	23	0	0	0	4	19	25	0	0	0	2	23
Prelim. Yield Eval. Trial 3	25	0	0	0	0	25	25	0	0	0	1	24
Prelim. Yield Eval. Trial 4	36	0	0	0	18	18	-	-	-	-	-	-
Prelim. Yield Eval. Trial 5	30	0	0	0	2	28	-	-	-	-	-	-
Prelim. Yield Eval. Trial 6	18	0	0	0	1	17	-	-	-	-	-	-
Prelim. Yield Eval. Trial 7	12	0	0	0	2	10	-	-	-	-	-	-
Elite Strains Trial 1	24	0	0	0	14	10	-	-	-	-	-	-
Elite Strains Trial 2	32	0	0	0	3	29	-	-	-	-	-	-
'Pops' Tolerant Variety Trial	-	-	-	-	-	-	50	0	0	0	2	48
Foliar Disease Nursery:												
Preliminary	58	0	0	2	30	26	52	0	0	0	13	39
Advanced	-	-	-	-	-	-	46	0	0	0	13	33
Groundnut Germplasm:												
Alternate	658	0	0	18	447	193	342	0	0	1	111	230
Sequential	188	0	1	19	14	154	216	0	0	0	22	194
Total	1189	0	1	39	559	590	890	0	0	1	181	708

1. 9-point disease scale (1 = highly resistant, 2-3 = resistant, 4-5 = tolerant, 6-7 = moderately susceptible, and 8-9 = highly susceptible).

Foliar Diseases

Early leaf spot {Cercospora arachidicola Hori) and late leaf spot(Phaeoisariopsis personata) are the two most serious diseases of groundnut in Zambia. Of the two, early leaf spot is more devastating to the crop. Yield losses are generally substantial when the crop is infected by both leaf spots. More emphasis is therefore given to leaf-spot resistance screening and chemical control. In both seasons groundnut entries planted in breeding, germplasm, and foliar disease nurseries at Msekera Regional Research Station were screened for leaf-spot resistance using a 9-point disease scale. Based on disease severity, entries were grouped into highly resistant (1), resistant (2-3), tolerant (4-5), moderately susceptible (6-7), and highly susceptible (8-9). The results of leaf-spot screening are presented in Table 1.

Of the 1189 groundnut entries screened in 1983/84, only one sequential accession was found to be resistant to leaf spots. A number of leaf-spot tolerant (39) and moderately susceptible entries (559) were also identified. Leaf-spot severity was relatively higher in 1984/85 than in the previous season. Because of this, many promising entries showed more disease in 1984/85. Of 890 entries screened, only one alternate accession was found to be tolerant to the disease and 181 showed moderate susceptibility.

Rust (Puccinia arachidis) occurs occasionally in Zambia. There was a very severe outbreak of rust disease during the 1983/84 seasonat Msekera and in many farmers' fields in the Eastern Province. Since the disease appeared in March 1984, many short-season cultivars escaped severe infection. However, long-season groundnut entries were severely affected by the disease. Breeding material, germplasm, and foliar disease nursery entries were screened on a 9-point disease scale. The results are summarized in Table 2.

Based on rust severity the entries were grouped into highly resistant (I), resistant (2-3), tolerant (4-5), and susceptible (6-9). Of the 1166 entries screened, only 11 were found to be highly resistant. These were PI 350680, PI 314817, ICGMS 30, ICG 7882,7888, 7889, 7890, 7893, 7894, 7895, and 7896. All these entries were also found resistant to rust at 1CRISAT, India (Subrahmanyam and McDonald 1983). In addition, a number of rust-resistant (158) and tolerant (129) entries were identified (Kannaiyan and Sandhu 1985).

Promising entries in regard to leaf-spot resistance identified in breeding material and germplasm were tested with the ICRISAT entries between suscepti-

Table 2. Reaction of groundnut entries in different trials to rust infection, Mkesera, Zambia, 1983/84.

Trial	Total entries	Highly resistant	Resistant	Tolerant	Susceptible
Advanced Variety Trial	8	0	0	0	8
Advanced Variety Trial 2	9	0	0	0	9
Advanced Variety Trial 3	8	0	0	0	8
ICRISAT Regional Variety Trial 1	2	16	0	7	7
ICRISAT Regional Variety Trial 2	0	36	1	34	1
Prelim. Yield Eval. Trial 1	18	0	0	0	18
Prelim. Yield Eval. Trial 2	23	0	0	0	23
Prelim. Yield Eval. Trial 3	25	0	0	0	25
Prelim. Yield Eval. Trial 4	26	0	0	0	26
Yield Eval. Trial 5	30	0	0	0	30
Prelim. Yield Eval. Trial 6	18	0	0	0	18
Yield Eval. Trial 7	12	0	2	1	9
Elite Strains Trial	24	0	4	18	2
Elite Strains Trial	32	0	17	15	0
Germplasm					
Alternate	645	0	3	7	635
Sequential	178	9	65	74	30
Foliar Disease Nursery	58	1	26	6	25
Total	1166	11	158	129	868

Table 3. Promising groundnut genotypes showing resistance to leaf spot and rust, Msekera, Zambia, 1983/84 and 1984/85.

Groundnut genotypes	1983/84 Leaf spot score	1983/84 Rust score	1984/85 Leaf spot score	1984/85 Defoliation (%)
ICG 1707	6.0	3.5	8.0	82
ICG 1710	6.0	3.0	8.5	79
ICG 2716	6.0	2.5	8.0	70
ICG 4747	5.5	3.0	8.0	72
ICG 6330	6.0	2.5	7.0	71
ICG 6340	5.5	2.0	8.0	70
ICG 7013	6.0	3.5	8.5	80
ICG 7885	6.0	2.5	8.0	68
ICG 7888	6.0	1.0	6.0	52
ICG 7897	6.0	2.0	8.0	71
PI 350680	6.0	2.0	8.0	72
183/66	6.0	8.5	7.0	78
MGS 1	7.5	6.5	6.0	70
Chalimbana Sel.	8.5	7.0	6.0	72
Comet (leaf-spot control)	9.0	3.0	9.0	87
Egret (rust control)	8.5	9.0	7.0	68
Grand mean	7.5	5.1	8.0	77
SE	±0.5	±0.8	±0.1	±2.6
CV (%)	10.0	21.9	2.5	4.9

ble spreader rows. No acceptable levels of leaf-spot resistance (Table 3) were found. However 13 entries showed low susceptibility to the disease in addition to rust resistance/ tolerance during the 1983/84 season. Some of the promising leaf-spot entries also had a lower percentage of defoliation than the control variety, Comet. Of these, ICG 7888 is the most promising entry, rating scores of 6 (leaf spot), 1 (rust), and 52% defoliation. This entry is already being utilized in our breeding program with others to develop leaf-spot and rust tolerant/ resistant high-yielding groundnut varieties.

Chemical Control

Since there is no agronomically acceptable groundnut variety with leaf-spot and rust resistance, chemical control is the best short-term solution to the problem. During the 1984/85 season, an experiment was initiated with an aim to find an economically suitable fungicide to minimize the yield losses caused by the major foliar diseases. The commonly cultivated groundnut variety Chalimbana, which is susceptible to all the three foliar diseases, was planted in a randomized block design with four replications. Natal Common, a cultivar highly susceptible to foliar diseases, was planted 2 weeks earlier in between and around that trial as a disease spreader. Four fungicides, Benlate® (0.27%), Bravo® (0.3%), Labilite® (thiophanatemethyl 20% + maneb50%)(0.2%), and Dithane M45® (0.25%) were sprayed at 55, 70, and 90 days after planting. In control plots water was sprayed. A wetting agent, Citowitt®, at 25 ml/ 100L was mixed with each treatment before spraying. Final observations on disease severity and percent defoliation were recorded 2 weeks before harvesting. The kernel yield and its components were also recorded. The economic analysis of fungicide application on groundnut yield was calculated. Results are summarized in Table 4.

During the season there was a severe outbreak of early leaf spot, but damage caused by late leaf spot and rust was negligible. The susceptible spreader rows provided uniform disease pressure to all the plots in the trial. All fungicides except Dithane M45® reduced disease severity significantly over the control. Benlate® gave an excellent control of the

Table 4. Effect of fungicides on leaf spot and yield, and cost benefit, Mkesera, Zambia, 1983/84.

Treatment (rate = 1000 L water ha^{-1})	Leaf-spot severity (1-9 scale)[1]	Defoliation (%)	Mean pod number	Kernel yield (kg ha^{-1})	Increase over control (%)	Gross return (ZK ha-')[2]	Net returns ZK^{-1} spent on fungicide
Benlate® 2.0 kg	3.0	33	12.9	1791	121	2052	4
Bravo® 3.0 L	4.3	41	11.7	1387	71	1589	5
Labilite ® 2.0 kg	5.8	42	11.5	1354	67	1552	15
Dithane M45® 2.5 kg	7.5	66	9.4	1112	37	1274	15
Control (water spray)	8.0	75	8.4	811	-	929	-
Grand mean	5.7	51	10.8	1297	-	-	-
SE	±0.2	±2	±0.6	±87	-	-	-
CV (%)	8	9	12	14	-	-	-

1. 9-point disease scale (1 == highly resistant, 2-3 = resistant, 4-5 = tolerant, 6-7 = moderately susceptible, and 8-9 = highly susceptible).
2. 1 US Dollar = approximately 6 Zambian Kwacha.

disease and was followed by Bravo® and Labilite®. Percent defoliation also followed this trend. All four fungicide treatments resulted in significant increases in kernel yield over the control. Benlate®, which controlled the disease most effectively, produced the greatest increase in yield (12%). Bravo®, Labilite®, and Dithane M45® gave 71,67, and 37% increases in yield, respectively.

The small-scale farmers who produce most of the groundnuts in Zambia do not spray any fungicides for disease control. By using any of the test fungicides the farmer could increase groundnut yield from a minimum of 37% (Dithane M45®) to as much as 121% (Benlate®). The net returns ZK^{-1} spent on fungicide was least with the costly fungicide Benlate®, even though its gross return was the highest. The medium-cost fungicide, Labilite® (effective against leaf spots and rust), can be recommended to farmers to secure better returns where the diseases are a serious problem. This fungicide is being tested during 1985/86 in a number of on-farm trials in the Eastern Province.

Other Important Diseases

Other than leaf spots and rust, the crop is also attacked by rosette, aflaroot, and aflatoxin, which are potentially important diseases. During the period of the trial, low incidence of phomopsis blight (Phomopsis pehennigsii) and tomato spotted wilt virus were also recorded for the first time in Zambia.

The occurrence of rosette is erratic across seasons but rarely becomes epidemic. A few rosette-resistant lines, identified during the 1982/83 season, are being utilized in the breeding program. There was a low incidence of rosette in Chalimbana during the 1984/85 season. From infected plants, observations were made on the spread of the disease and consequent yield losses at various severity levels. In general the disease spread was significantly more than across rows. The rosetted plants produced significantly fewer pods (32 to 90%) as well as lower kernel yield (34 to 90%) than did healthy plants. A few severely rosetted plants did not yield any pods. Interestingly, there was no difference in the number of seeds 100 g^{-1} between diseased (105 to 110) and healthy (110) plants, because rosetted plants produced normal kernels even though numbers were reduced (Kannaiyan et al. 1985b).

Both aflaroot and aflatoxin are caused by Aspergillus flavus. The incidence of aflaroot has become important because of continuous cropping of groundnut in the same field and lack of availability of certified treated seeds. In alfaroot, the fungus infected cotyledons of emergent seedlings, covering them with a mass of yellow-green spores. The infected seedlings were stunted, with chlorosis of leaves. Such infected plants in the variety Chalimbana produced 12% fewer pods and 75% lower kernel yield in comparison to healthy plants. These infected plants also produced slightly smaller seeds. The seeds from infected plants yielded 1% seed-borne A. flavus in comparison to none in healthy plant seeds (Kannaiyan and Kelly 1985).

A. flavus also infects groundnut kernels and produces a toxin called aflatoxin. This problem is commonly prevalent in Zambia. Kernels from plants that have dried prematurely or where shell damage and kernel splitting occurs during development are more prone to this problem. Infection also occurs after harvest and before the drying process reduces the moisture in kernels below the critical level of 9%. Groundnuts should be harvested at peak maturity and dried without delay to minimize the aflatoxin problem.

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Recent Developments in Groundnut Agronomic Investigations in Zambia

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Abstract

Significant findings from agronomic investigations involving plant populations, time of planting, nutrient response, intercropping, and farmers' field trials carried out at Msekera and Masumba Research Stations, and in farmers' fields in the Eastern Province of Zambia are summarized. The current program of agronomic studies is described.

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

At research stations, the groundnut yield is 1500-3000 kg ha^{-1}, depending upon the cultivar. With proper management under farmers' conditions, 1000-1600 kg ha^{-1} should be an easily attainable yield. Actual mean yields by small-scale farmers do not exceed 560 kg ha^{-1}.

Records of agronomic investigations on groundnuts in Zambia go back to the 1954/55 season. Prior to 1980, simple time of planting, plant population, and nutrient response trials were initiated at Mount Makulu Central Research Station, and in Eastern and Southern Provinces. A review of agronomic work carried out in Zambia prior to 1981 was presented at the First Regional Groundnut Workshop for Southern Africa. Subsequent agronomic investigations on groundnuts are briefly discussed in this paper.

Sumario

Recentes avancos na investigacao) agronomica sobre o amendoim na Zambia. Conclusoes significativas sobre investigacoes agronomicas envolvendo populacao de plantas, data de sementeira, resposta a nutrientes, consociacao e ensaios nos campos dos agricultores, conduzidos nas Estacoes de Investigacao de Msekera e Masumba e nos campos dos agricultores na Provincia Oriental da Zambia, sao sumarisados. O corrente programa de estudos agronomicos e descrito.

Na Zambia, grande parte do amendoim e produzido por pequenos agricultores, sendo importante como fonte de proteinas e de dinheiro. De acordo com recentes estudos sobre comercializacao na Provincia Oriental, mais de 50% dos produtores de amendoim cultivam menos de 4 ha, dos quais apenas 0.6 ha sao cultivados com amendoim.

Nas estacoes de investigacao o rendimento do amendoim varia entre 1500-3000 kg ha^{-1} , dependendo do cultivar utilizado. Com um maneio apropriado, nas condicoes dos agricultores, 1000-1600 kg ha^{-1} pode ser um rendimento facil de obter. O rendimento medio actual dos pequenos agricultores nao excede os 560 kg ha^{-1}.

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Dados de investigacoes agronomicas sobre amendoim na Zambia datam dos anos de 1954/55. Antes de 1980 ensaios simples sobre datas de sementeira, populacao de plantas e resposta a nutrientes, foram iniciados na Estacao Central de Investigacao de Mount Makulu (Mount Makulu Central Research Station) e nas Provincias Oriental e Sul. Um resumo do trabalho agronomico levado a cabo na Zambia antes de 1980, foi apresentado durante a Primeira Conferencia Regional do Amendoim para a Africa Austral. Investigacoes agronomicas realizadas posteriormente, sao brevemente apresentadas neste artigo.

Rainfall Distribution Patterns

Monthly distribution of rainfall at Msekera Regional Research Station (plateau) and Masumba Research Substation (Luangwa Valley) for the three seasons 1982/83 to 1984/85 is given in Table I.

Total rainfall at Msekera for 1982/83 (1003.9 mm) was 69.8 mm less than the 1970/83 mean, and that for 1983/84 (874.0 mm) was 199.7 mm below the average. While the 1982/83 season received below average rainfall during Feb-Mar, the 1983/84 season was exceptionally dry during the crucial months of Nov, Jan, and Feb. The same trend was observed at Masumba where during the drier 1983/84 season less rainfall was received during Dec-Jan and Mar.

The present groundnut agronomy program is geared to a thorough investigation of agronomic production aspects covering the following broad areas.

Spacing Trials

A series of spacing trials was initiated in 1982/83 involving two predominant groundnut varieties, Chalimbana and Makulu Red, to investigate any gaps in knowledge about the behavior of these two varieties and to test the validity of existing recommendations (Tables 2-5). After 3 years of trials (1982/85), both at Msekera and Masumba, and on farmers' fields, it must be said that there can be no major objection, agronomically, to a 75-cm ridge for Chalimbana with an espacement of 10-15 cm between seeds within the ridge. One hundred-cm ridges, which are presently practised by farmers, are considered unnecessarily wide. Sixty-cm ridges are not recommended for Chalimbana types because ridging and reridging is difficult. Moreover, significant yield advantages have not been found in particular for the 60 x 15 cm spacing currently recommended for Chalimbana in Malawi (Tables 2 and 3).

Makulu Red in a sole-crop situation should not be planted at an interridge distance of more than 75 cm. Ridges at 60 cm are permissible with this variety but are feasible only if the farmer can construct and maintain them in a satisfactory way. A distance of 10 cm between seeds suits the upright habit of this variety and may be considered ideal (Tables 4 and 5).

Based on these trials the plant population recommended for Chalimbana is about 90000 plants ha^{-1} and for Makulu Red about 133 000 plants ha^{1}. Other major conclusions from recent spacing trials were that the use of plant populations above those recommended for each cultivar served no useful pur-

Table 1. Monthly rainfall distribution (mm), Mkesera and Masumba Research Stations, Zambia, 1982/83 to 1984/85.

	Msekera				Masumba		
Month	Mean 1970/83	1982/83	1983/84	1984/85	1982/83	1983/84	1984/85
Oct	20.9	22.1	5.6	17	27.0	9.0	32.0
Nov	63.8	184.3	24.3	114.0	118.6	58.0	75.5
Dec	235.8	199.2	372.7	270.4	171.7	21.3	297.3
Jan	263.4	305.0	153.7	290.6	202.1	106.8	192.2
Feb	255.4	115.5	154.5	192.2	168.1	164.3	224.0
Mar	161.7	93.5	148.7	122.3	140.6	81.4	224.6
Apr	69.2	84.4	12.4	48.2	116.5	69.5	60.5
May	3.0	-	2.3	-	-	-	-

Table 2. Effect of spacing on yield of Chalimbana groundnut cultivar, Msekera, Zambia, 1982/83 and 1983/84.

Treatments							
Between-ridge distance (cm)		Within-ridge distance (cm)	Target plant population ('000 ha^{-1})	Plant stand at harvest ('000 ha^{-1})		Kernel yield (kg ha-')	
				1982/83	1983/84	1982/83	1983/84
60	X	20	83.3	63.7	62.1	331	1892
60	X	40	83.3	62.9	55.3	460	1720
75	X	15	88.9	67.1	64.8	493	1987
75	X	30	88.9	63.7	63.7	458	1977
90	X	12.5	88.9	67.0	62.2	374	1923
90	x	25	88.9	71.3	62.2	616	1714
100	x	12.5	80.0	59.5	60.7	460	1798
100	X	25	80.0	58.5	53.2	556	1650
Grand mean				64.2	60.5	463	1836
SE(MP)[1]				±3.45	±1.66	±47	±60
SE (SP)[2]				±1.25	±1.24	±25	±30
CV(%)(MP)				17.0	8.7	31.9	10.4
CV (%) (SP)				8.7	9.2	23.6	7.3

1. MP = Mainplot (between-ridge distance).
2. SP = Subplot (within-ridge distance).

pose: yields were not increased, kernel quality was depressed, and the cost of seed rose to an unacceptably high level.

Although there has been exhaustive work on old cultivars, new cultivars emerging from the breeding program must be included in agronomic trials to establish whether or not their growth behavior is similar to that of existing cultivars, and if not, what changes must be made in recommendations to **the** farmer. Keeping this in view, the current spacing trials program includes new cultivars such as M-13, Egret, and Comet.

Table 3. Effect of spacing on yield of Chalimbana groundnut cultivar, Msekera, Zambia, 1982/83 to 1984/85.

Treatments									
Between-ridge spacing (cm)		Within-ridge spacing (cm)	Target Population ('000 ha')	Actual population ('000 ha^{-1})			Kernel yield (kg ha''')		
				1982/83	1983/84	1984/85	1982/83	1983/84	1984/85
90		20	55			51.1	-	-	1083
75	X	20	67	55.3	61.1	59.2	517	1497	1032
90	x	15	74	-	55.8	64.1	-	1468	1061
100	X	12.5	80	64.8	58.4	63.6	490	1424	1057
90	X	12.5	89	72.6	64.2	71.9	619	1477	1 147
90	X	10	111	0	745.2	81.5	-	1522	1102
60	X	15	111	-	-	10	-	-	1265
75	X	10	133	96.2	92.4	99.2	775	1646	1316
Grand mean				72.2	67.8	73.9	600	1506	1133
SE				±2.9	±2.83	±3.14	±65	±49	±72
CV (%)				10	10	10	26	8	14

Table 4. Effect of spacing on yield of Makulu Red groundnut cultivar, MsekeraA, Zambia, 1982/83 and 1983/84.

Treatments							
Between-ridge distance (cm)		Within-ridge distance (cm)	Target population ('000 ha^{-1})	Actual population (XXX) ha-')		Kernel yield (kg ha^{-1})	
				1982/83	1983/84	1982/83	1983/84
60	X	12.5	133	126	99	1248	2715
60	X	25	133	102	103	1296	2642
75	X	10	133	102	92	1048	2404
75	X	20	133	105	104	1 185	2 585
90	X	9	123	97	83	1177	2 333
90	X	18	123	95	89	1079	2481
100	X	7.5	133	96	85	1 100	2 290
100	X	15	133	91	91	1 119	2 379
Grand mean				103	93	I 156	2472
SE (MP)[1]				±3.5	±2.7	±104	±117
SE (SP)[2]				±3.2	±1.6	±53	±595
CV(%)(MP)				11	9	29	18
CV (%) (SP)				14	8	21	11

1. MP = Mainplots (between-ridge distance).
2. SP = Subplots (within-ridge distance).

Table 5. Effect of spacing on yield of Makulu Red groundnut cultivar, Msekera, Zambia, 1982/83 and 1983/84.

Treatments							
Between-ridge distance (cm)		Within-ridge distance (cm)	Target population (XXX) ha')	Actual population ('000 ha^{-1})		Kernel yield (kg ha^{-1})	
				1982/83	1[983/84	1982/83	1983/84
75	X	15	89	77	66	431	1898
100	X	10	100	81	67	546	1821
90	X	10	111	-	77	-	1866
75	X	10	133	108	78	537	1851
60	X	10	167	137	117	667	2170
75	X	7.5	178	-	112	-	2112
Grand mean				100	85	545	1970
SE				±2.8	±3.1	±57	±66
CV (%)				6.7	8.9	26	8.2

Time of Planting Trials

Previous studies on time of planting have shown that the earlier groundnuts are planted after the first good rains (usually mid-Nov), the better the yield. A delay of 2-3 weeks in planting could result in halving the yields. The general recommendation is that groundnuts should under no circumstances be planted beyond the third week of Dec.

A series of variety * time of planting trials were carried out during the 1983/84 and 1984/85 seasons at Masumba, featuring six established and promising groundnut varieties, to assess yield loss from delayed planting, and to seek a shorter-season type that would be versatile enough for late planting (Table 6).

During 1983/84, which was a low rainfall year, decline in mean yields of all varieties resulted in planting after 30 Nov. Even a delay in planting from 30 Nov to 14 Dec resulted in the following percentage kernel yield decreases: Copperbelt Runner, 35%; Makulu Red, 30%; Chalimbana, 22%; Dixie Runner, 21%; Apollo, 24%; MGS-1, 21%. Yields resulting from the 30 Nov and 13 Jan plantings during the 1983/84 season were very low, but it may be noted that Copperbelt Runner still produced a crop of harvestible size (450 kg ha^{-1}) at the latest sowing date, whereas Chalimbana and MGS 1 produced 100 kg ha^{-1} and 11 kg ha^{-1}, respectively. The inflexibility and long maturity of these two varieties make them unlikely candidates for late sowing (Table 6).

During the 1984/85 season, kernel yields were very high due in part to favourable rainfall

Table 6. Variety * time of planting (TOP) groundnut trials, Msekera, Zambia, 1983/84 and 1984/85.

Treatments	1983/84	Treatments	1984/85
First TOP	Kernel yields	First TOP	Kernel yields
(30-11-83)	(kg ha^{-1})	(22-11-84)	(kg ha-')
Copperbelt Runner	1958	Copperbelt Runner	3307
Makulu Red	1673	Makulu Red	3631
Chalimbana	1173	Chalimbana	2286
Dixie Runner	1649	Egret	3732
Apollo	1882	Robut 33-1	3219
MGS 1	1209	M 13	3226
Second TOP		Second TOP	
(14-12-83)		(6-12-84)	
Copperbelt Runner	1276	Copperbelt Runner	2590
Makulu Red	1 172	Makulu Red	3262
Chalimbana	913	Chalimbana	2271
Dixie Runner	1302	Egret	2976
Apollo	1429	Robut 33-1	2011
MGS 1	959	M 13	3 735
Third TOP		Third TOP	
(30-12-83)		(20-12-84)	
Copperbelt Runner	451	Copperbelt Runner	2322
Makulu Red	413	Makulu Red	2772
Chalimbana	381	Chalimbana	1848
Dixie Runner	483	Egret	2918
Apollo	430	Robut 33-1	3438
MGS 1	251	M 13	3496
Fourth TOP		Fourth TOP	
(13-1-84)		(3-1-85)	
Copperbelt Runner	446	Copperbelt Runner	2244
Makulu Red	348	Makulu Red	2754
Chalimbana	101	Chalimbana	2103
Dixie Runner	270	Egret	3030
Apollo	318	Robut 33-1	2657
MGS 1	11	M 13	2581
Grand mean	854		2850
SE (varieties)	±46		±80
SE (TOP)	±372		±65
CV (%)	21.3		11.2

distribution. Even the last planting date (3 Jan) produced excellent yields, with Egret in particular still highly productive and yielding over 3 t ha^{-1} kernels. The variety Robut 33-1 matured in about 120 days but its non-dormant characteristics make it unsuitable for early planting. The performance of this variety in later plantings was impressive (3.4 t ha^{-1} and 2.7 t ha^{-1} from three and four plantings, respectively). Chalimbana yields were also satisfactory for all plantings (Table 6).

In the current agronomic trials program, a population * time of planting trial on a promising recent introduction (M-13) was initiated.

Nutrition and Recommended Crop Rotation

A considerable amount of fertilizer response work was conducted on the groundnut crop in Zambia prior to 1980, but it must be admitted that response to directly applied fertilizers in Zambia has been inconsistent. In virgin lands of inherently low fertility, the recommendation is for a basal dressing of 200 kg ha^{-1} of 'D' Compound (analysis 10-20-10-10 [S]).

A series of phosphate response trials was carried out during the 1982/83 and 1983/84 seasons on the varieties Chalimbana and Makulu Red to examine the possible differences in effectiveness of single and triple superphosphates and a range of phosphate levels (Table 7).

The effect of directly applied phosphate fertilizer (under Msekera conditions) is negligible for Chalimbana, and has not produced significant yield responses in the case of Makulu Red (Table 7). Single superphosphate application has been shown to result in higher mean yields than those resulting from triple superphosphate application (for Makulu Red). Use of either of these fertilizers has not, however, resulted in yields superior to the nil application control. The beneficial effect of single superphosphate, in this case, may possibly be ascribed to the higher percentage of sulphur in the formulation of this fertilizer.

As groundnut should not be grown continuously in rotation for crop hygiene reasons, it makes sense to fertilize the other component(s) of the rotation and use groundnut as a leguminous break-crop for 1 year in a 3-4 year rotation. Current research is focused on an examination of the effects on groundnut yield of fertilization, at different levels, of other crops in the rotation, such as maize.

Table 7. Response of Makulu Red and Chalimbana groundnut cultivars to phosphate, Msekera, Zambia, 1982/83 and 1983/84.

Treatments P_2O_5 (kg ha-')	Makulu Red variety kernel yield (kg ha^{-1})		Chalimbana variety kernel yield (kg ha^{-1})
	1982/83	1983/84	1982/83
0	921	1420	703
30 (SSP)[1]	963	1652	612
30 (TSP)[2]	918	1520	712
60 (SSP)	913	1554	750
60 (TSP)	833	1474	735
90 (SSP)	1185	1479	569
90 (TSP)	805	1462	749
120 (SSP)	1283	1581	653
120 (TSP)	1008	1560	679
Grand mean	975	1522	686
SE (source)	±66	±24	±511
SE (levels)	±129	±80	±837
CV (%) (source)	28	8	26
CV (%) (levels)	35	17	27

1. SSP = single superphosphate.
2. TSP = triple superphosphate.

Research on the "Pops" Problem

Low soil pH tends to restrict groundut production, particularly in the northern belt of Zambia where rainfall is high and of longer duration, resulting in leached soil. The "pops" phenomenon is characterized by early-seed abortion, and although pods remain apparently normal, they contain either no seeds or only their minute shrivelled remains. Most trials showed that on soils of pH less than 4.5, the response to lime or gypsum application was positive. Lime had a positive residual effect over at least 9 years, after an initial application of finely ground limestone at 1-2 t ha^{-1}. Lime application at the above rate remains the current recommendation. There are a number of lime deposits located in the "pops" problem areas in Zambia, which are yet to be exploited.

Table 8. Response of some groundnut varieties to lime and their performance in farmers' fields (mean of 2! farmers' field trials), Eastern Province, Zambia, 1984/85

Treatment	Mean "pops" (%)	Mean kernel yield (kg ha-')
Chalimbana	7.26	1450
Chalimbana + lime	3.90	1328
MGS 1	9.72	1299
MGS 1 + lime	5.96	1283
Makulu Red	9.54	1946
Makulu Red + lime	4.16	1930
Egret	16.76	1708
Egret + lime	3.82	1972
Copperbelt Runner	3.28	1230
Copperbelt Runner + lime	3.06	1294

Farmers' Field Trials

Little is known in the Eastern Province about the effectiveness of lime application as a prophylactic measure to reduce the incidence of "pops". A total of 25 trials were therefore laid out on farmers' fields in the 1984/85 season, to test the practical value of lime over many locations. Apart from this, the trials were utilized to detect varietal differences in "pops" incidence. They were also used to provide further information on the apparent yield superiority of Mani Pintar derivatives over Chalimbana types at a range of contrasting locations. The varieties chosen were Chalimbana, MGS 1, Makulu Red, Egret, and Copperbelt Runner.

At all locations the variety Copperbelt Runner yielded poorly, although it showed some tolerance to "pops". MGS 1 was slightly less productive than Chalimbana in terms of mean kernel yields. Egret and Makulu Red yields were high and at par, and were clearly superior to the control variety Chalimbana. Although more prone to "pops" than Chalimbana and MGS 1, the final yields from these two varieties at the 25 locations were substantially higher than those of the control variety. Lime application on this series of trials had little effect on final kernel yields per hectare (Table 8), because the 1984/85 season was characterized by well-distributed and adequate rainfall at all locations. In addition the pH at most sites was higher than 4.5.

This series of trials on farmers* fields is being continued during the 1985/86 season and includes an additional input of leaf-spot control using the fungicide Labilite®.

Groundnut/Maize Intercropping Trials

A series of intercropping trials was carried out at Msekera during 1982/83 and 1983/84 by the Adaptive Research Planning Team of the EPAD Project to assess increase in land-use efficiency or monetary advantage from intercropping maize with groundnuts.

During the 1982/83 season an intercropping advantage of 22% was recorded in the treatment combining 100% maize stand with 100% groundnut in the same ridge (groundnut giving only 20% without reducing maize yields). During the 1983/84 season no such gain was found, and there was no benefit even by staggering the planting dates of the two crops. The results did not economically justify intercropping maize with this apparently shade-susceptible crop (Table 9).

During the current season (1985/86) a new series of maize/groundnut intercropping trials is being initiated to assess the intercropping benefits by planting the two crops in different rows (1:1 and 2:1) and also by varying the plant populations and fertilizer input of the two component crops.

Table 9. Yield (kg ha^{-1}), Land Equivalent Ratio (LER), and gross returns of maize/groundnut intercropping trial, Msekera, Zambia, 1982/83 and 1983/84.

Treatment	Maize grain yield/ maize LER		Groundnut kernel yield/ groundnut LER		Total land equivalent ratio		Total gross returns (Kwacha)[1]	
	1982/83	1983/84	1982/83	1983/84	1982/83	1983/84	1982/83	1983/84
100 % G'nut + 100% maize same ridges, same planting	5 230/1.02	5 636/0.93	220/0.20	91/0.15	1.22	1.08	1 370	1 877
33% G'nut + 100% maize same ridges, maize planted date	-	5 097/0.84	-	65/0.11	-	0.95	-	1 678
100% G'nut + 100% maize same ridges, maize planted 2 weeks after groundnuts	-	2 874/0.47	-	298/0.49	-	0.96	-	1 245
100% G'nut + 100% maize same ridges, maize planted 4 weeks after groundnuts	-	1 448/0.24	-	430/0.70	-	0.94	-	949
Sole groundnuts	-	-	1 070/1.0	613/1.0	1.00	1.00	1 470	782
Sole maize planted at groundnut planted date	5 140/1.0	6 059/1.0	-	-	1.00	1.00	1 050	1 907
Sole maize planted 4 weeks after groundnuts	-	3 308/0.55	-	-	-	0.55	-	1 041

1. 1 US Dollar = approximately 6 Zambian Kwacha.

Source: Msekera R.R.S., ARPT Annual Reports, 1982/83 and 1983/84.

Development and Evaluation of Simple Machinery for Culture and Processing of Groundnut Crop

During conversations with farmers in the Eastern Province of Zambia it is repeatedly stated that one of the major impediments to increased acreage is the labour-intensive nature of the crop. One of the functions, therefore, of the groundnut agronomists at Msekera, is to develop and evaluate a range of labour-saving equipment for use in the cultivation and processing of the groundut crop. Cooperative work between the groundnut agronomists and the IRDP engineering team based at Katopola Institute has resulted in the following achievements.

1. Procurement of plans for a low-cost sheller made entirely of local materials, with a capacity for shelling Chalimbana or smaller-seeded types such as Makulu Red.
2. Construction of a prototype and initiation of a production line at Katopola workshop to satisfy demand from local farmers.
3. Design and testing of an ox-drawn wooden reinforced tool bar with ridger attachments.
4. Re-testing of an ox-drawn groundnut lifter developed at Magoye Research Station some years ago, and initial design work on a copy of this machine using a higher proportion of local material instead of box section steel, which is currently scarce and expensive in Zambia.
5. Investigations to find a suitable design for a small oil-expeller for village or family use.

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Groundnut Research Program in Botswana

A. Mayeux*

Abstract

Several factors that limit yield in Botswana have been identified: these include low and erratic rainfall of limited duration, low nocturnal temperatures, relatively poor sandy soils that tend to be acid, and local husbandry practices that involve broadcast sowing of seed. The selection of varieties adapted to local conditions, especially those possessing short-maturation periods and tolerance to drought, is of first priority, and is being pursued through a cooperative program with the Institut senegalais de recherches agricoles and by evaluation of varieties introduced from ICRISA T and elsewhere.

Sumario

Programa de investigacao do amendoim no Botswana. Diversosfactores que limitam os rendimentos no Botswana foram identificados e incluem: baixa e erratica precipitacao de duracao limitada, baixas temperaturas nocturnas, solos arenosos relativamente pobres, com tendencia para serem acidos, e praticas culturais locals, que incluem a sementeira a lanco. A seleccao de variedades adaptadas as condicoes locais, especialmente aquelas de maturacao precoce e com tolerancia a seca, assume primeira prioridade, estando a ser feita atraves de um programa de cooperacao com o Instituto Senegales de Investigacao Agricola (ISRA) e pela avaliacao de variedades introduzidas do ICRISA T e outros lugares.

In favorable growing seasons in the past, unshelled groundnut production in Botswana reached a level of 5000 t, while at present it is only about 1500 t. The country imports about 2000 t of vegetable oil; the development of a successful, stable groundnut industry would significantly reduce imports. The objective of the Oil Crops Division is to identify important environmental and other constraints and to attempt to find solutions to them that will result in improved production.

Several areas of research have been initiated:

1. Variety testing: the development of a continuing variety screening program involving local as well as introduced germplasm.
2. Studies on tillage and planting practices: to devise a set of tillage/ planting practices whereby an acceptable alternative to broadcasting of seed, which is at present generally used by farmers, is developed.
3. Seed treatment: to improve emergence and plant number by chemical protection of seeds during germination.
4. Fertilizer requirements: to delimit phosphorous and calcium needs.
5. Plant population studies: to determine optimum plant populations and row spacings under dry-land conditions on sandy soils.
6. Seed production: to ensure a supply of basic seed to the seed multiplication unit.

Climatic Conditions

Table 1 gives rainfall and other climatic parameters that prevailed at Sebele Research Station (10 km from Gaborone) in the 1984/85 season. Effective

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ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1987. Proceedings of the Second Regional Groundnut Workshop for Southern Africa, 10-14 Feb 1986, Harare, Zimbabwe. Patancheru, A.P. 502 324, India: ICRISAT.

Table 1. Rainfall and other climatic parameters at Sebele Research Station, Botswana, 1984/85.

	Nov	Dec	Jan	Feb	Mar	Apr
Rainfall (ram)	45.9	11.5	47.4	44.7	62.1	0.3
Sunshine (mean hrs day)	9.5	11.0	9.8	9.8	9.3	10.3
Evaporation (mm day):						
Grass cover	7.0	8.9	8.1	7.4	6.2	5.5
Bare soil	8.8	11.3	10.2	8.7	8.0	7.3
Air temp (monthly mean):						
Max	31.1	34.1	33.5	32.3	31.5	28.8
Min	17.6	19.4	20.9	20.7	18.0	11.9
Relative humidity (%):						
800 hrs	63	54	65	73	86	27
1400 hrs	37	27	37	45	56	28

rainfall from sowing to harvesting was 205.1 mm, 56.8% less than average of the last 10 years. The season was marked by a period of 25 days (20 December to 14 January) without significant rainfall.

Selection for Resistance to Drought

We received from the Institut Senegalais de Recherches Agricoles (ISRA) three progenies of hybrid germplasm, which were sown under dryland conditions at Sebele Research Station. Yields of these progenies are given in Table 2. Progeny 35 performed well, significantly outyielding the control variety Sellie. The heterogeneity within the populations of each progeny was fairly high, and bulk harvesting of all satisfactory plants in each progeny was made.

In addition to testing hybrid progenies, we also have an agreement with ISRA in regard to varietal intercross testing that allows the planting of two crops each year, one in Botswana and one in Senegal. In this way we hope to accelerate the selection program, which is of common interest to both Botswana and Senegal. We are employing the technique of pyramidal crosses with the following eight varieties:

Virginia types	Spanish types
47-16	55-437
59-127	TS 32-1
57-422	79-40
73-33	68-111

Table 2. Yield data of three progenies of West African hybrid groundnuts, Sebele, Botwana, 1984/85.

Cross parentage	Hybrid	Progeny	Unshelled wt (kg ha-»)
55-437 x PI 851	H71-15	01	587
		35	999
		46	865
Scllic (control)			695
SE			±168.5
CV (%)			19.4

International Groundnut Early Maturing Cultivar Trial (IGEMCT)

We received two groups of cultivars from ICRISAT Center. The primary object of these international cooperative trials is to supply useful material to national program breeders, enabling them to select lines that are adapted to local conditions, with short-maturation cycles and good yields. Table 3 summarizes observations made in the 1984/85 trial.

Yield Trials Involving Oil-content Determination

Three separate variety trials involving introductions from Senegal, Burkina Faso, and South Africa were conducted at Sebele to evaluate yield potential and oil content. The results are given in Tables 4,5 and 6.

Among introductions from Senegal, variety 55-437 outyielded the control Sellie and gave a significantly higher shelling percentage. The Virginia variety 73-33 is also of interest. It has an apparently similar yield potential to Sellie, but, because of its dormancy factor, is better able to retain quality of seed in the event of rain during the end of the growing season.

None of the introductions from Burkina Faso was superior to the Sellie control in yield, although some of them appeared to possess better technological characteristics.

The trial involving introductions from South Africa planted at the Goodhope substation received only 296.4 mm rainfall during growth. With the exception of the variety Elna, all yielded less than the standard control Sellie.

Table 3. Data obtained from ICRISAT Groundnut Early Maturing Cultivar Trial, Sebele Research Station, Botwana, 1984/85.

Origin		Growing season (days)	Unshelled weight (kg ha^{-1})	Shelled weight (kg ha^{-1})	Shelling (%)	Good seeds (%)	Plants died (%)
Sellie (control)		142	527	275	52.1	32.3	8.0
ICGS (E)	1	141	567	289	51.0	28.6	12.1
ICGS (E)	4	141	591	259	43.9	31.7	6.0
ICGS (E)	5	141	591	294	49.8	30.5	3.6
ICGS (E)	6	128	627	269	42.9	26.0	8.8
ICGS (E)	7	128	707	322	45.5	30.2	2.9
ICGS (E)	11	141	603	323	53.3	21.9	29.3
ICGS (E)	12	141	619	326	52.7	36.9	14.1
ICGS (E)	13	141	593	307	51.8	25.9	3.1
ICGS (E)	22	141	625	300	48.0	23.2	-
ICGS (E)	23	141	612	360	58.9	28.6	1.5
ICGS (E)	26	141	546	295	54.0	29.2	-
ICGS (E)	28	141	549	285	52.0	-	7.5
ICGS (E)	36	119	883	573	64.9	57.3	2.0
ICGS (E)	38	126	752	396	52.7	47.7	1.0
ICGS (E)	40	126	669	345	51.5	42.0	16.0
ICGS (E)	48	142	646	404	62.6	42.4	11.0
ICGS (E)	49	142	743	432	58.2	43.3	1.0
ICGS (E)	50	142	757	459	60.6	38.9	7.0
ICGS (E)	51	142	740	479	64.7	51.8	27.0
ICGS (E)	55	126	815	460	56.5	43.5	10.0
ICGS (E)	58	142	831	302	36.4	222	9.0
ICGS (E)	60	141	738	420	56.9	45.8	12.0
ICGS (E)	62	142	998	609	61.0	49.0	13.0
ICGS (E)	66	142	650	300	46.1	23.1	36.0
ICGS (E)	72	142	757	410	54.2	36.4	7.0
ICGS (E)	73	128	844	464	55.0	44.0	15.0
ICGS (E)	74	142	763	439	57.5	36.8	19.0
ICGS (E)	75	142	831	533	64.2	50.5	14.0
ICGS(E)	76	142	712	264	37.2	19.1	21.0
ICGS (E)	78	142	826	379	44.8	24.1	16.0
ICGS (E)	85	142	770	395	51.3	37.7	6.0
ICGS (E)	88	142	752	353	47.0	29.0	12.0
ICGS (E)	89	142	716	395	55.1	36.9	17.0
ICGS (E)	91	142	751	360	48.0	36.5	7.0
ICGS (E)	92	126	725	392	54.0	45.5	4.0
ICGS (E)	97	126	923	533	57.8	47.8	20.0
ICGS (E)	98	142	704	360	51.2	35.1	3.0
ICGS (E)	103	142	643	325	50.5	42.3	23.0
ICGS (E)	114	155	730	367	50.3	28.9	17.0
Chico		119	250	156	62.4	39.6	7.5

ICRISAT Southern Africa Regional Cooperative Yield Trial

We received a seed set of the ICRISAT Regional Spanish Bunch Trial from the regional program in Malawi. The experiment was planted at Sebele but unfortunately extreme soil variation at the site resulted in only two of the four replications being harvested and even these showed wide variation in yield. Results are summarized in Table 7. This trial will be repeated in the 1985/86 season.

Table 4. Yield and oil content of groundnut introductions from Senegal, Sebele Research Station, Botswana, 1984/85.

Introduction	Stand at harvest (plants ha-1)	Unshelled weight (kg ha-')	Shelled weight (kg ha-1)	Shelling (%)	Good seed wt (8 100-1)	Oil content of dry seed(%)
Sellie	77 100	708	380	53.7	23.1	48.40
55-437	76 800	933	564	60.5	26.0	49.30
73-30	35 300	467	196	42.0	23.9	48.40
73-33	87 700	715	390	54.5	28.7	47.45
LSD 5%		143	95.2	4.9		
1%		203	132	6.8		
CV(%)		16.9	20.2	7.6		

Table 5. Yield and oil content of groundnut introductions from Burkina Faso, Sebele Research Station, Botswana, 1984/85.

Introduction	Stand at harvest (plants ha-1)	Unshelled weight (kg ha-1)	Shelled weight (kg ha-')	Shelling (%)	Good seed wt (g 100-1)	Oil content of dry seed (%)
Sellie	70 900	802	415	51.7	26.6	50.45
CN 116A	83 300	947	538	56.8	30.7	51.35
TS 3-1	78 700	950	502	52.8	36.4	48.90
CN 1I5B	78 600	885	442	58.3	29.9	50.55
CN94C	82 400	846	476	56.3	31.9	50.65
TS 32-1	84 000	818	508	62.1	30.9	49.25
Te3	81 900	780	425	54.5	33.5	51.65
CN309B	80 000	753	435	57.8	29.1	50.65
TS9-3	76 900	733	382	52.2	34.4	51.70
TS 18-1	75 800	701	402	57.4	29.5	50.20
CN33D	63 700	625	373	59.6	30.3	50.40
LSD 5%		202		3.0		
1%		NS		3.9		
CV (%)		21.6		5.2		

Table 6. Yield and oil content of groundnut introductions from South Africa, Goodhope Substation, Botswana, 1984/85.

Introduction	Stand at harvest (plants ha-')	Unshelled weight (kg ha*')	Shelled weight (kg ha-')	Shelling (%)	Good seed wt (g 100-1)	Oil content of dry seed (%)
Upright						
Sellie	61800	1655	1 024	61.9	34.0	52.45
Boal	32800	903	564	62.5	35.0	49.40
Elna	46300	1652	1 152	69.6	32.0	49.80
79 V 4	77900	1277	770	60.3	34.2	52.40
79 H 1	80600	1 119	705	63.0	35.4	52.45
Runner						
Sclmani	40900	741	381	51.4	50.1	49.90
Mani Pintar	59200	540	228	42.3	41.1	50.30
Norden	66300	1021	612	59.9	31.2	52.55
Florunner	32600	936	569	60.8	31.2	51.40
Makulu red	76900	773	312	40.3	39.3	49.80
LSD 5%		547				
1%		738				
CV(%)		35				

Effect of Seed Dressings on Germination

We conducted an experiment at Sebele Research Station to compare the effect and the efficacy of a number of different seed dressings on germination of selected good undamaged seeds (intact testae) and of similarly selected seeds that were then wounded artificially by light abrasion of that part of the seed opposite the embryo. Seeds were mixed with dust from the groundnut store, known to contain spores of various fungi, a month before sowing, and were treated with the various dressings the day before planting. Two postemergence stand counts were made, at 10 and 18 days after sowing. Results are given in Table 8, where it can be seen that almost all seedlings had emerged by the tenth day.

The data indicate clearly the importance of seed quality (selected undamaged seeds) on emergence, and also illustrate the additional advantage of seed dressing prior to sowing. The best effect was obtained with the mixture of two fungicides and an insecticide (treatment 3); Benlate® alone gave the least response.

Table 7. Observations on yield of some of the groundnut varieties included in the ICRISAT Regional Cooperative Yield Trial (Spanish Bunch), Sebele, Botswana, 1984/85.

Variety	Growing season (days)	Unshelled weight (kg ha-')	Shelled weight (kg ha^{-1})	Shelling (%)	Good seed wt (g 100^{-1})	Single seed pods (%)
Sellie	144	653	398	60.9	23.1	21.9
ICGMS 1	134	1 184	794	67.1	32.5	12.7
ICGMS 2	134	1040	580	55.8	26.5	12.3
ICGMS 9	134	1 165	750	64.4	30.2	11.4
ICGMS 13	167	1082	518	47.9	28.1	29.0
ICGMS 21	145	I 139	628	55.1	26.0	14.3
ICGMS 22	145	1 111	631	56.8	29.6	14.2

Table 8. Effect of some seed dressings on the germination of intact and damaged seeds of groundnut cultivars, Sebele Research Station, 1Botswana, 1984/85.

	Treatment[1]									
	1	2	3	4	5	6	Mean	Percent of control	SE	CV (%)
Emergence 10 days: after sowing:										
Intact seeds	73.5	78.8	86.6	86.5	79.9	82.2	80.4	100	±2.4	22.0
Damaged seeds	6.1	70.4**	81.7**	70.3**	68.3**	22.0*	53.9	67	±5.9	21.5
% of Control	100	187	211	198	186	130				
Mean	39.8	74.6**	84.1**	79.0**	74.1**	52.0*				
SE				±5.3						
CV (%)				16						
Emergence 18 days after sowing:										
Intact seeds	77.2	82.0	87.6	87.6	80.7	78.3	81.3	100	±8.6	22.1
Damaged seeds	6.3	67.1**	81.7**	74.3**	70.4**	24.9**	55.1	68	+5.3	19.1
% of Control	100	178	203	194	181	123				
Mean	41.8	74.6**	84.7**	81.0**	75.6**	51.6*				
SE				±4.4						
CV (%)				13.3						

1. Treatments: 1. Untreated control; 2. Cupravit@ (copper oxychloride 85%); 3. Granox@ (captafol 10% benomyl 10%) + carbofuran 20%; 4. Captan@ (captane 83%); 5. Dithane M45@ (mancozeb 50%); 6. Benlate@ (benonomyl 50%).

Discussion

Observations and experimental results obtained from our first year of research (1984/85) have defined several climatic, agronomic, technical, and other constraints that limit yield.

Climatic factors include erratic rainfall, a useful period of precipitation that is rarely longer than 4 months, and low nocturnal temperatures that are often less than 20° C. Agronomic constraints involve soils that are often crusted and capped, are relatively poor and sandy, and which tend to be acid. In addition, many farmers sow by broadcasting seeds, a technique to which the groundnut is badly adapted. This often results in poor germination, precludes any form of mechanized tillage, weeding, or harvesting, and requires large labor inputs. The situation is greatly aggravated where labor is in short supply.

Due to the relatively dry conditions, losses caused by insect pests seem in general to be low. Nevertheless in each year Spodoptera, Heliothis, Aphis craccivora and termites are recorded. It will be necessary to assess losses caused both by these pests and by diseases, and, if necessary, to devise appropriate means of control.

We are tackling these problems in three ways. The selection of varieties adapted to local conditions is of primary importance and this mainly involves improving adaptation to drought. The Institut Senegalais de Recherches Agricoles is conducting a genetic improvement program based on a pyramid-cross scheme involving eight varieties, and consists of recurrent selection of progenies obtained through selfing. Botswana is participating in this program. The low night temperatures have the effect of prolonging the vegetative cycle of varieties: for instance Sellie, a short-maturation Spanish type, takes 150 days to mature in our environment. A selection program has been initiated with progenies obtained from Senegal with the aim of shortening the cycle to about 120 days. In parallel with this program, we are evaluating introductions from India, Malawi, Burkina Faso, Senegal, and other countries in our search for better-adapted, high-yielding material.

Our agronomy research will involve plant population trials to find out which spacing is best adapted to local climate conditions. We also see the urgent need for farmers' demonstration plots, to demonstrate the advantages of sowing by row, of using selected seed, and of using appropriate fertilizer and lime treatments.

Discussion on the Paper from Botswana

Nigam: My comment pertains to the "pyramid'' system of crossing being followed by the Botswana program in cooperation with the Senegal program. The Malawi program has experience with the selective diallel mating system that they have used to develop superior varieties with multiple resistance. The results of their work suggest that there is no difference in the performance of lines derived from single and double crosses. Some of the single-cross derived lines are even better and they have come to the conclusion that the extra effort involved in making double crosses and the larger F_2 populations that are required is not justified. I notice big differences in plant stand at harvest. Did you adjust pod yields for variable plant stands?

Mayeux: Termites were mainly responsible for variations in plant stand, and their particular preference seems to be for runner types. No yield adjustments were made for plant stand.

Doto: Can you elaborate on the "pyramid" crossing scheme?

Mayeux: The "pyramid" crossing scheme is the same as the convergent crossing scheme.

Doto: Were there any symptoms of drought stress in your material, bearing in mind that your experiments received only 300 mm rain?

Mayeux: No. Groundnuts are generally tolerant to drought and in addition our soils possess good moisture-holding capacity.

Groundnut Production and Research in Swaziland

Y. P. Rao and G. T. Masina*

Abstract

There has been a marked and continuous decline in groundnut production in Swaziland over the past 10 years, the reasons for which are not clear. Foliar-disease resistant and locally adapted lines have been introduced from ICRISAT, India, from the ICRISAT Regional Groundnut Improvement Program, Malawi, and from the University of Zimbabwe. Results of preliminary assessments of their yield performance and susceptibility to major diseases are reported. Several of these introductions outyielded the standard local variety, Natal Common. At least four accessions (ICGMS 42, Egret, P/105/3/7, and P84/6/108) have been identified that appear to combine high yield with disease tolerance.

Sumario

Producao e investigacao do amendoim na Swazilandia. Tem-se registado urn declinio demarcado e continuo na producao de amendoim na Swazilandia nos ultimos 10 anos. As razoes para tal acontecimento nao sao muito claras. Linhas resistentes contra doencas foliares e localmente adaptadas foram introduzidas a partir do ICRISAT (India), do Programa Regional de Melhoramento do Amendoim do ICRISA T (Malawi) e da Universidade do Zimbabwe. Os resultados de testes preliminares, em termos de rendimento e susceptibilidade para com as mais importantes doencas sao apresentados. Muitas destas introducoes superaram em rendimento a variedade local normalmente utilizada, Natal Common. Pelo menos quatro aquisicoes (ICGMS 42, Egret, P/105/3/7 e P 84/6/108) foram identificadas por paracerem combinar alto rendimento e tolerancia a doencas.

Swaziland is situated between 25° and 26° S latitude and has a surface area of 17 638 km^2. It contains four distinct agroecological zones aligned successively from west to east, known as the High veld (5200 km^2 in area), Middleveld (4700 km^2), Lowveld (6200 km^2), and the Lubombo Plateau(1300 km^2). The first three zones are characterized by decreasing altitude (1300, 700, and 200 m mean elevations) and rainfall (2300-1000, 1150-650, and 900-500 mm). In the extreme east the Lubombo Plateau has a mean elevation of 700 m and an erratic, unreliable rainfall of 750 mm.

Approximately 60% of all land is Swazi Nation Land, held in trust by the Monarch for the Swazi people. There is no private ownership of Nation Land, but the remaining land is open to individual tenure.

Groundnut is a subsistence food crop and its cultivation is confined to Swazi Nation Land. National statistics indicate that an average of 0.25 ha is planted to groundnut and other legumes on an arable area of 1.50 ha per household. Although no detailed surveys have been made, it seems likely that Natal Common is the only variety grown by farmers.

Production

Table 1 gives the area under groundnut and average yields over the period from 1975 to 1983. There has

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ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1987. Proceedings of the Second Regional Groundnut Workshop for Southern Africa, 10-14 Feb 1986, Harare, Zimbabwe. Patancheru, A.P. 502 324, India: ICRISAT.

Table 1. Area under cultivation and average yield of groundnut on Swazi Nation Land, 1975/1983.

Season	Total area (ha)	Production (t)	Average yield (kg ha-')
1975/76	4142	1976	447
1976/77	2812	1584	563
1977/78	n/a	1589	n/a
1978/79	2 738	1542	563
1979/80	2740	1271	464
1980/81	1494	636	426
1981/82	1665	481	288
1982/83	1336	355	266

Source: Hunting Technical Services Limited. 1983. Review of the Rural Development Areas Programme. Final Report (Annexes). Mbabane, Swaziland: Ministry of Agriculture and Cooperatives.

been a marked and continuous fall in production, for which there seems to be no obvious facile explanation. A comparative analysis of production costs in relation to gross profit margin indicates that groundnut cannot compete favorably with other crops such as beans, sorghum, cotton, tobacco, or maize. It seems likely that poor price structure has contributed at least in part to the apparent decline in demand.

Groundnut Research in Swaziland

Experiments conducted at Malkerns Research Station and at Nhlangano have shown that pod yields of 2 500-4 000 kg ha^{-1} are possible with good management (Swaziland Agricultural Research Division 1977).

The observations and experiments reported in this paper were made at the Luyengo Campus of the University of Swaziland, situated 3 km from Malkerns Research Station, and located in the moist western edge of the Middleveld. Mean annual rainfall is 960 mm and mean maximum and mean minimum temperatures are 25.2 and 13.6°C, respectively.

Soils are sandy loams or sandy-clay loams with good drainage in spite of a clayey subsoil. They are rich in iron and aluminium oxides and generally of low pH (5.0), but are also low in exchangeable aluminium so that addition of more than 1 t lime ha^{-1} is seldom required. Organic matter is 2% or less.

Germplasm Introduction and Evaluation

In 1980,12 cultivars were imported from ICRISAT, India, only one of which (MG-5-9) has survived. Subsequently, 10 rust-resistant accessions were obtained from ICRISAT (1983), 9 high-yielding locally-adapted lines and the Zimbabwe cultivar Egret from the ICRISAT Regional Program, Malawi (1984), and 10 phoma-resistant entries from the University of Zimbabwe (1984).

Preliminary evaluations of the 1983 and 1984 introductions were made in the 1984/85 season. The experiments were planted in Oct/ Nov and harvested in Feb/Mar.

Accessions from ICRISAT, India were assessed against Natal Common in a randomized-block experiment replicated three times, in which plot size was 4.0 x 1.8 m. Accessions from Malawi and Zimbabwe were tested against Natal Common in unreplicated 4.5 x 2.4 m observation plots. DAP at 300 kg ha^{-1}, SSP at 140 kg ha^{-1}, potash at 110 kg ha^{-1}, and dolomitic lime at 250 kg ha^{-1} were applied at planting. Yields were estimated by harvesting 2 rows, each 1 m in length, from the middle of the experimental plots. This represents a sampling area of 1.2 m^2. Disease was assessed on a 0-4 scale where 0 = no infection, 1 = light, 2 = moderate, 3 = severe, and 4 = very severe infections. In addition, quantitative assessment of disease was made by counting numbers of lesions on leaflets.

Results are summarized in Tables 2 and 3. Several of the introduced lines outyielded Natal Common significantly in the replicated experiment, and many introductions tested in the observation plots show great promise. In particular, two Zimbabwe phoma-resistant lines, P105/3/7 and P84/6/108, gave unshelled yields in excess of 4000 kg ha^{-1}. These results augur well for future progress of groundnut improvement in Swaziland.

Diseases

Phoma leaf blotch (Phoma arachidicola), early leaf spot (Cercospora arachidicola), late leaf spot (Phaeoisariopsis personatum), rust (Puccinia arachidicola), groundnut rosette virus, and bacterial wilt (Pseudomonas solanacearum) occur in Swaziland but their distribution and relative importance

Table 2. Pod yield, yield components, and foliar-disease reactions of 10 groundnut cultivars from ICRISAT, India, grown at Luyengo Campus, Swaziland.

Cultivar	Pod yield (kg ha-')	Shelling (%)	100-seed weight (g)	Pods plant^{-1}	Disease ratings[1]				
					ELS	LLS	PBL	R	CS
ICG (FDRS)-4	2365	60.0	54.4	34	0*	3	1	3	3
ICG (FDRS)-I3	2300	62.3	48.8	33	2	3	1	1	3
ICG (FDRS)-1	2265	61.3	64.2	25	1	3	2	2	3
ICG (FDRS)-2	2255	61.3	64.5	30	1	3	3	1	4
ICG (FDRS)-I2	1940	67.0	55.1	24	1	3	2	2	3
ICG (FDRS)-3	1825	53.0	39.8	41	1	1	3	1	4
ICG (FDRS)-16	1800	68.7	56.9	29	1	3	2	1	4
NC Ac 17090	1775	52.3	44.3	23	0	2	1	3	2
ICG(FDRS)-14	1 130	52.0	44.3	23	0	2	1	3	2
JL24	1000	71.3	60.9	26	1	4	4	4	2
Natal Common (Local control)	1630	64.3	43.2	32	1	2	4	4	2
Mean	1844	61.2	53.6	28.4					
SE	±221	±4.3	±5.6	±2.7					
CV (%)	21	12.2	18.1	16.5					

1. ELS = early leaf spot; LLS = late leaf spot; PLB = phoma leaf blotch; R = rust; CS = chlorotic spot.
2. Infection : 0 = none; 1 = trace; 2 = moderate; 3 = severe; 4 = very severe.

Table 3. Observations on yield and foliar-disease reactions in groundnut cultivars obtained from the ICRISAT Regional Program, Malawi (first 10 entries) and the University of Zimbabwe, Luyengo Campus, Swaziland, 1984/85.

Cultivar	Yield (kg ha-')		Shelling (%)	Disease ratings[1]				
	Unshelled	Shelled		ELS	LLS	PLB	R	CS
ICGMS 9	2300	1700	74	3[2]	3	4	2	
ICGMS 42	2100	1400	67	2	2	2	2	
Egret	1650	1350	51	1	1	2	1	
ICGM 336	2 050	1300	63	2	2	1	2	
ICGMS 2	2 450	1250	51	2	4	4	2	
ICGMS 22	2 250	1100	49	2	3	4	2	
ICGMS 36	1450	1050	72	1	2	1	2	
ICGMS 33	2600	1000	39	2	3	3	3	2
NC Ac 316	1550	800	52	2	2	1	2	
NC Ac 2821	1300	750	58	2	2	2	2	
P 105/3/7	4300	2900	67	1	2	2	3	
P 84/6/108	4700	2500	53	1	1	0	1	
P 84/6/106	2400	1500	63	1	1	1	1	
C 347/5/6	1900	1450	76	2	2	2	2	2
C 346/5/8	1800	1250	69	2	1	1	2	
P 84/6/124	2 650	1250	47	2	2	3	1	
P 84/6/67	2000	1200	60	1	1	1	1	
P 84/6/63	2000	1150	58	I	1	0	1	
P 84/6/256	1250	850	68	1	1	0	1	
P 84/6/66	1100	650	59	1	1	1	1	0
Natal Common	1750	1100	63	3	3	2	3	2

1. ELS = early leaf spot; LLS = late leaf spot; PLB = phoma leaf blotch; R = rust; CS = chlorotic spot.
2. Infection: 0 = none; 1 = trace; 2 = moderate; 3 = severe; 4 = very severe.

within the various ecological zones has not been determined.

At Luyengo, phoma leaf blotch and late leaf spot are particularly severe, appearing towards the middle of the growing season and rapidly assuming epidemic proportions. Early leaf spot and rust appear rather later in the season (mid-Jan to early Feb), but also increase rapidly; early leaf spot is rarely severe. Incidence of bacterial wilt is usually low and occurs in scattered plants during the seedling stage only; mature plants seem to escape infection.

An apparently undescribed chlorotic leaf spot of unknown etiology occurs at Luyengo and may be of increasing importance. This disorder causes the development of large, more or less circular, yellow or chlorotic areas near leaflet tips, particularly of younger leaves. Symptoms tend to appear in all plants in a plot at the same time and there is no evidence of plant to plant spread, suggesting perhaps a nutritional effect.

In our disease assessments Natal Common and JL 24 were the most susceptible varieties to phoma leaf blotch, late leaf spot, and rust, but all introductions were apparently susceptible, though in varying degree (Tables 2 and 3). However, many exhibited high levels of tolerance and in some, notably ICGMS 42, Egret, P105/3/7, and P84/6/108, tolerance was apparently combined with high yield.

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Groundnut Production: Present and Future Research Thrust in Tanzania

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Abstract

Groundnut production in Tanzania is not as low as it may appear from official figures. This is because farmers are more likely to sell their product privately because by doing so they can receive three times the official pur chase price. Furthermore, more land is coming into groundnut production as a response to improved prospects and price incentives. Constraints include the lack of seed of the four approved varieties, as well as pests, weeds, and diseases, of which groundnut rosette virus is the most feared. Methods of avoiding drought stress are also essential. Research is orientated towards identifying lines with good nitrogen-fixing ability and dormancy, as well as pest and disease resistance. As poor plant stands are common, the possibility of selecting lines that yield at low plant-density is put forward.

Sumario

Producao de amendoim: orientacao presente e futura da investigacao na Tanzania. A producao de amendoim na Tanzania, nao e tao baixa como pode parecer at raves das estatisticas oficiais. Isto e devido ao facto dos agricultores terem maior tendencia para vender o seu produto pessoalmente. Pois. fazendo-o, podem receber tres vezes mais do que o preco oficial de compra. Para alem disso, mais terra vem sendo utilizada para a producao de amendoim, como resposta ao melhoramento das perspectivas e aos precos incentivos. As principals limitacoes para o seu desenvolvimento, incluem a falta de semente das quatro variedades aprovadas, bem como pragas, doencas e infestantes, das quais o virus da roseta do amendoim e a mais temida. Metodos para evitar o efeito da seca sao tambem essenciais. A investigacao esta orientada no sentido da identificacao de linhas com boa habilidade para a fixacao de azoto e dormencia, bem como resistencia contra pragas e doencas. Como a utilizacao de baixa populacao de plant as e comum, e assinalada a possibilidade de seleccionar linhas com bom rendimento quando em condicoes de baixa densidade de plantas.

Production

The status of groundnut production, utilization, and research in Tanzania has been highlighted from time to time by various workers (Bolton 1980, Mwenda et al. 1984). In both presentations, considerable doubt was attached to the accuracy of production statistics. To date, the situation has not improved much in terms of the accuracy of figures or for groundnut production, and indeed, for many other food crops in the country.

General Agricultural Products Export Corporation (GAPEX), the official marketing agency, recorded the highest purchases in 1979/80 when 6676 t were bought (Table 1). Recently official purchases have been fluctuating at a figure above 500 t. There are also indications that much of the crop is now sold in informal markets. The most recent figure for the GAPEX collection suggests that the situation is improving: 744 and 2616 t were purchased in 1983/84 and 1984/85 respectively (Tables 1 and 2).

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Table 1. Marketed groundnut production (May-Apr), Tanzania, 1971/72 to 1984/85.

Year	t
1971/72	3295
1972/73	3454
1973/74	1363
1974/75	509
1975/76	510
1976/77	417
1977/78	1448
1978/79	2615
1979/80	6676
1980/81	1728
1981/82	227
1982/83	131
1983/84	845
1984/85	575

Source: GAPEX Headquarters.

We believe that the official GAPEX purchase figures do not accurately reflect groundnut production in Tanzania. Two factors account for this. First, the bulk of the crop in the major groundnut region is grown by small-scale farmers and is in turn consumed locally. Surpluses for sale thus vary from farmer to farmer. Second, the surplus for sale may be channelled through GAPEX or through informal markets. Due to attractive prices offered through the informal markets, a greater amount of the produce is sold outside the official channels. Currently the groundnut price on the informal market is more than US$ 3.00 kg^{-1}, three times the official price, shown in Table 3.

While production, as gauged by GAPEX purchases, does not seem to register sizeable increases over years, market observation and a more intensive search of data from the regions indicate an increase in the volume produced. For example, Morogoro is not regarded as one of the major groundnut producing regions (Anon. 1984) but is expected to have about 1451 ha under groundnuts in the 1985/86 season. The area is expected to contribute approximately 937 t. As the situation stands, the production figure of 50 000 t that is often quoted (Nigam 1983) is likely to have been exceeded. Much of the increase in production is because more land is devoted to groundnut production, particularly in Tabora, Dodoma, Mtwara, Singida, and Rukwa regions in response to campaigns and price incentive.

Table 2. Regional purchases of groundnut by GAPEX, Tanzania, 1983/84 and 1984/85.

Region	t 1983/84[1]	t 1984/85[2]
Arusha	-	3
Coast	-	-
Dodoma	81	1000
Iringa	-	3
Kagera	-	-
Kigoma	-	-
Kilimanjaro	-	-
Lindi	3	-
Mara	-	-
Mbeya	-	-
Morogoro	3	10
Mtwara	254	1000
Mwanza	3	2
Rukwa	283	420
Ruvuma	44	55
Shinyanga	31	50
Singida	17	11
Tabora	25	65
Tanga	-	-
Total	744	2616

Source: I. MDB (in preparation).
2. GAPEX Headquarters.

Constraints to Increased Production

In the past, lack of price incentive has been cited as a major factor contributing to low groundnut production. Recent price increases (Table 3) in the formal

Table 3. Producer prices for groundnut, Tanzania, 1975-1986.[1]

Year	Tz. shillings t^{-1}
1975/76	2000
1976/77	2 500
1977/78	4000
1978/79	4000
1979/80	4000
1980/81	4 200
1981/82	4800
1982/83	5800
1983/84	8000
1984/85	12800
1985/86	17900

1. 17 Tanzanian shillings = approximately 1 $ US

channel seem to have stimulated interest among farmers in increasing groundnut production. In addition, the lack of edible oils and the expanding local confectionery markets are developments in the country that are making groundnut a more attractive crop. Thus, price appears no longer to belong to the group of constraints that limit groundnut production.

While it is now more attractive to grow groundnuts, the supply of seed has not matched the demand (Tarimo 1985). Tanzania has four recommended varieties whose identity is certain. Natal Common and Red Mwitunde are varieties with a long history in the country. In 1983 and 1985, Nyota and Johari (Robut 33-1) were released as varieties from the Oilseeds Research Project supported by ODA. However, it may be sometime from now before the seed actually reaches the farmers. As the situation stands, farmers often plant material that is of mixed origin and the recommended populations are often not attained due to the high cost and/ or unavailability of the seed.

Weeds, insect pests, and diseases are old problems that still greatly influence groundnut production. Work done by the Oilseeds Research Project indicates that Cercosporidium per sonata, Cercospora arachidicola, and Puccinia arachidis are diseases that greatly affect groundnut yields. Similar observations have also been documented by the Pulses and Groundnut Research Project supported by IDRC. Hilda patruelis has now been confirmed to be present (Simons and Raya 1985, Kimbi 1985) and to be of greater importance than previously thought. On the other hand, groundnut rosette virus has not been as widespread recently. However, the disease still remains the most feared among groundnut farmers.

It has already been mentioned that the bulk of the crop is produced by small-scale farmers. These farmers, in general, depend on the hand hoe for most land operations, including weed control. Since weeding groundnuts is a delicate, labour-intensive operation, it presents an important bottleneck in groundnut production; it actually determines the total area to be cropped. In addition, yield losses through suboptimal weed control are a common feature in the country.

Moisture availability at critical stages of crop growth has often been mentioned as one of the factors limiting groundnut production. Agriculture in Tanzania is more or less dependent upon rainfall. Crop failures due to its lack are quite common. Many of our groundnut research trials for the last 3 years performed poorly if yield and data reliability are taken into account. Farmers in the semi-arid zones of Tanzania experience similar problems. In this regard it may be of value for researchers and planners to identify drought as a factor that affects production, both quantitatively and in terms of stability.

Research Thrust

Current and future research activities are oriented towards tackling some of the constraints to increased production and at making groundnut a more attractive crop. Work based at Naliendele and Morogoro is strongly tailored to the provision of adequate and more improved varieties of groundnuts. Thus, a good part of the resources in both research projects is associated with genetic improvement work. There have been encouraging results from the breeding programs: already two new improved varieties have been added to the list of released varieties in Tanzania.

Apart from high yields, the emphasis of genetic improvement is on improved disease and insect-pest resistance, and drought tolerance. Realising the problems of drought and erratic rainfall, short-season materials are being developed for the areas with a short rainy-season; long-season material is aimed at areas with more reliable rainfall.

In addition, it is generally recognized that farmers often cannot afford to use inputs such as fertilizer, and that harvesting may be delayed due to unavoidable reasons. Thus, research is now focusing on the identification of varieties with exceptionally high nitrogen-fixing ability, and on varieties that do not display sprouting problems. Johari (Robut 33-1) is an example of a variety with seed dormancy (Mwenda 1985).

Closely related to genetic improvement is the protection work. So far, entomologists and pathologists attached to the research projects have been working hand in hand with the breeders, by screening for resistance to the important pests and diseases. In addition, many of the research activities in this field are geared towards this goal (Simons and Raya 1985, Reuben et al. 1985).

A considerable volume of the groundnut crop is produced under intercrop conditions, with maize and sorghum forming the major component in the mixtures. In the past, little attention was given to improving the intercropping system in Tanzania.

Currently, much of the cereal-based research and the legume-based research emphasizes intercropping. In some regions, for example Tabora, Regional Integrated Development Projects are devoting much of their agriculture-based resources to intercropping studies. There are indications that such studies are generating useful practical information, and are therefore likely to continue in the near future.

The problem of low plant populations that is associated with the lack of adequate seed material has been documented by many authors, for example, Bolton (1980) and Tarimo (1985). As a solution to this problem, Tarimo (1985) has proposed the identification of varieties that can attain high-yield potential at low plant populations. The idea has several appealing merits, such as reduced cost of seed and the fact that the burden of sowing (particularly by hand) is reduced somewhat. What are the views of fellow scientists gathered here today on this line of approach? If the idea is worth pursuing, a number of questions related to, for example, plant type and the evaluation of spacing procedures may have to be resolved.

Other workers believe in tackling the problem through a concerted extension thrust and the provision of cheap improved seed. These two aspects are now receiving equal emphasis in Tanzania. There is, however, a good deal of discussion going on as to how best to handle groundnut seed production. So far seed for the released varieties is under multiplication at one of the Foundation-seed farms (Msimba). The project based at SUA has some provision to handle modest seed multiplication. In a few years time, the experience gained at Msimba farm, SUA, and from other contract farmers should provide good guidance on approaches to efficient groundnut seed production under the variables operating in Tanzania.

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Search for Improved Groundnut Varieties in Tanzania: Genetic versus Environmental Challenges

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Abstract

The objectives of the Tanzanian groundnut breeding program are to develop varieties with stable high yields, to improve crop management, and to create coordinated, interdisciplinary teams for food-legume improvement. Varietal trials have identified some promising lines but the results are inconsistent across locations, mainly because of the variation in rainfall between sites. This experience points to the farmer-based requirement of cultivars with drought resistance or tolerance, an analysis of rainfall records to optimize sowing dates, and increasing the amount of irrigation available. The data collected in our trials also indicates the importance of measuring the components of yield.

Sumario

Pesquisa de variedades melhoradas de amendoim na Tanzania: A genetica contra o desafio do ambiente. Os objectivos do programa de melhoramento de amendoim na Tanzania sao o desenvolvimento de variedades com rendimento alto e estavel, o melhoramento do maneio cultural e, ainda, criar e coordenar equipas interdisciplinares para o melhoramento de leguminosas alimentares. Ensaios de variedades indentificaram algumas linhas promissoras, mas os resultados sao inconsistentes para os diferentes locals, principalmente devido a diferencas na precipitacao entre os varios locais. Esta experiencia aponta para a necessidade dos agricultores em cultivares com resistencia ou tolerancia a seca, uma analise dos registos de precipitacao com vista a optimizacao das datas de sementeira e o aumento da quantidade de agua de irrigacao disponivel. Os dados colhidos nos nossos ensaios tambem indicam a importancia da medicao dos componentes do rendimento.

The undesirable imbalance between production and domestic demand for groundnuts, which has existed for more than a decade in Tanzania, still persists. As a result domestic demand, even in major groundnut-producing areas in the country, is often not satisfied. Prices in informal markets, where the bulk of the crop is sold, are generally several times the official price (Doto and Mwenda 1986). The Pulses and Groundnut Project, based at Morogoro, aims to assist in augmenting groundnut production in Tanzania, through production-oriented research. Project objectives were defined as early as 1980 and **were** reviewed in 1984. Broadly, the Project aims at:

1. Developing groundnut varieties with higher and more stable yields that are appropriate to farmers' needs;
2. Developing improved management practices for new groundnut varieties in collaboration with on-farm research groups; and
3. Helping to create coordinated, well-trained interdisciplinary teams for food legume improvement in Tanzania.

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Improved groundnut varieties are expected to emerge through the screening and evaluation of local and introduced germplasm collections, the selection of improved strains from existing accessions, and the development of improved genotypes through hybridization followed by selection.

The bulk of the crop is produced by small-scale farmers who very often intercrop groundnuts with maize, millet, sorghum, or cassava. Irrigation and other inputs are rarely used. Improved genotypes, therefore, have to meet the challenging conditions under which they are expected to be grown. Thus, apart from good yield performance, the material to be finally recommended must possess drought tolerance and insect and disease resistance.

Available information suggests that Hilda patruelis (Simons and Raya 1985), thrips, and leaf hoppers are the important insect pests in Tanzania. Similarly, Cercosporidium personatum, Cercospora arachidicola, Puccinia arachidis, and groundnut rosette virus (GRV) also pose serious problems (Reuben et al. 1985, Simons and Raya 1985). Since farmers rarely use pesticides, the development of high-yielding varieties that possess acceptable levels of resistance to the important pests and diseases is essential in our planned effort to boost groundnut production.

In this paper, an attempt is made to review work conducted in groundnut breeding at Morogoro. Results obtained so far will then be discussed with emphasis on future research strategies. In turn, it is hoped that this presentation will stimulate discussion on important aspects of research of either local or regional application.

Preliminary Yield Evaluation

Preliminary yield evaluations conducted in 1982 at Morogoro demonstrated the superiority of runner types over the bunch types. It was, however, possible to find resistance to the three major diseases in both groups. Makambako, Ex-Njombe, Mbeya, and PHI 200 PI 314817 were found to be outstanding in yield and were also found to be resistant to leaf spots, rust and GRV.

Performance of Selected Lines

In a 1983 trial involving 25 groundnut lines, where both runner and bunch types were assessed at a 50 * 20 cm spacing, four entries outyielded the standard variety, Natal Common. The trial was characterized by low shelling percentage and low seed size (Table 1), most probably as a result of dry conditions at the pod formation and pod-filling stages. Also, many entries matured earlier than expected.

While the results of the 1983 trial are limited to the material and site in question, there were indications that outstanding genotypes could be found among the accessions available at Morogoro. As far as yield was concerned, Tamnut-74 and Spanhoma seemed promising. A few genotypes, including Mbeya, Makambako, Dixie Runner, and Ileje, were only slightly affected by drought, as far as shelling percentage was concerned. Mbeya, KH 149A, and Ex-Chimala displayed remarkable levels of resistance to rosette.

Eleven of the 25 lines from the 1983 trial were evaluated in a set of trials at three sites in 1984. The set of trials at Ukiriguru gave very poor results, thus data from only two sites are given (Table 2).

The trials at Tumbi gave higher yields than those at Morogoro in both the bunch and runner groups. While no combined analysis was attempted, there was evidence for genotype * site interaction in Tamnut; PI 337409 outyielded Natal Common, the control variety, at Tumbi in the bunch trial. On the other hand, Spanhoma and Tamnut-74 were the two top entries at Morogoro (Table 2). Tamnut-74 was the best entry overall.

Yield figures from the runner group also suggested the presence of appreciable genotype * location interaction. For example, Virginia 72 R had a high kernel yield at Tumbi but performed poorly at Morogoro (Table 2). The overall poor performance at Morogoro was attributed to inadequate rainfall during the growing season.

Two sets of trials, each comprising of 25 lines, were carried out at seven locations. However, a full set of results were received only from four locations. In addition, a trial involving 15 lines was carried out at Morogoro where two supplementary irrigations were applied during the pod-filling stage.

The trial at Morogoro, which received supplementary irrigation, gave very encouraging yields averaging above 2 t ha^{-1} (Table 3). The superiority of Spanhoma over the control, Natal Common, was again demonstrated in this trial. Tamnut-74, on the other hand, was outyielded by the control. Good shelling percentage was recorded from Mamboleo, 2/106, Natal Common, and 1/117, again confirming the usefulness of local material in a breeding program. All varieties, except 47-10, matured within 100 days.

Table 1. Performance of 25 lines of groundnuts at Morogoro, Tanzania, 1983.

Groundnut varieties		Days to maturity	100-seed weight (g)	Shelling (%)	Kernel yield (kg ha-')
MGC64	Tamnut-74	87.3	35.5	35.3	I 316(a)
MGC213	Spanhoma	88.0	33.4	41.4	1 228 (ab)
MGC 129	1/30	87.0	41.3	39.0	1 206 (ab)
MGC96	Starr	87.0	32.4	39.4	1 116(ab)
MGC 184	Natal Common	87.0	33.2	32.3	1 097 (abc)
MGC 6	Mbeya	105.0	40.1	59.1	1 089 (abc)
MGC 88	Comet	87.0	37.3	37.7	1 068 (abc)
MGC 50	Mamboleo	87.3	38.9	42.1	I 033 (abc)
MGC 110	1/69	85.0	30.1	40.8	1 031 (abc)
MGC 124	1/88	87.8	35.4	41.7	1 020 (abc)
MGC 28	NC343	103.0	40.0	53.9	1 001 (abc)
MGC 121	Spancross	87.0	35.8	28.5	996 (abc)
MGC 81	1/94	87.3	35.1	42.9	992 (abc)
MGC 201	Tarapoto PI 350680	88.0	29.8	27.9	986 (abc)
MGC 18	Dixie Runner	106.0	31.9	59.2	914 (abc)
MGC 8	Ex-Chunya	106.5	50.5	54.9	905 (abcd)
MGC 167	Jabulaya	87.3	26.5	30.4	905 (abc)
MGC 71	Virginia 72 R	105.0	55.1	54.1	880 (abcd)
MGC 52	Ex-Chimala	106.5	46.7	56.5	838 (abcd)
MGC 53	Ileje (Ex-Ulambia)	106.0	57.0	55.4	784 (abcd)
MGC 126	KH 149 A	91.0	33.8	23.8	774 (abcd)
MGC 19	Ex-Njombe	105.5	52.6	53.1	765 (abcd)
MGC 13	Makambako	104.5	35.2	64.2	658 (bcd)
MGC 10	Karanga Kubwa	105.5	40.5	46.3	482 (cd)
	2/108	85.0	33.3	27.3	366 (d)
Mean		94.5	38.5	43.5	938
SE		±0.29	±2.25	±3.12	±54.2

Table 2. Kernel yield (kg ha^{-1} for 30 lines of groundnuts at two locations, Tanzania, 1984.

	Bush			Runner	
Variety	Morogoro	Tumbi	Variety	Morogoro	Tumbi
Spanhoma	1531	-	Dixie-Runner	745	-
Tamnut-74	1445	1915	Red Mwitunde	660	1010
Comet	1304	1822	Kinyika	647	1376
1/69	1261	1357	Makambako (a)	627	1066
Unknown	1220	1569	Mbeya	618	-
1/117	1217	1676	Ex-Njombe	604	1 188
Natal Common	1 148	1862	Unknown	560	1410
1/84	1 131	1423	NC343	551	1598
PI 315608	1091	1583	Asilia Mamboleo	542	833
2/106	1015	1423	Ex-Kiwele	536	1354
PI 337409	979	1942	Ex-Ismani	519	1 121
Za Kisukuma	949	1583	Mbozi	482	1399
Za Kienyeji	921	1729	Ex-Madibira	341	1388
2/97	890	1676	Virginia 72 R	319	1789
47-10	322	918	Makambako (b)	300	1221
Mean	1095	1606	Mean	537	1289

Table 3. Performance of 15 lines of groundnuts at Morogoro, Taniania, 1985.

Groundnut varieties	Days to maturity	100-seed weight (8)	Shelling (%)	Kernel yield (kg ha-1)
Spanhoma	87.5	41.7	69.9	2557(a)
1/84	90.5	42.3	69.3	2501 (ab)
Mamboleo	86.8	43.8	72.2	2487 (ab)
2/106	90.3	40.6	70.8	2476 (ab)
1/69	87.5	40.7	73.9	2476 (ab)
Za Kienyeji	88.5	39.4	64.9	2392 (abc)
Stan-	89.8	35.7	66.4	2383 (abc)
Natal Common	89.3	36.1	70.6	2282 (abc)
Tamnut-74	90.3	37.1	58.8	2 126 (abc)
1/117	90.8	37.0	73.0	2117 (bc)
Israel line 136 PI 315608	89.3	37.3	65.0	2099 (bc)
2/97	86.5	38.2	62.6	2069 (bc)
Comet	88.0	36.9	68.9	2057 (bc)
PI 33709	88.8	33.0	67.8	1925 (c)
47-10	114.8	32.0	58.6	1 354 (d)
Mean	90.6	38.1	67.5	2220
CV (%)	0.7	6.4	8.8	28.2
SE	±0.33	±1.21	±2.96	±153.4

Table 4. Yield parameters of groundnut for various locations, Tanzania, 1985.

Trial location and type	Mean (kg ha-')	Range	CV (%)	SE
Ukiriguru				
Bunch	410	260- 580	28.0	
Runner	160	50- 310	54.3	±50
Mwanhala				
Bunch	280	130- 390	24.2	
Runner	190	90- 280	52.5	
Ilonga				
Bunch	470	200- 780	30.1	
Runner				
Tumbi				
Bunch	930	680-1130	24.4	±90
Runner	930	610-1100	19.1	±70

Yields from the other locations were generally poor, with the exception of those from Tumbi (Table 4).

The results as they stand do not provide an optimistic picture of the potential of the lines at the testing locations. The trials at Ukiriguru, Mwanhala, and Ilonga suffered considerable moisture stress during the growing period. Thus, the yields obtained, low as they appear, more than help to underscore the significance of inadequate and unreliable rainfall in parts of the major groundnut areas in Tanzania.

Character Association

Pod number per plant was found to be closely associated with final kernel yield in both the 1983 and 1985 trials at Morogoro. The variety trial at Morogoro (1985) further indicated that shelling percentage and 100-seed weight are other characters that are closely related to kernel yield. On the other hand, earliness was found to be positively associated with yield.

The positive association between earliness and kernel yield would be expected in a situation where rainfall was of limited duration. It would, therefore, appear that the supplementary irrigation, which was applied after the pod-formation stage, did not significantly affect the relationship. It was also pleasing to note that pods per plant, pod weight, shelling percentage, and 100-seed weight were all positively related among themselves (Table 5).

Table 5. Correlation coefficients among selected groundnut characters for Morogoro trial, Tanzania, 1985.

	Days to 50% flowering	Days to maturity	Pods per plant	Pod weight	Shelling (%)	100-seed weight
Days to maturity	0.86**					
Pods per plant	-0.61*	-0.80**				
Pod weight	-0.56*	-0.41	0.51			
Shelling percentage	-0.34	-0.51	0.55*	0.25		
100-seed weight	-0.38	-0.55*	0.28	0.72**	0.52	
Kernel yield	-0.55*	-0.76**	0.61*	0.89**	0.64*	0.58*

Discussion

Most of the trials reported from 1982 to 1985 suffered moisture stress, particularly during flowering and pod formation. Thus, soil moisture appears to be one of the most important environmental factors affecting production. In this brief presentation it may be useful to discuss some of the options that could be adopted to overcome this constraint. One of the options that should be given serious attention is the development of varieties that are resistant to drought. This could be achieved through the development of early-maturing types or drought-tolerant material. The approach has already received attention in Senegal (Gautreau and De Pins 1980). In Tanzania, much of the variety improvement work aimed at the Shinyanga, Mwanza, Dodoma, and Singida regions could emphasize drought tolerance.

An in-depth analysis of rainfall and other related parameters could also be another way of dealing with this problem. Rainfall data for the major agroecological zones is available, which goes back for more than 30 years. A careful study of this data could provide invaluable information to agronomists and breeders in pinpointing planting dates for the different maturity groups of groundnuts and other crops.

The third option is that of intensifying irrigated agriculture. Sudan has a long history of irrigated groundnut production. Similarly, Zimbabwe has recently done much to increase its capacity for irrigation. Yields obtained from the trial at Morogoro, which received supplementary irrigation, do lend much support to the need and urgency of exploiting the vast potential for irrigation in Tanzania. Thus, a strategy aimed at increasing and stabilizing groundnut production in Tanzania may have to combine the three options that would minimize the impact of crop failures arising from inadequate rainfall.

From the 1984/85 trials it appears that varieties rank differently across locations. Whereas it may be undesirable to have too many recommended varieties for different agroecological zones, it could be of value to identify major areas that could benefit by growing a given variety. In this way, farmers would be provided with the best variety for the area in question, rather than be given a variety with a general adaptation. There is no doubt that Makambako, PI 200, and PI 314817 could serve as useful sources of resistance to leaf spots, rust, and particularly GRV in groundnuts. The 3 years' data, though useful, are rather difficult to interpret in terms of possible variety recommendations. Varieties like Spanhoma and Tamnut-74 deserve special attention, as they have shown some potential in the 1983 and 1984 seasons. Spanhoma further demonstrated its worth at Morogoro in the 1985 irrigated trial. The picture, however, is not conclusive as the results from other sites are not consistent. Due to the erratic environmental variables, particularly rainfall, it may require more than 3 years' data before a variety can be recommended with confidence.

The period under review has further demonstrated the benefits of measuring the components of yield, such as pods per plant, pod weight, shelling percentage, and 100-seed weight, in a selection program. Results reported earlier and those from the 1985 trial (Morogoro) suggest that the four characters are positively associated among themselves, and in turn each was positively related to kernel yield. Thus, selection for yield could partly be based upon these characters. In addition, data for the period 1983 and 1985 is now under in-depth analysis, with the aim of identifying important yield determinants under stress and non-stress conditions. Results from the analysis will be communicated to researchers in the region through the ICRISAT Regional Groundnut News.

Acknowledgements

The authors express their appreciation to the field staff at Sokoine University of Agriculture and Tanzanian Agricultural Research Organization who, in various ways, helped to carry out the research work. Further we wish to thank IDRC and SUA for the support given to the Research Project.

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Genetic and Ecological Diversity of Local Groundnuts in Tanzania

F. F. Mwenda*

Abstract

Groundnuts are grown in most parts of Tanzania by small-scale farmers. At present a seed production and distribution system for the crop is non-existent. In a recent collection mission it was found that all major botanical groups are grown and these exhibit significant variations. Furthermore it was observed that the cultivars grown varied with altitude as well as with the length of rains in particular ecological areas.

Sumario

Diversidade genetica e ecologics dos amendoins locais na Tanzania. O amendoim e cultivado na maior parte da Tanzania por pequenos agricultores. **Presentemente**, **a producao de semente e o** sistema de distribuicao para esta cultura sao inexistentes. **Numa recente missao de coleccao,** observou-se que todos os principals grupos botanicos sao cultivados e que estes **exibem variacoes** significativas. Para alem disso,foi observado **que** os cultivares utilizados **variam com a altitude, bem** como com a duracao das chuvas, em areas ecologicas particulars.

Tanzania is an important groundnut-growing country in East Africa. Most of the crop is grown by the small-scale farmer and extends from sea level to about 1500 m (Mwenda et al. 1984). However, in a recent survey groundnuts were found growing at higher altitudes (e.g., Mufindi, at 1750 m).

In the major groundnut-growing areas, the crop is grown by most farmers but usually only in small holdings, often just small backyard plots, or mixed with other crops. The type of groundnuts grown varies from area to area, farmer to farmer, and in some cases even within the same farmer's lot. That significant variation exists in the local groundnuts grown in the country was revealed in the local cultivars used as controls in our multilocational trial conducted throughout the country (Table 1). However, previous research and the current phase of the groundnut improvement program was started without adequately appraising this reservoir of genetic variability, which can be greatly exploited to enhance the breeder's task of producing new and improved cultivars.

This paper gives a brief account of the genetic and ecological diversity discovered in recent collecting missions conducted in 10 out of 20 regions of mainland Tanzania.

Probable Origin and Sources of Diversity

It is likely that different forms of groundnuts were grown in the country from the 15th century onwards, having been introduced into Africa by the Portuguese in 1502 (Gregory et al. 1951). More recently groundnuts were introduced into the country by the British Overseas Food Corporation

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(OFC) in the late 1940s. Hemingway (1957) reports that a total of 135 groundnut collections from all over the world were established at Kongwa by 1950/51. These consisted of 98 early bunch types, 31 spreading bunches, and 6 runner types. It seems likely that these introduced materials may have found their way into the hands of individual farmers around the research centers run by the OFC (Kongwa, Urambo, and Nachingwea), thus adding variability to the genetic pool that already existed. At present, locally grown cultivars are very mixed and hence unidentifiable as individual cultivars. A third source of variability is the movement of groundnut material across borders in neighbouring countries, e.g., Mwitunde in the west (probably from Zaire), and Malavi along the shores of Lake Nyasa (probably from Malawi). In all cases where the seed got to the individual farmer, he would almost always retain part of the crop for the next planting. If the seed got lost he would get some from his neighbour. For this reason, it is safe to assume that most of the existing cultivars are true landraces. It is very unlikely that material introduced in the last 5 years has reached the individual farmers, as it is still confined to the research stations.

Current Status of Diversity

Genetic Diversity

All major botanical groups of groundnuts, namely Spanish, Valencia, and Virginia, are widely grown in the country. More significantly, there exists a wider genetic diversity in Tanzania than has previously been assumed. There are a great number of different and nondescript types grown by the Tanzanian farmer. Genetic diversity ranges from cultivars maturing in 3 months to those maturing in over 6 months, while significant variation exists in pod type, seed size, and seed color. Table 2 summarizes the range of existing variability based on seed size and seed color for 10 regions of mainland Tanzania.

Classified very crudely, and omitting the finer details contained in the more recent classification of groundnut cultivars (Bunting 1958), most of the bold- and medium-sized kernels of all color shades are assumed to belong to the late-maturing Virginia types (var hypogaea) of groundnut. Small-seeded kernels of tan color would belong to the early-maturing Spanish group (var fastigiata), while most small-seeded kernels with red or off-white color would belong to the early-maturing Valencia group (var vulgaris). Other types found in the country had medium to bold kernels with two colors, i.e., red and white, on the same kernels (not to be confused with variegated red/ white color as in Mani Pintar). These are found in the Irigna Region and along the shores of Lake Nyasa in the Ruvuma Region.

Because very little of the groundnut production enters the official market where certain standards would be demanded, most farmers tend to plant mixed types. Based on these kernel characteristics, it is evident that all major groups of groundnuts are grown in the country and have significant variation between and within groups.

Ecological Diversity

Ecological factors may largely influence the distribution of groundnut cultivars. In Tanzania, altitude and the length of the rainy season are important ecological factors that affect the types of groundnuts grown. It was reported by Mwenda et al. (1984) that groundnuts are grown in most areas below an altitude of 1500 m. However in a recent survey, ground-

Table 1. Common groundnut types grown in Tanzania.

Name	Region	Type
Red Mwitunde	Mtwara, Lindi	Mixture of spreading bunch and runner
Dodoma Bold	Ruvuma	Mainly runner
Amani	Ruvuma	Mainly runner
Mango Mango	Mtwara	Mixture of spreading bunch and runner
Kabalagara	Mwanza	Mainly upright bunches
Bwanga	Mwanza	Mixture of spreading bunch and runner
Mwanjelwa	Mbeya	Mainly runner
Malavi	Ruvuma Dodoma	Upright bunches

Table 2. Kernel characteristics of local groundnut cultivars collected in Tanzania, 1985.

	Kernel types										
	Bold			Medium			Small				
Region	Pink	Red	Tan	Pink	Red	Tan	Pink	Red	Tan	Other	Totals
Arusha	-	-	-	-	I	2	-	-	-	-	3
Dodoma	4	I	5	13	6	12	1	11	4	-	57
Iringa	1	1	I	4	1	2	2	5	2	2	21
Morogoro	-	-	-	1	1	2	-	-	-	-	4
Mbeya	1	-	-	1	-	2	-	-	-	-	4
Mtwara	-	-	-	3	3	1	-	-	-	-	7
Ruvuma	4	1	2	1	7	6	-	8	-	2	31
Shinyanga	-	-	2	-	-	-	-	I	-	-	3
Singida	1	-	1	1	1	3	-	-	-	-	7
Tabora	-	-	3	-	7	5	1	4	1	-	21
Total	11	3	14	24	27	35	4	29	7	4	
Type Total		28 Bold			86 Medium			40 Small			

nut samples were collected at places above 1700 m (e.g., Haubi, 1650 m; Mufindi, 1750 m; and Njombe, 1800 m). Table 3 shows the distribution of types of groundnuts according to altitude ranges. Most types of groundnuts seem to be concentrated from sea level up to 1500 m. The bold- and medium-seeded types are more widespread at all altitudes than the small-seeded types that were found mainly at medium altitudes (500-1000 m).

It is likely that both the length and distribution of rainfall influences the types of groundnuts grown. The area surveyed is characterized by a single peaked rainfall pattern differing only in the distribution of the rainfall. Thus, Mbeya, Mtwara, and Ruvuma generally have long periods of rain (4-5 months). In these regions late-maturing types (bold- and medium-seeded) predominate. Dodoma, Iringa, and Tabora have short periods of rains (3-4 months). In these regions all types are found, but it is significant that the early-maturing types (small-seeded) are more widespread than in the other regions (Table 3).

The report given here is far from complete. The samples on which this account is based were collected from only a fraction of the major groundnut growing areas of the country, and the variability described is based almost entirely on kernel characteristics. A more complete account will be available when the collections have been fully characterized and a preliminary evaluation made. Additional information may also be available when the remaining areas of the country have been surveyed.

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Altitude (m)	Kernel size			
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0-500	5	5	I	11
500-1000		7	4	11
1000-1500	13	21	26	60
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The Effect of Plant Population and Defoliation on the Yield of Groundnut (Arachis hypogaea L.)

A. J. P. Tarimo and M. K. A. Mkesele*

Abstract

The yield of a local groundnut (Arachis hypogaea L.) cultivar (Ex-Turian) in Tanzania was increased by increasing plant population from 10 plants m^{-2} to 44 plants m^{-2}. Plants were artificially defoliated so that either 0%, 25%, 50%, or 100% of leaf was removed for each population. Defoliation of plants within populations reduced kernel yield.

Higher levels of defoliation had more depressing effects on yield in the lower plant populations than in the higher pnpulatons, suggesting the importance of increased leaf area index (LAI) in the accumulation of photosynthetic products in the stems, branches, and roots of groundnuts during the vegetative growth phase. This facilitates pod filling even after the plants are defoliated.

The highest yield reduction (66%) was recorded from the 100% defoliated plants in the 13 plants m^{-2} population. While pod yield ha^{-1} decreased with increasing defoliation intensity, the shelling percentage and the 100-kernel mass were increased.

Sumario

O efeito da populacao de plantas e da defoliacao no rendimento do amendoim (Arachis hypogaea L.). O rendimento de um cultivar de amendoim (Arachis hypogaea L.) local da Tanzania foi aumentado por se aumentar a populacao de plantas de 10 plantas m^{-2} para 44 plantas m^{-2}. As plantas foram artificialmente defoliadas de forma que 0%, 25%, 50% ou 100% das folhas foram removidas em cada uma das populacoes. A defoliacao das plantas dentro da mesma populacao reduziu o rendimento de semen tes.

Altos niveis de defoliacao tiveram efeitos mais negativos em populacoes baixas do que em altas densidades, sugerindo a importancia de altos valores de indice de area foliar (LAI—Leaf Area Index) na acumulacao de fotossintatos nos caules, ramos e raizes do amendoim durante afase de crescimento vegetativo. Isto facilita o enchimento das vagens mesmo depois das plantas serem defoliadas.

A maior reducao do rendimento (66%) foi obtida de plantas defoliadas em 100% numa populacao de 13 plantas m^{-2}. Enquanto que o rendimento de vagens por hectare diminuiu com o aumento da intensidade de defoliacao, a percentagem de descasque e o peso de 100 graos aumentou.

Groundnut (Arachis hypogaea L.) is an important oil and confectionery crop of both the tropical and temperate regions of the world. Eighty percent of the world production comes from the developing countries of the tropical regions. Sixty-seven percent of the total world production is from the seasonally-dry rainfed regions of the semi-arid tropics where yields are commonly very low (800-900 kg ha^{-1}) compared with yields of approximately 2500 kg ha^{-1} in the developed countries (Gibbons 1980).

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Groundnut yields in Tanzania are very low even under large-scale cultivation (about 700 kg ha^{-1}). The peasant farmer gets even less (about 450 kg ha-'). The main factors contributing to low productivity of groundnuts in Tanzania include low plant-population establishments, foliar pests and disease damage, and generally poor crop-husbandry practices.

Various researchers on groundnuts have emphasized the need for closer plant spacing in order to increase yield ha^{-1} (Arnon 1972). The main reason for establishing high plant populations in groundnuts has been to increase canopy size in order to effectively intercept solar radiation during crop growth. High solar energy interception is associated with increased groundnut yield. Many farmers in Tanzania are unable to establish a high plant population of groundnuts because of seed shortage during the cropping season.

Leaf damage in groundnuts is common, and reduces the efficiency and effectiveness of photosynthesis in optimum plant populations. Several species of caterpillars attack the foliage, sometimes causing complete defoliation (Shields and Wyman 1984). Also, foliar diseases such as leaf spots (Cercospora spp) and rusts reduce the photosynthetic surface of the crop. Control of these insects and diseases require frequent insecticide and fungicide use, which is not cost effective under small-holder farmer conditions.

It has been suggested (Enyi 1974) that greater yield reduction occurred when plants were defoliated at the reproductive growth stages, than during the vegetative growth stages. At full flowering, the photosynthates are diverted mostly to pod development and later to pod filling, during which kernels are produced.

Although substantial information on the effects of plant population and defoliation on groundnuts is available in the literature, very little is known about the possible interaction of plant population and defoliation intensities on the yield of the crop. The present work attempts to explore those effects with the objective of studying plant population as a cultural means of minimizing the impact of foliar pests and diseases on groundnut production.

Materials and Methods

A plant-population and defoliation trial was set out at the Sokoine University of Agriculture Farm, Morogoro, Tanzania, using a local groundnut cultivar, Ex-Turian, during the cropping season of 1984/85. The cultivar was of the erect bunch-type, belonging to the spanish-valencia group.

Plots 4 x 5 m were laid out in randomized complete blocks and replicated three times. The plant populations varied from an intrarow spacing of 5 cm to 20 cm while maintaining a constant interrow spacing of 0.5 m. Plant populations established were 100000 plants ha^{-1} (20 cm), 133 333 plants ha^{1} (15 cm), 200 000 plants ha^{-1} (10 cm), and 444 444 plants ha^{-1} (5 cm). Sowing was done on 30 Mar 1985, placing one seed per hole. Each plot received a basal fertilizer at the rate of 60 kg $P_2 0_5$ ha^{-1} in the form of TSP placed in shallow furrows (5 cm deep) and covered shallowly by soil before seed placement. No top dressing fertilizer was used.

Foliar pests were controlled by a weekly application of endosulfan (35% EC at the rate 900 g a. i. ha^{-1}) starting from 3 weeks after planting. Plots were kept weed-free throughout the growth period of the crop.

At flowering stage, 10 plants from each plot, covering an area of 4.5 m^2 were selected and defoliated artificially so that 0%, 15%, 50%, or 100% leaf remained. This was done by counting the number of primary branches of each plant and removing the leaves by hand according to the desired defoliation intensity. All the plots were defoliated on the same day (6 May 1985).

At the crop-maturity stage, crop height (central axis only), number of primary branches, pod yield ha^{-1}, and kernel yield ha^{-1} from the 4.5 m^2defoliated area were recorded. A sample of 100 kernels was taken from each sampled plot to measure the 100-kernel mass. Data recorded were analysed by the analysis of variance technique.

Results and Discussion

Groundnut yields were significantly increased by increasing plant populations from 10 plants m^{-2} to 44 plants m^{2} (Table 1), irrespective of the defoliation intensity ($P < 0.01$). The magnitude of the increase varied with the defoliation intensity within a given plant population. The magnitude of yield losses was dependent on the amount of leaves removed from the plant at flowering and the rate of leaf replacement. The rate of leaf replacement was mainly dependent upon the genotype, while the rate of leaf shedding depended mainly on the prevailing environmental conditions during crop growth. The main environmental factors asociated with natural defoliation included low soil moisture availability,

Table 1. Effects of plant population and defoliation on the yield and other yield characters of groundnut cultivar Ex-Turian, Morogoro, Tanzania, 1984/85.

Plant spacing[1] (cm)	Population density (10^4 plants ha^{-1})	Defoliation intensity (%)	Kernel yield (kg ha^{-1})	Pod yield (kg ha')	Shelling (%)	100-kernel mass (g)
20	10	0	330	630	52.3	38.1
		25	330	600	54.5	32.8
		50	120	360	57.4	30.3
		100	210	350	59.8	31.7
10	13	0	720	1430	50.7	42.0
		25	580	1000	57.5	39.7
		50	510	860	58.9	37.1
		100	240	400	61.4	32.2
15	20	0	1020	1790	56.9	42.4
		25	710	1 110	63.0	40.4
		50	650	1030	63.5	41.2
		100	590	840	69.6	35.1
5	44	0	1600	2 550	62.6	43.0
		25	1080	1620	66.4	41.5
		50	990	1360	72.6	41.7
		100	1000	1310	76.4	40.7
Significance		-	**	**	**	**
CV (%)		-	17.6	13.8	7.4	7.8

1. 0.5 m between rows
** Significant at $P < 0.01$

presence of foliar pests and diseases, and extreme temperatures.

The effects of plant population were related to those of defoliation intensities (Table I). Defoliation had less effect in high plant populations, and at 50 and 100% defoliation, the yield reductions were only 7 and 6% respectively, compared with the low populations where yield reduction figures as high as 66% were recorded.

Leaf replacement after defoliation in the present study on cultivar Ex-Turian was observed to be higher in the lower populations, although this was not statistically analysed. This characteristic might have contributed to the yields even at the 100% defoliation intensity within populations. Enyi (1974) noted that crop productivity even after intense defoliation might have been due to high efficiency of assimilate accumulation in the stems during late vegetative growth. It is also possible that the stems and branches of groundnuts continued to photosynthesize even after leaf removal because they normally remained green during most of the growth period. The erect bunch-type cultivars have been observed to have higher yield potential even after intense defoliation (Enyi 1974, Mercer 1976).

The plant populations and defoliation intensities significantly influenced the performance of some important yield components of groundnuts such as pod yield ha^{-1}, shelling percentage, and 100-kernel mass (Table 1). The yield of pods increased with increasing plant population. These yields varied from 1710 kg ha^{-1} in the highest populations to 486 kg ha^{-1} in the lowest population. Defoliation of plants decreased pod yield. Hodgson and Blackman (1957) noted that defoliation, besides reducing the assimilatory surface and thus the supply of carbohydrates, also removed the exportable reserves of nitrogen that were necessary for pod formation. Mercer (1976) and Enyi (1974) reported similar declines in pod number per plant with increasing defoliation intensities in both the erect bunch-type and the runner-type cultivars. Mercer (1976) also noted increased pod yield per plant at 100% defoliation in the bunch-type cultivar compared with the runner-type cultivar. The growth of pods after leaf removal is a genotypic characteristic that could be associated with the cultivar's ability to withstand environmental stresses.

The shelling percentages showed significant variations among treatments (Table 1, P< 0.01). The highest shelling percentage was observed from the highest plant population with the highest (100%) defoliation intensity (Table 1). High shelling-percentage implies effective pod filling. Closely-spaced groundnut plants suppress late pod formation, therefore facilitating proper Tilling of pods at the base of the plant (Enyi 1977). Enyi(1974) also noted the tendency toward increased shelling percentage/with increasing defoliation intensities. The present study confirms the positive relationships between groundnut shelling percentage and plant population and defoliation intensities. It appears that high plant populations accumulate more dry matter in the stems and branches, which are effectively used for filling the few pods produced per plant after leaf defoliation. Pod formation in groundnut is dependent upon the amount of dry matter partitioned to the stems, branches, and possibly roots. Kernel growth depends to a large extent on the amount of assimilates partitioned to the pods during growth.

Higher plant population in groundnuts increases the efficiency of solar radiation interception by the crop canopy. This characteristic directly contributes to increased photosynthetic productivity during the vegetative growth phase. Natural shedding of leaves as a result of self shading with increased plant population does not affect groundnut yield because of the relatively high accumulation of assimilates in the crop during the early vegetative growth phase. Defoliation of such plants during the flowering stage might result in stabilized yield due to increased shelling percentage of the crop. Increased shelling percentage with increasing plant population was also associated with increased seed mass (Table 1). Increased defoliation intensity, however, decreased the 100-kernel mass. Hammerton (1972) reported declines in seed size following defoliation of soybeans. Similar results have been reported by Enyi (1974) in groundnuts, soybean, cowpeas, and greengram. The observed yield variations within a plant population following variations in defoliation intensities were associated with increased shelling percentages and reduced seed sizes. The two characteristics tended to counterbalance the effects of defoliation on kernels within a population.

From the present study and earlier work by others, it is clear that defoliation of groundnuts has a negative effect on kernel yield. Foliar pests and diseases require intensive control measures in order to minimize the losses associated with leaf removal in groundnuts. A knowledge of the possible impacts of defoliation of a given crop such as groundnuts would aid crop yield modelers in simulating the impacts of pests and diseases in a given cropping season.

From the present results, it appears possible to minimize the impacts of defoliation on kernel yield by increasing plant populations. However, more work is required in order to confirm this observation.

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Insect Pests of Groundnut (Arachis hypogaea L.) in Tanzania and their Control

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Abstract

Investigations were carried out to study the insect pest complex of groundnut (Arachis hypogaea L.) and their control in Tanzania. Of the insects evaluated, groundnut aphid (Aphis craccivora Koch), groundnut hopper (Hilda patruelis Stal), termites (Odontotermes morogorensis Harris and Hodotermes mossambicus Haig), flower thrips (Taeniothrips sjostedti), flower beetles (Coryna and Mylabris ssp), and the seeding beetle (Gonocephalum simplex F.) cause most damage in the field, and considerable reduction in the seed kernel yield. Postflowering pests cause more damage and, therefore, reduce seed kernel yield more than preflowering pests. Spraying of insecticide, i.e., DDT and endosulfan, significantly reduced the insect populations on the crop. Highest kernel yields were observed from the fully controlled plants. However, kernel yield was not increased when insecticide applications were made during the postflowering growth stage or throughout the growing season.

Sumario

Insectos como pragas do amendoim (Arachis hypogaea L.) na Tanzania e o seu controlo. Investigacoes foram conduzidas para estudar o complexo das pragas de insectos do amendoim (Arachis hypogaea L.) na Tanzania e o seu controlo. Dos insectos avaliados, o afldeo do amendoim (Aphis craccivora Koch), o saltador do amendoim (Hilda patruelis Stal), as termites (Odontermes morogorensis Harris e Hodotermes mossambicus Haig), as tripes daflor (Taeniothrips sjostedti), os escaravelhos da flor (Coryna e Mylabris ssp) e o escaravelho da semente (Gonoccphalum simplex F.) causam grandes danos no campo, causando consideravel reducao no rendimento do amendoim descascado. Pragas de pos-floracao causam mais dano, causando maiores reducoes no rendimento de grao que as pragas de pre-floracao. Aplicacao de insecticidas como DDT e endosulfao, reduzem signiflcativamente a populacao de insectos na cultura. Os maiores rendimentos de amendoim em graoforam observados em plantas onde o controlo foi total. Contudo, o rendimento de amendoim em grao nao aumentou quando o insecticida foi aplicado durante o periodo de crescimento pos-floracao ou durante o periodo de crescimento da cultura.

Groundnut {Arachis hypogaea L.) is a common oil and protein crop in the tropic and subtropic regions of the world. The protein and oil contents average 30.4 and 47.7%, respectively (Purseglove 1975).

In Tanzania, the crop is grown in the low elevation areas (from sea level to about 1500 m asl), especially in the drier parts of the country such as the Dodoma, Shinyanga, Tabora, and Singida regions. The crop is grown in small quantities for home consumption in many parts of the country.

Intercropping and mixed cropping of groundnut with cereals is the more common practice among the peasant farmers in the country. Groundnuts are more commonly intercropped with maize than with any other cereal crop. The most common groundnut cultivars grown in Tanzania include Valencia, Natal

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Common, Barbeton types, Local Kongwa, Dodoma Edible, Gambia bunch, Matevere types, Asyria Mwitunde, Nyasa, Kabempa, Kenyema, Kano Wima, and Urambo type.

Groundnut seed yields are generally low, 400 to 800 kg ha^{-1}. Under good cultural practices with pest and disease control, however, improved cultivars produce up to 2.5 t ha^{-1}. The low yields stem from the use of low-yielding varieties, heavy pest and disease infestations, and poor agronomic practices.

Insect pests are one of the main constraints to yield in groundnuts. Every part of the groundnut plant is attacked by several pest species throughout the growing period, and kernels are attacked during storage. Although much work has been done on various insect pests elsewhere (Smith 1946, Broad 1966, Math and Pal 1971, Smith and Hoelscher 1975), very little work has been reported from East Africa (Jepson 1948, Hill 1975).

Materials and Methods

The insect-pest complex of groundnut was studied by collecting insects from unsprayed plots in the trials conducted at the Sokoine University of Agriculture, as well as from other parts of the country. Specimens were identified by using keys or by comparisons with named specimens in the reference collection. Observations on the life cycle and behavior of important pests were made in the field and laboratory, and are presented in brief. Insecticide effects were also investigated at Sokoine University of Agriculture, Morogoro (latitude 5.8°S, altitude 525 m; oxisol) during the Feb-Jun 1980 cropping season. The groundnut cultivar, Natal Common (bunch type), was used. We applied 75 kg ha^{-1} of nitrogen and 90 kg ha^{-1} of P_2O_5 (phosphate) in the form of ammonium sulphate and triple superphosphate after normal soil preparation.

The experiment was a randomized complete block design, replicated three times with four insecticide regimes as the four treatments. Individual plots consisted of twelve 6-m rows 60 cm apart. Plants within the rows were 10 cm apart, giving a plant population of 166 666 plants ha^{-1}.

The four insecticide regimes applied were: (a) insect control with insecticide before flowering, (b) insect control after flowering, (c) insect control throughout the growth stages, and (d) control (no insecticide application). Endosulfan (35% EC) at the rate of 600g ai per 300 L of water ha^{-1} was applied at intervals of 19 days from 20 days after planting (DAP). Thus treatments (b) and (c) received 2, 3, or 5 applications of insecticide, respectively, during the cropping season.

The effectiveness of insecticide regimes was determined by insect counts, plant damage caused by insects, and the seed-kernel yield. Only the seven central rows of each plot were harvested.

The incidence of insect pests in the groundnut crop was determined by collecting insects with sweep nets at an interval of 10 days from 10 DAP until the crop matured. The insects collected from each block were counted and identified.

Insects attacking the plants in the soil were also observed by roguing two plants from the guard rows in the plots. This was done at the same intervals as for the sweeping net sampling. The incidence of aphids (Aphis craccivora Koch) and groundnut rosette virus (GRV) were also assessed.

The incidence of flower thrips (Taeniothrips sjostedti Trybom) was estimated by counting thrips in 20 flowers collected at random from each plot following the method used earlier (Karel 1979). Polythene bags were used for collecting the flowers from the field to avoid the escape of thrips from the flowers before they reached the laboratory. The damage to flowers was recorded twice a week in each plot. Pod production was also recorded at the same intervals. Forty plants were tagged in each plot for these assessments. Other insects that were studied specifically were Coryna spp and termites (Odontotermes spp).

At harvest, pod and seed-kernel yields were estimated from the seven central rows of each plot and reported as kg ha^{1}.

Varietal Performance

The aim of this experiment was to study the yield potential of two groundnut cultivars, Natal Common and Slim Matevere. The experiment was planted in a randomized block design in 7 * 6 m plots at a spacing of 60 x 10 cm giving a population of 166 666 plants ha^{-1}.

The experiment received full control of insect pests throughout the growing season. Endosulfan (35% EC) at the rate of 600 g ai per 300 L of water ha^{-1} was sprayed to the plots before flowering. DDT (25% EC) at the rate of 800 g ai per 500 L water ha^{-1} was sprayed on the soil to control soil pests. Spraying of insecticide was at 10-day intervals commencing at seedling emergence. Supadiel was sprayed only once during the growing season.

During the course of growth of the crop, insect populations were assessed on the two varieties to study effectiveness of the insecticides used. However, only those observations on flower and pod production, pod yield, and seed kernel yield are reported for this experiment.

Results and Discussion

Pest Complex of Groundnuts in Tanzania

A total of 67 species of insects feeding on groundnuts were recorded. In all, 8 orthopterans, 3 isopterans, 15 hemipterans, 10 thysanopterans, 3 dipterans,and 28 coleopterans were found to be associated with groundnuts (Table 1).

The most important pest of groundnut was Hilda patruelis Stal, the groundnut hopper. The adults and nymphs suck sap from the stem, pegs, and pods usually just below groundlevel (Hill 1975). Under severe damage, wilting and collapse of the plant occur. Black ants are associated with Hilda bugs in the field. The pest can effectively be controlled by eliminating the ants associated with it or by treating the insect itself with insecticide.

Aphis craccivora Koch is another sap-sucking insect of groundnuts in Tanzania. The insect causes wilting of plants, particularly in hot weather (Hill 1975). The most serious damage caused by groundnut aphids is the transmission of GRV. The leaves of attacked plants become mottled with either chlorotic or dark green spots according to the form of virus, and the plant develops a stunted growth habit (Hill 1975).

Table 1. List of insects associated with groundnuts (Arachis hypogaea L.) in Tanzania.

Order	Family	Genus and species
Orthoptera	Gryllidae	Liogryllus morio F.
	Tettigoniidae	Homorocuryphus nitidulus Wlk
	Acndidae	Locusta migaratoria migsratorioes RUF
		Ornithosis spp[1]
		Chrotogonus rotandus Kirby[1]
		Nomadacris septemfasciata Sen.
		Schistocerca gregaria Forsk.
		Zonocerus elegans (Thun.)
Isoptera	Termitidae	Allodontermes morogorensis Harris
		Odontotormes morogasrensis, Harris[1]
	Hodotermitidae	Hodotermes mossambicus Hag.[1]
Hemiptera Homoptera	Tettigometridae	Hilda pa true/is Stal[1]
	Cicadellidae	Empoasca fascia lis (Jacobi)
	Coccidae	Pseudococcus brevipes Ckll.
	Aphididae	Aphis craccivora Koch.[1]
	Aleyrodidae	Bemisia tabaci Genn
Hemiptera Hemiptera	I.ygaeidae	I.ygus festivus
	Miridae	Creontiades tellini
	Coreidae	Acanthomia spp
		Anoploenemis curvipes[1]
		Clotus fasciens
	Pyrrhocoridae	Dysdorcus spp
	Pentatomidae	Calidea dregii Germar
		Piezodorus hyhneri
		Nezara virdula L.
		Cydnus spp
Thysanoptera	Thripidae	Taeniothrips sjostedti Trybom[1]
Lepidoptera	Pyralidae	Antigastria catalaunalis (Dup)
		Lamprosema indica
		Maruca testulalis Geyer
	Limacodidae	Parada vivida Wilk.
	Noctuidae	Heliothis armigera Hubner
		Achaea finita Gn
		Agratis ipsilon (Hfn)
		Utathesia dulchella
		Spodoptera littoralis Bois

Continued.

Table 1. continued.

Order	Family	Genus and species
Diptera	Cecidomyiidae	Contarinia sorghicola (Cog)
	Agromyzidae	Ophimia phaseoli Tryon
	Tephritidac	Dacus curcurhitea Coq.
Coleoptera	Chrysomelidae	Luperodes spp
		Ootheca bennigseni (Salhb)
		Ergana bicolor Jac.
		Dicladispa armigera
		Lema legimbarti (Kuw.)
		Aphthona bimaculata
		Nisostra suahelorum[1]
	Meloidae	Mylabris amplectens[1]
		Coryna kersteni
		Coryna apicicornis Guest.[1]
		C. lanuginosa Gerst
	Curculionidae	Systates pollinosus Gerst.[1]
		.V. articollis Mshl
		Graphognatrus spp
		Sphrigodes globulus Mshl.
		Alcidodes dentipes Oliv.
		Diaecoderus spp
	Tenebrionidae	(Ionocephalum simplex (F.)[1]
		Nisostra maculiceps
		Zophosis congesta sjost.
		Zophosis spp
		Catamerus revodi Fairm.
		Emmallus major fairm.
		Macropoda nigrogemmata Fairm.
		Peristeptus gestroi Haag.
		Pogonobasis ornata Sol.
		Rhytinota acuitcollis fairm
		Rhytinota gracillima Accey.

1. Major pests of groundnuts in Tanzania.

Aphis craccivora Koch is distributed throughout the world. The control of this pest is better achieved by practising proper field sanitation, which involves roguing and destruction of volunteer groundnut plants and weeds. In this experiment, endosulfan spray gave satisfactory results in the control of the pest.

Anoplocnemis curvipes (F.) was also observed in the groundnut plots. This insect punctures the main branches and causes the attacked parts of the plant to wither and die.

The common pest of Citrus and coffee, Systoles pollinosus Gerst., was also observed feeding on groundnuts. This pest survives on a range of cultivated and wild plants (Hill 1975). The edges of attacked leaves have characteristic fjord-like indentations, where the adult weevils have eaten away the lamina (Hill 1975). Similar symptoms were observed on some leaves of groundnuts.

The common bean flower thrips (Taeniothrips sjostedti Trybom) was also recorded. It is a common pest of beans, peas, and groundnut. Sometimes it can be observed on coffee, avocado, and many other plants as alternative hosts (Hill 1975).

Both adults and nymphs are found inside the flowers of groundnuts and other legumes. Feeding punctures were seen at the base of the petals and stigma. It is one of the major pests of groundnut in Tanzania. The control of thrips is possible by the use of insecticides such as DDT and UBHC (Hill 1975).

Among the important soil pests of groundnut is the termite (Hodotermes mossambicus Hagen). It is a major pest of grassland below 1500 m in parts of Africa, especially during periods of drought or following overgrazing (Hill 1975). During the course of the experiment the weather was dry and favorable for the pest, which caused severe damage to both seedlings and mature plants. Yield lossess caused by termites and other soil pests were significant.

The dust brown beetle (Gonocephalus simplex F.) is another soil pest associated with the groundnut crop. It is commonly a pest of coffee, and many other wild and cultivated plants (Hill 1975). This beetle bores into the pods of groundnut, damaging the developing kernels, whereas termites feed on the whole pod. It is not yet established as to which stage of the life cycle causes most damage to the crop.

Most of the insects recorded in Table 1 damage those parts of the plant that are above ground level, except for the termites Odontotermes morogoroensis and Hodotermes mossambicus, Gonocephalum simplex, and Agrotis ipsilon. Millipedes also damaged the pods.

The most important pests of groundnut during the vegetative stage included groundnut hoppers Hilda patruelis, Ornithacris spp, homorococyphus nitidulus, Ootheca bennigseni. Systates spp, and Nisostra maculiceps.

In the postflowering stage, the most important pests were Odontotermes spp and Taeniothrips sjostedti (Table 2). The density of flower thrips was highest in the unsprayed plots. However, there was no significant difference in flower thrip counts between the unsprayed and the preflowering treatment plots.

Table 3 records insect scores per plot at different growth stages of the plant. These pests caused considerable damage to the plants and affected the yield and yield components. The postflowering and full control treatments gave similar yields (892 kg ha^{-1}), indicating the importance of postflowering pests of groundnuts. The unsprayed plants gave lower kernel yield of 676 kg ha^{1}. The lower yields obtained from the unsprayed plots emphasized the importance of insect pest control in groundnuts in order to increase productivity (Table 4).

The yield components of groundnuts, i.e., flowers per plant, pods per plant, and pod yield ha^{-1} varied significantly with the spraying regimes ($P < 0.05$) (Table 4). The unsprayed plots had the lowest values

Table 2. Effect of insecticide spraying regimes on the incidence of flower thrips and plant damage by insect pests of groundnut, Sokoine University of Agriculture, Tanzania, 1980.

Stage of insecticide application	Mean number of thrip counts per flower	Percentage damage by pod borers and termites	Number of plants damaged per plot
Preflowering	24.0	6.0	7.0
Postflowering	17.0	8.3	8.3
Full control	21.7	6.0	6.3
Unsprayed control	25.3	10.0	13.7
Mean	22.0	7.6	8.8
Significance	NS	NS	*

* Significant at 0.05 level of probability.
NS = not significant.

Table 3. Effect of insecticide spraying regimes on the incidence of insect pests on groundnuts, Sokoine University of Agriculture, Tanzania, 1980.

	Number of insects									
	Days after emergence									
Spraying regime	10	20	30	40	50	60	70	80	Mean	Significance
Preflowering	9	17	32	12	71	47	39	41	35.5	**
Postflowering	9	19	32	10	61	41	28	36	29.5	**
Full control	8	12	28	8	64	41	34	37	30.0	**
Unsprayed control	18	24	34	27	82	57	48	39	41	**
Mean	11	18	31.5	14.3	69.5	46.0	37.3	38.3	33.3	**
Significance	**	**	**	**	**	**	**	**	**	

** $P<0.01$.

Table 4. Effect of insecticide spraying on various plant characteristics of groundnuts, Sokoine University of Agriculture, Tanzania, 1980.

	Spraying regime					
Components of yield	Pre-flowering	Post-flowering	Full control	Un-sprayed	Mean	Significance
Flowers plant^{-1}	29.3	36.7	38.3	28.0	32.3	**
Pods plant^{-1}	32.1	42.3	43.0	32.3	37.5	**
Pod yield t ha^{-1}	1.39	11.9	1.39	1.04	1.25	**
Seed yield t ha^{-1}	0.80	0.87	0.68	0.76	NS	
Mass seed^{1} (g)	0.33	0.32	0.31	0.30	0.32	NS
Normal seed (%)	74.0	76.6	71.9	70.0	73.0	NS

*, ** significant at 0.05 and 0.01 levels of probability, respectively.
NS = Not significant.

for both characters. Yield component values were higher in the full control plots. The preflowering spraying treatment gave lower kernel yields. This implied that most of these pods were damaged by postflowering pests, thus reducing the number of effective pods. The percentage of normal seed did not vary directly with the time of spraying of the crop.

Results indicate that there were more insects associated with groundnuts at the time of flowering than at any other growth stage of the plants (Table 3). Therefore, spraying of insecticide at this time would be useful. The insecticide application was found to be effective in controlling most insect pests during flowering and postflowering, except for the flower thrips.

The damage by soil pests was found to be high. Therefore, control of foliar pests should go together with the control of soil pests, especially in the semi-arid climates or periods of inadequate rainfall. These pests caused considerable loss to the crop during the season.

The highest yield, which was obtained from the fully treated plots, indicates that the most effective control of pests should begin at the time of seedling emergence and continue through to flowering and pegging.

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Discussion on Tanzania Papers

Nigam: I was impressed with the Tanzanian presentations, particularly with their multidisciplinary approach. My question concerns the four varieties listed as resistant to leaf spot, rust, and rosette. One of these is PHI 200 PI 314817. 1 have not come across this variety. Could it be DHT 200? Also 1 should like further information on these lines in regard to their disease resistance.

Doto: There may have been an error in the labelling of the original accession. We will check and make the necessary correction known to you. Makambaka, Ex-Njombe, Mbeya, and PHI 200 PI 314817 have shown remarkable resistance/ tolerance to both early and late leaf spots, rust, and rosette in 1982. These varieties, particularly Mbeya, have continued to display high levels of resistance to these diseases, especially rosette, in 1983 and 1984.

Gibbons: One should be careful in claiming rosette-resistance without confirmatory laboratory tests using infective aphids. Many earlier claims of rosette resistance based on field observations were not substantiated when tested in the laboratory. Escapes from infection are frequent in the field.

Bock: Our program in Malawi is ready to make appropriate rosette-resistance tests for any national program. 1 suggest you send 10-15 seeds of any line apparently resistant to rosette and we will recheck resistance carefully under controlled conditions. This offer is open to anyone, at any time.

Omran: I hope this very relevant service, among others, will be emphasized in the Groundnut Newsletter and the Proceedings for everybody to know of it and to use it.

Nigam: Comparison has been frequently made between erect and runner types. Is there any preference for plant type, or is yield the main comparison?

Doto: Preferences are there but these are not clearly defined. Regional preferences generally exist, but again it is common to find both types in almost all the major groundnut-growing areas.

Mwenda: Most farmers in southeastern Tanzania prefer late-maturing spreading bunch-types such as Red Mwitunde. In other areas such as Dodoma in Central Tanzania, there is no preference. Our research objectives, however, aim to find suitable varieties for particular ecological zones. Short-season types are tested in areas with a short rainy season while long-season varieties are tested in areas where the rainy season is longer.

Reddy: You have shown a significant yield increase with increase in plant population from 10 to 44 plants nr^{2}. What is the recommended plant population in Tanzania? The 44 plants m^{-2} treatment seems very high compared to the recommended population because it will require a very high seed rate, which is a major constraint to the farmer. Do your data refer to only one year's results?

Tarimo: The recommended plant population in Tanzania is only 20 plants nr^{2}. I agree that 44 plants nr^{2} require a. very high seed rate; farmers on the other hand, plant very low plant populations. The trial reported was an exploratory one.

Nigam: I refer to Tarimo's suggestion on identification of varieties that attain high yield at low plant populations; whereas his results from plant population and defoliation studies indicate that higher populations give higher yields. How do you reconcile the two observations? If seed is a limiting factor, then the area under the crop could be reduced to maintain optimum populations, thereby ensuring higher yields. This would also reduce the farmer's labor requirement for land preparation and crop management.

Doto: We have posed the question in our paper so as to seek ideas from the delegates at this workshop. Merits that could arise from adopting the suggestion (from the farmer's point of view) have been indicated in our paper. Some of the implications in breeding and evaluation have also been aired. Perhaps Tarimo would comment before the matter is taken up in further discussion.

Tarimo: The suggestion to reduce land area to accommodate available seed is acceptable but will not necessarily result in increased production. High-yielding varieties at low population densities are intended for increasing the productivity of the arable land that is available to the farmer. The availability of seed is the main constraint, which requires the attention of both biological and social scientists involved in groundnut research.

Cole: Why do defoliation and population density affect shelling percentage?

Tarimo: Because fewer pods are formed that are better filled.

Omran: DDT is banned but I see in your paper that it is still used.

Tarimo: It is used only on a very small scale.

Sandhu: How would you develop varieties that can attain high yields at low plant densities? The only means of doing this is to develop indeterminate types, but these would not be suitable for the short-growing seasons commonly prevailing in Tanzania.

Research on Groundnut Pests at ICRISAT

J. A. Wightman, P. W. Amin, G. V. Ranga Rao, and K. M. Dick*

Abstract

Entomologists at the International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, India (ICRISA T Center) have identified 11 arthropod groupings or taxa as major field pests of groundnuts (Arachis hypogaea L.) in their mandate area. Their research is concentrated on 8 of these groupings and covers all relevant aspects of the contemporary pest control options. A common theme is rationalizing insecticide usage. A long-term, but achievable goal is the incorporation of multiple pest resistance into all cultivars released by ICRISAT. Termites, the thrips Frankliniella schultzei (Trybom) (a virus vector), the tobacco cutworm Spodoptera litura (F.), and the groundnut leafminer Aproaerema modicella (Deventer) have been selected as subjects of in-depth studies. The bruchid, Caryedon serratus (Olivier), has been identified as a potential pest of stored groundnuts in India. The kernels of groundnut genotypes are being tested for resistance to three other postharvest pests, the rust-red flour beetle Tribolium castaneum Hbst., the rice moth Corcyra cephalonica (StntJ, and the warehouse moth Ephestia cautella (Walker) by means of techniques specially developed at ICRISAT Center.

Sumario

Investigacao sobre pragas do amendoim no ICRISAT. Os entomologos no Instituto Internacional para a Investigacao de Culturas para os Tropicos Semi-Aridos, Patancheru, Andhra Pradesh, India (ICRISAT-Centro) identificaram 11 grupos de artropodes (taxa), como pragas importantes no amendoim (Arachis hypogaea L.) na regiao em que trabalham. A investigacao esta concentrada em 8 destes grupos, cobrindo os aspectos mais relevantes das opcoes contemporaneas para o controlo de pragas. Um tema comum e a racionalizacao do uso de insecticidas. Um objectivo a longo prazo mas possivel de atingir, e a inclusao de resistencia multipla a pragas, nos cultivares libertados pelo ICRISA T. As termites, as tripes (Frankliniella schultzei (Trybom) um vector de viroses), a lagarta do tabaco (Spodoptera litura F.) e o minador da folha do amendoim (Aproaema modicella Daventer) foram seleccionados para serem submetidos a estudos mais aprofundados. O bruquideo Caryedon serratus (Olivier), foi identificado como uma praga potencial para o amendoim armazenado na India. A semente de varios genotipos de amendoim esta sendo testada para a resistencia contra outras tres pragas depos-colheita, como sejam a ferrugem, o gorgulho vermelho da farinha (Tribolium castaneum Hbst.), a traca do arroz (Corcyra cephalonica Stnt.) e a traca dos armazens (Ephestia cautella Walker), atraves de tecnicas especialmente desenvolvidas no ICRISAT-Centro.

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ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1987. Proceedings of the Second Regional Groundnut Workshop for Southern Africa, 10-14 Feb 1986, Harare, Zimbabwe. Patancheru, A.P. 502 324, India: ICRISAT.

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has responsibility for carrying out research aimed at improving groundnut (Arachis hypogaea L.) production throughout the semi-arid tropics (SAT) and wherever else groundnuts are grown. The clients are the scientists and extension workers of the national programs of the countries served by ICRISAT.

The constraints to groundnut production in the SAT are:

- soil related problems including drought, mineral imbalances, deficiencies or excesses, and inadequate nitrogen fixation by Rhizobium populations;
- inappropriate cultural practices;
- cultivars with limited yield potential;
- insufficient finances to buy fertilizers, good seed, and pesticides, and to pay wages;
- fungal and viral diseases;
- invertebrate pests; and
- inadequate marketing facilities.

ICRlSAT's Groundnut Improvement Program is addressing the agricultural aspects of these problems. This paper is an overview of the recent, current, and planned research on invertebrate pests and their control. Our approach has been to identify the major pests or pest taxa in the SAT and to develop management techniques that are compatible with the cultural practices and financial status of the farmers concerned. Where possible we are seeking techniques that minimize their dependence on insecticides. Although pesticides have an important role to play in the control of some groundnut pests, we are aware that their over-application can lead to insecticide resistance, and will almost certainly eliminate many natural control factors. Furthermore, the correct insecticides and the means to apply them are often unavailable to many farmers in the SAT.

The Pests

Field pests either live underground where they damage the roots, pegs, and pods, or they feed on the leaves, stems, and flowers. The foliage feeders include vectors of virus diseases. We are directly involved with 8 of the 11 major pest taxa (Table 1) but see the need to extend our range of interest.

Pests of stored groundnuts tend to be pandemic and polyphagous. A succession of species can infest the product at all stages of the postharvest process—from harvesting onwards. A project on this aspect of groundnut entomology has recently been initiated.

Our research is discussed in terms of control strategies rather than by considering each pest individually. However, it should be mentioned that the groundnut leaf miner, Aproaerema modicella (Deventer), the thrips, Frankliniella schultzei(Trybom), and the tobacco caterpillar, Spodoptera litura (Fabricius), have been selected as subjects of in-depth studies because of their importance within the SAT. F. schultzei has been identified as the major vector of tomato spotted wilt virus (TSWV) that causes bud necrosis disease (BND), which has devastated groundnut crops over wide areas of India (Reddy et al. 1983). The other two species eat the leaves.

Heliothis armigera is included among the pests because there is a possibility that its flower-eating habits can delay harvest by extending the flowering period. If abundant, it is a serious defoliator but even when it is present in low numbers it may cause damage that goes undetected.

Hilda patruelis Stal. is in the list because it is a pest about which we need to know more. It occurs throughout southern Africa, especially in dry years, but is sporadic in appearance. It feeds on the upper roots of groundnut plants and causes the host to wilt and die. This could be because it removes water because of its sap-sucking habit. However, tests carried out in the laboratories of ICRlSAT's Regional Program for Southern Africa in Malawi show that there is more than a physical response involved. The observations indicate the possibility that the insect injects a toxin into the host or that it may open the way to infection by a pathogen such as Fusarium sp (Weaving 1980, ICRISAT 1985a).

A survey over a period of 3 to 5 years is needed to determine the extent and intensity of the damage caused by this pest. It can be controlled with insecticides but they may be unavailable or too expensive. Weaving (1980) indicated that cracked soil around the plant favored its proliferation. Perhaps interplant hoeing would slow its spread. H. patruelis is attended by ants. What is the nature of this symbiosis and can it be exploited to manage this pest? There are many more such questions that need to be answered.

Management of Field Pests

Insecticide Control

In some parts of Africa, groundnut cannot be grown without pesticides being mixed with the soil before

Table 1. Major field pests of the groundnut crop in the semi-arid tropics.

Pest	Damage, distribution, and comments
Taxa and pest groups covered by research projects at ICRISAT Center:	
Termites (especially Odontotermes and Microtermes)	Can eat all parts of the plant but are mainly root and pod borers; pods scarified by termites are prone to soil-borne diseases; problem extends throughout the SAT, but is most serious in northern Africa.
Thrips	Present throughout SAT but mainly a problem in Asia; distort leaves and cause chlorosis. Frankliniella schultzei transmits a virus.
Aphids	Distort plants and stunt their growth. Many are vectors of virus diseases. The groundnut aphid, Aphis craccivora, is a serious problem in Africa.
Groundnut leaf miner Aproaerema modicella	A major defoliator in India and Asia.
Tobacco caterpillar Spodoptera litura	A serious defoliator in India and Asia; also a pod borer.
Jassids	Cause chlorosis and leaf scorch and are associated with witches' broom disease; a problem throughout the SAT, especially Empoasca spp.
Bud worm Heliothis armigera	Flower-eating habits may delay harvest, can also be a serious defoliator in Asia.
'Pod-borers'	Includes millipedes (especially in W. Africa), ants, earwigs, S. litura and wire worms. Present throughout the SAT.
Taxa not covered by current research projects at ICRISAT Center:	
Hilda patruelis	Feeds on roots close to the hypocotyl; causes the host to wilt; a special problem in drought years; restricted to southern Africa.
Whiteflies	Cause foliar distortion and transmit viruses; mainly a problem in S.E. Asia.
White grubs (scarabaeid larvae)	Can destroy the root system; a special problem in light soils; crops grown in northern India are prone to attacks by these pests; a very widespread and often undetected pest.

sowing. This procedure is needed to control termites, which can reduce yields by more than 50% (Sands 1960, Johnson et al. 1981). The termites live in large nests that can be several meters underground. These colonies are also widely separated, perhaps with only one or two ha^{-1}. Attempting to destroy nests by physical means would involve major earth movements and would not necessarily prevent reinvasion from peripheral areas. Only persistent pesticides such as the cyclodiene insecticides endrin, dieldrin, and aldrin are suitable for controlling termites in this situation. However, this procedure may not be followed for much longer because the health authorities of consumer nations are becoming increasingly intolerant of pesticide residues in imported foodstuffs. Cyclodienes are highly soluble in the oil that makes up nearly 50% of the content of the kernels. Furthermore, they are highly toxic to mammals and create a hazard to the people involved with handling and applying them. Other types of insecticides (organophosphates, carbamates, and pyrethroids) will undoubtedly kill termites but they break down after several weeks in the soil, especially in tropical conditions. Ideally, pesticides applied for the control of soil insects should remain active for the entire crop season. There is a clear need for an alternative approach to this problem. However, this is not easy to find.

ICRISAT is joining with the Tropical Development Research Institute (TDRI), London, UK, and the University of Agricultural Sciences, Bangalore, India, in seeking alternative chemical-based methods for controlling termites. Initially, we plan to set up insecticide field trials in India to test some new chemicals, which are less toxic to humans than the cyclodienes, as well as slow-release formulations of well established, but short lived, insecticides. A fourth trial will test a new approach that has been developed by TDRI but which has not been fully tested in the field. This involves introducing either a slow-acting insecticide or a fungicide into nests by means of a cellulose bait. The target for both alternatives are the fungus gardens, upon which termites depend for their food. It is hoped that the insecticides will contaminate the fungus gardens via the organic matter collected by the foragers and kill the termites that subsequently eat it. Hopefully, the fungicide will kill the fungus "gardens" so that the colony starves. Treatments that prove successful in India will be tested in farm conditions in Africa.

A major research project at ICR1SAT Center is primarily directed at determining the economic threshold and the correct control strategy for the groundnut leaf miner. We are using different intensities of insecticides to regulate the numbers of this insect, which is the main dry-season (mid-Dec to mid-Apr) pest in India. There are usually three or four groundnut leaf-miner generations per growing season, each one having a higher population density than the last. This means that the younger plants are not usually damaged by this pest. Our results indicate that yield loss does not occur unless there are more than 60 larvae per plant. The host is usually in the pod-filling stage by the time the pest has achieved this density.

The implication is that if leaf-miner densities reach more than 5 to 10% of the damage threshold (according to our estimates) at the end of the second generation, an insecticide should be applied when the adults are emerging from the pupal cases. This research will be continued for several seasons to confirm our data. We are also examining the influence of insecticides on the natural enemies of the groundnut leaf miner. A similar approach will be taken with other pests.

Host Resistance

As would be expected in an institute that has a major interest in plant breeding, considerable progress has been made in identifying and exploiting insect resistance in the 11 458 accessions in the germplasm collection (Table 2). We are seeking genotypes in which multiple pest and disease resistance is combined with satisfactory agronomic characteristics, such as high-yield potential and drought resistance. A team of entomologists, pathologists, and breeders has already succeeded in incorporating resistance to the thrips vector of TSWV into agronomically promising, advanced breeding lines.

Noteworthy genotypes are:

- Robut 33-1 (Kadiri 3): accepted by the Indian Council of Agricultural Research (ICAR) as a cultivar for the postrainy season in several states. This line apparently has some resistance to F. schultzei so that it suffers less from BND than the commonly grown cultivar TMV 2 (Amin 1985a).
- ICG 2271: identified by ICAR as a source of multiple pest resistance for breeding purposes. This genotype has resistance to pod-boring insects, pod-scarifying termites, thrips, jassids, and the groundnut leaf miner. In addition, it has a high-yield potential in the rainy season.

Other genotypes with high levels of multiple pest resistance are NC Ac 343, 2214, 2230,2240, 2243. A "nursery" of insect resistant lines is being sent to 18 collaborators in 13 countries to determine their yield potential and the level of their resistance to pests in different geographical locations.

We are concerned that we have made little pro-

Table 2. Groundnut genotypes with resistance to insect pests.

Pest taxon	Genotypes
Jassids	NC Ac 343, 406, 489, 785, 1337, 1705, 1741, 2142, 2144 2214, 2230, 2232, 2240, 2243, 2666, 2700, 17888, M13, Gujarat narrow leaf
Thrips	NC Ac 102, 343,841, 1705, 1741, 1781, 2142, 2144, 2154, 2214, 2230,2232, 2240, 2242, 2243, 2460, 2462, 2772, 7302, 15926, 17888, C-108, C-121, C-136, C-145-12, Gujarat narrow leaf, Robut 33-1
Pod scarifying termites	NC Ac 343, 1705, 2142, 2230, 2240, 2242, 2243, 10033, 17888, RMP40
Groundnut leaf miner	Ah 477-1, 7215, C-154, CG-2145, 2157, 2187, 2232, GBFDS-17, 92, 93, 272, 273, M-13, NC Ac 343, 2491, RMP-40, S-7-2-14, TG-8 83/349/1
Pod borers	NC Ac 343 and 2240

gress in finding resistance to Aphis craccivora Koch. This is because it is ephemeral at ICRISAT Center, so special field screens cannot be set up to select resistant lines. However, we found that in glasshouse conditions, aphid reproduction was reduced on NC Ac 2214, NC Ac 2240, NC Ac 343, and M 13 in comparison to susceptible control genotypes such as TMV2.

The main reason for seeking resistance to A. craccivora is because it is the vector of the groundnut rosette virus (GRV), an important virus disease of groundnuts in Africa. As the "African" biotypes of A. craccivora are likely to be different from the "Indian" ones, we feel that Africa is the correct place to screen for resistance to this pest. Hopefully, the provision of improved facilities for the Regional Program in Malawi and cooperative ventures with other agencies will permit the number of genotypes tested to increase. Clearly, resistance to the vector and to the virus should be sought in parallel studies.

The preliminary experiments reported by Amin (1985b) and the research of other workers that he reviewed point to the existence of a high degree and a wide range of pest resistance within the genus Arachis. The groundnut cytogeneticists at ICRISAT Center are able to perform the chromosomal manipulations necessary for transferring "resistance" genes from wild to cultivated members of the genus Arachis. This is another field of research that will receive attention in the near future, with a view to finding sources of resistance to what may be the more intractable pests: S. litura, A. craccivora, and termites.

Research on the nature of resistance to pests indicates that it can be caused by physical and chemical factors. The presence of long, dense trichomes on the leaves of genotypes such as NC Ac 2214, 2230, and 2240 and the thick leaf-cuticle of NC Ac 2242 and 2243, for example, are associated with resistance to jassids Empoasca kerri Pruthi (ICRISAT 1985b). The trichome characteristics have a high degree of heritability and have been transferred to genotypes with favorable agronomic characteristics by normal breeding procedures (Dwivedi et al. 1986).

We plan to investigate the chemical basis of resistance in the hope of being able to screen plant material for resistance to pests under laboratory conditions. This procedure would not be totally satisfactory by itself. However, it would avoid the need for relying entirely on field experiments, which are expensive and time consuming, as well as frustrating, if the insects we are interested in do not infest the fields in which the material is growing.

Cultural Control

In some situations farmers are able to reduce pest damage by adopting simple modifications of existing cultural practices. It has been known for a long time that increasing the plant population density reduces the incidence of GRV (Farrell 1976). The same is true for BND (Table 3).

Similarly, as with GRV (Farrell 1976), farmers who sow early in the season (i.e., as soon as, or even before, the "monsoon" rains fall) will avoid or suffer little loss from BND. Similarly, with postrainy season crops, the later the sowing date the greater will be the plant mortality caused by BND. The late-sown plants will be susceptible to the virus carried by thrips dispersing from the plants sown previously. Early-sown crops appear to be well established and less susceptible to the virus by the time viruliferous thrips are migrating.

Experiments at ICRISAT Center have shown that when groundnut plants are intercropped with millet, in particular, the incidence of BND is reduced (Table 4). An experiment to find out why this happens is currently in progress.

Another project has been designed to provide information about the interaction between the groundnut leaf miner and its host when grown under drought stress. There is a belief, in India, that this pest "prefers" to feed on plants suffering in this way. We are testing this hypothesis by measuring the density of this pest sown along a drought stress gradient. Pest density, haulm biomass, crop yield, and soil water deficit are being measured.

Enhancement of Natural Pest Mortality Factors

We do not believe that mass releasing of introduced parasites and predators and the inundative release of natural enemies is a practical proposition for controlling groundnut pests in the SAT; we are not involved in conventional "biological control" procedures. As the land masses involved are large and have a diverse fauna it is highly likely that a number of parasites, predators, and diseases are already present. Furthermore, rearing and release procedures would be costly because of the infrastructural problems associated with mass rearing, distribution, and monitoring the effects of such programs. It is far more important to design pest-control strategies that do not reduce the numbers of beneficial organisms already present.

Table 3. Effect of plant population density of groundnut on bud necrosis disease (BND) incidence at ICRISAT Center, 1980 rainy season.

Spacing (cm)		No. of	No. of plants per plot[1]				Ratio of
Row	Plant	seeds per hill	Total	Healthy	Infected with BND	BND incidence (%)[2,3]	healthy to diseased plants
75	15	1	200	92	108	53.6(47.3)	1:1.17
75	15	2	392	275	117	29.8(29.9)	1:0.42
60	20	1	187	99	88	47.0(43.6)	1:0.88
60	20	2	348	200	148	42.1(42.4)	1:0.74
30	10	1	522	300	222	42.6(40.6)	1:0.74
30	10	2	1290	1044	246	19.1(25.9)	1:0.23
15	5	1	1620	1 138	482	29.7(33.0)	1:0.42
15	5	2	3 620	3218	402	11.1(19.5)	1:0.12
SE			±92.5			(±2.25)	
CV (%)			15.6			(11.06)	

1. Gross plot size 7 x 6 m; net plot size 5*4 m.
2. Mean of three replicates
3. Parentheses indicate are sine transformed values.
Source: Amin 1983.

Table 4. Effect of intercropping of groundnut on the incidence of bud necrosis disease, 1982 rainy season, ICRISAT Center.

Crop combination[2]	BND incidence[1] (%) Days after emergence 50	62	75	Reduction in BND incidence over control (%)
Groundnut sole crop (TMV 2)	35	57	70	
Groundnut + pearl millet (BK 560)	25	37	47	33
Groundnut + sorghum (CSH 6)	32	48	60	15
Groundnut + maize (Deccan 101)	32	50	62	11
Groundnut + pigeonpea (ICG 1-6)	36	54	67	4
Groundnut + castor (Aruna)	39	57	70	0
Groundnut + sunflower (Morden)	31	48	62	11
SE	±2.6	±2.8	±1.9	
CV {%)	13.7	7.5	5.3	

1. Mean of three replicates, plot size = 300 m^2
2. Row arrangements: 3 rows of groundnut to 1 row of pearl millet sorghum, and maize; 5 rows of groundnut to 1 row of pigeonpea, sunflower, and castor. Spacing within rows: 10 cm for groundnut. pigeonpea. castor; 15 cm for pearl millet; 20cm for sorghum, maize. and sunflower.

Source: Amin 1983.

At this stage we are concentrating on the groundnut leaf miner. There are about 25 species of parasites associated with this pest (Mohammad 1981) but we have not assessed their relative importance. In the 1984/85 postrainy-season crop at ICRISAT Center there was about 10% larval mortality caused by parasites in plots that were not treated with insecticides. In the 1985 rainy season, the groundnut leaf-miner population remained low, presumably because there was about 90% parasitism in the first two generations. Thus, with this species at least, there is the potential for letting nature take its course, especially if pest-resistant cultivars are grown.

At first sight, our research plots appear to be devoid of predacious arthropods. This is to be expected of land that is intensely cultivated for growing rotation crops. However, we have caught "reasonable" numbers of hunting spiders (Lyniphiidae) and ground beetles (Carabidae) in pitfall traps, especially in those placed in unsprayed plots. These predators must be eating something and therefore should not be killed, because their diets probably include jassids and groundnut leaf miner moths.

S. litura is a serious groundnut defoliator in many parts of India and Southeast Asia. It has recently been identified as a pod borer in Haryana (northern India). This species is a major tobacco pest and attacks a number of other crops, including cotton. It has been treated with a wide range of insecticides for many years and is now resistant to organophosphates, pyrethroids, and carbamates (eighty-fold resistance to carbaryl) according to reports that have come from India and China (Ramakrishnan et al. 1984, Chou et al. 1984). Insecticide application should, therefore, be discounted as a long-term control strategy for this pest.

S. litura has a number of parasites and predators (Patel et al. 1971), but, perhaps owing to its sporadic appearances, they do not seem to have much impact on decreasing its numbers. It is, however, subject to a number of specific diseases (Kore and Bhide 1978, Dhandapani et al. 1982). Once the basic research on the biology of this pest has been carried out we shall look in this direction for developing a control method. Hopefully, the development of management strategies for other pests, that involve little or no insecticide application, will allow the parasites of this species to increase and perform a significant regulatory function.

Modelling

The advantages of simulating the interaction between a pest and its host during the development of pest-management programs has been demonstrated by Gutierrez et al. (1975). S. litura has been selected as the subject of such a research project. This is because:

- it is a serious pest in Asia,
- ICRISAT Centre has the best facilities for carrying out the research in SAT Asia, and
- the complementary experience and training of our scientific staff is such that it is possible to execute an in-depth study of the type required.

This project, which is comparable to the one described by Bellows et al. (1983), is divided into a sequence of interconnected submodels (Figure 1):

- A study of the influence of temperature on egg, larval, pupal development, and oviposition rates in laboratory and field conditions throughout the year. The experimental approach accommodates both diurnal and seasonal fluctuations in temperature. The data will allow us to predict generation length from site-specific meteorological data and allow us to use ambient temperature records to drive the model.
- Within generation mortality. It is necessary to know the conditions under which larvae survive to the damage-causing stages (fifth and sixth larval instars).
- Quantification of the relationship between larval growth and leaf dry-matter consumed ("energetics'*). This phase is the link between the population dynamics study and the next aspect.
- Relationship between defoliation (i.e., larval consumption) and the loss in pod yield. The physiologists in ICRISAPs Groundnut Improvement Program have accumulated a considerable amount of the gravimetric data needed for modelling the growth of groundnuts. We shall investigate the influence of defoliation, as performed by caterpillars, on yield. One end point of this work—determining economic and damage thresholds for this pest on groundnuts—will have to take into account the genotype of the host and drought stress.
- Seasonal dispersal pattern. A network of flight traps in India has been arranged. They are baited with an effective synthetic male attractant. It should now be possible to obtain an impression of the migratory activity of at least male moths throughout the subcontinent. Early observations at ICRIS AT Center indicated a positive relationship between the number of male moths caught and the number of eggs laid in groundnut crops 7 days later. This relationship has not been recorded since, and we want to know why.

The above aspects encompass a "basic biology" study. The following are the "applied" aspects:

- Host resistance: a long-term goal is to provide groundnut genotypes with resistance to 5. litura for those areas that are subject to outbreaks. This process can be simulated and "tested" in a model of the type we are developing.

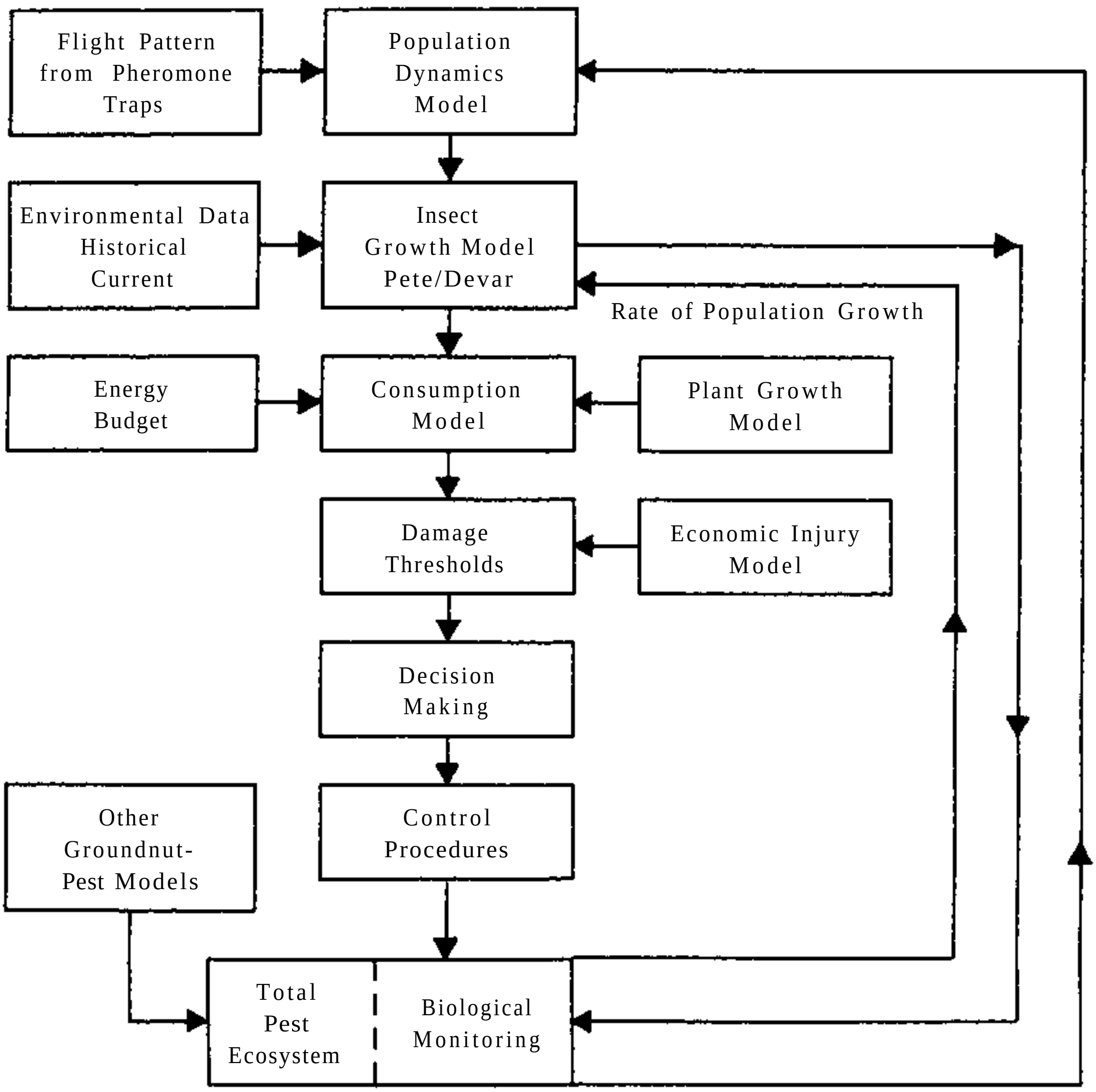

Figure 1. Flow diagram of the submodels that make up a simulation of the relationship between Spodoptera litura and the groundnut crop, including pest-management options.

Induction of epizootics. One of the few realistic control options for this pest that is open to farmers is to artificially increase the level of disease propagules present in a crop. A study carried out by TDRI on S. lit (oralis attacking cotton in Egypt points to the need to develop local facilities for producing a purified virus (TDRI 1984). This aspect is under consideration as a long-term goal. Its implementation awaits an evaluation of the TDRI's project in Egypt.

The integration of the basic ecological data emanating from this research into a model of the plant-pest relationship will enable us to simulate the potential economic benefits of the applied aspects of this work, as well as forming a basis for an outbreak forecasting procedure. A long-term goal is to include in such a model a range of pest and other constraints to yield.

Decision Making

How resistant to a given pest does a genotype have to be before a farmer has no need to apply insecticides to avoid crop losses? This is a question that entomologists and breeders should endeavour to answer. To that end, we are currently working with Dr R.A.E. Mueller (Resource Management Program, ICRISAT) and Dr N. Dudley (Bureau of Statistics, Canberra) on a dynamic programming process that will enable us to do this. In our initial test we used basic field data from the groundnut leaf miner control experiment (Table 5) and "overlaid" it with a range of "resistances". We have assumed that resistance acts by reducing the rate of increase of each generation. Natural mortality (in real life, mainly parasitism) ranging from 0 to 80% was introduced as an additional mortality factor at each level of resistance. The model has also been run with a number of insecticide "kill efficiencies". One spray of 95% efficiency is needed if there are four generations of larvae per season. There is no natural mortality and less than 70% resistance (Table 6). The need for insecticide application disappears if there is more than 60% natural mortality and at least 30% resistance.

This is a brief account of a piece of research that is in its early stages. It should be possible to extend this modelling procedure to other areas, e.g., resistance to disease and drought. This approach to decision making should be made available to research and extension workers in the SAT. Therefore, we are thinking in terms of converting it to a form that can be used with microcomputers.

Table 6. Combination of host-plant resistance and natural mortality and the number of sprays needed to avoid financial loss caused by the groundnut leaf miner Aproaerema modicella, as indicated by a dynamic programming model.

Number of insecticide applications										
Level of natural mortality	Level of host plant resistance									
	.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	2	2	2	2	2	1	1	1	0	0
0.2	2	2	2	2	1	1	1	0	0	0
0.4	2	2	1	1	1	1	0	0	0	0
0.6	1	1	1	1	0	0	0	0	0	0
0.8	0	0	0	0	0	0	0	0	0	0

Identification and Control of Postharvest Pests

Our work on postharvest insect pests of groundnut has concentrated on:

- The assessment of storage losses in India and the identification of the important pest species involved; and

- The development of appropriate methodologies for use in screening groundnut germplasm for resistance to the major storage pests found in the SAT.

Table 5. The parameters and assumptions used in a dynamic programming process used to indicate the levels of host resistance and natural mortality needed to avoid insecticide application on groundnuts without loss in revenue (based on unpublished data from ICRISAT Center).

Factor	Parameter or assumption
Plant density	200000 plants ha^{-1}
Initial pest population	P = 20 000
Number of generations	4
Potential rate of increase per generation	X20
Damage threshold	P = 12000000
Relationship between pest density and yield loss	Yield loss is linear between P = 12000 000 24 000000; if P> 24 000 000 yield = 0
Efficiency of insecticide	95%
Levels of resistance	0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9
Levels of natural mortality	0,0.2,0.4,0.6,0.8

P = Population density as larvae ha^{-1}.

Identification of Storage Pests in India

Very few attempts have been made in India to estimate losses to stored groundnuts caused by insects. A survey of farmers' stores in one area of Andhra Pradesh indicated that they do not suffer measurable storage losses because they generally sell their crop within one month of harvest. This is too short a period for sizeable pest populations to develop. These observations, in combination with the views of officials of oilseeds cooperatives, indicated that if problems exist, they would be confined to centralized storage sites.

A more detailed study was therefore carried out in the same area of Andhra Pradesh in a large warehouse attached to an oil mill operated by the State Oilseed Growers' Federation. Fifty sacks (total weight 1.5 t) of unshelled groundnuts were held in this warehouse for 5 months, during which time six samples were taken at monthly intervals from 10 bags chosen at random before each sampling date. The percentage weight loss caused by storage insects to each sample was calculated using the "count and weigh" method (Harris and Lindblad 1978). This technique allows damage by different species to be measured separately.

The most damaging pest was the groundnut bruchid Caryedon serratus (Ol.). This insect occurs in many parts of the SAT where it breeds on the seeds of common tree legumes such as Tamarindus spand Acacia spp, as well as groundnuts. Previous reports of C. serratus causing heavy losses to groundnuts have come exclusively from West Africa (Davey 1958, Green 1959 and I960, Conway 1983). Our results suggest that this insect may have a greater pest status in India than has hitherto been realized.

After 5 months, C. serratus caused, on average, 19% dry-weight loss of kernels. Populations of the other pest species infesting the experimental sacks—the rust-red flour beetle, Triholium castaneum (Hbst.), the rice weevil, Oryzaephilus mercator (Fauvel), and the rice moth, Corcyra cephalonica (Stnt.)—remained low and contributed little to the total weight loss.

Large numbers of the lygaeid, Elasmolomus sordidus(¥.), were on the sacks used in this experiment during their first 2 months in storage. This insect is known to be a pest of stored groundnuts in Africa (Gillier 1970, Conway 1976). Unlike other postharvest pests it can feed on kernels by piercing the shell with its moth parts. Its presence in heaps of drying groundnut plants at ICRISAT Center (K.M. Dick, J.A. Wightman personal observation) and in the warehouse indicates that it can infest the postharvest product at any stage up to processing.

The methodology used in this study represents a simple and relatively accurate way of estimating quantitative storage losses. Ideally, we should wish to see an extension of this work through parallel studies conducted in the other important groundnut-producing areas of India and the Asian SAT.

No attempt was made to assess the extent of qualitative losses in the groundnuts occurring over the 5-month storage period. Infestation by insect pests is known to affect the biochemical composition of stored oilseeds, for example, causing a decrease in thiamine levels and an increase in free fatty-acid content (Howe 1965). Oil pressed from nuts contaminated with insect larvae, dust, and frass will almost certainly be of poor quality and flavor. There is a need to determine in greater detail the relationship between population levels of the pest species, duration of storage, and the rate at which the biochemical changes occur that adversely affect flavor and oil characteristics.

Screening for Resistance to Storage Pests

We have developed methods for screening kernels for resistance to T. castaneum, C. cephalonica, and the tropical warehouse moth, Ephestia cautella (Walker). These species are polyphagous and are among the most important pests of stored groundnuts in the SAT. Resistance to C. serratus is being evaluated by TDRI (Slough, UK) in a parallel, collaborative project.

Studies on varietal susceptibility to 7. castaneum were initiated by Dr P.W. Amin, who screened 526 genotypes to determine the degree of variability of this character. He identified at least one promising line, Ah 8418, which suffered significantly less damage than the susceptible check cultivar, APAU 4. Although further experiments have given useful information on the behavior of T. castaneum when infesting groundnuts, progress toward the development of a quick and reliable screening method has been hampered by the extent of variation between replicates of the same genotype. It is hoped that this problem will be overcome in future experiments.

An experiment in which 15 genotypes were examined for resistance to C. cephalonica provided more consistent results. The mean larval mortality was three times greater on the least susceptible than on the most susceptible genotype, and variation between replicates was small. Parallel studies are being carried out with E. cautella using the same genotypes.

Conclusion

It should be seen from this overview that the groundnut entomologists at ICRISAT are taking a broad view of developing pest-control procedures for the SAT. Many of our research plans are underway and the next year should see progress being made in the directions indicated.

There are still fundamental questions to be approached, especially at the farm level. For instance, we should know how farmers decide that they have a pest problem, and how effective their actions are (often insecticide application). Of course, we should also determine the damage thresholds of each pest in the multiplicity of situations under which groundnuts are grown, but that will take time.

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Discussion on Entomology Papers

Blair: Which soil insecticides are available in slow-release formulations?

Wightman: The insecticides that I know of are phorate, carbosulfan, carbofuran, and chlorpyriphos.

Blair: Might the formulation of chlorpyriphos in which the chemical is incorporated in plastic developed in Australia be applicable?

Wightman: This was developed originally for protecting sugarcane crops from white grubs and has been used in forest-tree nurseries in South Africa. If available and if reasonably priced it could be ideal.

Nigam: There are a few reports from India where they have tried to estimate yield loss caused by thrips in groundnut.

Wightman: True. The problem is separating the damage caused by one pest from another. There can be at least two species of thrips within a crop, as well as jassids and other insects.

Nigam: Will the threshold levels of different pests vary according to the variety?

Wightman: Almost certainly; it is important that when a cultivar is released it should be accompanied by a dossier including an indication of its susceptibility to a range of pests.

Gridley: Are there any indications that resistance to insecticides has broken down?

Gibbons/Wightman: No, testing in the USA and ICRISAT has not given any indication of this happening. We are aware that biotypes that can counteract resistance mechanisms can develop or may exist, especially in insects with short life cycles like aphids and thrips.

Ramanaiah: We notice that every year one pest is more important than the others; could you comment?

Wightman: This is true for many crops. It is probably because low levels of natural mortality factors allow one pest to increase in numbers early in the season or suppress other pests in some way. The pest that achieves dominance early in the season may cause so much damage that the crop is not a desirable host for other insects.

Effect of Superphosphate Application on the Yield of Groundnut

K. V. Ramanaiah, A. D. Malithano, and M. J. Freire*

Abstract

Most farmers grow groundnuts on the coastal sandy loam soils of Mozambique. These are of low fertility, but a single dose of granular superphosphate (250 kg ha^{-1}) applied preplanting increased yields by 125-200% over the untreated.

Sumario

Efeito da aplicacao de superfosfato no rendimento do amendoim. Grande parte dos camponeses cultiva amendoim em solos franco-arenosos da zona costeira de Mocambique. Estes sao de baixa fertilidade, mas a aplicacao de uma dose simples de superfosfato (250 kg ha^{-1}) antes da sementeira, aumentou os rendimentos em 125 a 200% sobre a nao aplicacao.

Groundnuts have been grown in Mozambique for many years. They are grown mainly by peasant farmers under rainfed conditions along the coastal belt on infertile light soils.

During the field surveys conducted in the groundnut improvement project, deficiency symptoms of plant nutrients such as phosphorus, calcium, zinc, and nitrogen were noticed in groundnut-growing areas.

Fertilizer trials were conducted on research stations and State farms, where soil fertility was high, varying from 0.09 to 0.14% of total nitrogen and 60-175 g P ha^{-1}. As these soils did not represent the general farming conditions, on-farm trials were conducted on farmers' fields. The soils of these sites were sandy loam with pH ranging from 6.8 to 7.2, and low fertility (nitrogen and phosphorus low, and potassium status medium to high).

The objective was to determine the effect of phosphatic fertilizers on the yields of groundnut with a possibility of recommending them for rainfed groundnut.

Materials and Methods

These on-farm trials had been carried out in many locations during earlier years, but during the crop year 1984/85 they were conducted on five cooperative farms. Due to transport problems, harvesting was done in two sites only: Filipe Samuel Magaia Cooperative Farm and Tseretse Khama Cooperative Farm. These have sandy loam soils with low N and P.

Treatments

In 1982 there was only one rate of phosphorus application, 40 kg P_2O_5 ha^{-1}. In the year 1984/85 there were four treatments:

F0-Control-no fertilizer was applied;
Fl -40 kg P_2O_5 ha^{-1} = single superphosphate 250 kg;
F2-80 kg P_20_5 ha^1 = single superphosphate 500 kg;
F3-120 kg P_2O_5 ha^{-1} = single superphosphate 750 kg.

Phosphorus was applied in the form of granular single superphosphate (16-18% P_2O_5), by broadcasting during final preparation of the land with hand hoes. During this operation the farmers tried to incorporate the fertilizer as deep as possible. A local groundnut cultivar, Bebiano Branco, was grown as a pure crop under rainfed conditions. All other cultural practices such as weeding, harvesting, etc., were done as practised by the farmers.

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At the time of harvesting, air-dry fresh masses were recorded and samples were collected for moisture determination. However, moisture determinations could not be made because of rats, so pod yields were not corrected to a standard percentage.

Results

The yield data of these trials are presented in Tables 1 and 2. The results indicate a positive effect of superphosphate application on the yields of groundnut.

Table 1. Effect of application of 40 kgP_3O_5 ha^{-1} to sandy loam soils on the pod yields of groundnut, Bebiano Branco, Mozambique, 1982.

Fertilizer ($kg\ P_2O_5\ ha^{-1}$)	Yield (kg ha-') Site 1	Site 2
0	968	949
40 kg	2920	2 230

The effect of application of superphosphate was seen mainly on the pod size, pod filling, and pod number per plant.

Conclusion

The effect of fertilizers was conspicuous on farmers' fields, which are sandy loam in texture. The application of 250 kg ha^{-1} of single superphosphate is recommended for groundnuts in the areas where phosphorus deficiency is noted, especially on sandy loams.

This work on farmers' fields influenced the linkage between the Faculty and farmers and formed the beginning of a future extension program.

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Table 2. Effect of superphosphate on pod yield of groundnut at two sites on sandy loam soil, Mozambique, 1984/85.

Location	Treatment	Superphoshate applied (kg ha^{-1})	Pod yields (kg ha-')	Increase over the control (%)
Filipe Samuel Magaia Cooperative Farm	F0	Control: no fertilizer	707	
	F1	250	884	25
	F2	500	1060	50
	F3	750	1414	100
Tseretse Khama Cooperative Farm	F0	Control: no fertilizer	1060	
	FI	250	1767	66
	F2	500	1767	66
	F3	750	2121	100

Groundnut/Maize Intercropping in Mozambique

K. V. Ramanaiah, A. D. Malithano, and M. J. Freire*

Abstract

In Mozambique, groundnut is usually intercropped with cassava, maize, beans, sorghum, etc., depending upon the locality and season. Some combinations have advantages during drought years.
This study was conducted on a research station and on farmers' fields to determine the best geometry of planting groundnut/maize intercrops, and to compare the results obtained on research stations with those obtained under farming conditions.

Sumario

Consociacao amendoim/milho em Mocambique. Em Mocambique, o amendoim e geralmente consociado com mandioca, milho, feijao, sorgo, etc., dependendo do local e da estacao. Algumas combinacoes apresentam vantagens durante anos de seca.
Este estudo foi conduzido numa estacao experimental e nos campos dos agricullores, para determinar a melhor geometria para a sementeira de amendoim e milho consociados e para comparar os resultados obtidos nas estacoes experimentais, com aqueles obtidos em condicoes de cultivo.

Materials and Methods

Research Station

The experiments were conducted at the Agronomy Faculty farm (Universidade Eduardo Mondlane) during the first year, 1983/84, and at the State Farm (25 Jun) at Boane in Maputo Province during 1984/85. The soils are sandy loams with medium levels of soil fertility and low levels of organic matter. The sites had little slope; planting was across the slope to prevent erosion. Local varieties of groundnut (Bebiano Branco) and maize were planted. The experiment was conducted under unfertilized, rainfed conditions. Planting was in Sep and harvesting was in Jan. The results of the following treatments are shown in Table 1.

Treatments

- Maize and groundnut planted in a zig-zag fashion: three maize seeds per hole; one groundnut seed per hole, as is practised by the local farmers (T1).
- Line planting: spacing in maize—90 x 90 cm using three seeds per hole; spacing in groundnut—one line of groundnut between two lines of maize with 10 cm between holes, one seed per hole (T2).
- Line planting: spacing in maize—90 x 30 cm, one seed per hole; spacing in groundnut—one line of groundnut between two lines of maize and 10 cm between plants in the line, one seed per hole(T3).
- Line planting: spacing in maize—135 x 30 cm, one seed per hole; spacing in groundnut—two lines of groundnut between two lines of maize with a spacing of 45 * 10 cm, one seed per hole (T4).
- Line planting: groundnut + maize: spacing in maize— 180 x 30 cm, one seed per hole; spacing in groundnut—three lines of groundnut between two lines of maize with a spacing of 45 * 10 cm, one seed per hole (T5).
- Sole crop of maize planted in a zig-zag fashion: three seeds per hole, as practised by farmers (T6).

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Table 1. Yield of groundnut and maize (kg ha^{-1}) in Research Station trials, Mozambique, 1983/84 and 1984/85.

Treatment	1983/84 Groundnut	1983/84 Maize	1984/85 Groundnut	1984/85 Maize	Mean Groundnut	Mean Maize
Tl Traditional	631	25	1253	153	942	89
T2 Line planting	590	67	1097	245	844	156
T3 Line planting	598	85	838	472	718	279
T4 Line planting	693	84	1054	228	875	156
T5 Line planting	1 133	84	1360	144	1247	114
T6 Sole maize traditional	-	399	-	679	-	539
T7 Sole maize	-	483	.	686	_	585
T8 Sole maize	-	485	-	731	-	608
T9 Sole maize line planting	-	644	-	824	-	734
T10 Sole groundnut line planting	1 177	-	1673	-	1425	-
Tl 1 Sole groundnut zig-zag	892	-	1556	-	1224	-
T12 Sole groundnut zig-zag	593	-	1294	-	944	-

Table 2. Yields of groundnut and maize (kg ha^{-1}) in farmers' field trials, Mozambique, 1984/85.

Farmer	Sole groundnut	Intercrop Groundnut	Intercrop Maize	Sole maize
Felimina Nwamba	1071	476	357	833
Matilde Jossefa	385	115	462	885
Arminda Magaia	885	265	354	364
Painteta Langa	654	407	174	465
Hanhane Mpfume	1876	1010	791	837
Felismina Paulo Tembe	833	611	878	500
Rachel Matola	531	531	88	337
Mean	890.7	487.9	443.4	631.6
SE	±185.7	±107.4	±111.7	±82.1

- Sole crop of maize planted in a zig-zag fashion: one seed per hole, but with the same plant density as in T6 (T7).
- Line planting maize: spacing of 90 * 90 cm, three seeds per hole (T8).
- Line planting maize: spacing 90 * 30 cm, one seed per hole (T9).
- Line planting groundnut: spacing 45 x 10 cm, one seed per hole (T10).
- Sole crop of groundnut planted in a zig-zag fashion: same plant density as in T10 (T11).
- Sole crop of groundnut planted in a zig-zag fashion: half the seed rate of T10 (T12).

On-farm Trials

The following three treatments were selected for testing on farmers' fields on the basis of the results of the field-station experiments. The results are shown in Table 2.

- Groundnut and maize planted in a zig-zag fashion (control): three maize seeds per hole and one groundnut seed per hole, as practised by farmers (Tl).
- Sole crop of maize planted in a zig-zag fashion: three maize seeds per hole as practised by farmers (T2).
- Sole crop of groundnut planted in a zig-zag fashion: one seed per hole as practised by farmers (T3).

Locations

These on-farm trials were conducted on farmers' fields in the green-belt zone surrounding Maputo.

Soils are sandy loams, with light texture, good drainage, and medium soil fertility and organic matter content. The experiments were conducted by the farmers themselves except for the assessment of treatment effects, which were measured by field technicians.

The local variety of groundnut (Bebiano Branco) and a local mixture of maize were planted. Fertilizers were not added. The area of trial plots varied from 200 to 5000 m^2. The area harvested varied from 50 to 150 m^2. Air-dried, fresh weights were recorded at the time of harvest.

The dates of planting and harvesting were not the same in all cases, but all the trials were conducted during the same season (Aug 1984 to Jan 1985). All the cultural practices followed in the trials are the same as those practised by the farmers. All the treatments mentioned above are practised by the farmers except the sole crop of maize. In this case, farmers usually plant other crops at first weeding.

Results

Research Station Trials

The yield of maize was greatly reduced when intercropped with groundnut (Table 1). Line planting facilitated easier weeding than the zig-zag pattern. Line planting took more labour than the zig-zag method at the time of sowing. This is very important for the farmer as he has to plant as much area as possible to capture the available moisture before it escapes from the ground. In some places where rats and birds are a problem, line planting was disadvantageous because they can easily pick up seeds if they are in a line.

On-farm Trials

Difficulties in achieving standard moisture contents resulted in the omission of some data. The results (Table 2) reflect the variable nature of each farm and the non-uniform rainfall pattern.

In general, intercropping groundnut with maize is not advantageous. The maize crop, when associated with groundnut, was short in height, pale yellow in foliage colour (nitrogen deficiency) and was infected with stem borers.

Many of the cooperating farmers were of the opinion that it is better to select crops like cassava, sorghum, and beans rather than maize. Similarly, these farmers are now of the opinion that maize should be grown as a sole crop or intercropped with beans.

Conclusion

Intercropping of groundnut with maize is not always advantageous, especially in a dry year. Maize suffers if it is intercropped with groundnut.

Although farmers are convinced by the results, some still intercrop groundnut with maize because they need both maize and groundnut for consumption. If sufficient land is available they prefer to grow groundnut as a sole crop, but maize is always grown with some other crop such as beans, cassava, etc.

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Discussion on Mozambique Papers

Tarimo: Did Dr Ramanaiah have control plots for the maize/ groundnut intercrop? Did he observe similar symptoms?

Ramanaiah: Yes, similar symptoms were observed in all plots. Our Biochemistry Department is identifying the cause of the yellow leaves in the maize crops.

Bock: Does maize, in cowpea/maize intercrops, show 'deficiency' symptoms similar to those observed in groundnut/ maize intercrops?

Ramanaiah: These severe symptoms did not occur in the cowpea/ maize intercrops.

Kannaiyan: In what way did the disease spectrum change in the early to late plantings?

Ramanaiah: Late-planted groundnuts are more susceptible to rosette.

Doto: I should like to commend the Mozambique team for their work aimed at boosting groundnut production. The team is small, the facilities are restricted, but still they have managed to make headway. I should like to make the following observations:

- The team should seek ways of 'improving the infrastructures' needed to facilitate research, for example, the provision of a well-equipped laboratory would greatly enhance research productivity.
- There may be a need to broaden the research team by means of an aggressive training and recruitment program.
- The team could benefit from more frequent visits by various crop specialists. For example, visits by ICRISAT scientists to offer on-the-spot advice on various biological problems related to groundnut production and research.

Gibbons: Were the cultivars 69-101, RMP 12, and 55-437 (which was imported from W. Africa) yield tested before being multiplied for distribution to farmers?

Ramanaiah: No. There was little coordination between research and extension (seed) people in this matter. There were no data on their yield potential before they were multiplied.

Constraints to Groundnut Production and Research Priorities for Communal Areas in Zimbabwe

S. Dendere*

Abstract

The hulk of the groundnut crop in Zimbabwe is grown and consumed by the communal farmers, although commercial farmers produce most of the nuts presently received by the Grain Marketing Board. There has been a decline in groundnut production as a result of drought, seed unavailability, poor prices, and the low priority that groundnuts are given in the cropping system.

Research aimed at improving the status of groundnuts in the cropping system by encouraging farmers to apply basic nutrients and establish good plant populations to overcome disease problems and improve yield, is discussed with incentives of seed availability and improved prices.

Sumario

Limitacoes na producao de amendoim e prioridades para a investigacao nas areas comunais. Embora os agricultores comerciais produzam a maior parte do amendoim presentemente recebido pelo Conselho de Comercializacdo de Graos, a maior parte do amendoim no Zimbabwe e produzido e consumido pelos agricultores comunais. Tem-se registado um declinio na producao de amendoim como resultado da seca,falta de semente, baixos precos e a baixa prioridade que e dada ao amendoim no sistema do cultivo.

Investigacao apontada para o melhoramento da importancia do amendoim no sistema de cultivo, encorajando os agricultores para a aplicacao dos nutrientes bdsicos e para o estabalecimento de boa populacao de plantas, com vista a resolver o problema das doencas e melhorar os rendimentos, e discutido paralelamente a disponibilidade de sementes e aumento dos precos.

Groundnuts are grown in Zimbabwe by both commercial and communal farmers but the latter have dominated production, accounting for over 90% of the crop sold to the Grain Marketing Board (GMB) up to 1976 (Oilseeds Handbook 1981). Groundnuts constitute an important part of the staple diet as a protein source for rural dwellers in the following forms: relish, roasted nuts, peanut butter, boiled fresh nuts, or mixed with maize (mutakura). With the establishment of oil expressor industries, the demand for groundnuts increased, and production also increased, providing communal farmers with additional income, thus contributing significantly to the economy of this sector. But as production declined after 1976, expressors looked for alternative crops such as cottonseed and soybean, and the oil market for groundnuts is now of no significance. Early records indicate that groundnuts used to be one of the major crops in the communal areas. Because of its uses in confectionery, mainly for export, and as a vegetable oil source, the groundnut producer price has been substantially increased recently.

According to Agritex estimates for the period 1977-1985, the area put to maize increased by 66% while that for groundnuts decreased by 51%. Maize production during the same period increased by 44% compared to a decrease of 45% for groundnuts.

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Yield per hectare increased by 95% for maize while it was only 9% for groundnuts. The decrease in groundnut production in the communal areas can be shown by the trend in the sales to the GMB in comparison with other major crops in the farming system (Table 1).

In 1979/80 groundnut yields were in the order of 1640 and 310 kg ha^{-1} for the dryland crop for commercial and communal farmers, respectively (Hildebrand 1980). The Agritex estimate for communal groundnut production in 1985 now stands at 420 kg ha^{-1}, but these figures remain relatively low.

This paper attempts to explain the factors that could have influenced the decline in groundnut production and deliveries to the GMB. Surveys carried out in Mangwende and Chivi in 1982 and 1984 are used as sources of information. Groundnuts play an important role in the farming system as a source of protein for humans, as livestock feed, and for improving soil fertility by nitrogen fixation. However, the potential role of groundnuts lies in its low requirements for starter nitrogen and its nitrogen-fixing capacity, which has a net effect of reducing erosion and increasing yields of the subsequent crop. Groundnuts are thought to be nematode-resistant, and so can follow tobacco and benefit from residual fertilizer.

Table 1. Yearly sales (t) of major crops to the Grain Marketing Board by communal (CA) and small-scale commercial farmers, Zimbabwe, 1972-1983.

Harvest year	Groundnuts (shelled)	Sunflowers	Maize (CA only)	Cotton
1972	54 500	1402	59646	40 771
1973[1]	41400	1270	10618	29 849
1974	25 700	1278	46683	38455
1975	25 500	3 352	49 358	39 740
1976	26600	8 709	83982	32635
1977	6000	23 438	84 265	36612
1978	8 500	21423	63 605	42929
1979[1]	4100	5 570	38 184	32060
1980	4900	3521	86 296	36928
1981	3 135	8 174	363262	77023
1982[1]	1575	4000	269374	49 207
1983[1]	628	3 760	147515	60406

1. Drought years.

Sources: 1. AMA Oilseed Outlook/Muir, Working Paper 4/81.
2. AM A Sunflower Controlled Product Discusssion Paper.
3. AMA Grain Outlook.
4. AMA Cotton Outlook.

Factors Limiting Production

Seed Quality and Soil Fertility Problems

Farmers retain approximately 53% of the season's harvest for local consumption, local sales, and seed. In general, the shortage of certified seed has been a problem in the communal areas as it is not included in the Agricultural Finance Corporation credit package. Farmers plant anything from the third generation onwards and the use of this seed has contributed to poor crop stands.

In experiments carried out by the Agronomy Institute, Ministry of Agriculture, to investigate the effect of seed source and cultivar on plant stand, the farmers who used retained seed had a final stand as low as 40% in Mhondoro, while a 100% stand was established using certified seed. Variety x fertilizer trials to demonstrate the yield potential of the late and early cultivars showed that, under normal rainfall conditions, Valencia, a short season cultivar, would give better yields than Egret in Mangwende (Table 2).

Metelerkamp (1967) reported that research on plant populations and spacing have made significant contributions to increased production, for all agroecological regions. Plant populations may be drastically reduced if seed dressing is not used. Thiram or captan plus synthetic pyrethroids are recommended.

Most communal areas are on light, sandy soils of granite origin, with low nitrogen, phosphorus, and variable potash levels. The soils have low water-holding capacity and are very prone to leaching and compaction. Boron, sulphur, and calcium levels are low but they have not received adequate attention specifically for groundnut production. Fertilizer utilization has been limited in communal areas, and the low soil-pH severely curtails successful groundnut production.

Results of fertilizer and liming trials have been erratic. In 1983/84 fertilizer application did not influence yield to any significant extent across sites, probably because of the poor season. In the 1984/85 season, application of fertilizer significantly increased yields, with an application of 200 kg single superphosphate ha^{-1} giving the best yields (Table 2). Application of lime and gypsum had no significant effect on groundnut yields, but did slightly increase yields over groundnuts that received none. Limited research on nutrition of groundnuts on poor soils in the communal areas has indicated that large

Table 2. Pod yields in groundnut: cultivar * fertility * liming trial in Mangwende sites, Zimbabwe, 1984/85.

	Trial sites										
	Musani			Zihute		Muchinjike			Rota	Mukarakete	
	(a)	(b)	(c)	(a)	(b)	(a)	(b)	(c)		(a)	(b)
Cultivar											
Valencia	2824	2 705	2097	1534	1399	2100	1408	1379	1275	983	1265
Egret	1766	2666	2164	I 177	1315	2228	1608	1403	869	667	1203
Mean	2295	2686	2130	1355	1356	2164	1508	1391	1072	825	1234
SE	±233.1	±105.9	±25.1	±120.6	±105.3	±142.5	±54.4	±70.3	±60.3	±86.8	±178.2
Fertilization											
Control (none)	2496	2 720	1955	1474	1387	2168	1565	1390	1074	921	1367
200 kg S ha^{-11}	1905	2 554	2172	1 146	1217	1999	1241	1254	948	32	977
200 kg SS ha^{-11}	2485	2781	2 265	1446	1465	2 324	1717	1528	1 194	933	1358
SE	±78.2	±92.3	±82.8	±84.4	±71.7	±74.8	±105.9	±58.9	±64.8	±45.2	±71.7
Liming											
Control (none)	2237	2657	2076	1382	1296	2162	1488	1439	1038	804	1 179
600 kg ha^{-1}	2354	2714	2 185	1329	1416	2 166	1527	1343	1 106	846	1289
SE	±63.9	±75.3	±67.6	±68.9	±58.6	±61.1	±86.5	±48.9	±53.0	±36.9	±58.5
Gypsum											
Control (none)	2231	2642	2076	1382	1308	2148	1486	1390	1085	799	1 131
200 kg ha^{-1}	2 359	2 730	2185	1329	1404	2 180	1530	1392	1059	851	1337
SE	±63.9	±75.3	±67.6	±68.9	±58.6	±61.1	±86.5	±48.9	±53.0	±36.9	±58.5

1. S = Compound S (N7:$P_2O_5$21:$K_2$07).
2. SS = single superphosphate (18.5% P_2O_5).

responses to the application of manure, manure and gypsum, and phosphate could be achieved (Metelerkamp 1967). Responses to rhizobia have been insignificant, indicating that there are adequate populations of naturally occurring bacteria that are effective.

The research effort should concentrate on investigating responses to sulphur gypsum as a source of sulphur rather than calcium under marginal rainfall conditions. The forms in which such nutrients should best be applied and their bearing or interaction with pH could present a breakthrough in groundnut nutrition and its indirect effects on diseases and pests.

Planting Date

The groundnut enterprise has relatively less importance in the farming system because it is considered a woman's crop. This results in delayed planting because preference is given to other crops such as maize, on which the scarce draught power is used. Thus land being allocated to groundnuts has seriously diminished over the last decade.

It has been found that tillage did not seem to be a critical limiting factor to groundnut yields (Dasberg and Amir 1964), and although the soils in their study might have been different, this provides a background for investigating the effects of various tillage systems on groundnut yields. Planting directly onto winter-ploughed land using a planter or tine could increase the proportion of early-planted groundnut fields in the communal areas. Reduced tillage is associated with heavy weed infestation and increased erosion, but since herbicides are now included in the maize package from AFC, it is hoped that labor will be released for groundnut weeding, which tends to have low priority.

Pest and Disease Problems

Groundnut rosette, a viral disease, is of economic importance in the communal areas. Rosette disease can be controlled by good husbandry practices including early planting, high plant-population, and adequate soil fertility. These do not usually occur in the communal areas because of the small amount of poor quality seed that is planted, resulting in low population-stands. Thus the disease is likely to persist.

Cercospora leaf spot, a serious leaf disease (Cole 1981), is also of economic importance in the communal areas because it results in premature leaf loss, and thus increased pod rot and poor shelling percent. Cercospora leaf spot often appears much earlier on a crop that is not growing vigorously, thereby exacerbating the situation. Web blotch can be of significance in communal areas with reasonable rainfall but unlike commercial areas, its presence is for noting only.

Effective control of leaf diseases using fungicides has been positive on early-planted crops or those receiving supplementary irrigation (Cole 1981). Spraying results in leaf retention, and in crops grown under conditions of limiting moisture, this will increase stress and possibly lead to yield reduction. For this reason spraying on a dryland crop has not been generally recommended.

The effect of nematodes on groundnuts has not yet been conclusively established. The marked response to fumigation at the Makoholi Experiment Station did not seem to be due to nematode control. More controlled experiments are needed to determine their real effects.

Sclerotium rolfsii is of sporadic and patchy occurrence in the sandy communal area soils.

Labor Bottlenecks

Groundnuts are a labor intensive crop and farmers in the communal areas cannot afford to hire casual labor, so this has also become a constraint for planting, weeding, and harvesting. It is particularly serious at harvesting when there are heavy losses of kernels due to sprouting and pod rots. If lifting occurs after the rains have stopped, it becomes difficult to get all the pods out of the dry ground.

In an attempt to make the crop attractive to farmers, serious consideration has to be given to the development and use of labor-saving implements for critical operations as a means of enhancing net returns to labor. Specifically, the expected benefits of this research strategy would be:

1. The lowering of labor requirements per operation;
2. Quicker and more timely completion of key operations; and
3. Increased cash returns to labor per groundnut enterprise and family net cash income.

For example, the use of a planter will ensure uniform placement of fertilizer relative to the seed. The groundnut lifter will ensure more timely lifting of groundnuts, thus reducing pod rot and the leaving of pods in the soil when the soil dries out. An exact criterion of maturity is essential if maximum yields are to be realized. This should be facilitated by training extension workers to communicate the correct information to the peasant farmers.

Price Structure

The poor price structure for groundnuts has played a notable role in the decline of production. The producer prices have not been sufficiently attractive. From 1978-1984, groundnut prices increased only by 16% from Z$ 387 to Z$ 450, compared to maize 164%, sorghum 87%, cotton 73%, and soybean 105%. It would seem that communal farmers are rational; they have opted out of groundnuts in favor of other, more profitable crops.

The government has now increased the producer prices by nearly 61 % (from Z$ 500 to Z$ 750) for the 1985/86 growing season because of deficits in previous years. The response from both commercial and communal farmers at this juncture seems positive, and delivery estimates are high as indicated by the area allocated to groundnuts. With the increase in the cost of inputs for production, producer prices must be adjusted accordingly for sustained production.

Conclusion

Although the five limiting factors discussed stem from various sources in the physiobiological and socioeconomic environment in which the communal area farmers operate, the combined effect of these factors has been detrimental to groundnuts.

Improvements

Research aimed at developing component technology and improved systems for groundnut production is imperative. Developments in any of the cited research areas could offer the communal farmers a valuable crop alternative, both in terms of food quality/security as well as cash income.

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Groundnut Complementary Crop in the Irrigated Areas of the Great Rift Valley of Ethiopia

Yebio Woldemariam, Bulcha Woyessa, and Adugna Wakjira*

Abstract

Sixteen groundnut cultivars of Arachis hypogaea ssp hypogaea and Arachis hypogaea ssp fastigiata were tested for yield (nut and oil) on Vertisols and alluvial-type soils of the Middle Awash of the Great Rift Valley for three seasons, May 1980, 1982, and 1983.

Among the cultivars under test, two cultivars NC 4X and Florispan showed promising performance. The 3 years' mean yield shows 770 kg ha^{-1} for NC 4X, and 700 kg ha^{-1} for Florispan. In particular the cultivar Florispan, besides being high yielding, is early maturing and has a relatively high oil content.

Earlier studies on irrigation at Melkawerer Research Center showed that a watering interval of 2 weeks applying 125 mm of water gave maximum pod yield.

The study also showed that the most critical stage from the irrigation aspect was from peak flowering to pod development, i.e., 50 to 90 days from sowing.

Sumario

Amendoim como cultura complementar nas areas de regadio do Grande Rift Valley na Etiopia. Dezasseis cultivares de amendoim, Arachis hypogaea ssp hypogaea e Arachis hypogaea ssp fastigiata, foram testados no seu rendimento (semente e oleo) em Vertissolos e em solos aluviais de Middle Awash no Grande Rift Valley durante tres anos em Maio de 1980. 1982 e 1983.

Entre os cultivares testados, NC 4X e Florispan, tiveram urn comportamento promissor. O rendimento medio nos tres anos foi de 770 kg ha^{-1} para o NC 4 X e de 700 kg ha^{-1} para o Florispan. Particularmente o cultivar Florispan, para alem de ter alto rendimento, e de maturacao precoce e tern urn conteudo de oleo relativamente alto.

Estudos previos sobre irrigacao, realizados no Centro de Investigacao de Melkawerer, mostraram que regando com um intervalo de 2 (duas) semanas, aplicando 125 mm de agua de cada vez, produziu rendimento maximo em casca.

O estudo mostrou tambem, que o periodo critico para irrigacao vai do pico da floracao ate ao desenvolvimento das vagens, isto e, de 50 a 90 dias depots da sementeira.

In Ethiopia groundnut is grown widely in two administrative regions, namely Harerge (east) and Eritrea (north). It is also grown in a few localities in the south and western parts of the country. However, studies on crop adaptability and performance show that the potential of raising the crop in the marginal rainfall of the mid- and lower-altitude areas of the country still exists.

In practice groundnut is rarely considered a major crop that can be relied upon for subsistence. It is planted rather as a companion crop with other food crops as a supplementary source of income. In terms of preference, the peasants treat groundnut as an alternative crop to be used only in risk-aversion measures brought about by unforeseen weather conditions such as drought.

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The total annual land area occupied by groundnut up to 1980 amounted to less than 50 000 ha, presumably excluding lands in Eritrea. In the course of the last 15 years an estimated 15000 ha of land were added (FAO Production Year Book 1980). This insignificant expansion of land did little to alleviate the oil shortages that the country is experiencing today. This situation is further aggravated by the low average national yield, which remained below 600 kg ha'.

None of the groundnut crop in Ethiopia is presently under irrigation, but the potential for growing the crop under irrigation has been demonstrated in numerous field trials in some of the irrigated valleys of the country, including the Great Rift Valley. The general performance and yield obtained across the years is encouraging enough to advocate the profitability of growing the crop under irrigation. Groundnut could also lend itself as a rotational crop in a monocropping system as is practised now in the lower and middle portion of the Awash Valley, which constitutes part of the Great Rift Valley. Furthermore, in association with short life-cycle crops having early-maturing characteristics such as sesame, wheat, and cowpea, groundnut could be an excellent partner in a double-cropping program.

The middle portion of the Awash Valley, at 750 m elevation, is characterized by a hot and moderately humid climate during April to September and is warm and dry during October to March. The long-term mean annual rainfall is about 500 mm, of which the highest rain precipitation occurs in July and August. December is the coldest month with mean maximum and minimum temperatures of 31° and 13°C, respectively. The hottest month is June with a maximum temperature of 38° and minimum of 23° C. This latter type of weather condition ideally meets the climatic requirement of groundnut.

During the past few years impressive results have been obtained to encourage large- and medium-sized farmers in the Awash valley to adopt groundnut as a complementary crop to cotton. The specific objective of the study is, therefore, aimed at showing the feasibility of growing groundnut in the irrigated valley of the middle Awash and possibly, in the lower valley.

Materials and Methods

Sixteen groundnut cultivars, Arachis hypogaea var hypogaea and Arachis hypogaea var fastigiata were planted for three consecutive seasons beginning mid- to end-May in the experimental field of Melkawerer Research Center. The row spacing used was 80 cm, and seeds were planted every 10 cm in a row. The experimental design was randomized blocks with four replications. The gross plot size was 20 m^2 with the two outer rows designated as guard rows.

The number of cultivars used in the first 2 years was reduced to 12, based on the evaluation done on previous seasons with regard to yield and other desirable agronomic attributes.

In order to ensure maximum plant growth, irrigation water was supplied at 2-week intervals for 126 days. Application of water was withheld 3 weeks prior to harvesting but shallow irrigation water of approximately 50 mm depth was applied a few days before uprooting plants to facilitate harvest. The trial was carried out on a heavy Vertisol soil in the first year and light alluvial soil in subsequent years. No fertilizer was applied.

The study was undertaken during the 'main seasons' of 1980, 1982, and 1983 under irrigation, supplemented by rainfall of nearly 250 mm during the growing season.

Results and Discussion

Groundnut cultivation appears to be successful in areas where soils are light and temperatures warm. In Surinam the entire groundnut cultivation is practised on sandy ridges in the coastal clay belt (Wienk et al. 1983). In eastern Ethiopia, nearly the entire crop is grown in light soils including sandy loams of poor organic matter. With proper farm management practices, yields of up to 300 kg ha^{-1} are attainable.

In the Sudan a sizeable amount of the estimated 8 million ha of land under groundnut is on clay soil. Despite this, in the central clay plain of the Sudan the crop is lifted manually instead of the digger-shaker-windrower combine machines quite extensively used in the groundnut belt of North America. Intensive research work on heavy clay soils in that part of the Sudan showed that the potential pod yield is only 670 kg ha^{1} (Ishag et al. 1980).

At the field of the Research Center where the experiment was carried out for 3 years, the soils ranged from a black heavy Vertisol-type to brown soils whose texture is generally silt to loam. The yield obtained based on experimental plots with such soils was 470 kg ha^{-1} and 660 kg ha^{-1}, respectively. The soils of the Center are not deficient of the major elements, although minor elements such as zinc and iron may be lacking. The soil is basically alkaline with a pH ranging from 7.7 to 8.5. A series of experiments on soil exhaustion done in the mid-1970s show that there were no significant differences between the different levels of N, P, K, and the control.

Groundnut is known to be a drought-tolerant crop grown in areas where the soils are nutrient-poor and effective rainfall is limited to only 2-4 months a year. However, the crop can show its maximum potential in an environment where moisture stress is overcome by well-distributed rainfall or irrigation water.

With the exception of the USA, where the tendency is to increase areas under irrigation, most countries in the semi-arid tropics depend on rain to grow groundnut. However, India and Sudan, two leading groundnut-producing countries in the less-developed world, have sizeable areas under irrigation. In those countries, irrigation water is provided either as a sole source of moisture to the plant or as a supplement to rain. In the Sudan alone a quarter of the 8 million ha of land planted to groundnut are under irrigation (Ishag et al. 1980).

Groundnut has been reported to be a drought-resistant crop with remarkable characteristics of resilience. But recent work on the influence of irrigation frequency in the Sudan showed that moisture stress at any stage of plant development reduced yield appreciably. Ishag (1982) found that watering intervals significantly affected pod yield.

Experimental evidence at Melkawerer indicates that a watering interval of 2 weeks with applications of 125 mm gave the maximum pod yield. If irrigation intervals are wide apart but an extra 50 mm of water per application is added, yield increase is possible.

The most critical stage for moisture stress was found to be from peak flowering to pod development, i e., 50 to 90 days from sowing. Thus groundnut is most sensitive to water deficiency during the periods of early pod formation, peg penetration and elongation, pod expansion, and photosynthesis, which are also reduced. Table 1 gives yield information for 16 groundnut cultivars tested at the Center. Yield comparisons of the different treatments were more or less consistent throughout the last 2 years of the study. However, the mean cultivar yield value for the first year was less than the subsequent years of the study by 180 kg ha^{-1} or 28%.

Yield reduction in the 1980 cropping season is attributed to heavy rust (Puccinia arachidis) infection that occurred early in the season as well as unusual late harvesting of the crop, which induced pod sprouting in the ground. This affected both groups of cultivars but dominantly the fastigata group, which are known to have shorter or no dormancy period. Due to the heavier-textured soils on which the trial was performed, pod loss at harvest could have also been enormous (Henning et al. 1982).

Table 1. Pod yield (kg ha^{-1}) of 16 groundnut cultivars tested at Melkawerer Research Center, Ethiopia.

	Pod yield			
Cultivar	1980	1982	1983	Mean
NC4X	610	820	870	766
NC2	570	630	670	623
NC343	430	710	720	620
Shulamit	700	590	760	683
Schwarz 21	350	640	680	556
Florispan	580	700	810	696
Nambyquarae	480	630	590	566
PI 314817	500	630	560	563
PI 298115	390	480	-	435
PI 315608	330	630	-	480
Pearl	360	580	-	470
Improved Spanish 2B	470	570	550	530
Spanish 191-1	470	500	520	496
Tifspan	390	660	640	563
PI 250680	488	660	590	576
New Mexico Valencia	400	510	-	455
Mean	469	621	663	567
SE	±38.7	±81.0	±52.6	

Table 1 shows that there were highly significant differences between cultivars ($P < 0.01$) in 1980. Overall the mean cultivar yield for the three seasons was 570 kg ha^{-1}. The highest cultivar mean yield of 660 kg ha^{-1} was obtained during the 1983 cropping season, surpassing that of the previous season by 40 kg ha^{-1} and that of 1980 by nearly 200 kg ha^{-1}. Yield values computed from Table 1 show that the cultivar NC 4X gave the highest mean yield of 770 kg ha^{-1} followed by Florispan and Shulamit each giving yields of 700 and 680 kg ha^{-1}, respectively. In the second and third seasons after 1980, the cultivar NC 4X gave record yields of up to 840 kg ha^{-1}, making it an undisputed candidate for release and consequently for large-scale production in the Valley.

The cultivar NC 4X may have many advantages over the others but is equally susceptible to rust and leaf spots. In any case both diseases occurred only once in the Valley and cannot be considered as limiting factors for production. It is also generally believed that in most cases disease-resistant groundnut cultivars arc lower yielding than susceptible cultivars (Subrahmanyam et al. 1980). Experience at one of the Institute of Agriculture Research Stations located in the east showed that the moderately disease-tolerant 250680 is by far a lower yielder than the highly susceptible NC 4X or Shulamit cultivars.

Among the two groups of groundnut included in the study, the var fastigiata were low yielders. This group of cultivars showed the tendency to flower and mature early. They also have a low 100-seed mass when compared with var hypogaea, which usually have large- to medium-sized pods. Table 2 shows the agronomic characteristics of each cultivar.

The Spanish and Valencia type cultivars, which fall under the category of var fastigiata, have a relatively higher oil content (Table 3). According to Seegeler (1983) the oil content of cultivars in var hypogaea with 38-47%, is lower than that in cultivars of var fastigiata. The normal range in the latter subspecies is 47-50%.

Table 3. Oil content (%) of 16 groundnut cultivars grown at Melkawerer Research Center, Ethiopia.

	Year	
Cultivar	1980	1983
NC4X	38.8	47.3
NC2	36.2	48.2
NC343	40.2	49.0
Shulamit	38.6	49.2
Schwarz21	40.4	51.4
Florispan	40.1	52.1
Nambyquarae	39.3	50.1
PI 314817	42.0	52.8
PI 298115	-	-
PI 315608	-	-
Pearl	-	-
Improved Spanish 2B	40.4	51.5
Spanish 191-1	36.7	50.7
Tifspan	43.3	49.0
PI 250680	41.9	52.9
New Mexico Valencia	39.8	50.4

Table 2. Mean shelling percentage, 100-seed mass, and days to maturity of 16 groundnut cultivars grown at Melkawerer Research Center, Ethiopia.

	Shelling (%)				100-seed mass (g)				Days to mature		
Cultivar	1980	1982	1983	Mean	1980	1982	1983	Mean	1980[1]	1983	Mean
NC4X	71.00	67.90	67.25	68.72	71.58	73.75	68.75	71.36	200	135	167.5
NC2	63.50	63.40	70.25	65.72	82.75	67.00	75.00	74.92	200	162	181.0
NC343	72.80	69.50	70.50	70.93	78.88	69.63	76.25	74.92	200	158	179.0
Florispan	75.50	66.30	63.63	68.48	64.00	68.00	60.00	64.00	200	155	177.5
Spanish 191-1	74.00	66.30	68.13	69.48	49.85	52.50	55.00	52.45	185	151	168.0
Nambyquarac	73.50	66.90	66.54	68.98	100.00	83.38	78.75	87.38	200	160	180.0
Improved Spanish 2B	67.30	57.10	70.00	64.80	56.93	49.75	55.00	53.89	185	151	168.0
New Mexico Valencia	66.80	63.80	-	65.30	44.03	49.38	-	46.71	175	-	175.0
Schwarz 21	70.00	62.90	69.00	67.30	81.05	76.25	77.50	78.25	200	155	177.5
Tifspan	71.50	69.90	62.88	68.09	40.73	47.88	52.50	47.04	185	152	168.5
Shulamit	62.30	65.10	64.50	65.63	85.08	68.63	72.50	75.40	200	161	180.5
PI 25068C	66.80	64.10	65.13	65.34	55.58	51.25	48.75	51.86	194	134	164.0
PI 314817	68.80	66.80	61.00	65.53	40.10	40.13	41.25	40.83	192	156	174.0
PI 315608	67.30	66.80	-	67.05	90.70	81.25	-	85.98	200.5	-	200.5
PI 298115	70.80	67.90	-	69.35	91.20	88.13	-	89.67	200.5	-	200.5
Pearl	67.50	64.00	-	65.75	45.53	52.13	-	48.83	185	-	185.0
Mean	69.65	66.07	66.57	67.28	67.37	63.69	63.44	65.22	193.88	157	177.91
SE	±3.5	±2.96	±2.84		±2.48	±5.29	±2.25		±1.27	±1.50	

1. Off-season.

As shown in Table 3 the wide variation observed in the mean oil yield between the years 1980 and 1983 for the same cultivars grown under similar conditions is perhaps due to the technique by which the oil determination was carried out. In the first year of study the RAFTEC extraction method was used to analyse the content of oil in each cultivar, while in the 1983 season, Nuclear Magnetic Resonance (NMR) equipment with high precision was used. The difference between the highest and lowest oil-yielding cultivars in both years is an average 6%.

In the case of the nuts produced in middle Awash, few cultivars have surpassed the theoretical value of 50% oil expected from groundnut. The high oil percentage recorded at Melkawerer could very well be associated with the relative temperature and elevation of the area at which the study was undertaken. Seegeler (1983), using information obtained from Bald rati, indicated that higher temperatures seem to increase the fat content but lower the protein value of groundnut. Groundnut cultivars grown at Keren at an elevation of 1300 m resulted in lower oil content than those cultivars grown at Ghinda (lower elevation). A comparative study of some groundnut cultivars grown at different altitudes ranging from 750 to 1700 m gave similar results.

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Discussion on Ethiopian Paper

Gibbons: **1** am surprised at the data in Table 2 showing a long growing season in this area. What is the altitude?

Woyessa: The altitude is 700 m.

Gibbons: The yields of 7-8 t ha^{-1} are impressive, particularly as many of the US varieties, like NC 4X and NC 2, are now considered to be obsolete. Perhaps some of the newer, large-seeded Virginias from the U.S. could do well in your area.

Woyessa: We have received more germplasm from ICRISAT and are comparing its yield with the best of the established cultivars.

Mwenda: Why did most of the varieties listed in Table 2 take longer to mature in 1980 than in 1983? For example, NC 4X took almost 2 months longer to mature in 1980 than in 1983.

Woyessa: In 1980, the experiment was grown in the off-season (October-February) when cooler temperatures prevail.

Epidemiology of Foliar Fungal Diseases of Groundnut and their Control with Fungicides in the 1984/85 Season, Malawr[1]

C. T. Kisyombe*

Abstract

Cercospora arachidicola is an important disease in the area of Malawi where 70% of the crop is produced. Puccinia arachidis, a potentially serious disease, becomes serious late in the season. Leptosphaerulina crassiasca, Phoma arachidicola, and Phaeoisariopsis personata also occur on groundnut. High rainfall recorded in the 1984/85 season offered favourable environmental conditions for the rapid development of all foliar fungal diseases and also provided conditions suitable for rigorous testing of fungicides. The application of Daconil® 2787 W-75, Kocids® 404S, Bravo® 500, Bay cor® 300 E.C. + Agridex® Wetter, and Baytan® 250 E.C. gave outstanding kernel and haulm yields. Recent high price increases offered by the Malawi Marketing Corporation for premium groundnut are an incentive to farmers to grow more using newly recommended technology from the Malawi Government Department of Agricultural Research and private organizations.

Sumario

Epidemiologia das doencas micoticas foliares do amendoim e **o seu controlo com fungkidas durante a estacao 1984/85 no Malawi.** Cercospora arachidicola e uma doenca importante numa zona do Malawi onde 70% do amendoim e produzido. Puccinia arachidis, uma doenca potencialmente importante, torna-se importante nofim da estacao. Leptosphaerulina crassiasca, Phoma arachidicola e Phaeoisariopsis personata tambem ocorrem no amendoim. A grande precipitacao que ocorreu durante a estacao de 1984/85 forneceu condicoes ambientais favoraveis para o rapido desenvolvimento de todas as doencas foliares micoticas e tambem providenciou condicoes proprias para um teste rigoroso dos fungicidas. A aplicacao de Daconil® 2787 w-75, Kocids® 404s, Bravo® 500, Bay cor® 300 E.C. + Agridex®wetter e Bay tan® 250 E.C. produziu altos rendimentos de sementes e forragem. Os recentes altos precos oferecidos pela Corporacao de Comer cializacao do Malawi (Malawi Marketing Croporation) para amendoim de alta qualidade (premium) sao um incentivo para os agricultores para cultivarem mais, usando tecnologia recentemente recomendada pelo Departamento de Investigacao Agricola do Governo do Malawi e por organizacoes privadas.

1. The use of chemical names in this paper neither represents a criticism or discrimination of similarly effective chemicals nor does it reflect the official policy or position on the use of chemicals by the Ministry of Agriculture in the Republic of Malawi.

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Foliar Fungal Diseases

The following foliar fungal diseases have been reported in Malawi:

1. Cercospora arachidicola (early leaf spot);
2. Leptosphaerulina crassiasca (leaf scorch and pepper-spot);
3. Puccinia arachidicola (rust);
4. Phoma arachidicola (web blotch); and
5. Phaeoisariopsis personata (late leaf spot).

Early leaf spot is serious throughout Malawi, and it is the most serious disease in the area where more than 70% of the crop is produced. This disease begins to attack groundnut when the crop is about 2 weeks old and infection increases to harvest time. This disease also causes severe leaf fall.

Leaf scorch and pepper-spot disease is invariably present and associated with early leaf spot. Observations made over several years show that continuous rainfall leads to an epiphytotic caused by L. crassiasca that is typified by leaf scorch and pepper-spot symptoms occurring on the upper surface of the leaflets. Severe leaf fall occurs and this situation changes only when rainfall decreases.

When groundnuts are planted in November, rust begins to attack in mid-February. When planting is in December, rust attacks in mid-March. Rust attacks start mostly from the older leaves at the bottom of the plant and spread upwards, in localized scattered and patchy "hot spots" in the field. It has also been observed that when groundnuts are grown in the off-season, between June and October, rust begins to attack groundnuts from the time they are about 12 weeks old; incidence increases until harvest. These observations have been made consistently over many seasons. Rust is attacked by a mycoparasite known as Darluca filum.

Rust is considered to be a serious foliar fungal disease in those areas where it is warm and humid, either on the plateau or in the low-lying areas, but is most prevalent between 500-1000 m above sea level. In these areas early leaf spot, leaf scorch, and sometimes late leaf spot first attack the young groundnut plants from about 4 weeks after planting; the incidence of these diseases increases until rust sets in, when the crop is about 12 weeks old. In these warm and humid areas rust attack increases and spreads so fast that, within a short time, depending on favorable environmental conditions, it overtakes the severity of the other diseases, and becomes the most serious foliar fungal disease by harvest time.

In Malawi, we are lucky that rust is of minor importance on the plateau where 70% of the crop is produced.

Rust was first observed in Malawi in the 1974/75 season and since then it has followed the same trend of occurrence on the plateau and in the warm and humid areas.

Web blotch is a disease that is easily confused with late leaf spot because the two diseases mainly attack groundnuts late in the season. However, observations made in Malawi and particularly at Chitedze show that web blotch becomes prevalent on groundnut plants when there is rainfall later in the season. An epiphytotic of web blotch was unintentionally induced on Egret and Mani Pintar groundnuts sprayed with Bavistin® (Carbendazim) at 0.5 kg ha^{-1} (used to control early leaf spot in a 1984/85 yield-loss assessment trial).

Late leaf spot is invariably associated with rust in those areas where rust is serious on groundnut plants.

In areas where it is warm and humid, late leaf spot attacks groundnuts throughout the growing season, but on the plateau where it is cool and moist in the rainy season, it attacks groundnuts and becomes more prevalent towards harvest time.

Groundnut wilt induced by the groundnut hopper, Hilda patruelis and attendant black ants, Pheidole meqacephale, is invariably associated with Fusarium oxysporum and/ or F. solani. The groundnut hopper was negligible in its infestation of the crop, probably due to high rainfall, which was well distributed from Nov 1984-Mar 1985 (Table 1).

Table 1. Rainfall data at Chitedze, Malawi, Jul 1984-Jun 1985.

Month	Rainfall (mm)	30-year mean (mm)	Deviation from 30-yr mean
Jul	5.5	0.5	+5.0
Aug	0	0.5	-0.5
Sep	0.1	1.8	-1.7
Oct	Trace	6.3	-6.3
Nov	115.7	80.7	+35.0
Dec	253.0	198.4	+54.6
Jan	192.0	235.3	-43.3
Feb	208.1	195.3	+ 12.8
Mar	245.3	134.3	+ 111.0
Apr	48.4	46.6	+ 1.8
May	Trace	8.6	-8.6
Jun	Trace	2.1	-2.1
Total	1068.1	910.4	+ 157.7

Groundnut wilt becomes serious on the crop when there is drought.

Fungicides were tested only for control of early leaf spot before the arrival of rust in Malawi. The appearance of rust on groundnuts in 1984/85 resulted in the fungicide testing program being changed from screening fungicides for control of only early leaf spot to screening fungicides that would control all foliar fungal diseases simultaneously. For example, Bavistin®, which was very effective in controlling early leaf spot, was substituted with Daconil® 2787 W-75 which became effective in controlling all foliar fungal diseases of the groundnut.

Agricultural sulphur dust (elemental sulphur) was used as an interim recommendation for control of early leaf spot before rust arrived.

Daconil® 2787 W-75 (a wettable powder formulation of chlorothalonil) is currently recommended for effective and economical control of all foliar fungal diseases of groundnuts (mainly early leaf spot and rust). Daconil® 2787 W-75 has consistently given good yield of groundnut. Its application gave the highest yield of kernels in the 1984/85 season (Table 2).

I will recommend Bravo® 500 (a flowable formulation on chlorothalonil) along with Daconil® 2787 W-75 for use on groundnut as soon as possible after the 1985/86 season trials have been harvested.

The high rainfall, which was well distributed in the 1984/85 season, provided most favorable conditions for groundnut production in the country. The high rainfall also, however, provided environmental conditions that favored the development of foliar fungal diseases. These conditions offered an opportunity for "tough testing" of fungicides for disease control. Therefore fungicides such as Daconil® 2787 W-75, Kocide® 404S, Bravo® 500, Baycor® 300 EC. at 0.6 L ha^{-1} application, and Baytan® 250 E.C, which gave high groundnut kernel yields, were outstanding in controlling fungal diseases (Table 2). The yields of dry groundnut haulms were also appreciably increased by these fungicides.

The price of premium-grade Chalimbana groundnuts had been increased by 17% by the Malawi Marketing Corporation for the 1984/85 crop. The price has been increased again by more than 7% for the 1985/86 crop. The good price will allow farmers to benefit from their groundnut and it will also give them an incentive to grow more groundnut with the aid of new technology in the coming seasons.

Farmers in several rural areas are being assisted by the Ministry of Agriculture and certain private organizations with packages of improved seed, Daconil® 2787 W-75, and knapsack sprayers. The farmers are encouraged to use the new technology along with good cultural practices in order to increase the yield and quality of the crop.

Table 2. Yield of Chalimbana groundnut kernels and dry haulms (kg ha'[1]), Chitedze, Malawi, 1984/85.

Fungicide treatment[1] and rate of product ha^{-1}	Mean yield of kernels (kg ha-')[2]	Yield increase of kernels (%)	Shelling (%)	Mean yield of dry kernels (kg ha-')[2]
Daconil® 2787 1.6 kg	3 326	77	75	2653
Kocide® 404S 2.0 L	3 264	73	74	2649
Bravo® 500 2.4 L	3042	62	67	3 170
Baycor® 300 EC 0.6 L	2972	58	66	3042
Baytan® EC 0.5 L	2958	57	68	2201
Baytan® 250 EC 1.0 L	2938	56	68	2 792
Baycor® 300 EC 0.5 L + Agridex 0.5 L	2528	34	67	2 764
Tacto® 60 0.5 kg + Mancozeb 1.5 kg	2389	27	67	2608
Untreated control	1882	-	68	2066
Site mean	2811	56	69	2660
SE	±160.5	-	±2.6	±230.4
CV (%)	11.4	-	7.6	17.3

1. Six applications were made per season at 2-week intervals. The first application was made on 21 Dec 1984 and the sixth application on 28 Feb 1985.
2. Mean of four replicates.

Acknowledgements

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Performance of Single and Double Cross Progenies of Groundnuts

A. J. Chiyembekeza and P. K. Sibale*

Abstract

Single- and double-cross progenies of groundnuts selected from a 6 x 6 diallel selective mating program were evaluated for yield at Chitedze Agricultural Research Station. The overall performance of both the single- and the double-cross progenies was superior to the check varieties over the 3-year period of evaluation. There was, however, no yield benefit from the double cross over the single cross progenies. This suggests that the extra effort put into intermating the F_1 genotypes would not be beneficial in improving the population mean.

Sumario

Com portamento de descendencias de cruzamentos simples e duplos em amendoim. Amendoins descendentes de cruzamentos simples e duplos seleccionados a partir de um programa de conjugacao selectiva dialelo 6 x 6, foram avaliados no seu rendimento na Estacao de Investigacao Agricola de Chitedze (Chitedze Agricultural Research Station). Em geral, o comportamento das descendencias dos cruzamentos simples e duplos foi superior ao das variedades de controlo, durante um periodo de avaliacao de tres anos. Contudo, naoforam registados beneficios no rendimento dos descendentes de cruzamentos duplos em relacao ao dos descendentes de cruzamentos simples. Isto sugere que um esforco extra, posto no intercruzamento de genotipos da geracao F_1; nao traria beneficios na melhoraria da media da populacao.

Efficient methods to obtain useful recombinations are crucial for multiple-trait selection in a breeding program, especially where cultivars have been repeatedly selected for specific adaptation over time. Random intermating in self-pollinated species followed by selection could increase the probability of obtaining useful recombinations as compared to selection without intermating (Hanson 1959, Jensen 1970). However, reports on the feasibility of using random intermating systems in self-pollinated crops are scarce, and no reports of its use in groundnuts have been found in the literature. Very little has, moreover, been reported in other self-pollinated species.

Altman and Busch (1984) intermated three populations of spring wheat (*Triticum aestivum* L.) from adapted single crosses. Thirty random lines from each cycle and from two samples of the base single cross for each population were analysed in three line experiments. They found that the highest-yielding lines from intermating cycles were only similar in yields to the best lines derived from the single crosses in all populations. Comparisons of individual elite lines did not generally change over levels of intermating. They concluded from this study that random intermating within single-cross populations resulted in insufficient useful recombination to justify its use as a primary breeding procedure prior to selection.

Bos (1977) reported that selection applied to the F_2 population of self-pollinating crops, in general, followed by random mating of the remaining plants

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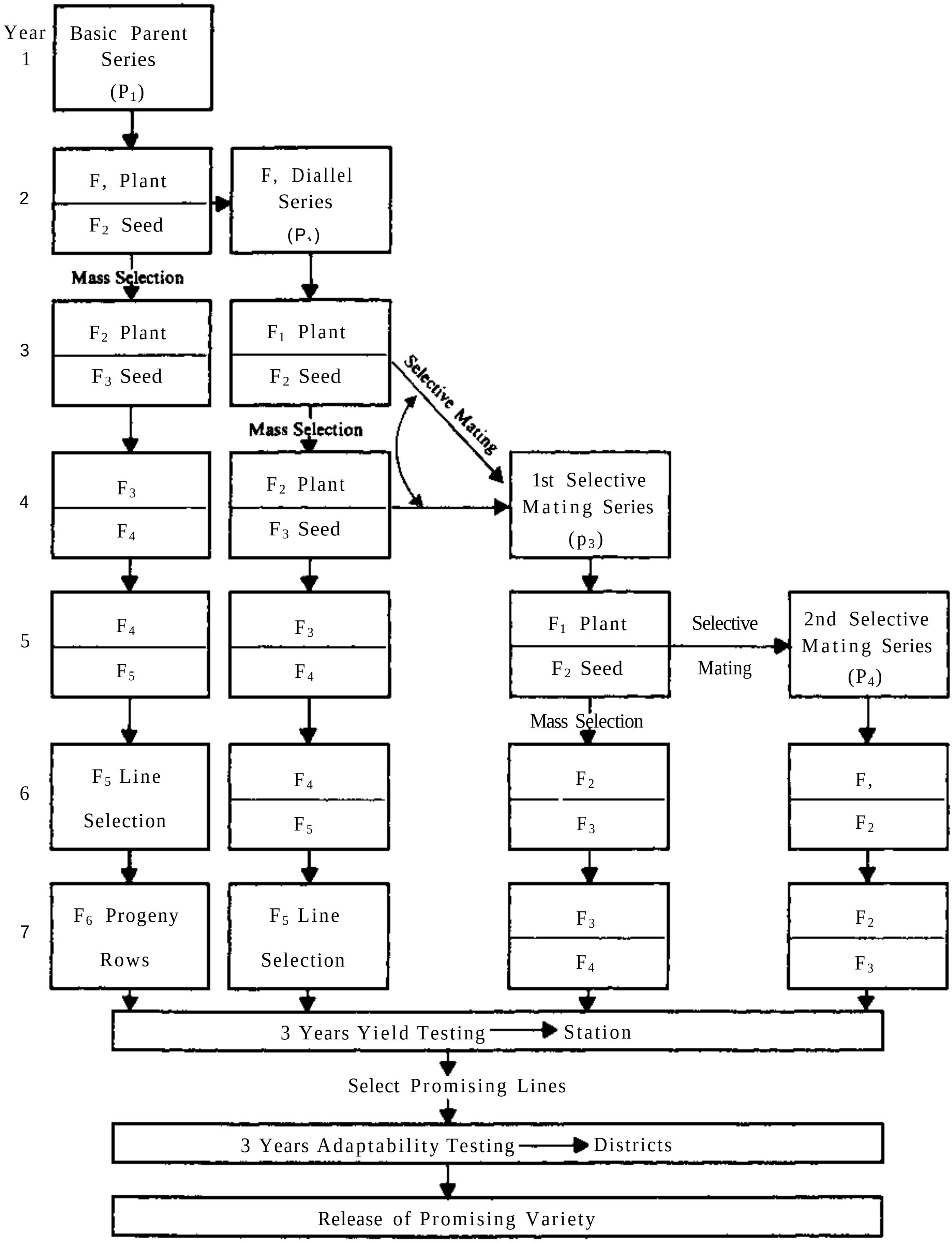

Figure 1. Diagram of implementing steps in the diallel selective mating system for groundnut.

selected from the F_2 has a negative effect on the F_3 and no effect at all on the later generations. He concluded that intermating of F_2 plants cannot be considered to increase the expected number of plants with the desired genotypes.

This paper presents part of the data from an ongoing breeding program that was aimed at combining desirable traits from six selected parents using the diallel selective mating procedure (Jensen 1970).

Materials and Methods

Six groundnut cultivars were selected on the basis of their desirable yield attributes and were utilized as the basic parents in a 6 * 6 diallel cross. The selected cultivars were: SPI and Shulamith, selected for their yield potential and bold-seededness; Chalimbana, selected for its yield potential and seed size; RGI, selected for its resistance to the groundnut rosette virus (GRV); FESR 14, selected for its resistance to groundnut rust (Puccinia arachidis)\ and Spancross, selected for its earliness and uniformity in maturity.

The projected achievements from this program were:

1. Higher yields coupled with increased seed size;
2. Better quality;
3. Resistance to groundnut rust {Puccinia arachidis);
4. Resistance to groundnut rosette virus (GRV); and
5. Earliness and uniformity in maturity.

In order to fully exploit the potential of the cultivars, an extensive crossing program of the basic parents (P_1) was undertaken in 1975, followed by the F_1 diallel series and selective matings in subsequent years (Figure 1). Progenies resulting from the basic parent series featured two parents in their background, referred to, herein, as single-cross progenies, while the F, diallel series, referred to herein as double-cross progenies (F_1 x F_1), featured four parents in their background. Each series of crosses was advanced to further generations using a breeding procedure routinely followed at Chitedze Agricultural Research Station. The selected genotypes were progeny rowed in F_6 generation and yield evaluation commenced in the F_7 generation for each series and continued for three successive seasons. Both the single- and the double-cross progenies were evaluated in separate trials at the same location. Analysis of variance was done on each set throughout the three seasons of evaluation in order to compare the performance of the lines with the check cultivars. Evaluation of the single-cross progenies started in the 1981/82 growing season while that for the double-cross progenies started in the 1982/83 growing season.

In order to determine how the breeding lines performed, the percent increase in yield over Chalimbana (a commercial variety) was calculated. The percent increase in yield was helpful in selecting superior breeding lines for further evaluation and use in breeding programs. The performance of the single- and double-cross progenies over the 3-year period was compared using the overall means and variances of the two sets with a t-test.

Results and Discussion

The yield data for the single- and the double-cross progenies are presented in Tables 1 and 2. In general, all single-cross progenies except line E267/11 performed equally well in the 1981/82 growing season with line C851/7 coming second to SPI (Table 1). The yield differences between most of the crosses and the lowest-yielding check variety Chalimbana was significant (P = 0.05). In the 1982/83 and 1983/84 growing seasons, the lowest-yielding check varieties Chalimbana and RGI were significantly outyielded (P = 0.05) by all the crosses, except line E268/3 in the 1982/83 season and lines D478/8 and E268/3 in the 1983/84 season. Overall, the lowest yielding check variety RGI was outyielded by all the lines (Table 1).

Table 2 presents yield data for the double-cross progenies. Here again, the lowest yielding check variety Chalimbana was significantly outyielded (P - 0.05) by all the crosses in the 1982/83 season, except line CI86/2/1 in the 1983/84 and 1984/85 seasons (Table 2). The overall performance of the double-cross progenies over the 3-year period was inferior to the single-cross progenies. This is shown in Tables 1 and 2 where five out of the eight single-cross progenies gave more than a 20% yield increase over Chalimbana. Only two out of the eight double cross progenies gave the same yield increase over Chalimbana. Even in the 1982/83 season, which was rather good as compared to the other seasons (Tables 1 and 2), the performance of the single-cross progenies was superior to the double-cross progenies.

The overall mean yield and variance of the single-cross progenies were 2365 and 9.22. That of the double-cross progenies were 2319 and 9.79 (Table 3).

Table 1. Pod yield (kg ha^{-1}) of single-cross groundnut progenies at Chitedze Agricultural Research Station, Malawi.

Line	Pedigree	J981/82	1982/83	1983/84	Mean	Yield increase over Chalimbana (%)
E267/2	(RG1 x Shulamith)	2422	3 108	1956	2495	27
E267/3	"	2 377	3092	2 228	2 566	31
E267/5	"	2474	2642	2178	2431	24
E267/6	"	2 333	3 133	1928	2465	26
E267/11	"	1711	2942	2 238	2 297	17
D478/8	(RG1 * SP1)	2 304	2 350	1567	2074	6
E268/3	(SP1 x Chalimbana)	2 170	2 525	1339	2011	3
C851/7	(RG1 x Chalimbana)	2622	2975	2144	2 580	32
Chalimbana	(Check)	2163	2 333	1389	1962	-
SP1	(Check)	2 874	2 583	2 178	2 545	-
RG1	(Check)	2241	2 183	1322	1915	-
SE		±170.1	±123.6	±130.9		
CV (%)		13	2	9		

Table 2. Pod yield (kg ha^{-1}) of double-cross groundnut progenies at Chitedze Agricultural Research Station, Malawi.

Line	Pedigree	1982/83	1983/84	1984/85	Mean	Yield increase over Chalimbana (%)
D45/2/1	(Chal. x SPl) (Shul. x Span.)	2983	1456	2 267	2 235	8
D198/2/1	(Chal. x SPl)(Chal. x Shul.)	2 567	1783	2189	2 179	6
B477/1/2	(RG1 x Shul.) (Chal. x Shul.)	2850	2 122	2578	2517	22
C726/I/I	(Chal. x Shul.)(RGI * Chal.)	2450	1422	2350	2074	0.5
E530/2/1	(Chal. * Shul.)(RGI * Shul.)	2 742	1989	2 183	2 305	12
C186/2/1	(RG1 * SPI)(Chai. * Shul.)	2633	1600	2006	2080	0.8
C264/1/2	(SP1 * Chal.) (Chal. * Shul.)	3 192	2 122	2 856	2 723	32
E343/1/1	(SP1 x Chal.)(SPl x Shul.)	3 142	1683	2489	2438	18
Chalimbana	(Check)	2 292	1883	2013	2063	-
SP1	(Check)	2 300	1639	2 706	2215	-
RG1	(Check)	2 358	1289	2600	2082	-
SE		±198.1	±131.9	±125.7		
CV (%)		15	15	10		

A t-test showed no significant difference between the two yield means and variances, suggesting that intercrossing of F_1 progenies did not improve the population mean of the double-cross progenies. This was contrary to expectation. However, the magnitude of the variances for both sets suggests that there is still more room for improvement through selection.

The superior performance of the single-cross progenies over the double-cross progenies suggests that random intercrossing would not be expected to change the population means of a trait if high proportions of additive genetic variance are assumed (Altman and Busch 1984). However, changes in mean performance have been reported in other empirical studies, and this has been attributed to either epistatic effects (Humphrey et al. 1969) or inadvertent selection (Miller and Rawlings 1967, Meredith and Bridge 1971). In tobacco, intermating was associated with a small decrease in yield, which the authors thought would be quickly offset by one

Table 3. Means and variances of single- and double-cross groundnut progenies, Chitedze Agricultural Research Station, Malawi.

Single-cross progenies			Double-cross progenies		
Line	Pedigree	Mean yield (kg ha-')	Line	Pedigree	Mean yield (kg ha')
E267/2	(RGJ Shulamith)	2495	D45/2/1	(Chal. x SPI)(Shul.x Span.)	2 235
E267/3	"	2 566	D198/2/1	(Chal. x SPI)(Chal. x Shul.)	2 179
E267/5	"	2431	B477/1/2	(RGI x Shul.)(Chal. x Shul.)	2517
E267/6	"	2465	C726/1/1	(Chal. x Shul.) (RG1 x Chal.)	2074
E267/11	"	2 297	E530/2/1	(Chal. x ShuI.)(RGI x Shul.)	2305
D478/8	(RG1 x SPI)	2074	C186/2/1	(RGI x SPI) (Chal. x Shul.)	2080
E268/3	(SPI xx Chalimbana)	2011	C264/1/2	(SPI x Chal.) (Chal. x Shul.)	2 723
C851/7	(RG1 * Chalimbana)	2 580	E343/1/1	(SPI x Chal.) (SPI x Shul.)	2438
Chalimbana		1962	Chalimbana		2063
SPI		2 545	SPI		2215
RG1		1915	RG1		2082
Overall mean[1]		2 365	Overall mean		2319
Variance[1]		9.22	Variance		9.79

I. For the breeding lines only.

generation of selection (Humphrey et al. 1969). In cotton, a 10% increase in lint yield was reported by Miller and Rawlings (1967) and a 6% decrease was reported by Meredith and Bridge (1971). In both of these studies, the authors suggested that inadvertent selection of the parents was a possible cause of the mean changes. This appears to be a possible explanation for the differences observed in this study. All crossing in this study was done in a greenhouse with no growth or disease problems encountered. Random genetic drift seems to be an improbable cause of the differences based on estimates reported by Baker (1968). Selection of the crosses or complex gene interactions may be possible causes.

The intermating of selected single-cross progenies did not increase the yield of subsequent selections. This suggests that the extra effort put into intermating selected F, genotypes would not be beneficial in improving the population mean. However, subsequent intermating would be useful in breaking up linkage blocks existing between certain desirable traits (Jensen 1970, Hanson 1959). The generated population would also serve as a source of variation from which selection of good lines for use in further breeding programs would be beneficial.

The high-yielding lines from both sets will be evaluated together in further yield trials. Also an intercrossing program of the selected high-yielding lines will be undertaken to further improve on the yield potential of these lines.

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General Discussion and Recommendations

A Review of Regional Activities, 1984/1985

Dr K.R. Bock presented a review of Regional Program activities since the first regional meeting was held at Lilongwe in March 1984.

Introduction

The 1CRISAT Regional Groundnut Program has, as its principal objective, the introduction and subsequent development of high-yielding breeding lines and populations adapted to the different agroecological zones of the region, and having resistance to the main factors limiting production at the small-scale farmer level. That is the broad objective: we are a regional program and as such are correctly charged with a multitude of regional responsibilities in addition to the accepted predominance of our own research activities.

Guidelines for these regional responsibilities were enumerated at the first workshop in the form of recommendations arising out of that successful meeting. I propose to review these recommendations briefly, recording such progress as may have been made towards meeting their demands, and commenting on those areas where progress has been elusive.

Recommendation 1

The meeting expressed appreciation of the work of the ICR1SAT Regional Groundnut Program since its inception and recommended that it continues to assist with groundnut improvement in relation to the priorities of the region, by operating through and cooperating with national programs.

It was noted that the strengthening of the national programs themselves would enable most effective use of and maximum benefits to accrue from the regional program.

Response

Details of research progress made by the Regional Program and our continued close cooperation with national programs have been reported in our respective presentations. These reports provide one means of assessment of our work and it would not be appropriate for me to prejudge evaluation in any way.

In regard to the second paragraph, however, it is most heartening to record the remarkable progress made by Departments of Agricultural Research of all countries represented here today in strengthening their respective national research teams.

Recommendation 2

The meeting endorsed the regional program's existing priorities being directed towards the Cercospora leaf spots, rust, and rosette disease. The meeting emphasized the importance of Hilda and termites and other widespread pests such as jassids and thrips in the region, and recognized the need for an understanding of their ecology.

Response

A brief review of pathology research being pursued by the regional program on early leaf spot and rosette disease has been given and Dr Nigam has reported in detail on his work in these and other priority areas.

We continue to consider that these two pathogens are the most serious constraints to production on a regional basis and regard their resolution, or amelioration, by means of tolerance or resistance, as our most important task.

We have not, as yet, directed equivalent energies towards rust or late leaf spot. These diseases occur only in trace amounts late in the season at our research base at Chitedze, and we are thus denied the opportunity of intensive on-station work. For the time being, our strategy is to search among the 1CR1SAT resistant lines that we have introduced into the region for resistance or tolerance to early leaf spot, in an attempt to identify possible multiple sources of resistance. It is also our intention, at some future date, to initiate collaborative research in a carefully selected area of the region where the diseases occur in epidemic proportions every season.

In regard to entomology, as far as we are aware, it is only within the last year that one national program (Mozambique) has formally included an entomologist in its groundnut improvement program. ICRISAT continues to maintain a watching brief on groundnut entomology in southern Africa. Those participants who attended the first workshop will recall the presence of Dr P. W. Amin. All programs should have received copies of his report on his visit to the region. At this meeting we have in attendance Dr John A. Wightman, Principal Groundnut Entomologist, ICRISAT Center Groundnut Program. We hope you have taken this opportunity of discussing with Dr Wightman any aspects of groundnut entomology in your respective areas that you consider to be in need of attention.

Recommendation 3

The meeting recommended that the regional program continues to acquire new germplasm and to develop breeding populations; to disseminate these and to assist with their evaluation; and to respond to specific requests for assistance with hybridization.

Response

The broadening of the genetic base of groundnut in southern Africa constitutes the main thrust of our program and Dr Nigam has reported briefly on the acquisition and evaluation of new germplasm, on the development of breeding populations, and on the cooperative regional trials. 1 need not comment on the extent and quality of Dr Nigam's work, nor on his dedication to the discharge of his regional responsibilities. 1 believe these are evident to all of us.

We have received one request for assistance with hybridization (Mozambique) and work is in progress in this regard.

Recommendation 4

The meeting recommended that where appropriate, the Regional Program foster cooperative research among countries of the region, particularly on such aspects as the epidemiology of rosette disease and the evaluation of material in regional trials and of germplasm.

The Regional Program was therefore asked to devise an effective strategy to enable the national programs, each within its own particular limits, to be involved in cooperative research and to feed back results effectively and rapidly.

Response

Evaluation of material in regional trials is now a continuing seasonal process, cooperation is firmly established, and the many advantages of interchange of data are already in evidence.

Progress with a regional approach to rosette disease epidemiology has been more elusive. Mozambique, Zambia, and Zimbabwe responded and have supplied useful information, but so far the problem seems to rest with an almost universal lack of national program scientists who have no responsibilities additional to those of the pathology of groundnut. Most, if not all, of these few are engaged in the pathology of two or more crops, and several also have teaching duties. Prospects for cooperative work on rosette disease will improve with the gradual return of pathologists from postgraduate studies abroad. In the meantime, limitations in the way of regional cooperative effort remain, but are understood.

Recommendation 5

Noting that the national programs were not strong in all areas, the meeting recognized the need for consultancy services to be provided by the regional program. The regional program should therefore make every effort to respond to requests for visits, both for training and for advice on specific technical procedures.

Response

The regional program has responded to all requests from national programs during the past 2 years in regard to reprints of scientific papers, assistance with identification of pathogens, and information on research technique and methods. We visited national programs in Zambia, Mozambique, and Zimbabwe in 1984, and Botswana and Tanzania in 1985.

Recommendation 6

The meeting noted the urgent need for strengthening the national programs by appropriate and relevant training of personnel at various levels. It recommended that the regional program develop training programs within the region, drawing jointly on the expertise of ICR1SAT and of local institutes, to ensure high relevance and to minimize costs.

Response

We have assisted actively, where necessary, with the placement of national program technicians at the ICRISAT 6-month in-service Training Scheme in India. During the past year technicians from Botswana (1), Tanzania (2), Malawi (2), Mozambique (1), and Zambia (1) have attended the course and we have no doubt of the beneficial effects such training will bring to the respective national programs.

We have not, as yet, addressed ourselves to the possibility of developing a training program within the region. There are at present severe limitations imposed upon our time, both by our own research commitments and by the annual organization of either a workshop or a specialist group tour, which for obvious reasons must coincide with the crop season.

Recommendation 7

The meeting noted the fact that while much ecological, economic, and social variation existed within the region, much was often common across countries and that this should be exploited through the facility of the regional program, by means of a newsletter and regular meetings.

The meeting therefore warmly welcomed the suggestion that the regional program develop a newsletter on groundnut improvement, and recommended that this be used to facilitate the exchange of information on research results, national programs, specific technology, training and workshops, both within and outside the region.

The meeting further recommended that an effort be made to make the information available in both English and Portuguese, and therefore requested the regional program to explore the feasibility of publishing all or part in Portuguese.

Response

We have initiated a newsletter, Regional Groundnut News, based entirely on contributions from national program scientists themselves. Response to requests for contributions has been most satisfactory indeed and the publication appears to have met with success. Thus far, our newsletter has been in the main a useful means for the wide dissemination of local reports or reviews, which would otherwise not be available to the region's groundnut scientists. That alone is a worthwhile cause.

We regret that we have not been able to organize translation into Portuguese of what is now a publication of substantial length. It is our intention to ask contributors to future issues of the Newsletter to provide a brief abstract of each paper, which could then more readily be translated.

Recommendation 8

The meeting recommended that:

1. A regional multidisciplinary workshop be organized by the regional programs at least once every 2 years in different countries of the region, and that these should be held at a time when maximum benefit would be derived from field visits during the course of the meeting.
2. Such workshops be supplemented by monitoring tours or visits made by restricted groups drawn from the national programs, which would focus on specialised areas.
3. ICRISAT Center staff make specialist visits to meet particular needs or requests of national programs when these arise, and these visits be coordinated at the regional level.

Response

1. We enjoy a multidisciplinary workshop every 2 years because IDRC wisely and generously included financial provision for such meetings in the regional program budget. In accordance with Recommendation 8, we have met in Harare, by kind consent of the Government of Zimbabwe.

   I would like to take this opportunity of thanking Dr D.L. Cole and Mr G.L. Hildebrand most warmly for their assistance with local organization: without their help, organization of this meeting would have been difficult, if not impossible.
2. In further accordance with Recommendation 8,

we organized a Breeders' Meeting and Tour in February, 1985. National program breeders from Zimbabwe, Malawi, Zambia, Mozambique, Tanzania, and Botswana were thus enabled to visit breeding programs in Zimbabwe, Zambia, and Malawi, where they examined and discussed trials and germplasm in those three countries, including the genetic resources of the regional program at Chitedze.

The meeting produced its own set of valuable recommendations, which are contained in the Proceedings that were published in July 1985 by the regional program.

3. Dr P.W. Amin and Dr D. McDonald of ICRISAT Center were in attendance at the first workshop; Dr L.J. Reddy attended the Breeders' Meeting, where he delivered a key paper on drought tolerance in groundnut. ICRISAT Center has also enabled Dr R.W. Gibbons and Dr J. A. Wightman to be in attendance at this second workshop. The funding of these successive visits is tangible evidence of ICRISAT Center's commitment to the wellbeing of the regional program and to the furtherance of groundnut improvement in the region.

Recommendation 9

While emphasizing the great benefits of easy germplasm flow, the meeting noted the stringent need for vigilance and appropriate quarantine procedures.

It requested that representations be made to convene a meeting to develop appropriate regional practices.

The meeting appreciated further that there was a need to assist host countries of regional programs to upgrade and improve existing facilities in order to handle the increased volume of material.

Response

In pursuance of Recommendation 9, we have suggested to the Director, Southern African Centre for Coordination of Agricultural Research (SACCAR), that a meeting of all Plant Import/ Plant Export Officers of the region be convened under his aegis, to attempt to fashion a common regional policy in regard to those crops for which regional programs exist or are under consideration. This suggestion was well received and it is our hope that positive action will ensue.

Summary

In summary, we submit that we have fulfilled or have gone some distance towards fulfilling the majority of the responsibilities with which we were charged at the first regional workshop. This we could not have done without the interest and the encouragement of the national programs and their own positive commitment to regional cooperation.

Discussion of the Review of Regional Activities, 1984/85

Dr Kirkby, co-chairman, welcomed the review prepared by Dr Bock and remarked that in his experience of the many similar meetings he had attended, this 'self-assessment' was unique, and most useful. A lively discussion, based on the review, then followed the salient points. The recommendations arising from the discussions, are given below.

Roster of Scientists in the Region

It was recommended that ICRISAT approach the Southern African Centre for Cooperation in Agricultural Research (SACCAR) to obtain an up-to-date computer printout of all agricultural scientists in the region. This is particularly important where ICRISAT or national programs have no specific expertise in a particular discipline. This list would also be useful in locating consultants from the region.

It was also noted that the Editorial Board of the Zimbabwe Journal of Agricultural Research (ZJAR)and SACCAR have agreed that the Journal will become the designated journal for the SADCC region. SACCAR will pay page charges for publications concerning agricultural research in the SADCC region. Abstracts will be published in both English and Portuguese. It was recommended that ICRISAT consult with the ZJAR on the possibility of getting abstracts of newsletter articles translated into Portuguese.

Early Leaf Spot

It was recommended that ICRISAT Center puts more emphasis on locating sources of resistance to early leaf spot in the wild species collection. As there is evidence of variation in the pathogen, it was emphasized that this work would have to be done at the Chitedze Research Station.

Wild species are currently being screened at Chitedze during this season.

Results will be sent to ICR1SAT Center and resistant species will be crossed by the cytogeneticists with cultivars adapted to the SADCC region. Triploids and hexaploids will be produced in India and these will be tested in Malawi. Cytogeneticists from ICRISAT Center should then visit Malawi and assess their material and make further crosses and backcrosses as necessary.

Entomology

All delegates agreed that much more research needs to be done on arthropod pests in the region. There was obviously a lack of experienced, specialized groundnut entomologists in all SADCC countries. Immediate priorities were to assess the role of Hilda patruelis as an economic pest. There has also been very little detailed work on the biology of Hilda. Other major pests include termites and Aphis craccivora, the vector of groundnut rosette virus. The role of root- and pod-feeding pests (white grubs, millipedes, etc.) should also be investigated. It was recommended that ICRISAT be asked to provide an entomologist to the ICRISAT Regional Program, if funds could be found. It was also recommended that ICRISAT follow up on a previous suggestion made by the Kenya-based organization, ICIPE (the International Centre of Insect Physiology and Ecology), that they initiate work on resistance to A. craccivora in groundnuts. It was also explained that ICRISAT hopes to work with TDRI (Tropical Development and Research Institute) on new methods of termite control in India by using newer, and safer, insecticides and fungicides. If the project is approved, and is successful, then the results would be extended to Africa.

Other suggestions were that ICRISAT should provide more literature and bulletins on important pests as well as to update previous publications such as the PANS manual on Tests of Groundnuts'. Dr Kirkby also noted that a project on agroforestry in Kenya had identified some plants whose leaves, when spread on the ground, deter termites.

It was also recommended that ICRISAT should consider obtaining funds for a postdoctoral position in entomology from their training program. The candidate would be best located in Zimbabwe at the University under the direction of Dr D. Cole with additional supervision.by Dr K.R. Bock.

It was also hoped that more countries would cooperate, and intensify their efforts on the epidemiology and biology of Aphis craccivora as a virus vector.

The collection of germplasm within the region was discussed. ICRISAT Center has made collections in the region in cooperation with the national programs and IBPGR. Future collections organized by the Center will depend on priorities vis-a-vis other endangered habitats such as Brazil. Collections in the region have been done in the past and the ICRISAT Regional Program is attempting to assemble these at Chitedze, and properly evaluate them. It is estimated that this exercise is occupying some 15% of the breeder's activities.

Regional Trials, International Trials, and Breeding Material

It was agreed that the Regional Trials were useful and that promising material had already been identified and entered into national trials. It was also agreed that national programs should interchange promising new cultivars. Specific International Trials, from ICRlSAT Center, were also available for distribution to the region. These include trials of large-seeded cultivars, early-maturing cultivars, cultivars with resistance to pests, and with resistance to rust and late leaf spot. It was urged that national programs that took on ICRISAT trials should give them adequate attention, although it was realized that national programs had problems of staff and logistics, particularly when external-aid projects on oilseeds were withdrawn.

ICRISAT Center agreed to help as much as possible with analyses of regional trials if this was required.

Several countries, particularly those with breeders, welcomed the supply of segregating populations to enable them to reselect promising materials under local conditions. Specific crosses could also be made on demand, and it was also pointed out that resistance to rosette disease and early leaf spot, in particular, could be rechecked and confirmed by the ICRISAT pathologists in Malawi for any national program interested in this service.

Quarantine

In a general discussion on quarantine it was recommended that national programs and the ICRISAT program should keep the authorities in the region informed about recent findings on the seedborne nature of various diseases (both positive and negative). It was also agreed that SACCAR should be approached again to try and get a measure of uniformity of phytosanitary regulations within the region. ICRISAT Center would also be approached to help in this matter, when they organized visits by senior officials of national programs to India. In 1985, several Directors of Research visited India; perhaps quarantine officials could visit in the future.

Agronomy

The agronomic aspects of groundnut production in the region were discussed and it was pointed out that the ICRISAT Regional Program did not have the capability at present to conduct this type of research. In general ICRISAT feels that basic agronomy is the responsibility of the national program, as conditions and production methods vary from country to country. It was agreed that Zambia, with its current expertise in groundnut intercropping methodology, should disseminate their results widely to countries in the region. Similarly, basic studies at ICRISAT Center in India relating to drought and nutritional problems, biological nitrogen fixation, etc., would be made available, as would the results of intercropping and relay cropping carried out by the Resource Management Group.

Training

It was agreed that training requests should be notified, as far as possible, to the ICRISAT Regional Program so they can provide information and recommendations to the ICRISAT Center Training Program. Some specialized, short-term training could be given at Chitedze but accommodation was a problem. Specialized training could also be given at ICRISAT Center in many aspects of groundnuts. If the SADCC Grain Legume Improvement Program (GLIP) were furded then a Training Officer would be available.

Communications

The role of ICRISAT in distributing annual reports, newsletters, specialized publications, and abstracts was appreciated and it was recommended that this should be intensified due to the problems of getting journals and up-to-date information in some of the countries of the region.

Further Meetings

It was strongly recommended that in alternate years between workshops, specialized meetings and tours should continue. As the 1985 specialized meeting was a 'breeders' tour', it was recommended that plant-protection scientists should meet and visit different countries in 1986. It was recommended that as at this meeting, ICRISAT Center plant-protection scientists should attend and give specialist lectures on topics such as aflatoxin. It was also recommended that disease-scoring methods should be discussed.

Chairman Summary

Dr Kirkby summed up the discussions and remarked that the national programs must make the ICRISAT Regional Program what they wanted it to be, and must not expect ICRISAT to do everything. He also believed that there were many more resources available in the region than people thought. Dr Kirkby remarked that it was a privilege for him, on behalf of IDRC, to be associated with the program. He considered that remarkable progress had been achieved in a very short term.

Dr R.W. Gibbons, on behalf of ICRISAT, also thanked the participants for their excellent participation and cooperation with the ICRISAT Regional Program.

Both Chairmen thanked the Zimbabwe scientists for their most excellent arrangements for the Second Regional Workshop.

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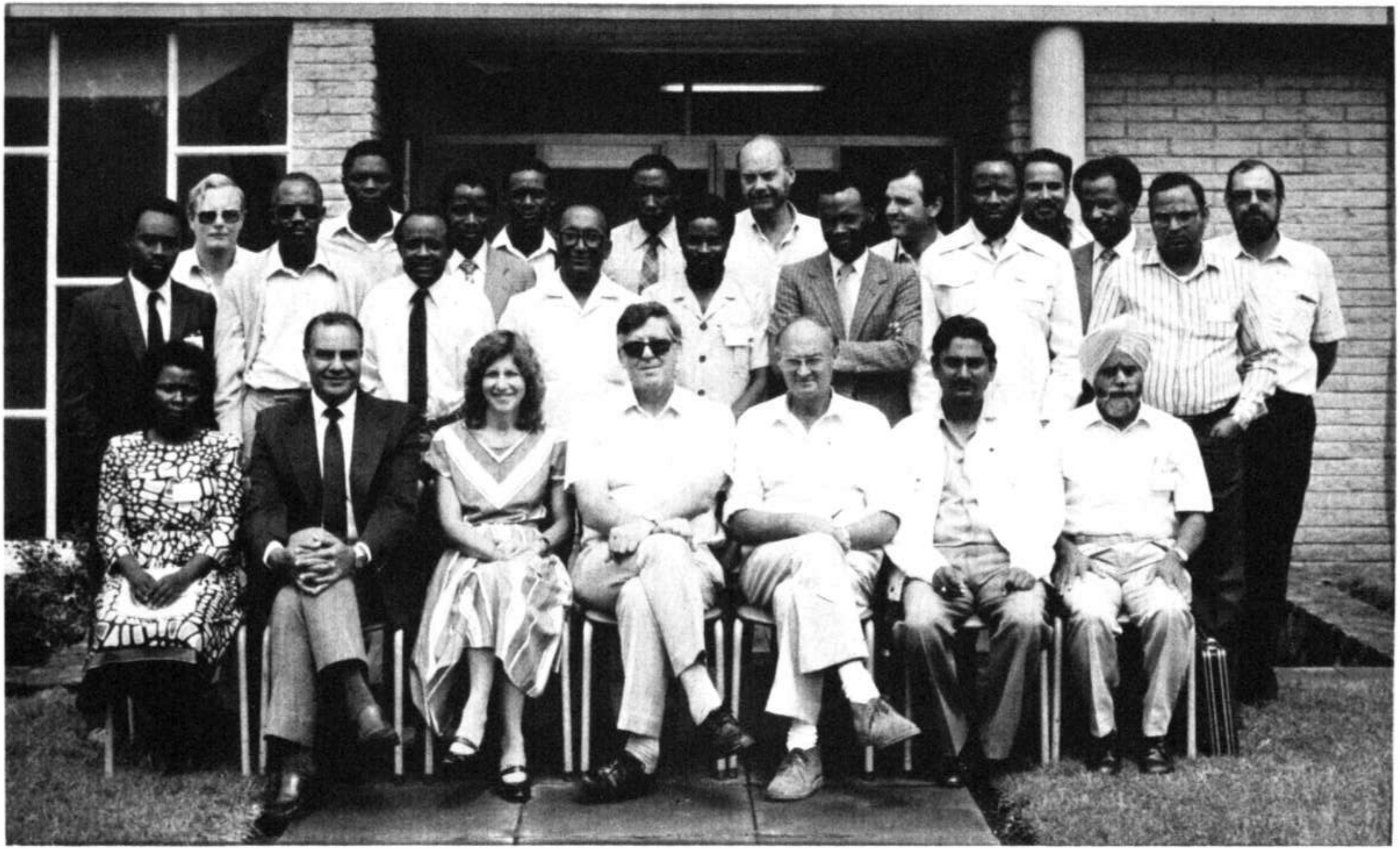

Attendants at the Second Regional Groundnut Workshop for Southern Africa, 10-14 Feb 1986, Harare, Zimbabwe

Front row (sitting, left to right): E. Manyara, A. Omran, D.L. Cole, R.W. Gibbons, K.R. Bock, S.N. Nigam, and R.S. Sandhu.
Middle row (standing, left to right): M. Amane, F.F. Mwenda, S.O.W.M. Reuben, Y.P. Rao, J.C. Musanya, G.T. Masina, A.J.P. Tarimo, and M.S. Reddy.
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