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Coordinated Research on Groundnut Rosette Virus Disease

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Cover: Rosette screening trials at the SADCC/ICRISAT Regional Groundnut Improvement Program, Chitedze, Malawi. The dark green rows of groundnut plants contain lines with resistance to rosette virus disease.

Coordinated Research on Groundnut Rosette Virus Disease

Summary Proceedings
of the Consultative Group Meeting
to Discuss Collaborative Research
on Groundnut Rosette Virus Disease
held at Lilongwe, Malawi
8-10 March 1987

ICRISAT

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Welcome Address

K.R. Bock[1]

On behalf of ICRISAT, it gives me great pleasure to welcome you all to Malawi, and to our meeting on the groundnut rosette virus (GRV) disease. We last met in Cambridge 2 years ago under rather different climatic conditions. Almost everyone who attended the Cambridge meeting is again assembled here, and that is particularly pleasing.

We have the pleasure of the company of additional participants this year. I would like to extend a special welcome to our three Malawian colleagues, Dr Sibale, Mr Chiyembekeza, and Mr Kisyombe, who have made major contributions to the Malawi National Groundnut Program over the years. We are also especially pleased that both Drs John A'Brook and Michael Thresh have been able to attend. Dr A'Brook's excellent work on epidemiology of GRV in West Africa remains of great significance, and Dr Thresh brings to the meeting his wide and special knowledge on the epidemiology of plant viruses.

I would like to take this opportunity to thank the Malawi Government through the Ministry of Agriculture for their kind approval to hold this meeting in Lilongwe, and for their continued deep interest in the well-being of the SADCC/ICRISAT Regional Groundnut Improvement Program for Southern Africa in Malawi.

Malawi is indeed a most pleasant and welcoming land, and I know that you will enjoy your brief sojourn here.

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Objectives of the Meeting

D. McDonald[1]

The major objective of this Third Consultative Group Meeting is to bring together representatives of various research groups involved in research on groundnut rosette virus (GRV) disease to review their research findings and to coordinate plans for future research and cooperation. It is indeed pleasing that so many of you have been able to attend this meeting. I am sure the research reports will be of great interest and that we shall be able to make effective plans for further cooperation in research to combat this important virus disease.

Another objective is to consider the possible usefulness of producing an ICRISAT Information Bulletin on GRV. If such a publication is considered desirable in the near future, we may have to solicit your assistance in its preparation.

An additional objective, and one that influenced the choice of venue, is to give those of you from outside Africa the opportunity to see GRV disease in the field, and in particular to examine research currently in progress at ICRISAT's Regional Groundnut Improvement Program for Southern Africa. This program is located at the Chitedze Agricultural Research Station of the Malawi Ministry of Agriculture. You will also be shown some of the field trials conducted by research staff of the Malawi Ministry of Agriculture, and will be able to visit farmers' fields in Lilongwe district.

The meeting should provide us with ample opportunity for informal as well as formal discussions. I am sure that the objectives will be met, that valuable information will be presented, and important proposals formulated for continuing cooperative research.

1. Principal Pathologist and Groundnut Group Leader, Legumes Program, ICRISAT, Patancheru, Andhra Pradesh 502 324, India.

Summaries
of
Papers

Research on Groundnut Viruses in the Semi-Arid Tropics

D.V.R. Reddy[1] and D. McDonald[2]

Several virus diseases occur on groundnut, and they are currently recognized as important constraints on groundnut production in many countries. Research on plant virus diseases in developing countries suffers from a scarcity of fully trained virologists and lack of facilities required for virus isolation, characterization, and detection. Excellent work has been done on economically important virus diseases on aspects other than virus characterization and detection. The research carried out in Africa to develop cultural control measures for groundnut rosette virus (GRV) and to breed cultivars with rosette resistance is one such example. However, access to advanced technology is essential in order to characterize and detect the causal viruses. If well-equipped virus units in developed countries agree to provide the necessary assistance, it is essential that duplication of research by various groups involved should be minimized. Appreciation of these needs has led to increased interests in regional and international cooperation.

Groundnut Rosette Virus (GRV) Disease

GRV disease is recognized as the most important virus disease of groundnut in Africa, south of the Sahara. Research in India, by ICRISAT, showed that several diseases of groundnut, previously described as "rosette", had not been accurately diagnosed, and were not the GRV disease found in Africa.

Thus, it was apparent that any ICRISAT research on GRV would have to be conducted in Africa or in a "third country" where groundnuts are not grown but where good facilities are available for plant virology research. Accordingly, collaborative research projects were established with the Institute for Plant Protection in Braunschweig, Federal Republic of Germany, and with the Scottish Crop Research Institute, Invergowrie, UK. ICRISAT scientists have worked in both these establishments in cooperation with local experts in several fields of virology. The collaborative efforts have already resulted in the publication of important new information on the causal viruses of GRV.

The scope of the work on GRV has been considerably widened with the involvement of the United States Peanut Collaborative Research Support Program (Peanut CRSP) in Nigeria. Their project on the identification of groundnut viruses in West Africa was initiated in 1982. This led to the organization, by Peanut CRSP, of the first international meeting to discuss coordination of research on GRV. In May 1983, scientists from Peanut CRSP, ICRISAT, and Braunschweig met in Georgia, USA, to plan a coordinated approach to the problem of characterizing GRV and producing diagnostic aids. With the help of scientists in Nigeria, Peanut CRSP scientists have conclusively demonstrated that GRV can be mechanically transmitted. In 1982, the SADCC/ICRISAT Regional Groundnut Improvement Program for Southern Africa was started and research into epidemiology and breeding for resistance to GRV was given high priority.

The various groups involved with research on GRV made significant progress, but the need for coordination of effort was keenly felt and so ICRISAT organized the second Consultative Group Meeting in 1985 at Cambridge, UK. This was held as a satellite meeting to the Workshop on "Virus Detection", organized by

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2. Principal Pathologist and Groundnut Group Leader, of the same Group and Program.

the Association of Applied Biologists. All the research groups involved were present and useful discussions held. It was unanimously agreed that each group should work on specific problems related to GRV and that the various research groups involved would avoid duplication of research. ICRISAT and Peanut CRSP agreed to continue their role to coordinate research on GRV disease and to assist the various research groups in all possible ways to accomplish their research objectives. The Summary Proceedings of the Cambridge Meeting were published by ICRISAT and copies have been sent to all interested parties.

We are now participating in the third meeting to coordinate research on GRV disease. It is appropriate to hold this meeting in Africa where GRV is so important, and in Malawi where such excellent work has been done in breeding GRV-resistant cultivars. In addition, Malawi is the host country for ICRISAT's Regional Groundnut Improvement Network for Southern Africa. We note with immense pleasure that participation has been expanded to include scientists from Malawi: Dr Thresh as observer for the Overseas Development Administration (ODA) of the UK; Dr A'Brook who did so much work on GRV in Nigeria some years ago; and Dr Dubern from Institut de recherches pour les huiles et oléagineux (IRHO). It should be remembered how much is owed to the French workers who discovered the sources of resistance to GRV in West Africa and made this material freely available to breeders in Nigeria and Malawi.

The main aim of this meeting is to discuss the progress made by the various research groups over the past 2 years, and to chalk out an action plan for utilizing the results obtained. Diagnostic aids (developed) should assist in the detection of the causal viruses in breeding lines and in vectors. They may also be used to check possible alternative virus hosts and for determining the relationships between the different forms of GRV.

In fact, reliable means of detecting the component viruses of GRV disease are essential for progress in resistance breeding and in obtaining a full understanding of the epidemiology of the disease (Fig. 1).

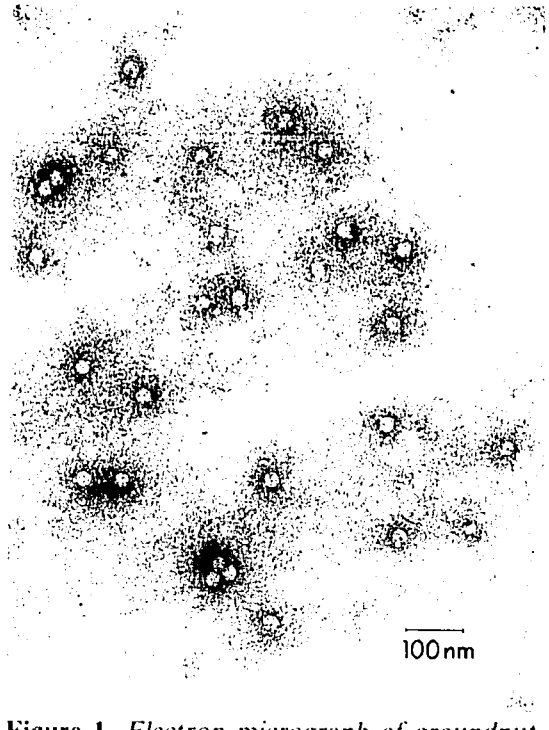

Figure 1. *Electron micrograph of groundnut rosette assistor virus particles (bar represents 100 nm).*

Other Important Groundnut Viruses in Africa

Since GRV is widely distributed and can occur at relatively high incidence, it is likely to have masked several other important viruses. For example, in our disease surveys in West Africa in 1981, cowpea mild mottle virus was frequently observed on GRV-resistant cultivars. Peanut clump is widely distributed in West Africa and is economically important in Niger, Burkina Faso, and Senegal. Peanut mottle virus is also widely distributed in Africa, but its economic importance is yet to be determined. Bud necrosis disease, caused by tomato spotted wilt virus (TSWV), has been reported from Nigeria and Niger. This disease is one of the

most important constraints for groundnut production in India and in parts of USA, and should be monitored in African countries because of its potential to cause severe yield losses. In order to identify and characterize other important groundnut viruses in Africa, it may be necessary to adopt an approach similar to ours on GRV.

Peanut Stripe Virus (PStV) Disease

PStV is the most important virus disease of groundnut in several southeastern countries of Asia. There are no reports of PStV occurring in Africa, but as the virus is seedborne, it could well spread to that continent. Thus, it is vital that every effort should be made by plant quarantine units, and by scientists interested in exchanging germplasm, to prevent PStV entry into Africa. In addition, we should be prepared to deal with PStV if it does arrive in Africa.

Peanut CRSP and ICRISAT will organize the first coordinators' meeting on PStV in Indonesia in June 1987 with support from the Australian Centre for International Agricultural Research (ACIAR). ICRISAT and Peanut CRSP will provide diagnostic aids, and assist in locating sources of resistance to PStV. ACIAR will assist in screening groundnut germplasm for resistance to PStV at several locations in disease-trap nurseries, which were planted with a set of genotypes in several key groundnut-growing areas in Indonesia, to record the incidence of economically important diseases in the region. Utilizing this concept, it may be possible to identify areas free from PStV so that they can be utilized to produce virus-free seed.

Conclusions

Research on virus diseases is expensive and requires elaborate equipment and well-trained staff. There are at present very few laboratories in Africa that are equipped to undertake work on virus characterization. With assistance rendered by several international organizations and by utilizing the expertise and excellent facilities available in developed countries, it has been possible to investigate the causal viruses of GRV disease.

Using a similar approach, it should be possible to investigate other economically important viruses that occur in Africa, to provide diagnostic aids for determining the distribution and economic importance of the viruses, and to detect the viruses in quarantine. Training for scientists currently working in Africa in the utilization of these diagnostic aids is vital. We believe that the success achieved in the case of groundnut rosette virus justifies the adoption of a similar approach to tackle other economically important groundnut viruses occurring in Africa and other tropical regions.

Methodology of Groundnut Rosette Resistance Screening and Vector-Ecology Studies in Malawi

K.R. Bock[1] and S.N. Nigam[2]

The challenge in the selection of acceptable groundnut rosette virus (GRV) resistant cultivars lies not with the generation of resistant × susceptible crosses, but in the effective screening of very large numbers of hybrids that the breeding program demands. Groundnut rosette is a disease which, though devastating, is sporadic in occurrence in southern Africa, often with intervals of several years between pandemics. Reliance cannot, therefore, be placed on natural incidence when screening crosses, and an alternative strategy must be evolved. The development of disease nurseries is one such means, and we report our progress in this direction. We remain ignorant of the seasonal origins of GRV, the resolution of which must involve studies on the ecology of the vector, *Aphis craccivora* Koch.

Methodology of GRV-Resistance Screening

We have developed a satisfactory technique for GRV-resistance screening which involves the management of a field disease nursery during the rainy season and subsequent controlled greenhouse screening tests of apparently healthy field survivors.

We base our field nursery management on the GRV's pattern of spread in Malawi, where only primary infections give rise to typical patches of the disease.

At normal sowing time, generally at the onset of the rains, we plant one infector row of a susceptible variety (Malimba) between two contiguous rows of test lines. Previous to this period, we raise large numbers of susceptible seedlings in the greenhouse, inoculate them with GRV, and allow dense populations of viruliferous apterae to develop on the infected plants. About 1 week after seedling emergence, we transplant, at 1.5-m spacing in each of the infector rows, the diseased seedlings still heavily infested with vectors. We subsequently continue to harvest viruliferous aphids from greenhouse cultures and seed the nursery with them on many occasions. This resulted in a 90% incidence in 1984/85 (2.0-m spacing between infected transplants) and a 98% incidence in 1985/86 (1.5-m spacing between infected transplants) in the infector rows.

In 1985/86, when some 29 000 test plants from crosses between susceptible and resistant parents and from backcrosses were screened, the apparently healthy survivors consisted of a mixture of susceptible 'escapes' and plants that were homozygous for resistance (Table 1). 'Escapes' are screened out by greenhouse tests during the ensuing dry season. Agreement between observed and predicted numerical values for resistance among the progenies of resistant × susceptible parents and of backcrosses indicates the double-recessive nature of GRV resistance (Table 2).

Studies on Resistance: Grafting and Other Experiments

Mrs R. Rajeshwari and Dr A.F. Murant tested graft inoculated resistant plants from Malawi for the presence of the groundnut rosette assistor virus (GRAV) by means of Enzyme-Linked Immunosorbent Assay (ELISA), and for GRV by sap inoculation to *Chenopodium amaranticolor* and *Nicotiana benthamiana*.

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Table 1. Incidence of groundnut rosette virus (GRV) in all susceptible, resistant, and susceptible × resistant (S × R) tested at the field screening nursery, Chitedze, Malawi, 1985/86.

Type of line	Number of plants infected	Number of plants exposed	Rosette disease incidence (%)	
			Observed	Expected
Susceptible 'spreader' rows	20212	20680	97.7	100
Susceptible parents (S)	209	217	96.3	100
Resistant parents (R)	0	174	0.0	0
S × R crosses:				
F_1	76	79	96.2	100
F_2	2367	25927	91.3	93[1]
Backcrosses:				
(S × R) × S	1387	1444	96.1	100
(S × R) × R	1382	1899	72.8	75[2]

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

Table 2. Data for groundnut rosette virus (GRV) inheritance studies only: GRV susceptibility in susceptible × resistant (S × R) crosses, Chitedze, Malawi, 1985/86[1].

Type of line	Number of plants infected	Number of plants exposed	Rosette disease incidence (%)	
			Observed	Expected
S × R crosses:				
F_1 (R × S)	21	23		
S × R	30	30		
Total	51	53	96.2	100
F_2 (R × S)	4537	4791		
S × R	2728	2971		
Total	7265	7662	94.3	93.8[2]
Backcrosses:				
(R × S) × R	650	846		
(S × R) × R 348 457				
Total	998	1303	76.6	75[3]
(R × S) × S	865	873		
(S × R) × S	482	482		
Total	1347	1355	99.4	100

1. Results include greenhouse retests on apparently healthy survivors of field tests.
2. Predicted ratio = 1 resistant to 15 susceptible plants.
3. Predicted ratio = 1 resistant to 3 susceptible plants.

In Malawi, we inoculated seedlings of resistant varieties, RG 1, RMP 40, RMP 90, RMP 93, RRI/6, RRI/24 thrice, using batches of 20 viruliferous aphids. After 5 weeks, the resistant plants were top-grafted with healthy, susceptible shoots. As controls, we grafted healthy susceptible shoots into rosetted plants: these always developed GRV within 17 days of grafting, whereas no healthy scions grafted onto resistant inoculated plants developed symptoms of GRV. In a second experiment, we grafted healthy resistant shoots into fully rosetted plants. These grew well, produced side shoots, and behaved in one of three following ways:

1. Some of them remained free of symptoms for the duration of the experiment (6 months). Healthy susceptible scions grafted into these developed GRV disease, which was readily transmitted to healthy susceptible seedlings by the vector.
2. In others, the majority of side shoots of the scion remained symptomless, but often one or two of those nearest to the graft union developed suppressed or muted GRV-disease symptoms.
3. In very few grafts, the resistant scions developed more or less severe symptoms of GRV disease with severely shortened internodes.

These variations in reaction by the resistant shoots of essentially similar, if not identical, genotypes to continuous infection with virus is not understood, but the graft experiments indicate that the resistant varieties studied are all highly resistant (almost to the point of immunity) to inoculation of GRV by the vector. However, they are not immune to GRV. When infected by grafting, GRV symptoms are either completely suppressed or greatly muted, and only rarely do typical symptoms appear.

In a third series of experiments, we sent shoots of heavily inoculated, resistant varieties to Dr Murant at the Scottish Crop Research Institute. All inoculated plants of all resistant varieties contained groundnut rosette assistor virus (GRAV), which was readily transmitted to groundnut seedlings by *A. craccivora*. Genes conferring resistance to GRV in the cultivated groundnut, therefore, do not also confer resistance to GRAV.

Studies on Vector Ecology

We continue to study the vector using yellow water traps, bait plants, and dry-season bait plots.

All these methods indicate the continuous presence of *A. craccivora* throughout the year, including all months of the dry season. The dry-season population, however, apparently does not carry GRV. At the onset of the rains, the population migrating into the emerging groundnut crop contains a proportion of viruliferous individuals. Table 3 summarizes early rains observations on vector and virus, from 1983/84 to 1986/87 seasons.

Table 3. Relationship of emergence of crop to arrival of viruliferous alates and development of groundnut rosette virus (GRV), Chitedze, Malawi, 1983/84 to 1986/87.

Date(s)/duration	1983/84	1984/85	1985/86	1986/87
Date of approximate onset of rains	18 Dec	6 Nov	7 Nov	1 Dec
Dates of emergence of crop	28-31 Dec	26-29 Nov	30 Nov	17 Dec
Date when first alates were seen	4 Jan	7 Dec	5 Dec	18 Dec
Date when first few GRV symptoms were observed	18 Jan	20 Dec	19 Dec	8 Jan
Number of days between emergence and first few symptoms	19-21	21-24	20	22

Based on our own observations and the results of discussions with groundnut scientists working in the region, we do not think that volunteer plants are significantly involved in the maintenance of virus or vector during the dry season in Malawi.

We deduce a sequential movement of *A. craccivora* from plant host to plant host, as these become attractive in turn to the vector during the dry season. These dry-season hosts are not necessarily GRV reservoirs. We think that, at the beginning of the rains, one or more species of plants, which are hosts of the virus are briefly colonized by the vector just prior to its infestation of the emerging groundnut crop.

Inheritance of Resistance to Rosette Virus Disease in Groundnut

S.N. Nigam[1] and K.R. Bock[2]

The SADCC/ICRISAT Regional Groundnut Improvement Program for Southern Africa gives high priority to breeding agronomically acceptable, groundnut rosette virus (GRV) resistant groundnut (*Arachis hypogaea* L.) cultivars adapted to the region. The major emphasis is on short-duration types for the areas where rosette virus is most important, but there is also a need to breed bold-seeded, GRV-resistant cultivars for the confectionary trade. A breeding program was initiated in 1982, and material is now in the F_4 stage. In this paper, we report on studies on the inheritance of the resistance.

Studies in West Africa with virginia × virginia crosses (Berchoux 1960) indicated that resistance to groundnut rosette virus was controlled by two recessive genes. Berchoux (1960) attributed this resistance to production in the plants of antiviral substances. He noted that when subjected to massive inoculum pressure from viruliferous aphids, the resistant plants could be infected with GRV. He attributed this to the plants' inability under these conditions to produce a sufficient quantity of antiviral substances: this hypothesis was later confirmed (Daniel and Berchoux 1965).

Harkness (1977), working in Nigeria, reported low recovery of resistant plants from virginia × spanish crosses and ascribed this to the appearance of GRV-disease symptoms in double-recessive plants following heavy inoculation at early stages of plant growth. He also suggested that such loss of resistance from generation to generation in individuals of crossbred material was to be expected if double-recessive genotypes did not confer resistance in all nuclear backgrounds.

Gibbons (1985), while discussing breeding for GRV resistance, mentioned unconfirmed and unpublished reports indicating that rosette resistance may not be simply inherited as suggested by Berchoux (1960).

Materials and Methods

Two GRV-resistant virginia cultivars (RG 1 and RMP 40) were crossed with three susceptible cultivars, one from each of the spanish (JL 24), virginia (Mani Pintar), and valencia (ICGM 48) groups. F_1 reciprocal crosses and their F_2 backcross generations of the resistant × susceptible F_1 crosses were produced, and the field resistance screening of parents and filial generations was carried out following the method of Bock and Nigam (see page 7 in this Summary Proceedings). Plants not infected under field conditions were harvested individually and three seedlings raised from each of them were subsequently tested for GRV resistance in the greenhouse. If any seedling was found to be susceptible to GRV in this test, its preceding F_2 or backcross plant was recorded as susceptible. This helped in eliminating 'escapes' in field testing and allowed us to interpret more precisely the performance of the progeny. If none of the three plants could be infected under laboratory conditions, the remaining seeds were planted as progeny rows in the GRV screening nursery. The final observations on segregation for GRV resistance are awaited.

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Results and Discussion

All 12 F_1 crosses, including reciprocals, were susceptible to GRV, confirming the recessive nature of the resistance.

The F_2 data were subjected to X^2 analysis to test the fit of 3:1, 15:1, 13:3, and 63:1 F_2 ratios of susceptible to resistant plants. In all the 12 cases, the 3:1, 13:3, and 63:1 F_2 ratios, did not fit the observed distribution.

In six F_2 crosses, including reciprocals, involving the resistant parent RG 1, the fit for a 15:1 F_2 ratio for susceptibility to resistance was good. In the case of resistant parent RMP 40, except for the JL 24 × RMP 40 F_2 cross, the fit for a 15:1 F_2 ratio was within acceptable limits in spite of the low recovery of resistant plants in some crosses. On pooled analysis over all RMP 40 crosses, the fit was again within acceptable limits.

In the backcross generation of 12 crosses with the susceptible parents, all the plants in all but one cross, (RMP 40 × Mani Pintar) × Mani Pintar, were susceptible to GRV. In the cross (RMP 40 × Mani Pintar) × Mani Pintar, 3 plants from a total of 172 were not infected. Progenies of these plants are currently being tested to check if the original F_1 s could have been RMP 40 selfs.

In the backcross generation of 12 crosses with the resistant parents, all except (RMP 40 × ICGM 48) × RMP 40 had a good fit for a 3:1 ratio of susceptibility to resistance.

From the F_1, F_2, and backcross generations data of 12 crosses involving resistant parents and susceptible parents of different botanical types, it can be inferred that the resistance to GRV is recessive in nature and is governed by two genes. Furthermore, the botanical type had no influence on inheritance. From this study and from observations of progenies in the GRV-resistance breeding nursery, we could find no evidence to support Harkness' suggestion of differential expression of the double-recessive genes in different nuclear backgrounds. Resistant plants identified in the F_2 generation have maintained this character for at least four generations.

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Recent Developments in Groundnut Entomology Relevant to the Control of Groundnut Rosette Virus Disease

J.A. Wightman[1]

An outbreak of groundnut rosette virus (GRV) disease is the combination of a chain of events involving an off-season reservoir of the virus complex, alternative hosts of the vector *Aphis craccivora* Koch, the interaction between the vector and the host, and the response of the host to the virus. Currently, the major research effort has been directed towards understanding and describing the viruses and developing genotypes with resistance to GRV disease and high-yield potential.

Recent developments in groundnut entomology point to two more avenues of reducing the risk of crop loss caused by GRV disease. Both methods are, or can be made, applicable to the needs of no- or low-income farmers in the semi-arid tropics (SAT).

Insecticides

Most insecticides will kill aphids. However, even if their purchase and application are within the means of SAT farmers, the net effect of applying them is likely to reduce further outbreak of aphids and other pests. This is because most insecticides kill most insects, including those predators and parasites that suppress the population levels of potential pests. A possible method of avoiding this unfortunate side effect is to apply a systemic insecticide to the soil before sowing. The theory is good but most insecticides break down in the soil in a matter of weeks. A new insecticide formulation, controlled release granules (CRG), is currently under evaluation by ICRISAT and the Tropical Development and Research Institute, London for the control of termites in groundnuts. There is now evidence that a CRG formulation of phorate reduces GRV incidence and the population of termites and other pests living in the soil. The advantage of CRG is that it is relatively safe to handle and releases the insecticide to the soil over a relatively long and controllable period of time (months or years). Prices are not known but the application cost would be eliminated if the granules were incorporated with fertilizer. This approach would be applicable to SAT farms where groundnuts are a cash crop (e.g., Zimbabwe, Botswana, and possibly Malawi, although fertilizer is not usually applied to groundnut fields in that country).

Resistance to the Vector

Until recently, resistance to the vector of GRV had not been considered since Evans (1954) discovered that several lines from northern Tanzania had markedly lower levels of GRV disease and *A. craccivora* than controls. More recently Dr P.W. Amin showed that NC Ac 5240 had a high level of resistance to an Indian biotype of *A. craccivora* (ICRISAT 1987, page 229). Greenhouse tests in Malawi confirmed this observation and revealed several other genotypes with aphid resistance. However, the important point is that under field conditions, in high-infestation pressure of Dr K.R. Bock's GRV screening nursery, NC Ac 5240 had only 34% infection after 89 days, compared to 99% in control genotypes.

The important aspect of this set of observations is that aphid resistance may serve as additional protection and may have a lower 'cost' in terms of the trade-off between yield and resistance. This approach is applicable to farmers who grow groundnut as a subsistence crop with

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no cash flow. Recent developments in groundnut entomology, as a whole, may broaden the spectrum of techniques available to the applied ecologist for reducing losses caused by GRV to groundnut crops.

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Groundnut Rosette: Epidemiology and Management in Nigeria

S.M. Misari[1], O.A. Ansa[2], J.W. Demski[3], C.W. Kuhn[3], O.F.R. Casper[4], and E. Breyel[5]

Introduction

Groundnut rosette disease is endemic in Nigeria, with an annual incidence of about 5%. Occasionally however, due to factors not yet fully understood, localized epidemics occur. For example, groundnut rosette disease occurred in epidemic proportions in the Institute of Agricultural Research (IAR) fields (Samaru) in 1983, and in most parts of Kano and Kaduna states in 1985. Most other areas, however, experienced the normal low incidence. The extent of loss in 1985 was second only to the 1975 epidemic, which resulted in more than 55% loss of the expected yield. The crop losses were worth over U.S. $ 250 million.

Reasons for the Epidemics

It is estimated that less than 10% of farmers grow the recommended resistant varieties in the groundnut-growing areas of Nigeria. This is in spite of the fact that some of these varieties have been released since 1975. Groundnut rosette epidemics in 1983 and 1985 may be attributed to poor or inadequate seed multiplication and an inadequate seed distribution network. In addition, crop protection inputs, including chemicals and equipment, have not been made available to farmers in sufficient quantities and at the right time.

The recommendations for cultural practices are not followed by the farmers. For example, they do not plant groundnut early enough because cereals are given priority over groundnut; therefore they are more prone to aphid and GRV-disease attack. Farmers generally plant about half the seed recommended for dense plant population. This may be attributed to the unavailability of sufficient seed quantities.

Most farmers still grow groundnut as an intercrop. Even though there are certain advantages for this practice, from the point of view of aphid and virus control, it has several limitations.

Poor crop hygiene and sanitation are regarded as major problems. Farmers do not recognize the importance of destroying infected plants as soon as they are noticed.

With the proliferation of irrigation schemes in the country, the ecology of the aphid vector, *Aphis craccivora* Koch has changed. The aphid is able to survive and multiply on volunteer groundnut plants and numerous other plants throughout the year.

It is now common to find a very high population of aphids in April, prior to the planting season. The volunteer groundnut plants provide a suitable host for aphids that leads to a rapid population increase in the rainy season. The aphid vector can survive the dry season on wild hosts.

The dry-season reservoir of the virus, besides groundnut, is still unknown. This stresses the need for further epidemiological studies of the disease and the vector bioecology.

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Management by Resistance

Prior to and after the 1975 GRV-disease epidemic, breeding efforts were centered around green rosette, which was the most common form of GRV. This resulted in the identification and development of many varieties that are resistant to GRV. The varieties were however of long-season types. From 1975 to 1983, droughts were common and drought resistance received more attention than rosette resistance. For example, this resulted in the development of the variety RRB, which has the virtue of earliness and is resistant to drought though only tolerant to green rosette. This variety performed fairly well until 1985 when it succumbed to the chlorotic rosette which, hitherto, had been of minor importance in Nigeria.

Field screening of groundnut germplasm, under natural epidemic conditions at Samaru in the 1983 and 1985 seasons, revealed about 25 lines that showed some resistance to GRV disease. Greenhouse screening of about 120 entries revealed that over 50% of those which exhibited field resistance were 'escapes'. Many of the germplasm lines showed differential disease reactions and varying degrees of resistance to the green and chlorotic rosette. This may be due to their inherent genetic constitution or the segregation phenomena in the breeding processes. The incubation period of the virus in the resistant lines was longer than in the susceptible ones. The developmental rate of the aphid vector was not significantly affected by the different lines tested.

The most promising advanced lines included M554.76, M 516.791, M 578.79, M 25.68, MDR 8-15, MDR 8-19, and K 20.84. These are mainly suited for the Guinea Savanna zones with growing seasons of 120–150 days. Our problem has continued to be with the Sudan Savanna zone where, as of necessity, early-maturing varieties (about 100 days) are required. For the past several years there have been a series of attempts to transfer resistance to early-maturing lines. The current thinking is that there may be linkage between the gene for earliness and susceptibility. This requires further evaluation.

Management by Vector Control

IAR at Samaru has developed a number of lines that are promising in terms of high yield, earliness, and drought tolerance but lack GRV resistance. In order that farmers in the Sudan Savanna can benefit from these varieties, we have developed an integrated pest management (IPM) strategy that combines recommended cultural practices (close spacing and early planting) with the use of systemic insecticides to control the aphid vector.

Groundnut is attacked by a range of pests that includes aerial and subterranean species throughout its growth cycle. The IPM strategy, therefore, takes cognizance not only of safety, efficacy, and cost-effectiveness of insecticides but also of the phenological sequence of events inherent in the development of the crop. Viruliferous aphids (as well as millipedes and other soil organisms that reduce seedling establishment) constitute a serious threat to groundnut during the first 30 days after planting. Millipedes and termites are the major soil pests during the critical pod-development stage, i.e., 45–80 days. While the application of a granular formulation of carbofuran at the rate of 0.75–1.5 kg ha^{-1} could arrest the secondary spread of GRV throughout the season, the use of carbofuran/thiram or furathiocarb/thiram mixtures protected the crop from aphids and early pests for about 3 weeks after planting; the thiram component enhanced seedling establishment by protecting the germinating seeds from fungal pathogens. Our work has so far demonstrated that the prophylactic use of these inexpensive seed dressings followed by the application of carbofuran granules to the soil about 40 days after planting, effectively suppressed groundnut rosette and the major soil pests during the most vulnerable stages of groundnut production. Thus, the strategy of integrating the use of these chemicals with early planting of agronomically acceptable cultivars at high populations gave high yields of good quality seeds in Nigeria. Work is in progress to fine tune this approach for cost effectiveness.

"Little Leaf" Disease of Groundnut

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Groundnut plants with striking and unique symptoms have been observed in Nigeria during the last 4 years (1983-86). Most diseased plants occurred in experimental breeding plots, but a few have been observed in farmers' fields. The disease is characterized by three symptoms; very small leaves with margins cupped upward, severly stunted plants, and flattened stems with short internodes.

Mechanical inoculation with sap and aphid inoculation from diseased plants caused typical green-rosette symptoms in groundnut genotype F 452.4; the small leaves and severe stunting symptoms noted in the field did not occur in the inoculated plants.

In one experiment, graft transmission from a field-diseased plant to F 452.4 caused the small-leaf, stunting symptoms.

In 1986, about 50 diseased plants were tested electrophoretically for the small double-stranded ribonucleic acid (ds RNA, 900 base pairs) associated with groundnut rosette virus (GRV) and serologically for groundnut rosette assistor virus. All plants were positive in both tests. Electron microscopy did not detect either mycoplasma-like bodies or virus particles in diseased tissue. The latter observation is incongruent with the positive serological reactions.

The disease has tentatively been named "little leaf". Although the two casual agents of groundnut rosette virus have been associated with little-leaf diseased plants, it is premature to ascribe any causal agent to this disease. The possibility that the symptoms are due to the reaction of specific genotypes to GRV is not ruled out.

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Dual Infections and Cross Protection of Groundnut Rosette Virus in Nigeria

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In an attempt to determine the relationship of groundnut rosette virus (GRV) strains (isolates) and the casual agent(s) of "little-leaf" disease of groundnut in Nigeria, laboratory and field observations were made on their dual infections and possible cross protection. The natural occurrence of dual infections of green (GRV-G) and chlorotic (GRV-C) forms of GRV on single plants was also investigated in the field.

When GRV-G was first aphid inoculated and then challenged with GRV-C 1,2,4, and 8 days later, most plants infected during the first 2 days expressed GRV-G symptoms. When the situation was reversed, again GRV-C predominated. Simultaneous inoculation of the two isolates resulted in about 90% of infected plants manifesting GRV-C symptoms. Although no intermediate symptoms were expressed, there were wide variations on the leaf symptoms, particularly with GRV-C, irrespective of whether it was singly or simultaneously inoculated. The predominant symptom variation was green mosaic patches on a chlorotic background. Similar results were obtained when single aphids were allowed to acquire virus from one source, either GRV-G or GRV-C, and then the other before inoculation access feeding. We believe these results suggest that GRV-C is somehow more aggressive than GRV-G, perhaps in "competing" for sites for multiplication.

Field observations have revealed that as many as 5% or more of naturally infected plants are dually infected by both GRV-C and GRV-G. Field surveys conducted during the 1983 and 1985 epidemics showed that GRV-C incidence was 5-30% and GRV-G incidence was 85% or higher. In both years, an apparently new disease, tentatively called "little-leaf", occurred in epidemic proportions and was usually, if not always, predominantly associated with GRV-infected plants.

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Developments in Groundnut Rosette Virus Research in Samaru, Zaria, Nigeria

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Purification of Groundnut Rosette Virus Assistor Virus (GRAV)

Earlier attempts at purifying GRAV, using groundnut tissue, provided limited and erratic success. No bands could be consistently obtained in sucrose gradients and enzyme-linked immunosorbent assay (ELISA) analysis showed the presence of viral antigens throughout sucrose gradients. The presence of viscous material in groundnut tissue also made the process difficult. A shift away from groundnut to an alternative host for propagation of GRAV was attempted.

GRAV did not produce any visible symptoms in groundnut plants or in plants of 28 experimental host species that were aphid inoculated in the greenhouse with a mixture of GRAV and the groundnut rosette virus (GRV) for previous aphid-inoculated plants. Only CNS soybean and *Nicotiana benthamiana* showed visible symptoms. However, ELISA tests with potato leaf roll virus (PLRV) antiserum showed that soybean and *N. benthamiana* did not contain detectable levels of luteovirus. Sap from *Dolichos lablab* and cowpeas *(Vigna unguiculata)* reacted positively with PLRV antiserum, although at only 20% level of that in groundnut. Further tests were done on 26 cultivars of cowpea, and we are in the process of selecting the best five lines that contain high concentrations of GRAV.

Procedure to Screen for Resistance to Groundnut Rosette Virus (GRV)

1. ELISA tests showed that levels of GRAV were similar in both susceptible and resistant groundnut genotypes.
2. Aphid colonization and multiplication were similar on susceptible and resistant genotypes.
3. Sap inoculation proved to be useful in screening for resistance to GRV. The susceptible cultivars MK 374, F 452.4, and 55-437 were easily infected. Some cultivars like RRB and M 1204.78I were more difficult to infect, and others like MDR 8-15, MDR 8-19, and M 343-81 developed no symptoms.
4. Analysis of nucleic acids in the various cultivars showed that the double-stranded ribonucleic acid (ds RNA, 900 base pairs) was present in extracts from infected susceptible cultivars and absent in resistant cultivars.

Single and Dual Infection of Aphid-Inoculated Groundnut Plants with the Two Causal Agents of Groundnut Rosette Disease

A large number of naturally infested plants in farmers' fields and experimental plots, and aphid-inoculated plants in the greenhouse were assayed for presence of GRAV and GRV.

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Results showed that the GRAV occurred frequently in these plants irrespective of whether the cultivar was resistant or susceptible. Furthermore, the presence of GRAV was not dependent on the visible expression of symptoms. The incidence of GRAV appeared to be influenced by control measures used in the fields and in some cases by the cultivar.

The presence of GRV was associated with the ds RNA (900 base pairs) component symptoms in the plants and genotypes susceptible to GRV. In nature, plants containing GRV alone were not detected. However, GRV did occur alone in mechanically inoculated plants. GRV and GRAV occurred together in all cases of natural infection where GRV could be detected.

Detection of a Double-Stranded RNA Associated with Groundnut Rosette Virus

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The presence of a low-molecular weight double-stranded ribonucleic acid (ds RNA) 900 base pairs associated with groundnut rosette can be used as a diagnostic tool for groundnut rosette virus, the symptom-inducing agent. A simple procedure has been developed that is rapid, reliable, and requires minimal equipment. Using this procedure, the ds RNA was detected only in groundnut plants with green rosette or chlorotic-rosette symptoms. It was not found in noninoculated groundnut plants, in symptomless groundnut plants with groundnut rosette assistor virus alone, or in groundnut plants infected with several other known groundnut viruses. More than 2 μg of the ds RNA can be isolated and purified from each gram of rosetted tissue. Therefore, the ds RNA can be detected in 0.1 g or less of diseased tissue.

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Development of Groundnut Rosette Virus Resistant Cultivars in Malawi

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Groundnut is an important cash and food crop for farmers in most areas of Malawi. The five currently recommended groundnut varieties in Malawi are the four virginia types—Chalimbana, Chitembana, Mani Pintar, and Mawanga—and a spanish type—Malimba.

Despite having a good yield potential, all the five varieties are highly susceptible to the groundnut rosette virus (GRV). In years when the disease reaches epidemic proportions, yield losses up to 100% can be experienced. This, therefore, necessitated the development of GRV-resistant genotypes in Malawi.

Groundnut Rosette Virus Resistant Cultivars in Malawi

Now there are five GRV-resistant cultivars in Malawi with good agronomic attributes. These are RG 1 and four GRV Resistant Intercross (RRI) selections: RRI/1, RRI/6, RRI/24, and RRI/32. Of particular interest are the two cultivars RG 1 and RRI/6.

RG 1 and RRI/6

The cultivar RG 1 results from a cross made at Chitedze Agricultural Research Station between Makulu Red, an alternately branched, spreading-bunch variety of the Fung Bunch group of *Arachis hypogaea* subsp *hypogaea* var *hypogaea* as the female parent and line 48-14, an alternately branched, spreading bunch variety of the Castle Cary Bunch group of *A. hypogaea* subsp *hypogaea* var *hypogaea*, as the male parent.

Since resistance to GRV is governed by two recessive genes (aabb), the F_1 plant of the original cross was susceptible to GRV and it was therefore grown under insect-free conditions in the greenhouse. The F_2 population was field planted. Each plant was inoculated with GRV by feeding viruliferous aphids on the plants. Plants that remained symptomless after 1 month were again infected. The progeny of the symptom-free plants at harvest eventually became the cultivar RG 1 after further selection had taken place.

Although RG 1 was released in the country more than 15 years ago, it has remained unpopular among farmers due to the small seeds and poor shelling percentage.

There was almost a 10-year interval between the development of RG 1 and the RRI series, from which the cultivar RRI/6 was selected. RRI/6 resulted from a cross between PR 29B as a female parent and PR 20B as a male parent. Both PR 29B and PR 20B were rosette-resistant hybrids derived from the RG 1 breeding program. The crosses for the RRIs were made in 1975/76 season. RRI/6, like RG 1, is a long-season cultivar maturing in about 140 days but has a slight advantage over RG 1 in terms of shell thickness, seed size, and shelling percentage [92g (100 seeds)$^{-1}$ of 75g (100 seeds)$^{-1}$]. The yield potential for both cultivars is comparable; both give better crops than Chalimbana when GRV is epidemic.

Vigorous screening, both in greenhouses and fields, has shown that RG 1 and RRI/6 are totally resistant. These two cultivars and the other RRI selections will remain useful sources for future GRV-resistance studies and breeding programs.

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Current Research on Groundnut Rosette Virus Disease at the Scottish Crops Research Institute[1]

R. Rajeshwari[2] and A.F. Murant[3]

Tests with a panel of 10 monoclonal antibodies (MAbs) produced potato leaf roll virus (PLRV) at the Scottish Crop Resarch Institute (SCRI) by Dr P.R. Massalski revealed that 3 MAbs reacted with groundnut rosette assistor virus (GRAV) when used as the detecting antibody in a triple antibody sandwich enzyme-linked immunosorbent assay (TAS-ELISA). In these tests, polyclonal antisera to PLRV or beet western yellows virus (BWYV) were used as the plate-coating antibody. None of the MAbs reacted with four other luteoviruses: barley yellow dwarf, bean leaf roll, BWYV, and carrot red leaf. The most effective MAb, called SCR 6, was used to detect GRAV isolates from green and chlorotic forms of groundnut rosette virus (GRV) from Nigeria, and from chlorotic and mosaic forms from Malawi. TAS-ELISA with SCR 6 also detected GRAV in extracts of single *Aphis craccivora*.

TAS-ELISA with SCR 6 showed that GRAV was present in all plants of six rosette-resistant groundnut lines that had been exposed to aphid inoculation in Malawi by Dr K.R. Bock. The six lines were RG 1, RMP 40, RMP 91, RMP 93, RRI/16, and RRI/24. The GRAV concentration appeared to be slightly lower than that in GRV-susceptible plants.

None of the plants contained GRV, as shown by sap inoculation tests to *Chenopodium amaranticolor* and *Nicotiana benthamiana* or by analysis of double-stranded ribonucleic acid (ds RNA) extracted from groundnut leaf tissue. These results indicate that the resistance in these groundnut lines is directed primarily against the GRV component of the disease.

TAS-ELISA with SCR 6 was used as an aid to develop a purification procedure for GRAV. The procedure, based on the use of a cellulase/pectinase preparation (Celluclast), yielded 0.5–1 mg virus particles per kg groundnut leaf tissue. A polyclonal antiserum to GRAV was produced in a rabbit. Double antibody sandwich ELISA (DAS-ELISA), in which gamma-globulins from this antiserum were used for both plate coating antibody and detecting antibody, detected GRAV isolates from Nigeria and Malawi but not PLRV, BWYV, or beet mild yellowing virus.

Recently the Overseas Development Administration of UK extended this project by another 3 years. It is planned to determine the properties of GRV, develop specific nucleic acid probes for GRV, produce MAbs for GRAV, and continue joint studies with the SADCC/ICRISAT Regional Groundnut Improvement Program for Southern Africa in Malawi to determine the nature of rosette resistance in various breeding lines.

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Virus Diseases of Groundnut: The Present Situation in Francophone West Africa

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In the French institutes, research on groundnut diseases is in two phases: the first, related to the general schedule of the inventory of plant virus diseases of cultivated plants in West Africa, was decided in 1965 and begun in 1968 at Institut français de recherche scientifique pour le développement en coopération (ORSTOM) and Institut de recherches pour les huiles et oléagineux (IRHO); the second is production of resistant varieties at IRHO.

In a paper presented in 1985 at a conference organized by the Tropical Agricultural Research Center (Tsukuba, Japan), all the groundnut viral diseases observed in West Africa, specially in Côte d'Ivoire, Burkina Faso, Niger, Mali, Guinea, Gambia, and Senegal, have been described. Six groundnut viruses were identified and their main properties described: groundnut clump (two types: green and yellow mosaic), a rod-shaped virus transmitted by a fungus (*Polymyxa graminis*) and through seeds; groundnut rosette (two types: chlorotic and green), which is a complex of two viruses (one is a luteovirus) transmitted by the aphid *Aphis craccivora*; groundnut eyespot, a potyvirus also transmitted by aphids: groundnut crinkle, a carlavirus transmitted by white flies; groundnut chlorotic spotting, a potexvirus transmitted by aphids; and tomato spotted wilt viruses.

Moreover, four other diseases are described in part: groundnut streak, groundnut mosaic, groundnut flecking, and groundnut golden mosaic viruses. Two diseases are currently being studied; groundnut clump, which seems to be of major importance in Senegal and Burkina Faso, and which also infects many graminaceous plants including maize and sorghum, and tomato spotted wilt, which could become an important problem in groundnut. The latter is already recognized as economically important in Senegal in french bean and cowpea.

Several papers, published in a special number of Oléagineux (1983), reported the status of research carried out by IRHO on groundnut to breed varieties resistant to drought, pod rots, rust, and groundnut rosette virus (GRV). Two main centers have selected various groundnut varieties adapted to very different climatic conditions, ranging from the Sahel region to other zones with occasional rainfall. These are Institut national de recherche agricole (INRA) in Bambey, Senegal and IRHO in the framework of the Institut voltaïque de recherches agronomiques et zootechniques (IVRAZ), Burkina Faso. Nineteen varieties were described. Among these, five are resistant to GRV. RMP 12 and RMP 91 are adapted to regions with a long rainy season with heavy rainfall as they have a 135-day season. They have excellent resistance to GRV; they are not extensively grown in Africa but are commonly cultivated in Burkina Faso, Chad, Central African Republic, and Mozambique, and are used in the ICRISAT breeding program. Another long-season variety, 69101, suitable for zones with heavy rains and resistant to rosette is cultivated in southern Senegal (Casamance), Chad, Guinea-Bissau, and Mozambique. Two short-cycle varieties, KH 241 D and KH 149 A, suitable for zones with two rainy seasons and limited sunshine, are highly resistant to GRV, but only cultivated in Burkina Faso (Dollet et al. 1986).

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The current program in Senegal and Burkina Faso aims to select and breed for resistance to rosette and rust.

The French institutes at present do not work on GRV in southern Africa, but are concentrating on drought resistance in Botswana.

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Current Status of Funding for Peanut Collaborative Research Support Program

James W. Demski[1]

The planning stages and the formative aspects of the Peanut Collaborative Research Support Program (Peanut CRSP) were done in 1980 and 1981 by Drs C.R. Jackson and D.G. Cummins. The purpose of the U.S. institution was to provide a long-term collaborative research program to relieve constraints that would enable an increase in production and utilization of groundnuts in the developing countries. A total of 11 projects was approved. Funding for five of these projects started in 1982, and the remaining six started in 1983. The projects cover various aspects such as breeding, food science, aflatoxins, *Rhizobium*, entomology, and pathology, which includes one project on virology. Initial funding was for 5 years and centered in three world areas: Asia (Thailand and the Philippines), semi-arid Africa (Senegal, Burkina Faso, Nigeria, and Sudan), and the Caribbean (headquarters in Trinidad).

Because of monetary constraints, budgets were reduced and the Peanut CRSP projects were funded fully for only 4 of the 5 years. In January 1987, an additional 12.5% reduction was imposed on all projects for the remaining months of the initial 5-year project. Thus an effective 30% reduction has been experienced by all Peanut CRSP budgets. An additional 3-year extension, beginning 1 July 1987, has been approved. Funding for the extension period will be at the reduced yearly rate.

Since reduced funds are restricting most projects, the Technical Committee and Board of Directors for the Peanut CRSP are evaluating each project. The Peanut CRSP virus project is no exception. Recently, Thailand and the Philippines have requested support for their groundnut virus programs. I suspect the managing groups are questioning a phase down on support for groundnut rosette with increased support in Southeast Asia. Therefore, continued support for groundnut rosette research is unclear but decisions will be made soon.

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Field Visits

On the morning of the 2nd day of the Meeting, the participants visited Chitedze Agricultural Research Station of the Malawi Department of Agricultural Research where laboratory and field research facilities have been made available to the SADCC/ICRISAT Regional Groundnut Improvement Program. Chitedze is located 16 km west of Lilongwe at 14°S and 33°45' E at an altitude of 1050 m on the Lilongwe Plain, the major groundnut-producing area of Malawi. The Group was welcomed to Chitedze by Dr Godwin Mkamanga, Officer-in-Charge, who described the work of the Station. The Group then visited the ICRISAT Program's experimental fields where participants were shown trials and the rosette-screening nurseries. Much interest was shown in the method of field-resistance screening that ensured levels of over 90% incidence of rosette disease in susceptible test genotypes. Several advanced breeding lines with rosette disease-resistance were shown to participants, many of whom requested supply of seeds. There was considerable interest in two wild *Arachis* species (Accession numbers 30003 and 30017) that were resistant to rosette in field screening and free from both groundnut rosette virus and groundnut rosette assistor virus when examined at the Scottish Crop Research Institute by Dr Murant. It was noted that rosette-resistant spanish type breeding lines were showing good resistance to the disease in the screening nursery.

In the afternoon, Dr N.E. Nkawazi, Project Officer of the Lilongwe Agricultural Development Division, organized a visit to farmers' fields to show the participants the rosette disease under commercial growers' conditions. Incidence was low, but typical "patches" of rosetted plants could be found in most fields. Useful discussions with extension staff and farmers were held.

Recommendations

The recommendations made at the 1985 Consultative Group Meeting in Cambridge were considered in relation to the progress reported by the participating groups. It was agreed that the recommendations had been followed to a large extent and excellent research progress achieved.

Reports from the different research groups were fully discussed and the following recommendations made:

- The research collaboration and group meetings were useful. The exercise should be continued and the terms of reference expanded to include research on all groundnut viruses occurring in Africa.
- ICRISAT and Peanut CRSP, as coordinating institutions, should establish contacts with all research organizations concerned with groundnut virus disease research in Africa, and that collaborative projects should be encouraged.
- A proposal to prepare a publication on the control of groundnut rosette virus disease received strong support. The participants expressed their willingness to assist in producing this publication, as one in the series of ICRISAT's Information Bulletins.
- The need for virus disease surveys in Africa was recognized and participating groups were asked to collaborate in planning and conducting national and regional surveys.
- Organizing of training courses for national scientists in Africa, in the detection and epidemiology of groundnut virus diseases, was recommended. It was agreed that participating groups should assist in this exercise.
- Each group should continue their current research, cooperate with other groups, and exchange information.
- Areas indicated for research priority include:
    1. Development of specific identification methods for the important groundnut viruses.
    2. Epidemiology of groundnut viruses.
    3. Breeding of short-duration, rosette-resistant cultivars for all regions, and of bold-seeded, rosette-resistant cultivars for southern Africa.

There was considerable discussion on the selection of the time and location of the next Consultative Group Meeting. Preference was for a location in either West Africa or Europe in 1990. The choice of location would be left to ICRISAT.

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