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Groundnut Virus Diseases in Africa

International Crops Research Institute for the Semi-Arid Tropics

Abstract

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Groundnuts are an important oilseeds crop in many African countries. And groundnut rosette is the most important virus disease of groundnut in Africa. An International Working Group was established in 1983 to formulate cooperative research programs to characterize the causal viruses of groundnut rosette disease and develop methods for their detection. The group met in 1985 in Cambridge, England, and in 1987 in Lilongwe, Malawi. Since the efforts by this Group have resulted in considerable progress on the characterization of causal viruses of groundnut rosette disease and at the meeting held at Lilongwe, it was suggested that the Group activities should be expanded to include research on all groundnut viruses in Africa.

In this publication summaries of the papers delivered at the Group's fourth meeting are presented. The first part deals exclusively with the collaborative research on groundnut rosette virus disease. In Part 2 four technical papers cover the management of groundnut virus diseases, virus disease surveys, and seed-borne legume viruses. And scientists from Africa review research and the country-specific situations of groundnut virus diseases in Burkina Faso, Congo, Cote d'Ivoire, Niger, Senegal, and Sudan. Recommendations are made for further action on global cooperative research on groundnut virus diseases and future research activities, including their priorities, on groundnut viruses in Africa.

Résumé

Référence : ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1991. Les maladies virales de l'arachide en Afrique. Patancheru, A.P. 502 324, India : ICRISAT.

L'arachide constitue une importante culture oléagineuse dans plusieurs pays africains. Parmi les maladies virales de l'arachide, la rosette est la plus importante en Afrique. En 1983, un Groupe de travail international a été mis en place pour élaborer des programmes de recherche coopératifs permettant de caractériser les virus responsables de la maladie de rosette de l'arachide et de mettre au point des méthodes de détection. Le Groupe s'est réuni en 1985 à Cambridge, en Angleterre, et en 1987 à Lilongwe, au Malawi. Etant donné que les efforts de ce Groupe ont rendu possible des progrès considérables sur la caractérisation des virus responsables de cette maladie, il a été proposé, lors de la réunion tenue à Lilongwe, que les activités du Groupe doivent être étendues aux recherches sur tous les virus de l'arachide en Afrique.

Cette publication présente les résumés des communications délivrées à la quatrième réunion du Groupe. La première partie traite en exclusivité la recherche coopérative sur la rosette de l'arachide. Dans la Partie 2, quatre communications techniques portent sur la gestion des viroses de l'arachide, des enquêtes des maladies virales, et des virus des légumineuses transmis par les graines. Des chercheurs de l'Afrique font le point de la recherche et des situations par pays des viroses de l'arachide au Burkina Faso, au Congo, en Côte-d'Ivoire, au Niger, au Sénégal, et au Sudan. Des recommandations sont faites pour des actions soutenues en matière de la recherche globale coopérative sur les maladies virales de l'arachide, ainsi que pour des activités de recherche futures, y compris leurs priorités, sur les virus de l'arachide en Afrique.

Resumen

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El maní constituye un importante cultivo oleaginoso en muchos países africanos. Entre las enfermedades virales en maní, el virus de la "roseta" es la más importante enfermedad en Africa. Se estableció en 1983 un Grupo Internacional de Trabajo para elaborar programas de investigación cooperativa a fin de caracterizar el virus causante de ésta enfermedad y desarrollar métodos para su detección. El grupo se reunió en 1985 en Cambridge, Inglaterra y en 1987 en Lilongwe, Malawi. Desde entonces y gracias a los esfuerzos hechos por este grupo, han logrado considerables progresos en la caracterización de dicho virus. En la reunión de Lilongwe, se ha propuesto tambien que se ampliaran las actividades del Grupo incluyendo la investigación sobre todos los restantes virus de maní en Africa.

Esta publicación contiene los resúmenes de los trabajos presentados en la cuarta reunión del Grupo. La primera parte trata exclusivamente sobre investigación colaborativa en la enfermedad "roseta" de maní. En la segunda parte, cuatro trabajos técnicos abarcan el manejo de las enfermedades de virus en maní, el relevamiento de las enfermedades virales y los virus transmitidos por semillas en leguminosas. Además, científicos procedientes de Africa pasaron revista sobre el estado de la investigacíon como asi tambien las situaciones relacionadas con las enfermedades virales en Burkina Faso, Congo, Cote d'Ivoire, Niger, Senegal, y Sudan. Recomendaciones fueron propuestas para tomar futuras acciónes en la investigación cooperativa global y futuras actividades de investigación incluyendo las prioridades sobre virus de maní en Africa.

Groundnut Virus Diseases in Africa

Incorporating the Proceedings of the
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Consultative Group on Collaborative Research
on Groundnut Rosette Virus Disease held at
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Preface

Dr Gerard Fabre, Directeur, Institut français de recherche scientifique pour le développement en coopération (ORSTOM), welcomed all the participants to Montpellier and to the meeting on groundnut viruses in Africa. He gave a brief description of various activities of ORSTOM.

Following on, Dr de Nuce de Lamothe, Directeur, CIRAD, Montpellier, welcomed all the participants to CIRAD's center at Montpellier. He emphasized the importance of groundnut viruses in Africa and stated that CIRAD gives high priority to research on them. While stressing the need to take an integrated approach for the management of virus diseases of groundnut, he welcomed suggestions from the group to achieve this objective in collaboration with CIRAD. He also said that the group can expect full support for such an approach from CIRAD.

Objectives of the Meeting

D. McDonald[1]

Meetings of the Consultative Group to coordinate collaborative research on groundnut rosette virus disease have been held in Georgia, USA, in 1983, in Cambridge, UK, in 1985, in Lilongwe, Malawi, in 1987, and we are now holding the fourth meeting in Montpellier, France. Although the venues for our meetings have changed, the major objectives have remained relatively constant. These are as follows.

- To bring together scientists involved with various aspects of research into the causal agents of rosette virus disease of groundnut (*Arachis hypogaea* L.).
- To review progress made since the last meeting in identifying of the components of the virus complex and in developing diagnostic systems.
- To discuss progress made in Africa on management of groundnut rosette virus disease, with particular emphasis on resistance breeding.
- To coordinate research and training activities of the concerned national agricultural research systems, mentor institutions, and regional and international research organizations so as to facilitate further cooperation and reduce duplication of effort.

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If research carried out over the last 3 years has been as successful as that done in earlier years, we should be able to devote more time to planning research into the ecology of the disease so as to improve the prospects for integrated disease management. It is with this hope in mind that the participation of research workers from African groundnut-growing countries has been increased.

Another reason for expanding the participation relates to a recommendation made at the last Consultative Group meeting in Malawi in 1987. This was to the effect that, in view of the success of the 'International Working Group' approach as applied to the collaborative research on groundnut rosette virus disease, the Group should expand its activities to include research on other virus diseases affecting groundnut in Africa.

Following presentations on the different groundnut virus diseases found in Africa and problems associated with research into their management, we will:

- discuss the possible benefits of an international cooperative approach to groundnut virus diseases research in Africa;
- consider how cooperation in research, research facilitation, and training can best be organized; and
- discuss how to continue the work of the Consultative Group to cover all groundnut viruses in Africa, and to make recommendations to guide all concerned in implementing research projects and training plans.

We have only 2 days in which to do a great deal of work, but I am sure you will all do your best to ensure the success of this meeting.

Thank you.

Part 1. Collaborative Research on Groundnut Rosette Virus Disease

Current Status of Cooperative Research on Groundnut Rosette Virus Disease

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

Groundnut rosette virus (GRV) disease is the most important virus disease of groundnut in Africa where it was first reported in 1907. Although by the end of the 1970s resistant cultivars had been bred and cultural practices for the management of rosette disease had been worked out in several African countries, the causal virus(es) had still to be identified. We did not know why the occurrence of the different forms of rosette fluctuated over time or why severe epidemics occurred. The epidemics that occurred in western Africa in 1975 and 1976 were still green in our minds. The fact that resistant cultivars had succumbed in the face of severe disease pressure had given rise to serious doubts as to the utility of the rosette-resistant sources currently being used by our breeders.

In 1981 ICRISAT scientists surveyed groundnut crops in several countries in western Africa to determine the occurrence and severity of rosette disease. Materials collected were processed at the Institute for Plant Virus Research in Braunschweig, Germany. A luteovirus was detected in the GRV-infected groundnuts. This luteovirus failed to produce typical rosette disease symptoms when introduced into healthy GRV-susceptible groundnut plants, indicating that the agent responsible for producing the overt symptoms of GRV had still to be isolated and characterized.

In 1982 the U.S. Peanut Cooperative Research Support Program (Peanut CRSP) initiated a project on the identification of groundnut viruses in western Africa. They established cooperative links with scientists at the Institute for Agricultural Research of Ahmadu Bello University in Nigeria. It was suggested that research into the causal agents of GRV could best be conducted in a country where groundnut is not grown and in which researchers had access to the advanced facilities and expertise required for such an enterprise. This would also overcome the plant quarantine objections to doing such work in the USA or India.

Recognizing the need for international cooperative research on GRV disease, Peanut CRSP organized an international Consultative Group meeting in 1983 at the University of Georgia, Griffin, USA, to formulate cooperative research pro-

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grams to identify and characterize the causal viruses of GRV disease. Experts from the USA, ICRISAT, West Germany, and Nigeria participated. Cooperative links were later established with virologists of the Scottish Crop Research Institute (SCRI) in Invergowrie, Scotland, who had done pioneering research on dependent plant viruses.

Although considerable progress was made over the next 2 years, the need for further coordination of efforts to characterize the components of GRV disease was keenly felt, and the second Consultative Group meeting to coordinate research into GRV was held in 1985 at Cambridge, England. It was agreed that the various groups involved should continue their research programs but should cooperate fully with one another, and that the research findings of each group should be communicated rapidly to the other groups in order to avoid duplication of effort. Activities to be pursued by the various research groups were clearly defined.

Cooperation in research and training was very effective over the following 2 years, and the achievements of SCRI scientists were particularly noteworthy. The third Consultative Group meeting was held at Lilongwe, Malawi, in 1987. All the groups who attended the Cambridge meeting participated and French scientists of IRHO, who had done excellent work on the epidemiology of groundnut viruses, were also able to attend. The group had the opportunity to see the GRV-resistance screening nurseries established at Chitedze Research Station by SADCC/ICRISAT Regional Groundnut Program scientists. The technique employed is extremely effective for screening large numbers of genotypes and breeding lines for resistance to GRV disease. It was suggested at this meeting that the activities of the Consultative Group should be expanded to include research on all groundnut viruses occurring in Africa, and that, as a move towards this end, contacts should be established with all research organizations concerned with groundnut virus research in Africa. The need for well coordinated virus disease surveys of groundnut in Africa was emphasized, and it was hoped that the extensive research networks established by French organizations in francophone countries could be utilized when national and regional surveys were conducted. It was agreed that a fourth Consultative Group meeting to provide continued coordination of research on GRV and to plan wider activities involving research on other groundnut virus diseases should be held in one of the collaborating institutes in western Europe.

The present meeting here at CIRAD headquarters in Montpellier gives each research group the opportunity to describe its achievements since 1987 and to discuss plans for future research. The involvement of scientists from several African countries is most welcome. We also welcome the increased participation by the group from SCRI and the presence of Dr L. Bos from the Netherlands and Dr J.M. Thresh from the UK. Holding the meeting in Montpellier has permitted the participation of a significant number of French virologists, and this should be particularly useful when we consider the future for cooperative research on the whole range of groundnut virus diseases and how organizations such as CORAF may be involved.

The capability to diagnose precisely all three components of the GRV complex should give our breeders a better basis from which to undertake evaluation of germplasm and breeding lines, and should facilitate epidemiological studies. Research done by Nigerian scientists with assistance from Peanut CRSP to evaluate sources of resistance to the various components of GRV indicates what can be achieved with minimal facilities. Progress achieved on GRV, and new developments in biotechnology leading to the production of resistant sources to plant viruses utilizing nonconventional methods, have led to initiation of experiments on the use of biotechnology to develop GRV-resistant sources. We should encourage current efforts by SCRI and any other institute that may wish to pursue this approach. Continued efforts by ICRISAT regional programs in Africa and by African national agricultural research systems to breed short-duration and confectionery-type varieties with rosette resistance using conventional breeding methods should be encouraged. Their efforts should complement those utilizing biotechnology approaches.

Efforts should now be made to study systematically the epidemiology of GRV disease in Africa. More information is needed on sources of inoculum (other than volunteer groundnuts) on factors that contribute to disease outbreaks, especially in western Africa, and the ecology of the principal aphid vectors needs further investigation.

We are confident that by the end of this meeting the Group should be in a position to assist in developing an effective package of practices for the management of GRV, utilizing disease-resistant sources, improved cultural practices, etc.

Before we conclude it is appropriate to list the major achievements over the last 8 years in our international Consultative Group approach to identification of the causal viruses of rosette disease.

- Identification of groundnut rosette assistor virus (GRAV) as a luteovirus.
- Production of polyclonal antibodies for GRAV and determination of its host range and serological relationships.
- Characterization of groundnut rosette virus (GRV) as single-stranded RNA.
- Discovery that satellite RNA, dependent on GRV, is responsible for symptom production. Its presence is also essential for the aphid transmission of GRV.
- Development of simple methods to screen genotypes for the presence of GRAV, GRV, and its satellite RNA.
- Publication of data that showed rosette-resistant cultivars are resistant to GRV and its satellite but not to GRAV.

Current Status of Groundnut Rosette Virus Disease Research in Burkina Faso

J.P. Bosc[1], A. Schilling[2], and A. Bockelee-Morvan[3]

Groundnut rosette virus disease commonly occurs at high incidence in south-western Burkina Faso. In 1956, IRHO initiated a program at Niangoloko Research Center to identify resistant varieties. This became a collaborative project between INERA and IRHO in 1984. Three aspects of the research at Niangoloko were described.

Plant-vector relationships

GRV-resistant genotypes were compared with susceptible genotypes for their capacity to attract the aphid vector of GRV, *Aphis craccivora* Koch. No differences were found. The effects of sowing date and time of infection of the crop with GRV were investigated. Crops sown early were less severely damaged by the disease than late-sown crops. When GRV symptoms appeared within 40 days of sowing, the disease generally caused serious damage to the crop. The physiological basis of resistance to GRV was studied. Resistance could be confirmed by stock to scion, but not by scion to stock.

Breeding long-duration GRV-resistant varieties

Long-duration GRV-tolerant genotypes collected from the northern region of Cote d'Ivoire were crossed in 1963 with high-yielding exotic material, the most important of which was Mani Pintar that had been introduced from South America via Ghana. This breeding program led to the production of the GRV-resistant varieties RMP 12 and RMP 91 in 1972.

Breeding short-duration GRV-resistant varieties

This has proved to be a complex problem because early-maturing genotypes are mainly of the spanish type while resistance to GRV occurs in late-maturing virginia types. Using the back crossing method, several GRV-resistant lines were obtained and the varieties KH 149 A and KH 241 D were released in 1973. The program was reoriented in 1979 to breed confectionery types with tolerance of GRV.

We expect to collaborate with ICRISAT to achieve these objectives.

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Resistance in Groundnut to Mixed Infections of Groundnut Rosette Virus (GRV) and Groundnut Rosette Assistor Virus (GRAV), and to Infection by GRV alone

P.E. Olorunju[1], C.W. Kuhn[2], J.W. Demski[2], S.M. Misari[3], and O.A. Ansa[4]

Resistance breeding was initiated with green rosette disease, groundnut rosette virus (GRV), groundnut rosette assistor virus (GRAV) and GRV alone, utilizing eight genotypes. Crosses in a diallel test provided more genetic diversity than had been observed in previous studies of inheritance of resistance. Two groundnut genotypes, RMP 12 and RG 1, showed high-level resistance to groundnut rosette in 2 years of field study (mixed infections with GRV and GRAV). Six genotypes (M 1204, 78I, ICGS-56(E), RRB, 55-437, MK 374, JL 24) developed severe rosette symptoms. Under moderate to severe disease conditions in 1988, 5–10% of the plants of RMP 12 and RG 1 developed very mild leaf symptoms (no stunting). The disease incidence in these resistant genotypes was about 87% in 1989 when disease pressure were extremely high. Symptoms were delayed, and usually were mild, limited to leaves on a few branches, 50 days after exposure to inoculum, as compared with 8 days for susceptible plants. About 7% of the plants of resistant genotypes were severely stunted. While seed yield of susceptible plants was less than 0.4 g plant^{-1}, resistant genotypes produced an average of 13 g plant^{-1}.

Electrophoresis of a 900 base pair (b_p) double-stranded (ds) RNA (a satellite RNA) was used to detect GRV, and detection of GRAV was done by an ELISA test using antiserum to potato leaf roll virus. Susceptible groundnut plants tested positive for both viruses. Under field conditions in 1989, most resistant plants, both with and without rosette symptoms, had GRAV. GRV, however, could be detected only in plants with distinct symptoms. The 900 bp dsRNA from resistant plants was recovered at very low concentration compared with susceptible plants.

Inheritance of resistance was studied in two ways: (a) resistance to mixed infections of GRV and GRAV in field tests, following the procedure described by Bock and Nigam (1988), and (b) resistance to GRV only, using mechanical inoculation (Olorunju et al. 1990). In most crosses, resistance to green rosette was conditioned by two recessive genes, similar to the inheritance of resistance to chlorotic rosette.

The genetics of resistance was not the same for all crosses in this study. F_2 progeny of the RMP 12 × M 1204.78I cross showed resistance that is conditioned

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by a single dominant gene (1 susceptible : 3 resistant). The deviation from two recessive genes to a single dominant gene for the cross was observed in field tests with mixed infection in 2 years and in one test with a single infection of GRV where the reciprocal of the cross was evaluated, thus indicating that the genetic differences may be real.

In two test years, the field screening procedure (Bock and Nigam 1988) for resistance to groundnut rosette caused some evaluation problems. In 1988, only 89% of plants of susceptible genotypes became diseased. This situation was unfavorable for inheritance studies, and numerous symptomless plants had to be retested to determine their true reaction to disease. In 1989, 75% of the plants of susceptible genotypes had symptoms by 28 days after seeding, and 99% by 44 days. Under these severe disease conditions, most (87%) plants of the resistant genotypes became diseased (some severely), and classification of F_2 plants sometimes was difficult. For resistance screening, the 1989 conditions were much more desirable than the 1988 ones; however, environmental conditions, particularly rainfall, can have a significant impact on the screening process. On the other hand, screening for resistance by mechanical inoculation of GRV was highly effective in numerous tests over a period of 8 months in 1989. A single inoculation resulted in 100% infection of plants of susceptible genotypes and 2% of resistant plants. Resistant plants with symptoms could be distinguished from susceptible ones on the basis of delayed time of first appearance of symptoms and disease severity.

It is apparent from these studies that GRAV was detected in most plants of resistant genotypes and in resistant plants of segregating F_2 populations. The importance of GRAV in the rosette disease reaction remains unknown because the quantity of GRAV antigen in different genotypes has not been determined and infections with GRAV alone cause no leaf symptoms. However, recent studies indicate that GRAV can intensify rosette symptoms in a mixed infection with GRV and that mixed infections can cause a more severe disease than a single infection of GRV, with regard to plant size and seed yield. Therefore, GRAV should not be ignored in groundnut resistance screening and breeding programs.

We highly recommend the mechanical inoculation procedure for evaluating resistance to GRV for the following reasons.

1. It is not affected by rainfall for timely field planting or washing away of aphids.
2. Symptomless plants can be inoculated repeatedly to eliminate plants escaping infection.
3. Classification of resistant and susceptible plants in segregating populations is more precise than in the field.
4. Disease reactions are not complicated by a mixed virus infection.
5. Screening for resistance can be done throughout the year, allowing at least two generations/year to be evaluated.
6. It is much less labor-intensive than field screening.

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Current Research on Groundnut Rosette at SCRI

A.F. Murant[1], I.K. Kumar[2], and D.J. Robinson[3]

In both main forms of groundnut rosette disease, green and chlorotic, affected plants contain the manually transmissible groundnut rosette virus (GRV). This virus is transmitted in the persistent (circulative) manner by *Aphis craccivora*, but only from groundnut plants that also contain a second virus, groundnut rosette assistor virus (GRAV), which is a luteovirus and is not manually transmissible. No virus-like particles have been associated with GRV, but infected plants contain an infective single-stranded (ss) RNA of about 4.6 kbp. They also contain abundant double-stranded (ds) RNA, with three prominent species, two of which, dsRNA-1 (4.6 kbp) and dsRNA-2 (1.3 kbp), seem to be ds forms of genomic and subgenomic ssRNA molecules of GRV; the third (dsRNA-3; 0.9 kbp) can be eliminated from GRV cultures experimentally and has been shown to be the ds form of a *satellite* RNA, i.e., a RNA species that cannot replicate on its own because it depends on the replicase of another ('helper') virus, but is not itself required for the multiplication of that helper virus.

The satellite RNA is invariably present in naturally occurring GRV cultures and was shown previously to be largely responsible for the symptoms of rosette disease. Different variants of the GRV satellite have been shown to be responsible for the green and chlorotic forms of rosette. Other variants have been found that induce only mild chlorosis or mottle symptoms in groundnut or a striking yellow blotch symptom, instead of the usual mild mottle, in *Nicotiana benthamiana*.

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2. Deceased.
3. Virologist, SCRI.

Groundnut plants may contain more than one variant of the satellite and the relative predominance of different variants may determine the variable symptoms (ranging from overall yellowing to mosaic) seen in plants with chlorotic rosette.

Transmission of GRV by *A. craccivora* was found to depend not only on the presence of GRAV but also on that of the GRV satellite RNA. This was true whether the GRV isolates were from groundnuts from Nigeria or Malawi with either the green or chlorotic forms of rosette, or whether they contained homologous or heterologous satellites. This probably explains why satellite-free isolates of GRV have not been found in nature. The precise role played by the satellite in aphid transmission of GRV is not known. This is the first instance known of a satellite RNA being necessary for aphid transmission of a plant virus.

The resistance to rosette found in some lines of groundnut is directed against GRV and therefore operates against the satellite RNA too; these lines are, however, fully susceptible to GRAV. Tests with some wild *Arachis* selections or species have identified one (accession 30017) that is susceptible to both viruses but shows no symptoms, and another (*A. chacoensis*) that appears immune to both viruses. Some seedlings of accession 30003 may also be immune. The behavior of interspecific crosses between *A. hypogaea* and some of these species will be of interest.

The next phase of the work will be to learn more about the molecular biology of the casual agents. This may enable us to develop better diagnostic tools and to employ the latest genetic engineering techniques to introduce new types of resistance into groundnut.

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Groundnut Rosette Virus: Recent Research Progress in Southern Africa

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In this paper we report progress in breeding for groundnut rosette virus (GRV) resistance, and describe our continuing investigations into vector ecology and virus incidence.

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We remain ignorant of the seasonal origins of the disease. GRV last assumed epidemic proportions in Malawi in 1982/83 when incidences ranging from 40 to 100% were recorded in farmers' fields and on research stations. Incidences on ICRISAT experimental fields ranged from 22% on early-sown fields to 97% on mid-January sowings. In subsequent seasons GRV levels remained relatively low until 1988/89, when we recorded an average incidence of 11.2% on our experimental fields. Although incidence on farmers' fields was not considered serious, we recorded 13-42% on other fields at Chitedze Research Station. We recorded 7.1% on a field of ICGMS 42 at Chitedze in 1989/90.

We have no evidence to suggest that volunteer groundnut plants play any part in vector or virus survival. *Aphis craccivora* is present throughout the year in Malawi, but only those present soon after the onset of the rains appear to carry the virus. Aphids infest the newly emerged crop each year, and symptoms appear regularly, in large or small proportions, some 3 weeks later, regardless of the climatic conditions prevailing. It is possible that the aphid moves to a succession of dry-season hosts such as *Aeschynomene abyssinica*, *Dolichos* sp, and *Emilia* sp, some of which could serve as hosts for GRV. Thus a number of the hosts that aphids can colonize deserve a closer look. We cannot rule out the possibility of long-range aphid migration, but the brief colonization of some presently unknown dry-season GRV reservoirs by resident aphid populations, just prior to the infestation of the emerging groundnut crop, appears to be a likely possibility.

Even if the purchase and application of insecticides were within the means of resource-poor farmers, the side-effects of chemical use should be considered prior to recommending them. Resistance to the vector, recently identified in a number of genotypes, may serve as additional protection, but we believe that genetic resistance to the virus(es) remains the most effective method of minimizing yield reductions caused by GRV. It is in this direction that we devote considerable research effort.

Genetic resistance is available in the cultivated groundnut, but has been demonstrated only in germplasm collected from Cote d'Ivoire and Burkina Faso. These are of the alternately-branching virginia type and are similar in many respects. Few sources of rosette resistance have been reported in sequentially branching genotypes. However, we have made extensive use of a recently purified source (assumed to be KH 241D) in our hybridization program.

Recovery of resistant spanish plants from virginia × spanish crosses is low (Harkness 1977). He also suggested that double-recessive genotypes may not confer resistance in all nuclear backgrounds. Main-stem flowering, which is linked to season length, is a recessively inherited characteristic and is controlled by two sets of duplicate loci interacting with epistasis between loci. The probability of recovering genotypes combining two recessive characteristics is therefore low.

We have also noted the low recovery of sequentially branching resistant plants from such crosses in our program, but we have succeeded in selecting a small number of low-yielding, GRV-resistant spanish-type selections. Two of these were used as parents in crosses in 1989/90.

We have tested seven wild *Arachis* species for reaction to GRV. Five were susceptible but two remained symptom-free throughout the season. Neither GRV nor GRAV was detected in any of the 11 samples of *A.* sp 30003 or 12 samples of *A.* sp 30017.

The recessive genes governing resistance to GRV do not confer immunity, and preliminary examination of our greenhouse inoculation procedures suggest that resistance is overcome by the effects of high temperatures and the simultaneous inoculation of the virus by comparatively large numbers of aphids. Prior to 1989/90, we had recorded these abnormally high levels only in greenhouse screening. However, in a 1:1 alternation of test and infector rows in our 1989/90 GRV nursery, we recorded up to 80% incidence in RG 1 and some other resistant varieties, albeit late in the season. Less than 2% of RG 1 plants exposed to this pressure in 1988/89 developed symptoms. We do not, however, suspect any change in the resistance, but rather believe this reaction to be due to environmental factors.

The first rosette-resistant virginia selections were entered into replicated yield trials in 1988/89. Their performance was promising and four ICGV-SM's—88709, 88710, 88711, and 88734—were selected for inclusion in regional yield trials in 1989/90. These varieties performed favorably compared with local controls at Chitedze, but were inferior to some controls at two other locations. Seed size is disappointing and one has a variegated seed testa, which is not suitable for confectionery use. Nineteen new GRV-resistant virginia-type entries were included in a yield trial in 1989/90 and six significantly outyielded RG 1, the GRV-resistant control. All have smaller seed than the local controls and a large number have variegated testa.

Reference

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Development of Genetic Markers in *Arachis* spp for Resistance to Groundnut Rosette Virus

P. Lanham[1], S. Fennell[1], B.P. Forster[1], R. Waugh[1], W. Powell[1], and J.P.Moss[2]

Groundnut rosette virus is one of the most destructive diseases of groundnut (*Arachis hypogaea*) in Africa south of the Sahara. In cultivated groundnuts resistance is controlled by two recessive genes. Resistance to GRV has also been reported in members of section *Arachis* that unfortunately do not hybridize with *A. hypogaea*. Thus they cannot be used to introgress genes by conventional plant breeding methods. Nevertheless, members of section *Arachis* have genomic similarity (they contain A and B genomes) to *A. hypogaea* (2n = 40, AABB), and introgression into the crop species of alien genes is possible. ICRISAT is currently engaged in such gene transfers. A major limitation in any breeding program is the ability to select for desired traits. Selection of GRV resistance would proceed faster and with greater precision if genetic marker technology could be applied to the breeding process. Such genetic markers are being used in other crops.

SCRI has recently embarked on a project funded by the UK Overseas Development Administration to genetically fingerprint *Arachis* in collaboration with ICRISAT. The aim is to exploit ICRISAT's vast genetic stocks to develop a genetic map of *Arachis*. The map will be used to determine linkage between genetic markers (RFLPs and isozymes) and various important agronomic traits including GRV resistance.

DNA is extracted from a range of *Arachis* genotypes (including *Arachis* species, interspecific hybrids, and backcross derivatives). A range of restriction enzymes will be used to cut DNA and then probe with mung bean clones. A cDNA library of groundnut cultivar TMV 2 is being constructed and will be exploited in future RFLP work. The level of variation among *Arachis* genotypes will be assessed and useful enzyme/probe combinations will be identified. Isozyme variation using isoelectric focusing is also being studied. These techniques have great potential in the development of genetic markers for GRV resistance genes.

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Part 2. Problems of Groundnut Virus Disease in Africa

A: Possible Approach through International Cooperation

Prospects for Management of Plant Virus Diseases in Developing Countries

D.V.R. Reddy[1], L. Bos[2], and D. McDonald[3]

Lack of adequate and timely control of pests (which term includes insects and plant pathogens) is a major cause of crop losses in developing countries. Problems created by pests are dynamic and are strongly influenced by climatic factors and farming systems. The most effective way to prevent losses due to pests is to adopt integrated pest management (IPM) practices. IPM can be defined as an integrated system that takes into account environmental factors and the population dynamics of individual pests, and utilizes all suitable techniques and methods in as compatible a manner as possible in order to reduce the pest populations to levels below those causing economic injury (Irwin 1990).

In order to develop IPM for plant virus diseases, certain basic information is required. This includes the identity of the causal virus(es), the mode of transmission, the ecology of the disease (including that of its vector), the extent and value of crop losses, the availability of genetic resistance, the already available crop protection technologies and their applicability to specific farming systems and socioeconomic situations.

Identification and utilization of host-plant resistance is a very important component of IPM, and international agricultural research centers (IARCs) have contributed substantially in this area by setting up world collections of germplasm of important food crops and identifying disease-resistant genotypes and by breeding cultivars with good pest resistance and acceptable agronomic qualities.

While progress in understanding the ecology of plant virus diseases and in pursuing breeding and other approaches to control them has been satisfactory in some developing countries, an important constraint has been the identification of

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causal viruses and the development of effective diagnostic techniques. The research on groundnut rosette virus disease carried out over the last four decades provides an excellent example of what can be achieved in developing countries with minimal facilities. This work resulted in the formulation of effective cultural practices to reduce disease incidence, and in the identification and utilization of sources of resistance to all the known forms of rosette disease. Nevertheless, studies on the epidemiology of rosette disease did not yield very fruitful results, and this was largely due to the failure to understand the intricacy of the causal complex and the lack of methods to diagnose the various components involved in rosette disease.

Because of the need to use high-technology facilities for virus characterization, it is difficult for scientists in most national agricultural research systems (NARSs) to deal effectively with virus disease problems due to a lack of most of these facilities. The following points are relevant for NARS virologists who wish to achieve accurate identification of viruses in developing countries.

- *Improvement of physical facilities.*
  Setting up a full-scale plant virology facility will cost more than US$ 500 000. It requires a team of virologists specialized on various aspects of virus research, and it may not be a viable approach if power and water supplies are inadequate or if there is no effective technical support.
- *Provision of access to facilities and expertise in a developed country.*
  Research done at the Scottish Crops Research Institute on groundnut rosette viruses, and the current research on peanut clump and peanut stripe viruses in CIRAD, are good examples of what can be achieved by this approach.
- *Establishment of banks for maintenance and supply of virus antisera and seeds of diagnostic hosts.*
  A scheme to provide such a service to virologists in developing countries has recently been proposed.
- *Organization of training courses.*
  Development of effective and reliable methods for isolating and characterizing plant viruses may take years of research. The fruits of this work can be communicated to NARS virologists through training courses. These should be organized at regular intervals with emphasis on sensitive and reliable detection methods.
- *Improvement of access to literature and databases on plant virology.*
  One of the most important sources of information on virus identification is the VIDE developed at the Australian National University (ANU) in Canberra, Australia, and the CMI/AAB descriptions of plant viruses.

IARCs and organizations such as CIRAD, Peanut CRSP, and ACIAR can play important roles in establishing links between scientists in NARSs and those in advanced institutes in developed countries. We consider that this can be achieved by forming 'International Working Groups' such as the Consultative Group on groundnut rosette virus disease and the similar group set up to work on peanut stripe virus disease. Training in advanced virus laboratories should be given high

priority because this is important for NARS scientists in research institutes and also for those involved in plant quarantine.

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Seed-Borne Viruses: Importance, Detection, and Quarantine Implications

L. Bos[1]

Legume crops, including groundnut, are known to harbor viruses in their seeds. The number of viruses found able to be carried in seeds is steadily increasing. Hence the growing concern about the role of seed-borne viruses in the cultivation of legume crops and in the international transfer of germplasm of these crops.

Ecologically, seed transmission of viruses is important because seeds containing virus act as sources for carry-over of inoculum, and can act as primary sources of infection and facilitate long-distance dispersal. Infected plants from seed-borne inoculum can contribute to severe yield losses.

Contamination of viruses in seed, conserved as germplasm and distributed for crop diversification, for breeding, and for multilocational testing, is causing increasing concern.

Plant viruses can be grouped into three categories with respect to their relationships with seeds. Viruses (and the mycoplasmas) that are limited to the phloem cannot reach the embryo and they cannot be transferred from seed-coat to seedling. The viruses that move in plants beyond the vascular tissues but cannot reach the embryo may still survive in the seed-coat and can be transferred to the seedlings, e.g., stable and highly infectious viruses belonging to the tobamovirus group. Seed-transmitted viruses of groundnut (cucumber mosaic virus, peanut clump virus, peanut mottle virus, peanut stripe virus, and peanut stunt virus) can possibly infect the embryo provided mother plants are systemically infected before the egg cells are fertilized. Seed transmission depends on virus and virus strain, as well as on host species and cultivar, and distribution of infection, for instance in seeds within pods, is often erratic. Percentage of transmission may be

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extremely low, thus escaping attention, and the number of viruses found to be seed-transmissible is continually increasing.

Virus infection in seeds may be detected by visual observation of seeds (although unreliable because seed-coats are part of the mother plant and abnormalities on them may reflect only mother plant infection), grow-out tests, infectivity tests, and, increasingly, by serological methods. These last-named methods are highly sensitive, but may yield false positives as a result of reaction to noninfectious antigens remaining in the seed-coat after virus from systemic mother-plant infection has lost infectivity during seed maturation. An ELISA method developed at ICRISAT for peanut mottle and peanut stripe viruses in groundnut seeds has allowed efficient and large-scale testing of large numbers of seed groups and individual seeds in a nondestructive manner, so that seeds that proved to be virus-free can still be sown. For quarantine, a grow-out test combined with visual and serological testing of seedlings is useful to permit the production of virus-free plants.

For seeds that contain virus in the embryo (and that remain infected until the seed loses viability), as is the case with the viruses now known to be seed-borne in groundnut, there is no cure yet. Removal of visibly or otherwise physically abnormal seeds is inefficient and unreliable. The nondestructive routine test for peanut mottle and stripe viruses in groundnut seeds has provided a means to remove infected seeds individually while preserving viability of the seeds that tests showed were free of virus. For crops that do not permit such nondestructive testing, the only way of obtaining virus-free seed is by production from mother plants that have been shown to be virus-free. This can be done only for small quantities of seed passing through quarantine. Large-scale commercially produced seed can usually be produced only in the field, and testing usually is by random visual observation of mother plants and later sample testing of the harvested seed. Certification of such seed practically never guarantees absolute freedom from virus. It is for quality rather than quarantine (which requires a zero tolerance). Multiplication of breeders' seed for large-scale multilocational testing is often done in the open, thwarting adherence to zero tolerance with respect to viruses.

Consultation between CGIAR international agricultural research centers, quarantine organizations of their home countries, and representatives of donor organizations has led to an 'FAO/IBPGR global programme for the safe international transfer of germplasm.' Within this framework a panel of experts, convened by IPO in the Netherlands in Apr 1989, listed the viruses of quarantine importance in tropical legumes and developed guidelines for the safe movement of their germplasm. A total of 32 viruses was listed.

Continually, however, new viruses are found to be seed-transmitted and it is often hard to judge which viruses should be considered to be of quarantine importance in view, often, of inadequate knowledge of what is already occurring in the countries that try to protect their agriculture through quarantine. Moreover, through recent GATT negotiations there is increasing pressure on the international community to remove artificial trade barriers such as those created by

quarantine. Hence adoption of fool-proof systems is impracticable, and approaches should be realistic.

Need for Surveys and for Research into Epidemiology of Groundnut Viruses

J.W. Demski[1]

Plant virus disease surveys are necessary to determine the incidence, severity, and distribution of viruses. Thus virus diagnosis is an important component of surveys. With the exception of groundnut rosette virus, the incidence and distribution of other groundnut viruses in Africa, especially those that are seed-transmitted, has yet to be determined. Very recently peanut stripe virus (PStV) has been found in seedlots imported into a number of countries from the People's Republic of China, and this virus has the potential to spread very rapidly. Indeed, groundnut seed had earlier been imported into a considerable number of countries from South and Southeast Asia, where PStV is now known to be widely distributed, and so PStV may be more widely distributed than is now known. As increasing numbers of disease surveys are carried out in different areas of Africa, there is a need to establish a central diagnostic laboratory in the continent to which groundnut samples can be sent for test. The samples could be moved as desiccated tissues, which pose no quarantine risk and can be utilized in serological tests. The feasibility of establishing such a laboratory, and for a possible cooperative groundnut virus disease survey should be considered. How far data from surveys can be utilized for precise estimation of crop losses due to viruses is debatable. Nevertheless, survey data should give some insight into the economic importance of virus diseases and help to provide justification for further research on virus disease problems and necessary funds.

If survey data can be integrated into geographical information system (GIS) programs, this will help in determining the distribution and severity of the different virus diseases in specific agroecological zones, and assist in our understanding of the ecology of the diseases. Cropping systems, planting dates, etc., could then be manipulated for active cultural control of the virus diseases. Also, breeders would be better placed in determining what other factors to incorporate when breeding virus-resistant varieties.

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According to Harrison (1983) 'a sound understanding of the epidemiology of plant virus diseases should be the key to rational control measures.' Epidemiological data have been very effectively used to control groundnut viruses. For example, groundnut may be protected from peanut stunt virus by avoiding planting of white clover in the vicinity, and data on thrips and aphid population levels occurring at various times during the growing season has facilitated control of tomato spotted wilt virus and groundnut rosette virus, respectively, by cultural methods.

Important epidemiological factors specially applicable to groundnut virus diseases, are the following.

- Populations of aphid species that can transmit peanut mottle and peanut stripe viruses, and their efficiency.
- Thrips species that transmit tomato spotted wilt virus.
- Hosts that support survival of vectors and viruses, especially during the off-season.
- Environmental factors that contribute to the survival and spread of vectors.
- Importance of seed-borne inoculum, in the case of seed-transmitted viruses, for secondary spread.

Breeding for Resistance to Groundnut Virus Diseases at ICRISAT Center

S.N. Nigam[1], D.V.R. Reddy[1], J.P. Moss[1], S.L. Dwivedi[1], and L.J. Reddy[1].

At ICRISAT Center in India germplasm screening and resistance breeding projects are being carried out to produce varieties with resistance to bud necrosis disease caused by tomato spotted wilt (TSWV), peanut mottle virus (PMV), peanut stripe virus (PStV), and peanut clump virus (PCV) diseases. Breeding for resistance to groundnut rosette virus (GRV) disease is being done at the SADCC/ICRISAT Center in Chitedze, Malawi, in southern Africa.

TSWV has been reported in groundnut from many countries and is currently economically important in India and the USA. It is transmitted by *Thrips palmi* in India and by *Frankliniella occidentali* and *F. fusca* in the USA. TSWV is not seed-transmitted. Utilizing a field-screening technique developed at ICRISAT, more than 7000 germplasm accessions of cultivated groundnut and 42 wild *Arachis*

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species have been tested for resistance to TSWV. Two cultivars recently released in India, ICGS 11 and ICGS 44, also showed field-resistance to TSWV. Many genotypes resistant to thrips attack additionally showed field-resistance to TSWV and were used in a conventional breeding program to combine the resistance with high yield. Two of the high yielding breeding lines, ICGV 86029 and ICGV 86031 also showed resistance to TSWV. Efforts are being made to produce high-yielding breeding lines with resistance to the thrips vector and to TSWV. Studies have also been initiated on the mechanism and inheritance of resistance to TSWV in groundnut.

PMV is widespread and can cause crop losses as high as 30%. It is transmitted by several aphid species, and through seed up to 8%. Using a field inoculation technique, over 3000 *A. hypogaea* genotypes have been screened for tolerance to PMV. ICG 5043 (NCAc 2240) was found to be tolerant. PMV was not seed-transmitted in the genotypes ICG 1697 (NCAc 17090), and ICG 7013 (NCAc 17133 [RF]). Interestingly, these genotypes are also resistant to rust and late leaf spot. Inheritance studies on tolerance and nonseed transmission to PMV are in progress. Initial data suggest high heritability for nonseed transmission. The breeding strategy is to develop high-yielding cultivars with PMV tolerance from ICG 5043, and with the nonseed transmission characteristic.

PStV is widely distributed in the USA and in many countries in Asia. It is economically important in the People's Republic of China and in Indonesia. PStV is transmitted by several aphids, and is seed-transmitted at a higher frequency than PMV. Over 7000 *A. hypogaea* genotypes were field-screened in Indonesia and none was found to be resistant to PStV. In tests conducted under containment in India, *A. cardenasii* (ICG 11558) was shown to be immune, and *A. chacoense* (ICG 11562, ICG 12168, ICG 4983), ICG 11560, ICG 8215, and *A. paraguariensis* (ICG 8973) resistant to PStV. Several interspecific hybrid derivatives and *A. chacoense* are currently being tested in Indonesia for resistance to PStV.

PCV has been reported from western Africa and India. When infection occurs early, the disease can cause up to 100% yield loss. The virus occurs as serologically distinct isolates. It is transmitted by a soil-borne fungus *Polymyxa graminis* and also through groundnut seed as high as 20%. Although nearly 8000 groundnut genotypes were screened in PCV-infested farmers' fields, none was found to be resistant.

B: Country Reports on Groundnut Virus Diseases in Africa

Current Research on Groundnut Virus Diseases in Senegal

M. Dollet[1], A.A. Mbaye[2], and J. Dubern[1]

Groundnut is cultivated on about 1 million ha in Senegal and is of great importance for local use and as a cash crop for export.

The groundnut program is managed by ISRA which is based at the research stations in Bambey, Kaolack, and Nioro where three breeders, one plant pathologist, one entomologist, and two agronomists are working.

Virus research is conducted by ISRA and LPRC (IRHO and ORSTOM) under a collaborative program.

During the last 10 years several virus diseases were observed on groundnut in Senegal including peanut clump virus (PCV), peanut stunt virus (PSV), and tomato spotted wilt virus (TSWV).

PCV is at present the most important virus disease in Senegal. Symptomatology, seed transmission, soil transmission, mechanical transmission, serological properties, viability, and epidemiology (distribution and natural host plants) have been studied. The disease infects groundnut in all regions of Senegal. Many PCV strains have been described, differing by their symptoms and their serological properties. Monoclonal antibodies were produced and confirmed a distant relationship with the Indian PCV. The disease infects many wild and cultivated leguminous and graminaceous plants including sugarcane, maize, pearl millet, and french bean. It also infects members of some other families.

PSV disease was observed and identified in the western region of Cap Vert. Symptomatology, transmission, host range, and morphological and serological properties were studied. The virus appeared to be a mild strain.

Symptoms of TSWV disease were also observed on groundnut in the same region. Similarly, symptomatology, transmission, host range, and morphological and serological properties were studied. Different strains were observed; symptoms differed considerably: some strains were easily transmitted mechanically and others were not, some reacted with an antiserum produced by Agdia (USA) but some did not react with antisera produced for an Indian and European TSWV

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isolates. This disease often occurred in association with PCV disease and this complicated identification.

Observations were recently made on groundnut rosette virus (GRV) disease. Symptoms resembling those of green rosette, but not very typical, were observed in groundnut in the northwestern region. The typical symptoms of chlorotic rosette were never observed in Senegal.

Other diseases thought to be caused by viruses were observed on groundnut. They could not be transmitted mechanically and serological tests for furoviruses, cucumoviruses, potexviruses, potyviruses, and with TSWV were negative.

ICRISAT Sahelian Center Research on Peanut Clump Virus

F. Waliyar[1], D.V.R. Reddy[2], A.S. Reddy[2], J. Dubern[3], and S.B. Sharma[2]

Peanut clump virus (PCV) was first described in India and later in western Africa. It is currently known to occur in many countries in western Africa. The disease appears to be restricted to groundnut raised in sandy soils. Estimation of yield losses due to PCV is difficult because it appears in patches of variable size in farmers' fields. Yield losses of up to 60% have been reported. PCV is an economically important disease of groundnut in Niger. It has been difficult to grow a uniform groundnut crop on the ICRISAT Sahelian Center's farm at Sadoré, near Niamey, and various nematodes and PCV were shown to have important roles in inducing the crop growth variability.

During surveys in 1989 in western Africa, PCV was found to be widely distributed in Niger but disease severity varied from region to region.

Among several host plants tested for susceptibility to PCV in Sadoré, only groundnut showed overt symptoms. *Arachis hypogaea, Cajanus cajan, Pennisetum glaucum, Seasmum indicum, Sorghum bicolor, Stylosanthes fruticosa, S. hamata, Vigna aconifolia, V. radiata, V. unguiculata* (C 152), *V. unguiculata* (local), *V. subterranea*, and *Zea mays* were infected but did not show symptoms. PCV was not recovered from *Helianthus annuus*. Groundnut showed 5–10% and bambara groundnut approximately 1% seed transmission. More research is needed to determine the seed transmission rate of PCV in semi-arid tropical crops.

Since considerable variability in growth could occur in a single genotype grown in Sadoré, a procedure for evaluating groundnut genotypes for their response to crop growth variability was standardized. Of the 49 groundnut ge-

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notypes tested, three genotypes (ICG 86600, ICG 10964, and ICG 1697) showed less than 20% PCV incidence. ICG(FDRS) 4 showed uniform growth, but 22% of the plants were positive for PCV as against 65% for the control cultivar 55-437. These lines are currently being tested in large plots.

Since soil solarization was shown to reduce incidence of PCV in groundnut crops at ICRISAT Center in India, soil at Sadoré was solarized during the hot season. There was no difference in crop growth and pod yields between solarized and nonsolarized plots.

PCV can be controlled at Sadoré by the application to the infested soil of carbofuran or dibromochloropropane, but the dosages required are high and are uneconomical.

Future research on PCV will be focused on:

- the host range of PCV;
- seed transmission in legumes and cereals commonly grown in the region;
- screening for resistance, especially within advanced breeding lines, interspecific hybrid derivatives, and wild *Arachis* species; and
- virus disease surveys in western Africa.

Virus Diseases of Groundnut in Sudan

A.H. Ahmed[1]

Groundnut is an important cash and food crop in Sudan, but yields are low because of various abiotic and biotic factors. Virus diseases are the most important constraints for groundnut production. Three virus diseases have been definitively identified, but several diseases with virus-like symptoms also occur on groundnut and identification and characterization of the causal agents has still to be done.

Peanut mottle virus (PMV) is widespread on groundnut in Sudan. It induces symptoms ranging from mild mottle to severe mottle and leaf deformation. The identity of PMV was confirmed by host range and reaction, particle morphology, serology, aphid transmission, and physical properties. The PMV incidence in the field varied from 2 to 95%, depending on the locality and the growing season. Some fields had significantly less disease infection, and such fields were recommended as potential sites for PMV-free seed production.

Comparative field studies revealed that PMV infection reduced the yield of the groundnut cultivar MH383 by 41%, and similarly for Libyan (28%), Nigerian

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(25%), Ashford (24%), and Barberton (17%). None of the groundnut cultivars grown in Sudan was resistant to PMV. PMV was recovered from the seeds of groundnut, *Vicia faba*, and *Brassica juncea*.

Peanut stunt virus (PSV) induces pronounced leaf mottling, leaf deformation, and severe stunting of the infected groundnut plant. The identity of the virus was based on symptomatology, host range, physical properties, electron microscopy, and serology. The natural hosts of PSV include *Phaseolus vulgaris*, *Vigna unguiculata*, *Dolichos lablab*, *Medicago sativa*, *Clitoria* sp, and *P. trilobus*.

The incidence of PSV in groundnut is generally low, ranging from 1 to 5%, but sporadic epidemics have been recorded. High incidence of PSV was reported from aflalfa, faba bean, and several leguminous weeds. Field surveys revealed close association between *Aphis craccivora* infestation and PSV infection. Field experiments showed that PSV infection reduced growth and yield of several legumes including groundnut, faba beans, and cowpea. PSV had less effect on the green fodder production of alfalfa, but the role of such a perennial crop in harboring the virus and its vectors should not be underestimated.

Groundnut rosette virus (GRV) has been reported to cause severe damage to groundnut in southern Sudan. The disease was more prevalent in May and June sowings than when the crop was sown earlier. Research on the GRV disease has been affected by the unstable conditions in southern Sudan. Further work on this disease is needed, including a study of its relationships with the GRV disease that occurs in neighboring eastern African countries.

Numerous virus-like symptoms occur in field-grown groundnut. Due to lack of facilities the causal viruses have not been characterized and methods for their detection have not been developed. It is hoped that international collaborative research will facilitate intensive studies on virus diseases of groundnut in developing African countries.

Current Research on Groundnut Virus Diseases in Cote d'Ivoire

J. Dubern[1], J.C. Thouvenel[1], K.P. N'Guessan[2], and M. Dollet[3]

Groundnut rosette, groundnut eyespot, groundnut crinkle, groundnut chlorotic spotting, peanut clump, peanut mottle and several partly identified diseases of

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virus etiology have been described on groundnut from Cote d'Ivoire over the last 15 years.

Groundnut rosette disease has been observed everywhere in the country, incidence being high during the rainy season, especially in the southern region. Symptomatology, host range, mechanical transmission, and vector transmission have been studied. The virus causing the symptoms could not be isolated or purified, but the assistor virus, a luteovirus, was identified. Groundnut crinkle disease is characterized by leaf crinkling and stippling. The disease has been observed only in the southern region of Cote d'Ivoire. Symptomatology, host range, mechanical transmission, whitefly transmission, and serological properties were studied, and the virus was purified. The virus, a member of the carlavirus group, was examined serologically and was found to be distantly related to the cowpea mild mottle virus.

Groundnut chlorotic spotting disease induces small chlorotic spots, chlorosis, mottle, ringspot, and line patterns on the leaves. Symptomatology, host range, transmission by aphids, serological properties and purification of the virus were studied. The virus was not serologically related to the potatovirus x though it resembles potexviruses.

Groundnut eyespot disease induces on the leaves typical dark green spots surrounded by a chlorotic halo. The disease has been observed only in the northern region of Cote d'Ivoire and in the southern region of Burkina Faso. Symptomatology, host range, transmission by aphids, serological properties, and purification of the virus were studied. The virus, a member of the potyvirus group, is related to most African potyviruses, and is distantly related to the peanut mottle virus.

Peanut clump disease induces very variable symptoms depending on the variety of groundnut and strain of the virus; typical symptoms are stunting with small and dark green leaves. The disease was observed in the northern region. Symptomatology, host range, mechanical and soil transmission, serological properties, morphology, and purification of the virus were studied. The virus is also frequently transmitted through seeds. The virus is a member of the furovirus group.

Peanut mottle disease induces mosaic and mild mottle on the leaves. Symptomatology, host range, transmission by aphids, serological properties, and purification of the virus were studied. The virus, also a member of the potyvirus group, has recently been described from Cote d'Ivoire.

Other symptoms such as streak, mosaic, golden yellowing, and flecking were observed on groundnut in Cote d'Ivoire. All these diseases were transmitted by graft but not by mechanical sap inoculation. Causal agents of these diseases have yet to be established.

Groundnut Cultivation in Congo

R. Massala[1]

Cassava and banana are the Congo's main agricultural products and groundnut cultivation is restricted to small holdings. However, the crop is important in the social and economic life of the country because it satisfies two needs, for confectionery products and for the extraction of *n'kayi* (huilka) oil.

Groundnut research is currently limited to varietal selection and the study of certain agronomic problems. This is done at the Loudima Agricultural Research Centre (CRAL).

In order to cope with the increasing demand for groundnut, it is necessary to develop a coherent program capable of overcoming the numerous constraints that limit groundnut production in Congo. Participation in collaborative research on groundnut virus diseases could be a useful component of such a program.

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Peanut Clump in Burkina Faso

Konate Gnissa[1]

Peanut clump is a soil-borne disease of groundnut transmitted by the fungus *Polymyxa graminis*. It was described in Burkina Faso about 30 years ago. The disease is caused by peanut clump virus (PCV) which belongs to the furoviruses. The disease is characterized by stunting and dark green leaflets. It severely reduces yield, and losses of up to 80% have been reported.

PCV has recently been shown to infect sorghum, pearl millet and sugarcane. Though the effect of PCV on sorghum and pearl millet is not known, the virus can cause significant yield reductions in sugarcane.

The disease can be controlled effectively by the application of DD or Maposol®. Unfortunately, this is expensive and not economical to use for disease control at the farm level.

Interestingly, crop rotation with pearl millet considerably reduced the disease incidence. No explanation of this result can be given.

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Our current research in Burkina Faso is focused on the identification of groundnut genotypes resistant to PCV. Since considerable progress has been made on the characterization of PCV, aspects related to disease management should receive more emphasis in future investigations. These should include:

- effect of crop rotation and sowing dates on PCV incidence;
- identification of principal hosts involved in the perpetuation of inoculum; and
- estimation of yield losses in cereals caused by PCV.

Current Status of Research on Peanut Clump Virus in Western Africa

J. Dubern[1] and M. Dollet[2]

Peanut clump virus (PCV) is presently being studied in association with several institutions: At LPRC (CIRAD, ORSTOM) in France, ISC (ICRISAT) and at INRAN in Niger, at ISRA and IRHO in Senegal, and at INERA and IRHO in Burkina Faso. Various aspects studied are etiology (transmission, host range, variability, serological properties), epidemiology (geographical distribution, wild and cultivated alternate hosts), sanitation (seed thermotherapy), and selection for resistance or tolerance.

PCV is transmitted by seeds (groundnut), by seedlings (sugarcane), and by a soil-borne fungus (*Polymyxa graminis*). Many PCV strains have been collected in Senegal, Burkina Faso, and Niger which showed different symptoms and serological properties. Production of monoclonal antibodies facilitated precise detection of isolates. Large variation in serological cross-reaction was observed among PCV isolates collected in Burkina Faso and Niger. Monoclonal antibodies produced for African PCV showed weak serological relationships with the Indian PCV.

PCV infects groundnut and numerous cultivated plants (french bean, cowpea, pigeonpea, sugarcane, maize, sorghum, pearl millet, etc.,) in Senegal, Mali, Burkina Faso, Cote d'Ivoire, Benin, and Niger.

Preliminary experiments to eliminate the virus in the seeds by high temperature under dry conditions were begun at LPRC. No success has been obtained because of the necessity to maintain a high percentage of germination (over 85%) and because of the resistance of the virus to heat (over 70°C in vitro in the seeds).

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In Burkina Faso, experiments to prevent the disease by cultivating plants such as pearl millet, supposed to be resistant to the virus, are under way. Others were recently begun in Niger and Burkina Faso to select for resistance (or tolerance) to PCV.

Peanut Stripe Virus: Potential Danger for Groundnut in western Africa

M. Dollet[1] and J. Dubern[2]

Peanut stripe virus (PStV), a seed-transmitted potyvirus, is assumed to have originated from Asia, possibly from the People's Republic of China. In 1982 it was recorded in the USA in groundnuts grown from seed imported from China.

In 1989, in Senegal, groundnut seeds from China produced plants which showed symptoms resembling those caused by some isolates of PStV. Electron microscopy studies, mechanical transmission tests, and examination of serological properties conducted at LPRC confirmed the presence of PStV. The virus is easily transmitted mechanically. It induces two kinds of yellow spots on *Chenopodium amaranticolor*, and on groundnut a range of symptoms including green blotches, mosaic, stripe, and mottle, depending on the variety of groundnut and the duration of symptom expression. It is possible that more than one strain was present in these seeds. Negative staining (leaf dip) revealed long flexuous particles and, in ultrathin sections, pinwheel inclusions characteristic of potyvirus were observed.

No serological relationships were observed with peanut mottle, pepper veinal mottle (Cote d'Ivoire isolate) and groundnut eyespot viruses. Serological relationships were observed with different PStV strains. A weak reaction was observed with soybean mosaic virus (Thailand strain) antiserum.

It appears from these results that PStV was present in the seeds from China. It is clear that with increase in exchange of germplasm it is imperative for plant breeders and the plant virologists to work in close association. Special care should be taken when introducing exotic germplasm into Africa and other developing countries to avoid the introduction of PStV.

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Part 3. Recommendations

For Global Cooperative Research on Groundnut Rosette Virus

1. The molecular basis for variation of symptoms by groundnut rosette virus satellites should receive continued attention.
2. Production of monoclonal antibodies for groundnut rosette assistor virus is required.
3. Complementary DNA probes, preferably nonradioactive types, should be produced for detecting groundnut rosette virus satellites.
4. Epidemiological studies, with special emphasis on sources of inoculum and the ecology of *Aphis craccivora*, which is considered to be the principal vector of rosette virus, should be encouraged.
5. Genetic markers to aid in resistance breeding should be developed.
6. Production of short-duration, rosette-resistant cultivars should continue to have high priority.
7. Production of rosette-resistant cultivars with drought tolerance should also receive emphasis.

For Future Work on Groundnut Viruses in Africa

Recommended cooperative activities

8. Provide research workers in Africa with access to facilities for virus characterization in laboratories in western Europe, especially in the UK, France, and the Netherlands.
9. Provide help to strengthen research facilities in African countries, especially for virus identification.
10. Provide diagnostic tools for the identification of groundnut viruses to researchers in developing countries.
11. Organize training courses in plant virology techniques. Virologists in CIRAD, SCRI, and the Netherlands were willing to provide logistic support. ICRISAT and CIRAD were requested to cooperate in running the courses.
12. Publish an information bulletin on groundnut rosette disease. Drs A.F. Murant and D.V.R. Reddy were requested to coordinate this activity.
13. Publish an information bulletin on peanut clump disease. Virologists in CIRAD were requested to coordinate this activity.

14. Organize surveys for groundnut viruses. The need to encourage and involve scientists in national agricultural research systems was emphasized. ICRISAT and CIRAD were asked to initiate survey work in western Africa in 1991.

Priorities for future research in Africa

15. Development of detection methods for economically important groundnut viruses. The role of advanced virus laboratories in western Europe was emphasized.
16. Breeding for disease resistance using conventional methods. Emphasis will be on groundnut rosette (to incorporate both virus and vector resistance), and on peanut clump virus.
17. Research leading to development of practices for the integrated management of virus diseases. NRIs in the UK may be able to assist in studies on the ecology of *Aphis craccivora*.

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