VIRUS DISEASE PROBLEMS OF GROUNDNUT, CHICKPEA, AND PIGEONPEA IN ASIA

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ABSTRACT

Important virus diseases affecting groundnut, chickpea and pigeonpea in Asia are described and management practices given. In some countries, important virus diseases of the three ICRISAT mandate crops are yet to be characterized. Several international agencies are currently helping regional and national programs in Asia to find solutions to virus disease problems. Such cooperation is vital for identification and management of virus diseases of grain legumes.

Introduction

Over 70% of the world's production of the thre ICRISAT mandate legumes, groundnut (*Arachis hypogaea* L.), chickpea (*Cicer arietinum* L.) and pigeonpea (*Cajanus cajan* (L). Millsp.), is from Asia. Groundnut is an important source of vegetable oil. Chickpea and pigeonpea provide essential amino acids required in the human diet. All the three crops can be grown under low fertility and moisture conditions. They are also suitable for cultivation in some rice-based farming systems and as intercrops with cereals.

Average yields of these legumes are very low (600-700 kg/ha), and diseases have been identified as important production constraints in many areas. Several virus diseases have been reported on the three crops. Although some of the diseases have been known to be present in Asia for several years, only limited data are available on their distribution and economic importance, and several causal viruses have yet to be characterized. In this paper we describe economically important virus diseases of the three ICRISAT mandate legumes and consider methods available to manage them. Information on their viruses, though they are not fully characterized, is also included. Priorities for future research on the virus diseases of the three legumes are discussed.

Groundnut (peanut) virus diseases

1 Bud necrosis disease

Bud necrosis disease caused by tomato spotted wilt virus (TSWV) is the most important virus disease of groundnut in India (Ghanekar *et al.,* 1979). It is widely distributed and causes severe yield losses to groundnut in India (Amin and Reddy, 1983; Reddy, in press). TSWV has also been shown to infect other legumes, *Vigna mungo* (urd bean), *V. radiata* (mungbean), *V. unguiculata* L. (cowpea), and *Glycine max* (soybean). Recently, TSWV has also been reported on groundnut from Thailand (Wongkaew and Choopanya, 1985). The virus causes a wide variety of symptoms on groundnut, conspicuous among which are terminal bud necrosis, and ring spots on young quadrifoliates. Early infected plants are either killed or severely stunted with proliferation of shoots arising from axils. Leaves produced after infection are deformed and show general chlorosis.

TSWV can be transmitted by the thrips *Frankliniella schultzei* and *Scirtothrips dorsalis*. However, *F. schultzei* is the more effective vector and is responsible for the disease spread under

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field conditions (Amin *et al.,* 1981). Since BND incidence is associated with infestation by viruliferous immigrant thrips (Amin and Reddy, 1983; Reddy *et al.,* 1983a) vector management should help in reducing the disease incidence. Thus crops grown in months when the vector populations are low have low disease incidence and yield well. Growing groundnut at high plant density and as an intercrop with fast growing cereals such as pearl millet, decreases the proportion of infected plants. Genotypes with field tolerance to BND have been identified (Amin, 1985; Amin and Dwivedi, unpublished) and show consistently lower than average incidence of the disease (Table 1). Of several wild *Arachis* species tested for resistance to bud necrosis disease, *A. chacoense* (PI 10602), cannot be infected by TSWV by mechanical sap inoculations. Efforts are being made to breed high-yielding bud necrosis disease-resistant groundnut cultivars.

Table 1 Genotypes of groundnut with field tolerance to bud necrosis disease

ICRISAT accession number	Identity of the genotypes
5030	NC Ac 1741
6317	NC Ac 17888
2271	NC Ac 343
2546	C-108
799	Robut 33-1

2 Peanut clump disease

Peanut clump virus disease (PCV) was first reported from West Africa (Trochain, 1931; Bouhot, 1967) and subsequently from India (Reddy *et al.,* 1983b). The disease has not been reported from any other country of Asia. It is widely distributed in India and is economically important on groundnuts in the state of Punjab. The disease is soil-borne and infected plants occur in patches in the same position every year in the field whenever groundnuts are grown. Initial symptoms appear on young quadrifoliates as chlorotic ring spots and mottling. Subsequently, the leaflets become dark green, plants are severely stunted and appear dark green and bushy. Early infected plants rarely produce any pods, and yield losses of up to 60% have been recorded in late infections (Reddy and McDonald, unpublished).

Since the Indian PCV is serologically unrelated to the West African one, it is named Indian PCV (IPCV). The virus is rod-shaped with two predominant particle lengths, 190 mm and 245 nm (Reddy *et al.,* 1936b). Five isolates of IPCV differing in symptoms, host range, and serological properties have recently been identified (Nolt *et al.,* unpublished). Evidence obtained so far indicates that the phycomycete fungus *Polymyxa graminis* may transmit the virus.

Groundnut crops sown in the postrainy season, when temperatures are relatively low, escape the disease. Application of soil biocides such as carbofuran and Temik (Aldicarb) prior to planting groundnuts significantly reduces the disease incidence (Reddy, in press; Amin, unpublished). Efforts are being made to identify genotypes tolerant or resistant to IPCV.

3 Peanut mottle virus disease.

This disease, caused by peanut mottle virus (PMV) has been reported from several Asian countries including China (Zeyong *et al.,* 1984), India (Reddy *et al.,* 1978), Indonesia (Roechan *et al.,* 1978), Malaysia (Poh *et al.,* 1972), the Philippines (Benigno and Favali-Hedayat, 1977) and Thailand (Reddy *et al.,* 1985). Initial symptoms appear on young quadrifoliates as dark green islands interspersed with chlorotic areas. In some genotypes interveinal depression and upward rolling of edges of leaflets are also observed. Infected plants are not markedly stunted although the size of leaflets is reduced. PMV can cause yield reductions of up to 40% in groundnut (ICRISAT Annual Reports, 1982, 1983).

PMV belongs to the potyvirus group (Kuhn and Demski, 1984) and is serologically related to several potyviruses (Rajeshwari *et al.,* 1983).

PMV is seed-transmitted at a relatively low frequency (0–85) depending on the groundnut genotype, strains of PMV involved, and environment (Kuhn and Demski, 1984; Bharathan *et al.,* 1984).

The primary source of inoculum is provided by infected seed, and secondary spread is by the aphids (Kuhn and Demski, 1984). Methods are now available to eliminate PMV-infected seed from seed lots for quarantine purposes and for maintaining virus-free germplasm (Bharathan *et al.,* 1984). Genotypes in which PMV is not seed-transmitted are listed in Table 2. ICG 5043 (NC Ac 2240 DP) is tolerant to PMV infection. Non seed-transmitted and tolerant genotypes are currently being used in breeding programs to evolve PMV-tolerant genotypes with the non-seed transmission characteristic.

Table 2 Genotypes of groundnut in which PMV is not seed-transmitted

ICRISAT accession number	Identity of the genotypes
2716	EC 76446 (292)
7013	NC Ac 17133 (RF)
1260	Ah 7171

4 Peanut stripe virus disease

This disease caused by peanut stripe virus (PStV) was first discovered in the USA in plants raised from seed imported from the People's Republic of China (Demski *et al.,* 1984). Subsequently, PStV has been reported from the Philippines and Thailand (Wongkaew and Choopanya, 1984; Reddy *et al.,* 1985) and observed in Indonesia (D.V.R. Reddy, unpublished), and China (Zeyong, 1958). Characteristic symptoms are discontinuous stripes along the lateral veins followed by severe mosaic symptoms in the form of green islands or of an oak leaf pattern. PStV can cause yield reductions of up to 23% and can be seed-transmitted up to 38%. PStV has been shown to be a potyvirus serologically related to blackeye cowpea mosaic, clover yellow vein, and soybean mosaic viruses. However, it is serologically distinct from PMV (Demski *et al.,* 1984).

No management methods have been investigated. Priority should be given to identifying resistant and non seed transmission genotypes.

5 Minor groundnut virus diseases

(1) Cowpea mild mottle virus (CMMV): The disease caused by CMMV has been reported from India (Iizuka *et al.,* 1984), and Thailand (Iwaki *et al.,* 1982), and is suspected to occur in the Philippines (D.V.R. Reddy, unpublished). Disease symptoms are vein-clearing followed by downward rolling and necrosis of leaflets. CMMV is a carlavirus transmitted by whiteflies (Iwaki *et al.,* 1982; Muniyappa and Reddy, 1983).

(2) Peanut yellow spot virus: This disease is widely distributed in India and in Thailand. Characteristic symptoms on leaflets are bright yellow spots which later become necrotic. Several lesions may coalesce to cover the entire leaflet surface. The virus is non systemic; it belongs

to the TSWV group and is transmitted by the thrips *S. dorsalis* (P.W. Amin, unpublished; D.V.R. Reddy *et al.,* unpublished; Wongkaew and Choopanya, 1985). It has the potential to become economically important, and screening for disease resistance will soon be initiated at ICRISAT Center.

(3) Other virus diseases: Several minor diseases which include peanut green mosaic, peanut chlorotic leaf streak, and peanut yellow mosaic (Reddy, 1984; Iizuka *et al.,* 1979) have been reported from India. Peanut mosaic transmitted by the leafhopper *Orosius argentatus,* and peanut crinkle leaf diseases have been reported from Indonesia (Iwaki, 1979). Occurrence of cucumber mosaic virus has recently been reported from China (Zeyong *et al.,* 1984).

(4) Witches' broom disease: This disease is caused by mycoplasma-like organisms (MLO's); it is widely distributed in Asia and appears to be economically important in Indonesia, Southeast China and Taiwan.

Chickpea virus diseases

1 Chickpea stunt disease

Chickpea stunt caused by pea leafroll virus (a luteovirus) is economically important. The disease is widespread in the cooler regions of Asia. Infected plants are severely stunted and the foliage turns yellow (Kabuli types) or brown (Desi types). Phloem browning and the proliferation of axillary shoots are common symptoms. The virus is transmitted by several aphid species. ICRISAT had identified twenty resistant genotypes in field testing (Nene, 1979) (Table 3).

Table 3 Genotypes of chickpea with field resistance to chickpea stunt disease

ICRISAT accession number	Pedigree
403	P-298-1
591	P-466
685	P-537
2385	P-2151-1
2546	P-2512
3718	P-4341-2
6433	NEC-417
6934	NEC-1174
10495	RPSP-226
10596	Coll.327
4949	G-24

2 Minor chickpea virus diseases

Three virus diseases that are currently of only minor importance have been reported on chickpea in India. They include alfalfa mosaic virus, bean yellow mosaic virus, and cucumber mosaic virus (Nene, 1979, Chalam, 1982). Chickpea phyllody, probably caused by MLO's, has also been reported (Nene, 1979).

Pigeonpea virus diseases

1 Sterility mosaic virus

The sterility mosaic disease is recognized as a major constraint to pigeonpea production in India, causing an estimated annual yield loss valued at US$76 million (Kannaiyan *et al.,* 1984). Characteristic disease symptoms are stunting, and bushy and pale green appearance of plants.

Leaves are reduced in size and show characteristic mild mosaic or ring spot symptoms. Infected plants do not normally produce flowers (Nene, 1972). A similar disease has been reported from Burma (Su, 1931), Sri Lanka (Newton and Peeris, 1953) and Thailand (Nene, 1980). The causal agent is transmitted by eriophyid mite, *Aceria cajani* (Seth, 1962; Nene, 1972). Evidence obtained so far indicates that sterility mosaic disease is possibly caused by a flexuous rod-shaped virus (Ghanekar and Nene, unpublished).

By employing a leaf stapling inoculation method and by utilizing spreader rows, germplasm accessions have been screened for resistance. Several germplasm lines have been identified as resistant to sterility mosaic in multilocation testing and have been used to breed high-yielding sterility mosaic resistant cultivars (Table 4).

Table 4 Pigeonpea lines with resistance to sterility mosaic disease in 6 or more locations out of 10 tested in India (1981—83)

ICRISAT accession number			
1	ICP-410	11	ICP 8105
2	ICP-999	12	ICP 8129
3	ICP 2376	13	ICP 10976
4	ICP 6630	14	ICP 10977
5	ICP 6986	15	ICP 10984
6	ICP 7349	16	ICP 11040
7	ICP 7353	17	ICP 11047
8	ICP 7378	18	ICP BSMR-1
9	ICP 7867	19	CIP BSMR-2
10	ICP 8090	20	KSMR-80-2

2 Pigeonpea yellow mosaic disease

Pigeonpea yellow mosaic disease, transmitted by the whitefly *Bemisia tabaci,* Genn. is a common disease in India. The disease symptoms include yellow diffused spots interspersed with green islands on leaves and often the entire lamina becomes yellow (Nene, 1972). The causal agent is likely to be a gemini virus. The disease appears to be of minor importance. No management practices are available.

3 Other virus diseases

Cowpea mosaic and tobacco mosaic viruses have been reported to cause diseases on pigeonpea. A witches' broom disease occurs in pigeonpea in several countries including Taiwan and Bangladesh (Nene *et al.,* 1981). These diseases are currently considered to be of only minor importance. Fortunately none of the virus diseases of chickpea and pigeonpea are seed-transmitted.

Prospects for diagnosis and management of virus diseases of ICRISAT mandate legumes in Asia

Full virus characterization and reliable detection methods are essential for formulating integrated disease management systems, and to ensure that plant quarantine services are equipped with effective techniques for detecting seed-borne viruses. Several economically important viruses causing diseases of the ICRISAT mandate legumes in Indonesia, the Philippines, Burma, Pakistan and Bangladesh have yet to be characterized, and the identities of some of the causal viruses have yet to be clearly established. For example, PMV as reported from Indonesia and Malaysia strikingly resembles PStV in symptoms and host range. Groundnut rosette diseases reported from India and the Philippines are quite distinct from the rosette disease reported from Africa. In India bud necrosis disease and peanut clump disease had been confused with African rosette (Reddy, in press). The causal agent of sterility mosaic of pigeonpea requires characterization. The distribution of other viruses occurring on chickpea and pigeonpea in Asia requires further investigation.

Although the majority of recent reports on occurrence of virus diseases are not entirely based on symptoms, host range, and properties such as thermal inactivation point, dilution end point and longevity *in vitro,* precise methods for virus characterization and detection are still not being widely employed. Lack of the elaborate facilities necessary for full virus characterization and detection, and to some extent expertise, appear to be the major constraints for characterizing viruses.

Several international organizations including the Japan International Cooperation Agency, the Australian Centre for International Agricultural Research (ACIAR), and the Canadian International Development and Research Centre are currently helping the regional and national programs to find solutions to virus disease problems.

ICRISAT has provided several scientists from Asian countries with training in the characterization and detection of viruses and in methods for resistance screening of germplasm. Antisera, and necessary reagents for performing highly sensitive serological tests, including enzyme-linked immunosorbent assay, are made available to national scientists on request. ICRISAT has large collections of germplasm of its mandate crops that are available to scientists involved in resistance breeding.

By utilizing specific antisera and sets of diagnostic hosts (Hampton *et al.,* 1978) it is possible to identify several legume viruses, especially those which are mechanically transmissible. Virus-free and authentic diagnostic hosts are, unfortunately, not readily available at the present time. It is essential to maintain these hosts in a center where they can be multiplied and supplied to scientists requiring them. ICRISAT is currently maintaining antisera for several groundnut viruses. However, it will be essential in future to set up a sera bank for the majority of viruses occurring in Asia, to facilitate an adequate and continuous supply of antisera to virologists who need them. ACIAR is contemplating setting up such a bank of sera and diagnostic hosts in Australia. The ACIAR project also envisages production of antisera for viruses which are difficult to purify by conventional methods.

Cooperation with international agencies and training are vital if reliable data on the distribution, and economic importance of virus diseases of grain legumes are to be obtained and for the development of effective disease management systems.

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Discussion

Abu Kassim, A.B. (Malaysia): Could you identify the bud necrosis virus with any of the TSWV strains reported in Australia?

Answer: The strains reported in Australia resemble those in India.

Makkouk, K.M. (ICARDA): You mentioned that peanut clump virus is caused by a number of isolates, some of them not being serologically related. Is it likely that you may be dealing with different viruses that induce similar symptoms?

Answer: Experiments on sequence homology, including genome homology, particle morphology and distribution and host range suggest that these isolates are most likely strains of the same virus.

Senboku, T. (Japan): Can you distinguish peanut yellow spot virus from tomato spotted wilt virus?

Answer: Peanut yellow spot virus is serologically distinct from TSWV. When tested against several antisera of TSWV from other countries it did not react. The transmission characteristics are also different. Thrips larvae can acquire peanut yellow spot virus and transmit it. In the case of TSWV the larvae acquire the virus and only the adults can transmit it.

Tantera, D.M. (Indonesia): Based on serological studies, it appears that in Indonesia peanut mottle is the ring type of peanut mottle.

Could you make a few comments on the quarantine problems for the transport of seed-transmitted viruses from one country to another.

Answer: I believe that it is important to have a rigorous quarantine system. Also seeds should be tested prior to shipping them to another country.

Abu Kassim, A.B. (Malaysia): In Hawaii, certain strains of TSWV seem to be confined to certain plant groups such as ornamentals, weeds and crops. Have you compared TSWV isolates from groundnut with those from solanaceous crops found in India?

Answer: No, we have not performed comparative studies.

Honda, Y. (Japan): Are you going to assign peanut yellow spot virus to a new virus group distinct from tomato spotted wilt virus?

Answer: No. Peanut yellow spot virus should be considered as a distinct virus under the TSWV group. More chemical characterization is required to distinguish between yellow spot virus and TSWV.

Rossel, H.W. (IITA): Regarding the statement of the speaker that he can guarantee the absence of seed-borne viruses in groundnut because he indexed individual seeds by ELISA and by taking a small part of each seed cotyledon, we believe that it is very difficult to guarantee the absence of seed-borne infection in the case of seed-borne viruses of legumes in general but we are less concerned about it in the case of viruses which have proved to be of worldwide occurrence already. It is possible to prevent seed infection when seeds are shipped to other countries by sanitation. At IITA this approach together with the assessment of actual transmission rate is followed (in the case of worldwide-occurring viruses however, only seed lots with a very low rate of seed infection such as 1% are allowed to pass).

Answer: I believe that we should avoid as much as possible to transfer virus-infected seeds.