First Coordinators' Meeting on Peanut Stripe Virus

International Crops Research Institute for the Semi-Arid Tropics

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Cover: Symptoms caused by peanut stripe virus: oak leaf mosaic (top left,) *and blotch* (top right); *and typical field symptoms caused by the virus (* bottom).

Coordination of Research on Peanut Stripe Virus

Summary Proceedings of the First Meeting to Coordinate Research on Peanut Stripe Virus Disease of Groundnut

held at
Malang Research Institute for Food Crops (MARIF)
Jalan Raya Kendalpayak
P.O. Box 66, Malang 65101 East Java,
Indonesia

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Contents

Welcome Address

Sutaryo Brotonegoro

Director, Malang Research Institute for Food Crops (MARIF),
Jalan Raya Kendalpayak, P.O. Box 66, Malang 65101, Indonesia

Dr Sutaryo Brotonegoro, Director of the Malang Agricultural Research Institute for Food Crops (MARIF), welcomed the participants to Indonesia and to Malang. He expressed his pleasure that the meeting to coordinate research on peanut stripe virus disease was being held at MARIF, and stated that his institute was prepared to provide all possible assistance to ensure that the meeting was successful. Dr Sutaryo was appreciative of the work already done by ACIAR, the Peanut CRSP, and ICRISAT in cooperation with Indonesian scientists, that had documented the occurrence of peanut stripe virus disease on groundnuts in Indonesia. The distribution and economic importance of the disease in the Asia-Pacific region now has to be determined, and appropriate disease management strategies developed. He expressed his hope that the meeting would lay a sound foundation for international cooperative research.

Objectives of the Meeting

D.G. Faris

Coordinator, Asian Grain Legumes Network (AGLN), Legumes Program,
ICRISAT, Patancheru, Andhra Pradesh 502 324, India

Dr Faris described how peanut stripe virus disease had first been detected in the USA in groundnut crops grown from seed imported from Asia. Surveys carried out in East Asia by ICRISAT, the Peanut CRSP, and ACIAR had confirmed the presence of the disease in several countries of Southeast Asia. The disease is apparently of economic significance, and because the virus is seed-transmitted it is of considerable importance for plant quarantine. The situation led to this meeting of representatives from different national, regional, and international organizations concerned with research on groundnut diseases and with plant quarantine. They plan to review the situation and work out strategies to contain the spread of the disease and control it where it is already established. Dr Faris emphasized the need for effective international cooperation to devise research plans to meet these objectives and obtain the necessary funding.

Summaries of Papers

Country Papers

Peanut Stripe Virus Disease in Indonesia

N. Saleh

Virologist, Department of Plant Pathology, Malang Research Institute for Food Crops (MARIF), Jalan Raya Kendalpayak, P.O. Box 66, Malang 65101, Indonesia

D.M. Tantera

Virologist and Head, Department of Plant Pathology and Entomology, Central Research Institute for Food Crops, Jalan Merdeka 99, Bogor, Indonesia

Groundnut is second in hectarage only to soybean among the food legume crops in Indonesia. Each year 350 000-400 000 ha of groundnuts are sown in Indonesia. In view of its importance in the Indonesian diet, and its large production area, even a small improvement in its presently low average yield of 0.9 t ha^{-1} would significantly increase the quantity of groundnuts available in Indonesia. Peanut stripe virus (PStV), reported recently from the USA by Demski et al. (1984), has also been reported in all major groundnut-producing areas of Indonesia (D.V.R. Reddy, personal communication). PStV is seedborne and vectored by aphids in a nonpersistent manner. Peanut mottle virus (PMV), which was earlier reported from Indonesia by Roechan et al. in 1978, is another seedborne virus which produces symptoms in groundnut similar to those of PStV. Confusion between the two diseases is responsible for the delay in identifying PStV in Indonesia. Availability of antisera for both PMV and PStV and the application of sensitive serological tests such as enzyme-linked immunosorbent assay (ELISA) have helped to distinguish between PMV and PStV.

Preliminary studies conducted in Indonesia indicate that PStV has a wide host range. Infected seeds appear to be the primary sources of inoculum. Since PStV appears to be economically important, we suggest that research into the following aspects should immediately be undertaken:

- estimation of yield losses,
- prospects for producing virus-free seed, and
- location of sources of tolerance or resistance.

As an immediate measure to contain further spread of PStV, we suggest that farmers should be supplied with virus-free seed.

Bibliography

Demski, J.W., Reddy, D.V.R., Sowell, G. Jr., and Bays, D. 1984. Peanut stripe virus—a new seed-borne potyvirus from China infecting groundnut *(Arachis hypogaea).* Annals of Applied Biology 105: 495-501.

Roechan, M., Iwaki, M., Nasir, S., Tantera, D.M., and Hibino, H. 1978. Virus diseases of legume plants in Indonesia. Peanut mottle virus. Contribution of Central Research Institute for Agriculture, Bogor, Indonesia, 46: pp 1-11.

Peanut Stripe Virus Disease in Indonesia and the ACIAR Project

K.J. Middleton

Senior Plant Pathologist, Department of Primary Industries, J.Bjelke-Petersen Research Station, P.O. Box 23, Kingaroy, Queensland 4610, Australia

N. Saleh

Virologist, Department of Plant Pathology, Malang Research Institute for Food Crops (MARIF), Jalan Raya Kendalpayak, P.O. Box 66, Malang 65101, Indonesia

The groundnut viruses reported from Indonesia prior to 1986 included peanut mosaic and witches' broom (Thung 1964/1947), peanut crinkle leaf (Thung and Tojib Hadi - widjaja 1951), groundnut mottle (Triharso 1975), and peanut mottle (Roechan et al. 1978). A symptom in groundnuts previously attributed to peanut mottle (PMV) was visually diagnosed in August 1986 as the "blotch" symptom due to peanut stripe virus (PStV) (D.V.R. Reddy, ICRISAT, personal communication). During a survey of Java and South Sulawesi in September 1986, this diagnosis was confirmed using enzyme- linked immunosorbent assay (ELISA) procedures. Reddy had found PStV naturally infecting groundnuts in Indonesia in 1984 (Demski and Lovell 1985).

Symptoms consistant with those now known to be caused by PStV have been seen since 1972 in Sulawesi (Ir Sultan Wadeng, Head of Extension Services, Barru, personal communication) and since 1973 in South Sumatera (Roechan et al. 1978).

In disease surveys conducted during the 1985/86 rainy season throughout Java, South Sulawesi, and South Sumatera, PStV was found to be widely distributed (Table 1). During the rainy season, yield reductions do not appear to be serious, but dry-season crops inspected in South Sulawesi in 1986 were severely stunted, and a consensus among those present was that infected plants yielded less than 30% nearby plants without symptoms. At that time groundnuts were produced on 2500 ha in the region. Assessment of yield effects has been undertaken at Maros Research Institute for Food Crops (MORIF), but results are not yet known.

The typical stripe symptom (dark green stripes along secondary leaflet veins) has rarely been observed in Indonesia. It was observed on one local cultivar at Muneng in 1986. No "oak-leaf" pattern has been seen. Conversely, the "blotch" symptom (irregular green islands within chlorotic tissue) has been seen at all locations where PStV has been recorded. Blotch symptoms are persistent on mature leaves. No variations in level of infection or symptoms due to cultivar have been identified. Information on seed transmission of PStV in local cultivars is not available.

As a result of the correct identification of PStV in Indonesia, renewed interest has been shown in characterization of the virus present in this country.

PStV occurs in commercial crops sown in July or August, but not in May, September, or October. This may reflect the level of transmission in seed sown at these times or the level of aphid infestation. Aphids are common in dry-season crops sown in July and August.

In Indonesia, groundnuts are commonly grown adjacent to soybeans and cowpeas.

Open-field, virus-free seed production may be difficult to achieve in Indonesia. South Sulawesi and East Java would provide good sites to field screen for resistance; other parts of Indonesia such as West Sumatera may also be suitable. The Australian Centre for International Agricultural Research (ACIAR) project on peanut (groundnut) improvement in Indonesia will screen part of the world germplasm collection from ICRISAT, using Australian Development Assistance Bureau (ADAB) funding

Table 1. Disease index of peanut stripe virus on 14 groundnut cultivars at six sites in Indonesia.

	Sites					
Cultivars	Jambegede	Jakenan	Muneng	Tamanbogo	Cikeumeuh	Bontobili
Kidang	21.9	17.4	31.1	21.3	20.2	0
Pelanduk	30.4	18.3	34.0	21.4	17.3	0.2
Gajah	18.2	15.1	30.3	16.4	23.1	4.1
Tapir	14.1	15.8	31.9	19.4	21.1	1.8
Tupai	29.3	19.2	31.7	17.5	15.5	3.4
467	21.4	19.0	32.3	18.5	7.4	0.9
469	14.6	18.8	30.6	22.4	12.7	1.4
A27-146	29.9	22.5	38.3	15.7	5.6	7.9
Tifton B	30.7	22.9	38.1	16.5	1.3	4.7
RS 119	24.1	19.2	31.5	7.7	M	M
Chico	20.2	19.7	24.9	7.4	M	M
A32-20	18.6	20.0	33.3	16.3	7.1	9.6
Mani Pintar	18.0	19.6	33.3	11.3	16.0	0.6
Early Bunch	22.6	27.1	32.9	6.2	Trace	Trace

provided to strengthen links between Consultative Group on International Agricultural Research (CGIAR) centers (in this case ICRISAT) and existing ACIAR projects.

To date, Australia is free of PStV, and importation of the virus for research purposes is unlikely to be approved because the groundnut industry is of economic importance. Antisera for PStV is held in Australia for checking the identity of suspicious symptoms either on seed grown in quarantine or on commercial crops. As a step towards preparedness against any eventual outbreak of PStV in commercial groundnuts in Australia, ACIAR is willing to support the research in Indonesia for resistance to either infection or seed transmission.

Bibliography

Demski, J.W., and Lovell, G.R. 1985. Peanut stripe virus and the distribution of peanut seed. Plant Disease 69(9): 734-738.

Roechan, M., Iwaki, M., Nasir, S., Tantera, D.M., and Hibino, H. 1978. Virus diseases of legume plants in Indonesia, 4, Peanut mottle virus. Contribution of Central Research Institute for Agriculture, Bogor, No 46: pp 1-11.

Thung, T . H . 1964/1947. Virusziekten van *Arachis hypogaea.* Landbouw 19:337-347.

Thung, T.H., and Tojib Hadiwidjaja. 1951. Groerstof in verband met virusziekten, in het bijzonder bij. *Arachis hypogaea.* Tijdschrift over plantenziekten 57: 95-99.

Triharso. 1975. Penelitian penyakit virus belang pada kacang tanah. Presented at Kongres Nasional ke I I I . Perhimpunan Fitopatology Indonesia. 22-25 Feb 1975.

Research on Peanut Stripe Virus Disease in the People's Republic of China

Xu Zeyong

Head, Department of Plant Protection, Oil Crops Research Institute,
Chinese Academy of Agricultural Sciences, Wuchang Wuhan, Hubei, People's Republic of China

China is the second largest producer of groundnuts in the world. Virus diseases are economically important throughout the groundnut-producing regions in China, and several virus diseases have been recently reported. Peanut mottle virus (PMV) reported from China resembles peanut stripe virus (PStV). Peanut mild mottle disease reported to occur in China is the first record of PStV in China. It is regarded as the most important virus disease of groundnuts in China.

PStV has been detected in all the groundnut-growing regions of China. In the northern areas the incidence exceeds 50%. In southern China PStV appears to be restricted to institutional farms. PStV also occurs in nearby soybeans and sesamum.

In greenhouse tests, yield losses of up to 23% were observed in groundnuts. In northern China, crop loss due to PStV was estimated to be over 200 000 t. Initial symptoms of PStV appear as chlorotic spots and ring spots which later develop into mild mottle with green stripes along the lateral veins. Stunting was observed only in plants that were infected early.

In greenhouse tests, in addition to groundnuts and soybeans, PStV systemically infected *Cassica occidentalis, Sesamum indicum, Trifolium incarnatum, Nicotiana clevelandii, N. benthamiana,* and *Trigonella foenmum graecum. Chenopodium amaranticolor, C. album, C. quinoa,* and *Cassia tora* were locally infected by the virus.

For purification purposes PStV was propagated in *Nicotiana benthamiana.* A procedure which can yield 2 mg virus from 100 g tissue was developed. An antiserum was produced. In an indirect enzyme-linked immunosorbent assay (ELISA) test, PStV antiserum did not react with PMV. In polyacrilimide gel electrophoresis PStV contained two polypeptides of molecular weight 33 500 and 30 000 daltons, and a single component of RNA with a molecular weight of 3×10^6 daltons.

Seed transmission rates from field-infected groundnuts varied from 0.2 to 12.5%, and infected seed appears to be the primary source of inoculum. Seed transmission could be correlated to the size of groundnut seed; the smaller the seed, the higher the seed transmission rate.

The majority of groundnut plants in northern China were infected when they were 5-6 weeks old. The disease incidence could be correlated with the populations of *Aphis craccivora.*

When virus-free seed produced in greenhouses was sown in the field, PStV was not observed. This appears to be an effective method to control PStV. However, methods to obtain larger quantities of virus-free seed for commercial plantations are yet to be worked out.

Over 1400 germplasm lines were screened for resistance to PStV, but none was found to be resistant. However, the genotypes Xuzhou 68-4 and Hua-37 appeared to be tolerant and additional tests are currently being performed on them. *Arachis glabrata,* PI 262801, and PI 262794 were found to be resistant to PStV. Currently non-seed transmission and tolerant sources for PMV indentified at ICRISAT are being evaluated for tolerance and non-seed transmission to PStV in northern China.

Additional experiments are now being conducted on the epidemiology of the disease. These include the role played by weeds and crop plants in providing the primary source of inoculum, the efficiency of various aphid species in transmitting PStV, vectors, peak periods of occurrence, etc. Surveys for groundnut virus diseases to determine their occurrence and economic importance are continuing in China.

Peanut Stripe Virus Disease in Thailand

Sopone Wongkaew and Sumitra Kantrong

Department of Entomology and Plant Pathology, Faculty of Agriculture,
Khon Kaen University, Khon Kaen 40002, Thailand

Duangchai Choopanya

Plant Virology Section, Division of Plant Pathology and Microbiology,
Department of Agriculture, Bangken, Bangkok 10900, Thailand

Symptoms similar to those of peanut stripe virus (PStV) were noted on groundnuts in Thailand as early as 1973. Detailed characteristics of "peanut mottle virus" reported in 1979 and 1983 resemble more closely those of PStV than those of peanut mottle virus (PMV). It was speculated that peanut chlorotic ring mottle virus (PCRMV) and some isolates of soybean mosaic virus (SMV) reported in 1986 might be isolates of PStV. In Thailand, the identity of PStV was serologically confirmed in 1985.

The disease is widespread, but high incidence is still limited to research institute farms. Reports on yield losses are conflicting and no definitive data are available. Symptoms caused by PStV on groundnuts vary depending upon the genotypes grown, the virus isolate, and mixed infection with other viruses. PStV is serologically related to SMV and black-eye cowpea mosaic virus, but not to PMV. A distant serological relationship was detected between PStV and cowpea aphidborne mosaic virus. At present, three symptom variants (isolates) of PStV have been identified. They differ in symptomatology, host range, sap and aphid transmission frequency, and some other physical properties. The agar gel double diffusion serological test could not differentiate the three variants. Seed transmission varied from 0-7% depending on the cultivars. In Tainan 9 the transmission was 0.5-3.0%, independent of the test conditions. *Aphis craccivora* was the only aphid species found infesting groundnuts in Thailand. There were two peak infestation periods observed in the rainy-season crops, 15-20 days after sowing and 50-60 days after sowing. The transmission efficiencies of *A. craccivora* were 3-100% depending on the virus variants and the test conditions.

Many legume species grown as cover or pasture crops have been indexed and found to harbor PStV. Chemical applications to lessen the disease incidence were tried, but without success; therefore more emphasis has been given to screening germplasm. The program was started in 1985 when 85 lines were selected as having low PStV incidence. The test was repeated in 1986 with more replications and a more intensive insecticide spraying program. High PStV incidence was observed in all the lines tested including a line that had no infection in the previous year. It is suggested that the effect of insecticide sprays on PStV incidence should be investigated. Since PStV incidence appears to be confined to research institute farms, it may be possible to prevent its spread to farmers' crops by distributing seed from PStV-free areas. International organizations could be of great assistance in providing technical advice, reliable antisera, and potential PStV resistant or tolerant groundnut germplasm to the countries where PStV is endemic.

Peanut Stripe Virus Disease in the Philippines

Candida B. Adalla

Department of Entomology, College of Agriculture, University of the Philippines
at Los Bafios, Laguna 3720, Philippines

Marina P. Natural

Plant Pathologist, Institute of Plant Breeding, University of the Philippines
at Los Banos, Laguna 3720, Philippines

Groundnut production in the Philippines rose from a meagre 40800 t in 1976 to 486 000 t in 1982. This increase has been partly due to improved varieties and production technology from the National Research and Development Program. Despite this increase, the country still imports groundnuts. The present low average yield of 920 kg ha^{-1} indicates that more needs to be done to provide high-yielding varieties and a production technology adaptable to widely varied environments.

High incidence of peanut stripe virus (PStV) in the Philippines was first reported by D.V.R. Reddy of ICRISAT during a visit in 1984. Subsequent surveys have indicated that this disease is widespread in the country, although a few areas such as Midsayap in North Cotabato may be free of PStV. Additionally, PStV incidence appears to be more severe in the dry season than in the rainy season.

By using the agar gel double diffusion technique with PStV antiserum provided by Dr Demski, scientists in the Philippines have been able to demonstrate that PStV differs from peanut mottle virus (PMV), although the symptoms of PMV resembled those of the "mosaic variant" of PStV.

A wide range of symptoms have been observed, including discontinuous stripes, vein clearing, a mosaic pattern of dark green islands that persists in older leaflets and can be mistaken for PMV, and the oakleaf pattern. The range of symptoms seems to vary with variety. In all varieties, symptom expression is usually severe by 6 weeks after germination, and reaches a plateau 2 weeks later with no further symptom development as the plants mature.

Preliminary yield loss assessments using infected and virus-free potted plants showed a 0.5-24.0% reduction in yield depending on the cultivar. The cultivar UPL Pn 4 with about 10.0% infected plants in a 20 m^2 plot had about 67% lower yield than a similar plot with 1.7% infected plants.

Aphis craccivora and *A. gossypii* transmit PStV. ICG 5240, an aphid-resistant genotype, did not develop PStV infection when exposed to viruliferous aphids, whereas UPL Pn 4 had about 36% infected plants under the same treatment. At the moment, it is not clear if the resistance observed in ICG 5240 is due to resistance to aphids or to the virus. We are currently investigating this aspect.

Although much work needs to be done before economically feasible measures to control PStV can be recommended to Philippine groundnut farmers, there are currently no funds for organized research. However, a limited amount of work is being done by researchers through personal committment, so that when funding is identified it should be possible to move quickly into a full-fledged research program.

Peanut Stripe Virus Disease in the USA

J.W. Demski

Professor, Department of Plant Pathology
Georgia Experiment Station, Experiment, GA 30212, USA

D.V.R. Reddy

Principal Legumes Virologist, Legumes Program, ICR1SAT,
Patancheru, Andhra Pradesh 502 324, India

Peanut stripe virus (PStV) was first observed in the USA in 1982, and extensive surveys for this disease were conducted during the 1983-1986 growing seasons. PStV was detected only in institutional productions.

Although crop losses due to PStV in the USA have been estimated, no statistically significant data were obtained because yields varied widely. The long duration of cultivars commonly grown in the USA, the omnipresence of aphid vectors, the susceptibility of all commercially grown cultivars, the relatively high seed transmission rate, and the wide host range of PStV, are all factors which may contribute to frequent epidemics of PStV.

On the basis of symptoms in groundnut, at least two different isolates of PStV were identified. One isolate produces blotch symptoms and the other stripe symptoms. Following purification by serial transfer of single lesions produced on *Chenopodium amaranticolor,* both the isolates were maintained in lupine *(Lupinus albans).* Twenty of the most common U.S. groundnut cultivars were susceptible to both the PStV isolates.

For the purpose of purification, PStV was maintained in lupine. The method developed was reported by Demski et al. (1984). An antiserum was produced in rabbits. In enzyme-linked immunosorbent assay (ELISA) tests both blotch and stripe PStV isolates reacted strongly to antisera of black-eye cowpea mosaic, soybean mosaic, and clover yellow vein viruses. PStV isolates were not serologically related to PMV, bean yellow mosaic, potato virus Y, or tobacco etch viruses.

ELISA tests and dot blot hybridization using C-DNA probes were successfully used to detect PStV in seed. The dot blot hybridization test appears to be more sensitive than ELISA. Seed transmission rates were determined for the Florunner cultivar infected with PStV under field conditions. The infection rate varied from plant to plant, ranging from 1 to 32%.

Epidemiological tests conducted so far in the USA indicate localized secondary spread from a primary source. *Desmodium* sp. (beggarweed) and *Indigofera* sp. are likely to act as inoculum sources, however the major source of primary inoculum is seed. Soybeans and cowpeas are commonly grown along with groundnuts in the USA . In tests on over 15000 soybean and 10000 cowpea seeds, PStV was not seed transmitted in these crops.

Since PStV is largely restricted to institutional areas, guidelines have been formulated which would restrict virus spread from these locations. Resistance to PStV has not so far been identified in *Arachis hypogaea.*

Demski, J.W., Reddy, D.V.R., Sowell, G. Jr., and Bays, D. 1984. Peanut stripe virus -a new seed-borne potyvirus from China infecting groundnut *(Arachis hypogaea).* Annals of Applied Biology, 105: 495-501.

Special Papers

Virus Program in Southeast Asia Sponsored by the Tropical Agriculture Research Center, Japan

M. Kameya-Iwaki

Leader, Plant Pathology Department, National Agriculture Research Center, Yatabe, Tsukuba, Ibaraki 305, Japan

The Tropical Agriculture Research Centre (TARC) in Japan sponsored a project from April 1978 to March 1982 on virus diseases of legumes in Southeast Asia. In groundnuts, peanut mottle virus (PMV), peanut stripe virus (PStV), tomato spotted wilt virus (TSWV), and cowpea mild mottle virus (CMMV) were found to be widely distributed. In addition to production of antisera, host range and physicochemical properties were determined for the four viruses isolated from groundnuts. Data on PStV (earlier referred to as peanut chlorotic ring mottle virus) are presented in this paper.

PStV was found to be widely distributed in Thailand, Malaysia, and Indonesia. *Chenopodium amaranticolor, C. quinoa,* and *Tetragonia expansa,* were found to be good local lesion hosts. *Vicia faba, Vigna mungo, V. unguiculata, V. sesquipedalis, Nicotiana clevelandii, Petunia hybrida, Sesamum indicutn, Gomphrenaglobosa,* and *Lathyrus odoratus,* were symptomless hosts. Unlike PMV, PStV did not infect *Pisum sativum* and *Phaseolus vulgaris* (cv. Topcrop).

In the agar gel diffusion test, PStV reacted positively with black-eye cowpea mosaic virus (BICMV), bean common mosaic virus (BCMV), and soybean mosaic virus (SMV) antisera. In the precipitin ring test, PStV reacted strongly with BICMV, BCMV, and SMV, and weakly with PMV (PN strain from Japan). Antisera to four isolates of PMV from Africa and to peanut green mosaic virus failed to react with PStV in either agar gel diffusion or precipitin ring tests.

PStV was found to contain single-stranded RNA. The molecular weight of denatured RNA was 3.49×10^6 daltons. PStV contained a major polypeptide of 35 600 daltons and two minor polypeptides of 33 400 and 27 000 daltons. The two minor polypeptides may have been derived as a result of proteolysis of the major polypeptide.

An isolate of PStV recently observed in groundnuts in Japan is currently being characterized.

Surveys for Peanut Stripe Virus in East and Southeast Asia

D.V.R. Reddy

Principal Legumes Virologist, Legumes Program, ICRISAT,
Patancheru, Andhra Pradesh 502 324, India

J.W. Demski

Professoer, Department of Plant Pathology
Georgia Experiment Station, Experiment, GA 30212, USA

K.J. Middleton

Senior Plant Pathologist, Department of Primary Industries, J.Bjelke-Petersen
Research Station, P.O. Box 23, Kingaroy, Queensland 4610, Australia

J.C. Wynne

Professor, Crop Science Department,
North Carolina State University, Raleigh, NC 27695, USA

Peanut stripe virus (PStV) disease of groundnut was first reported in the USA in 1984, after it came into the country in seed from the People's Republic of China. The occurrence of PStV in the People's Republic of China was thus indicated, and a peanut mild mottle virus (PMMV) reported from China in 1983 was subsequently shown to be a strain of PStV. Groundnut mosaic virus (GMV), reported from Malaysia in 1972, produces symptoms in groundnut similar to those of PStV, and has a similar host range, but unlike PStV it is serologicaly related to PMV. However, this should be confirmed using enzyme-linked immunosorbent assay (ELISA), because the original investigations used rather insensitive serological methods. Peanut chlorotic ring mottle virus (PCRMV), reported in 1985 and 1986 from Thailand and Indonesia, has a striking resemblance to PStV in host range and in serological relationships, and can be regarded as a strain of PStV.

It was thought likely that PStV could be present in other countries of East and Southeast Asia in addition to China. Thus ICRISAT proposed surveys in the region to determine the occurrence and distribution of PStV. A survey was conducted in 1984 in Thailand, the Philippines, and Indonesia, with financial assistance provided by the USA Peanut CRSP. Samples collected in each country were processed by the double antibody sandwich form of ELISA (DAS-ELISA). Occurrence of PStV was confirmed in all the countries surveyed, although the ELISA test procedure used did not permit determination of serological relationships of the various PStV isolates processed during the surveys.

In 1986, a simple indirect ELISA test procedure (direct antigen coating, or DAC) suitable for the detection and determination of serological relationships of viruses in surveys was developed at ICRISAT. Surveys were undertaken in Indonesia in 1986, in cooperation with scientists working in the ACIAR project on groundnut diseases, and the samples were tested by DAC-ELISA. The presence of PStV was confirmed in several locations in Indonesia. It is apparent from the surveys conducted so far that PStV is economically important in Indonesia and in several other groundnut-growing countries in East and Southeast Asia.

PStV has been recorded in South Asia (Prasada Rao et al., 1988). We have surveyed groundnut crops in several locations in India and further disease surveys are proposed to cover Pakistan, Bangladesh, Nepal, Burma, and Sri Lanka. Since PStV is seed-transmitted, care should be taken to avoid spreading this disease in infected seed to countries where PStV is currently not known to occur.

Bibliography

Prasada Rao, R.D.V.J., Reddy, A.S., and Chakravarthy, S.K. 1988. Survey for peanut stripe virus in India. Indian Journal of Plant Protection, 16: 99-102.

Discussion Papers

Identification of Peanut Stripe Virus

D.V.R. Reddy

Principal Legumes Virologist, Legumes Program, ICRISAT,
Patancheru, Andhra Pradesh 502324, India

J.W. Demski

Professor, Department of Plant Pathology,
Georgia Experiment Station, Experiment, GA 30212, USA

N. Horn

Virologist, The Netherlands Project ATA-272 Malang Research Institute for Food Crops (MARIF),
Jalan Raya Kendalpayak, P.O. Box 66, Malang 65101, Indonesia

Peanut stripe virus (PStV) is a potyvirus that occurs as several isolates inducing distinct symptoms in groundnut. It can be distinguished from other groundnut potyviruses by serological tests such as enzyme-linked immunosorbent assay (ELISA). PStV is serologically related to black-eye cowpea mosaic (BICMV), clover yellow vein (CYVV), and soybean mosaic (SMV) viruses. PStV can also be distinguished by infectivity assays on *Chenopodium amaranticolor* and *C. quinoa.*

In surveys in Southeast Asia we often found PStV-infected groundnuts to be co-infected with peanut mottle virus (PMV), another widely distributed potyvirus. Both viruses are seed-transmitted, and are efficiently vectored by the same aphids.

Characteristics used to distinguish PMV from PStV.

Test	Peanut stripe	Peanut mottle
Serological, ELISA	Closely related to BICMV and CYVV. Not related to PMV.	Not related to BICMV or PStV.
Infectivity assays	Local lesions produced on: *Chenopodium amaranticolor* and *C. quinoa.* Does not infect *Phaseolus vulgaris* (cv Topcrop).	Local lesions produced on: *P. vulgaris* (cv Topcrop). Does not infect *C. amaranticolor.*
Symptoms on groundnut	Discontinuous stripes and severe mosaic symptoms on leaflets.	Mild mottling, interveinal depression and inward rolling of edges.

Occurrence of Isolates of Peanut Stripe Virus

D.V.R. Reddy

Principal Legumes Virologist, Legumes Program, ICRISAT,
Patancheru, Andhra Pradesh 502 324, India

J.W. Demski

Professor, Department of Plant Pathology,
Georgia Experiment Station, Experiment, GA 30212, USA

Sopone Wongkaew

Department of Entomology and Plant Pathology, Faculty of Agriculture,
Khon Kaen University, Khon Kaen 40002, Thailand

K.J. Middleton

Senior Plant Pathologist, Department of Primary Industries, J.Bjelke-Petersen
Research Station, P.O. Box 23, Kingaroy, Queensland 4610, Australia

The different isolates of peanut stripe virus (PStV) produce distinct symptoms in groundnuts, which is probably the reason for its description under different names by different authors. Two isolates, one of which produces blotch symptoms and the other stripe symptoms, were identified from the virus introduced through seed to the USA. Blotch appears to be the most common symptom produced by isolates from Southeast Asia. Chlorotic rings surrounding the blotches, especially on young quadifoliates, have been described as peanut chlorotic ring mottle virus. Severe blotch symptoms produced by PStV isolates in Malaysia were described as groundnut mosaic. Isolates which produce milder reactions, referred to as peanut mild mottle, have been reported from the People's Republic of China. More recently, three distinct isolates of PStV have been reported from Thailand.

The isolates of PStV tested to date cannot be distinguished by their serological cross reactions with black-eye cowpea mosaic virus (BICMV), soybean mosaic virus (SMV), and clover yellow vein virus (CYVV) antisera. However, they can be distinguished by the symptoms they produce on different genotypes of cowpea and soybeans.

In order to determine the relationships between different PStV isolates occuring in Southeast Asia and the USA, it will be necessary to test them under identical conditions. Thus it is essential to identify research institutions in Europe that can accept live infected groundnut material and are willing to provide facilities for characterizing the various PStV isolates. This is vital for precise identification of PStV isolates and for multilocational testing of groundnut germplasm for resistance to PStV.

Control of Peanut Stripe Virus through Vector Management

P.W. Amin

Groundnut Entomologist, Legumes Program, ICRISAT,
Patancheru, Andhra Pradesh 502 324, India

Prior to undertaking research into management of peanut stripe virus (PStV), it is essential to know its economic importance. The principal aphid vector appears to be *Aphis craccivora,* but other aphid species may be involved in transmission, and these should be identified. Several biotypes of A *craccivora* are known. It is essential to determine if these biotypes differ in the efficiency with which they transmit PStV. Aphids from different ecological zones should be collected and tested for their ability to transmit PStV. This would help to interpret the occurence of different levels of field incidence of PStV in different regions, and could identify areas where the aphid vectors are not so efficient in transmitting PStV.

It is essential to identify an aphid vector host immune to PStV. This would help in rearing virus-free aphid colonies. It is also essential to study the reproduction and migratory behavior of *A. craccivora* on legumes. Plant hosts which provide sources of inoculum should be identified.

Aphids can be easily controlled by using insecticides. Additionally, farmers in Southeast Asia are familiar with the application of insecticides. By controling aphids it is also possible to prevent secondary spread of PStV. It is essential to determine when it is best to apply the insecticides. PStV control utilizing insecticides is a short-term measure because insecticides are costly and may have adverse effects on the environment.

Adopting various cultural practices is a better alternative to insecticide applications for controling PStV. These include early sowing to avoid high PStV incidence in relatively young crops, sowing at high density, frequent rogueing of PStV-infected plants, and intercropping with non-hosts of PStV.

PStV can be controlled by growing cultivars which are resistant to aphid vectors or to the virus. PStV-tolerant cultivars should not be used unless they have low virus concentration and low seed transmission rates. IGG 5240 genotype has aphid resistance and should be evaluated for resistance to PStV. If a resistance breeding program is to be undertaken it would be beneficial to combine virus resistance with vector resistance.

Groundnut Virus Diseases and their Quarantine Implications in Seed Exchange

R.B. Singh

Regional Plant Production and Protection Officer, FAO Regional Office
for Asia and the Pacific, Maliwan Mansion, Phra Atit Road, Bangkok 10200, Thailand

Of the world groundnut production of 20 million t, 13 million t are produced in the Asia and Pacific region, comprising parts of West Asia, South Asia, Southeast Asia, East Asia, and South Pacific countries, including Australia and New Zealand. The major groundnut-producing countries in the region are India, the People's Republic of China, Indonesia, Burma, and Thailand. Groundnut yields are low in the region and seldom exceed 11 ha^{-1} under rainfed conditions. Diseases are considered to be one of the major constraints on yields. Among virus diseases of groundnut, tomato spotted wilt (TSMV), peanut mottle (PMV), peanut stripe (PStV), Indian peanut clump (IPCV), and cowpea mild mottle (CMMV) viruses are considered to be economically important. Nevertheless, the distribution of these viruses utilizing precise methods of virus diagnosis has not yet been studied. Thus surveys for the occurrence and distribution of important virus diseases are essential.

Among the virus diseases of groundnut reported from the Asia and Pacific region, PMV, PStV, and IPCV are seed-transmitted.

The fact that this meeting is entirely devoted to PStV underlines the importance of this disease to groundnut production in the region. Only recently has the occurrence of PStV in the region been realized; it appears now that it was earlier misidentified as PMV.

International exchange of germplasm and importation of large quantities of advanced breeding material to conduct regional trials is expected to increase considerably. Unless rigorous quarantine procedures are followed this may lead to introduction of exotic insect pests and diseases. Virus diseases are especially difficult to identify in quarantine because the highly specialized skills and equipment required for virus detection are lacking. Unfortunately, virus diseases cannot be eliminated from contaminated seed lots by using seed treatment. Additionally, in growing-out tests, seedborne viruses may not express any overt symptoms.

Thus in order to establish effective quarantine measures, precise diagnosis is a prerequisite both for pre-and post entry quarantine purposes. Serological tests such as latex flocculation, and enzyme-linked immunosorbent assay (ELISA) are recommended for virus detection in quarantine. Tests which provide results without destroying the viability of seed are preferred. It is also essential to adopt a throughput system which permits testing several thousand seeds in a day. Thus it is essential that the FAO/UNDP project on Technical Cooperation for Developing Countries on research and development of food legumes and coarse grains in the Asia and the Pacific region-RAS/82/002-should organize a training course on the diagnosis of groundnut virus diseases. An illustrated training manual should also be prepared to assist quarantine officials.

Following verification of the causal organisms of the various diseases of economic importance, an intergovernmental agreement about disease distribution could be arranged. It would be advisable to circulate this document widely among interested countries for use with quarantine procedures. In 1949 during the Phytosanitary Conference in the UK, the formation of a Plant Protection Commission for the Asia and Pacific Region was recommended. After FAO had received the formal governmental approvals for constituting the Commission, it met for the first time in 1956. Currently this Commission has representation from 24 member countries. One of the Commission's main functions is to monitor the disease and insect pest situation in the region, and keep the member countries informed of new pests. The Commission has also distributed a list of existing insect pests and diseases in the region.

It is essential that this meeting should make a suitable recommendation to the Commission to include specific insect pests and diseases of groundnut, including PStV, in the intergovernmental agreement. The 15th session of the Commission was scheduled to be held in October 1987 and the recommendations by the group could be considered for adoption during this session.

Peanut Stripe Virus Yield Loss Studies

J.W. Demski

Professor, Department of Plant Pathology,
Georgia Experiment Station, Experiment, GA 30212, USA

D.V.R. Reddy

Principal Legumes Virologist, ICRISAT,
Patancheru, Andhra Pradesh 502 324, India.

Accurate yield loss assessments for peanut stripe virus (PStV) in groundnuts are difficult to make. Estimates under greenhouse conditions are relatively easy to obtain, but may not reflect losses under field conditions. Crops raised under screen cages which can exclude aphids are severely affected by shading. Over 30% yield losses have been recorded in groundnuts from shading alone as compared to crops grown without screen cages. Screens also create temperature and humidity differences.

Yield losses estimated under natural growing conditions would probably give the most acceptable data. However, it is difficult to conduct these experiments because of virus spread from infected to healthy plants by aphids. Thus the following protocols are proposed for consideration:

- Plant a non-host crop such as maize in a large field (1 ha). Establish 12 small plots (4 x 4 m) for groundnuts within the maize field so that each groundnut plot is at least

20 m distant from any other groundnut plot. Use groundnut seeds that are not contaminated with PStV. Inoculate plants in six randomly selected plots, and leave the other six plots untreated for comparison. It may be essential to inoculate plants at different growth stages.

- Establish 24 groundnut plots (using virus-free seed) in one general location that is isolated from other groundnut plots. Apply a granular systemic insecticide such as Temik® (aldicarb) to the soil at sowing and apply foliar insecticides weekly after emergence. Inoculate the plants in six plots with PStV. After harvest compare the yield of inoculated plots to the yield of the six other plots that have the least incidence of PStV.
- Sow groundnut seed known to have a low level (about 1 %) of PStV seed infestation in a plot 50 x 50 m. Two weeks after emergence, place red flags beside each of 100 PStV-infected plants, and 600 white flags (randomly throughout the field) beside groundnut plants that are healthy. Six weeks after emergence, place a red mark on each white flag that is now beside an infected plant. Twelve weeks after emergence, place a blue mark on each white flag that is now beside an infected groundnut plant. Before harvest, place a yellow mark on each white flag that is beside an infected groundnut plant. After harvest, compare the average plant yield for those marked red, blue, yellow, and white.
- Many potyviruses lose their ability to be transmitted by aphids after several years of being mechanically transmitted in a greenhouse. When such an isolate of PStV is obtained it should be used to inoculate plants in randomized complete block designed plots in the field.
- Other tests may be appropriate such as open top chambers, but these usually are expensive and take considerable time to maintain.

Peanut Stripe Virus-free Seed Production

K J. Middleton

Senior Plant Pathologist, Department of Primary Industries, J.Bjelke-Petersen
Research Station, P.O. Box 23, Kingaroy, Queensland 4610, Australia

N. Saleh

Virologist, Department of Plant Pathology, Malang Research Institute for Food Crops (MARIF),
Jalan Raya Kendalpayak, P.O. Box 66, Malang 65101, Indonesia

It is well documented that PStV is transmitted in seed of groundnuts. Although reports of the incidence of infected seeds vary, it is generally agreed that this virus is more highly seed transmitted than peanut mottle virus in groundnuts. For this reason, the question of virus-free seed production must be addressed.

Advantages of producing virus-free seed are:

- gradual eradication of the virus from cultivars commonly grown in East and Southeast Asia because the primary source of inoculum is provided by seed-transmitted plants, and
- export of virus-free seed, especially to countries with inadequate quarantine facilities to detect the virus.

Virus-free seed can be produced by growing healthy seed, tested by enzyme-linked immunosorbent assay (ELISA), in areas where PStV is currently not known to occur. In areas where aphid vectors are not likely to be active when the groundnut crop is young, the proportion of seed containing PStV is not likely to be high. If a small number of plants with PStV infection from seeds are observed, they can be rogued. It may not be practical to import and multiply large quantities of seed from countries where PStV is currently not known to occur, because of transport costs and chances of introducing other seedborne pathogens.

Production of Peanut Stripe Virus-free Seed and Screening Groundnuts for Resistance to Peanut Stripe Virus

K.J. Middleton

Senior Plant Pathologist, Department of Primary Industries, J.Bjelke-Petersen Research Station, P.O. Box 23, Kingaroy, Queensland 4610, Australia

N. Saleh

Virologist, Department of Plant Pathology, Malang Research Institute for Food Crops (MARIF), Jalan Raya Kendalpayak, P.O. Box 66, Malang 65101, Indonesia

N. Horn

Virologist, The Netherlands Project ATA-272, Malang Research Institute for Food Crops (MARIF), Jalan Raya Kendalpayak, P.O. Box 66, Malang 65101, Indonesia

D.V.R. Reddy

Principal Legumes Virologist, Legumes Program, ICRISAT, Patancheru, Andhra Pradesh 502 324, India

Peanut stripe virus (PStV) is transmitted through seed at rates of between 4 and 30%. Under field conditions, and depending upon the time of infection, cultivar, environmental conditions, etc., seed transmission may vary from 0.1 to 10.0%. Infected seeds appear to be the primary source of inoculum. Thus if virus-free seed can be provided to farmers, disease incidence would be substantially reduced. This may be achieved by locating production areas within Indonesia where PStV incidence is low, and utilizing these areas to produce virus-free seed to supply farmers. Adequate seed storage facilities and an efficient seed distribution system would be essential. Crops intended for seed production would have to be constantly monitored for incidence of PStV, especially during early stages of plant growth and at harvest in order to minimize PStV contamination of seed.

Peanut stripe virus is currently recognized as one of the most important diseases of groundnuts in several countries in Southeast Asia. Although sources of resistance have been reported in wild *Arachis* spp., no systematic efforts have been made to screen large numbers of *Arachis hypogaea* germplasm lines. It is proposed that germplasm lines be screened under field conditions at sites known to experience high PStV incidence. By providing inoculum through seed-transmission and mechanical inoculation of plants, and by utilizing field designs that favor disease spread by aphids, it should be possible to achieve nearly 100% disease incidence. Efforts should be made to control other diseases and pests so that they do not mask or enhance symptoms. Scoring for PStV should take into account:

- percentage disease incidence,
- type of symptoms observed,
- serological testing of all plants which failed to show disease symptoms, and
- yield estimations, especially from PStV-infected genotypes which show either mild

or no overt disease symptoms. This is important in the search for sources of tolerance.

All genotypes that were not infected under high disease pressure in field trials should be evaluated under laboratory conditions by mechanical inoculation.

Long-term experiments to locate sources of resistance to PStV should include:

- the identification of genotypes with no seed transmission of PStV,
- the location of resistance in cross-compatible wild *Arachis* species, and
- the identification of genotypes that combine resistance to PStV with resistance to bacterial wilt.

When sources of resistance are found, it will be necessary to determine both the genetics and components of resistance to assist breeders' attempts to combine the various forms of resistance, especially tolerance and non- seed transmission.

Screening, Breeding, and Maintenance of Groundnut Varieties Resistant to Peanut Stripe Virus

Astanto Kasno

Peanut Breeder, Malang Research Institute for Food Crops (MARIF),
Jalan Raya Kendalpayak, P.O. Box 66, Malang 65101, Indonesia

Peanut stripe virus (PStV) was first reported in Indonesia in 1986 (D.V.R. Reddy, ICRISAT, personal communication). Another virus disease of groundnut that is widespread in Indonesia is peanut mottle virus (PMV) which can cause yield losses of up to 30%. It appears that PStV may be of greater economic importance than PMV in Indonesia, and research to screen for disease resistance and formulate cultural practices for controling PStV should be given high priority. There are plans to screen over 6000 groundnut genotypes from ICRISAT in Indonesia, along with 200 local cultivars. This will be the first large-scale, systematic screening of groundnut germplasm for resistance to PStV. About half of the genotypes will be screened at the Muneng Experimental Farm of MARIF, and the other half at the Barru Experimental Farm of the Maros Research Institute for Food Crops (MORIF). Field screening will be done using special techniques to ensure a high PStV incidence. Infector rows of cv Gajah will be sown at least 2 weeks prior to test rows. In addition, Gajah seed derived from field-infected PStV plants will be sown within test rows at regular intervals.

If groundnut genotypes possessing some degree of resistance to the PStV are identified, they will be used to breed suitable PStV-resistant cultivars. The easiest situation will be if resistance genes are found within existing commercial Indonesian varieties. Should the genes be found in unadapted genotypes, either a backcrossing program may be suitable, or the standard pedigree system following one or more crosses between appropriate genotypes may be used.

Recommendations

The participants at the meeting recommended that:

1. Future research on PStV should be coordinated by the Asian Grain Legume Network (AGLN) of ICRISAT and should involve:
   - Identification of sources of resistance to PStV;
   - Characterization of isolates of PStV, preferably in a country where groundnuts are not grown;
   - Epidemiological studies, including identification of alternate hosts, principal aphid vectors, and areas where virus-free seed can be produced;
   - Assessment of crop losses due to PStV in the field; and
   - Development of an integrated PStV disease management package for use by farmers.
2. A training workshop should be held on the identification and diagnosis of PStV. FAO should be approached for funds and the workshop should be held in Indonesia in mid-1988. Participants should be chosen from groundnut growing countries of the Asia-Pacific region and should have the capacity to utilize the procedures acquired for research in their home countries.
3. Surveys should be undertaken to determine if PStV is present in other countries of Asia and Oceania.
4. An information bulletin should be produced on PStV by ICRISAT. Dr J.W. Demski is to coordinate its production.
5. All groundnut seed for sowing that is exported from countries known or suspected to have PStV should be assayed for the presence of the virus using sensitive detection methods such as enzyme-linked immunosorbent assay (ELISA).
6. The coordinator of ICRISAT's Asian Grain Legumes Network (AGLN) should write to the Inter-Governmental Asia-Pacific Plant Protection Commission outlining the current importance of PStV in groundnut.
7. The ad hoc committee on PStV nomenclature should publish the results of their deliberations as a Letter to the Editor in an international journal, preferably in *Phytopathology.*
8. The following scientists are requested to coordinate research on PStV in their countries or for their organizations; they are encouraged to obtain the necessary approvals prior to undertaking this task:

Indonesia	Dr N. Saleh	China	Mr Xu Zeyong
Australia	Dr K.J. Middleton	ICRISAT	Dr D.V.R. Reddy
Japan	Dr M. Kameya-Iwaki	India	Dr R.D.V.J. Prasad Rao
Thailand	Dr S. Wongkaew	USA and Peanut CRSP	Dr J.W. Demski
Malaysia	Dr Ong		

9. The second meeting of PStV coordinators should be held in 1989, preferably in Thailand, to review the progress made by the various groups, and to plan future research on PStV.

Participants

Dr Candida B. Adalla
Department of Entomology
College of Agriculture
University of the Philippines
at Los Banos
Laguna 3720
Philippines

Dr P.W. Amin
Groundnut Entomologist
Legumes Program
ICRISAT Patancheru
Andhra Pradesh 502 324
India

Dr Sutaryo Brotonegoro
Director
Malang Research Institute
for Food Crops (MARIF)
Jalan Raya Kendalpayak
P.O. Box 66
Malang 65101
Indonesia

Dr Duangchai Choopanya
Plant Virology Section
Division of Plant Pathology
and Microbiology
Department of Agriculture,
Banken Bangkok 10900
Thailand

Dr J.W. Demski
Professor
Department of Plant Pathology
Georgia Experiment Station
Experiment, GA 30212
USA

Dr D.G. Faris
Coordinator, AGLN
Legumes Program
ICRISAT
Patancheru
Andhra Pradesh 502 324
India

Dr N. Horn
Virologist
The Netherlands Project ATA-272
Malang Research Institute
for Food Crops (MARIF)
Jalan Raya Kendalpayak
P.O. Box 66
Malang 65101
Indonesia

Dr M. Kameya-Iwaki
Leader, Plant Pathology Department
National Agriculture Research Center
Yatabe, Tsukuba
Ibaraki 305
Japan

Dr Astanto Kasno
Peanut Breeder
MARIF
Jalan Raya Kendalpayak
P.O. Box 66
Malang 65101
Indonesia

Mr K.J. Middleton
Senior Plant Pathologist
Department of Primary Industries
J.Bjelke-Petersen Research Station
P.O. Box 23, Kingaroy
Queensland 4610
Australia

Dr Marina P. Natural
Plant Pathologist
Institute of Plant Breeding
University of the Philippines
at Los Banos
Laguna 3720
Philippines

Dr D.V.R. Reddy
Principal Legumes Virologist
Legumes Program
ICRISAT
Patancheru
Andhra Pradesh 502 324
India

Dr N. Saleh
Virologist
Department of Plant Pathology
Malang Research Institute
for Food Crops (MARIF)
Jalan Raya Kendalpayak
P.O. Box 66
Malang 65101
Indonesia

Dr R.B. Singh
Regional Plant Production and
Protection Officer
FAO Regional Office for Asia
and the Pacific
Maliwan Mansion
Phra Atit Road
Bangkok 10200
Thailand

Mr Sadikin Somaatmadja
Researcher
Bogor Research Institute for
Food Crops (BORIF)
Jalan Cimanggu No. 3A
Bogor 16114
Indonesia

Dr D.M. Tantera
Virologist
Department of Plant Pathology
and Entomology
Central Research Institute
for Food Crops,
Jalan Merdeka 99
Bogor
Indonesia

Prof Triharso
Dean
Universitas Gajah Madah (UGM)
Yogyakarta
Indonesia

Dr Wasmo Wakman
Maros Research Institute
for Food Crops
P.O. Box 173
Ujung Pandang
Indonesia

Dr Sopone Wongkaew
Department of Entomology
and Plant Pathology
Faculty of Agriculture
Khon Kaen University
Khon Kaen 40002
Thailand

Dr Xu Zeyong
Head, Department of Plant Pathology
Oil Crops Research Institute
Chinese Academy of Agricultural
Science
Wuchang Wuhan,
Hubei
People's Republic of China

Observer

Mr Yuliantoro Baliado
Malang
Indonesia

RA-00148

ICRISAT

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

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