PRESENT STATUS OF RICE AND LEGUME VIRUS DISEASES IN INDONESIA

D. M. Tantera*

ABSTRACT

Rice tungro virus, grassy stunt virus and ragged stunt virus have been a potential menace to rice production. Research on these virus diseases in the past ten years has resulted in an improvement of the understanding of their biology and ecology to enable the development of effective methods to control these diseases. An integrated control technique combining the use of resistant varieties, cultural practices and insect control has brought about a considerable decrease in virus infection in our rice crop in the last 3 years.

A varietal rotation scheme has been successfully implemented for tungro virus in South Sulawesi. Varietal resistance is used extensively for grassy stunt virus, in combination with cultural practices and insecticidal spray. Yellow dwarf and orange leaf diseases are present but are less important.

Soybean, green gram, peanuts, cowpea are among the important legume crops in the country. New viruses identified in the last 10 years are soybean dwarf, soybean stunt, soybean mosaic, and bean yellow mosaic on soybean, black gram mosaic, bean yellow mosaic, mungbean mosaic on green gram; peanut mottle, on peanuts; cowpea aphid-borne mosaic, soybean yellow mosaic on cowpea. These viruses are considered to be the limiting factor in leguminous crop seed production.

Seed infection with some viruses plays an important role in the dissemination of the diseases and means of effective control of such a problem will be studied in the coming years.

Introduction

Indonesia is the largest nation in the tropics with more than 165 million people. About 7.5 million ha or rice are cropped every year and this is done most intensively in the islands of Java, Bali and the southern part of Sulawesi. In addition to rice, some leguminous crops are regularly planted, particularly in the dry monsoon season. The most important leguminous crops are soybeans, peanuts, green grams, cowpeas, etc. In the rainfed areas of Sumatera, legumes are frequently intercropped with upland rice or cassava.

In the last twenty years much effort has been made to increase food production to meet the demand for the increasing population. Each year the population increases by about 2.3% which roughly requires half a million ton of additional food. Therefore most of the agricultural land is cropped twice a year. Intensive efforts, in the past 20 years enabled Indonesia to achieve self-sufficiency in rice production. However, continuous efforts in research must be pursued to achieve the stability in production and to ensure improvement in crop yield potential.

One of the limiting factors in crop production is the yield loss due to pests and diseases. In general losses vary from year to year, depending upon varietal susceptibility, control measures adopted and environmental factors. Among the various pathogens viruses are considered as the most important factor of yield loss. In rice, rice tungro virus, grassy stunt virus and ragged stunt viruses are most dangerous. In the last ten years, rice tungro virus infected 126,408 ha and grassy stunt/ragged stunt damaged another 200,000 ha of crop. It will probably continue to be so in the future unless effective control measures are implemented, particularly in the endemic areas.

Among the diseases of leguminous crops, virus diseases are most significant. About 15 distinct virus diseases are known to affect 4 kinds of leguminous crops of economic importance, some of them being transmitted through seeds.

---

* Plant Pathologist, Bogor Research Institute for Food Crops, Bogor, Indonesia.

The seeds of most legumes are critical due to their relatively short viability. Unavailability of seeds at planting time often requires long distance seed transport to meet the farmers' demand. In many cases virus pathogens are disseminated by seeds. In this paper the author reviews some of the studies conducted by various researchers in relation to problems of rice and legume viruses in Indonesia. Some of the studies were carried out under the Indonesia-Japan Joint Food Crop Research Program which started in 1970 and continued up to 1978.

In this paper a review of the distribution and damage caused by rice virus diseases is briefly presented including new findings on legume viruses in relation to some biological and ecological aspects.

Rice virus diseases

1 Rice tungro virus (RTV)

1) Distribution and damage

In Java and Sumatera, a tungro-like disease was identified in 1969. In South Sumatera, the disease was called "mentek" possibly due to its similarity to a disease which occurred in Java causing great loss in 1920-1930. In the wet season of 1969-1970 the virus affected 5,000 ha of rice crop in South Sumatera. At about the same time "penyakit habang" also occurred in South Kalimantan affecting about 5,000 ha. The next year in the 1970/1971 wet season the disease caused an epidemic involving more than 10,000 ha of rice crop.

In late 1972 tungro-like disease called "cella pance" began to appear in the rice crop in South Sulawesi. By mid-1973 the disease had caused a serious epidemic infecting more than 50,000 ha. It was evident that Pelita and IR5 which were newly introduced into the area were susceptible. The total loss between 1970-1973 due to tungro alone in various regions of Sumatera, Kalimantan and Sulawesi was estimated at 140,000 ton of rice valued at US$42 million (Table 1).

Table 1 Total rice crop area infected with RTV in Indonesia 1970 — 1985

Year	Province	Area infected (ha)	Estimated loss (t) Rice	Estimated loss Total value (US$)	Variety affected
1969/1970	South Sumatera	5,000	8,300	2.490,000	Kwatik (local)
1980	West Sumatera	500	830	249,000	IR26, IR30
1982	North Sumatera	2,000	3,320	996,000	IR36, IR42
1972/1975	South Sulawesi	97,754	162,272	48.682,000	Pelita, IR5
1976/1978	〃 〃	8,625	14,318	4.295,400	IR20, IR26, IR30
1979/1981	〃 〃	4,526	7,513	2.253,900	IR36, IR38, IR42
1982/1985	〃 〃	600	996	298,800	Cisadane/IR26/IR42 IR54 (Rotation)
1973/1985	Central Sulawesi	15,000	24,900	7.470,000	Pelita, IR20, IR36
1973/1985	North Sulawesi	6,000	9,960	2.988,000	Pelita, IR20, IR36
1980/1985	Bali	20,000	33,200	9.960,000	IR36, IR42, IR50
	East Java	5,000	8,300	2.490,000	IR36, Cisadane, IR50
	Central Java	10,000	16,600	4.980,000	IR36, Cisadane
	West Java	—	—	—	—
	Nusa Tenggara	5,000	8,300	2.490,000	Pelita, IR36
	Total	180,005	298,809	89.643,100	

1) Actual loss varies from 1 ton/ha to total loss. In this table an average loss of 2 ton/ha paddy or 1.66 ton rice/ha valued at US$300/ton is used for estimating losses.

Almost all the rice varieties available in the early seventies were susceptible, i.e. Pelita, IR5, local varieties Lemo, Kwatik, etc. Later IR20 and C4-63 were introduced but these soon became susceptible. In the later years of the 1970s new varieties with tungro resistance were planted. Many of these varieties were resistant to the green leafhopper but not to the tungro virus.

2) Rice tungro virus and vector

The disease known as "penyakit habang" (penyakit = disease, habang = red) is characterized by yellow-orange leaf discoloration, reduced tillering, slight stunting and incomplete panicle exsertion. The viral nature of the causal agent was confirmed by Rivera (1967). Insect transmission and other characteristics were similar to tungro in the Philippines and rice yellow orange disease in Thailand.

The most efficient insect vector for viral transmission was *Nephotettix virescens* (Tantera *et al.,* 1975). However other *Nephotettix* spp. also transmitted the disease in a lesser capacity such as *N. nigropictus, N. malayanus, N. parvus, N. virescens* × *N. nigropictus* hybrid and *Recilia dorsalis* (Sri Suharni Siwi, 1982). The virus is transmitted in a semi-persistent manner by the insect vectors, with *N. virescens* transmitting the virus in 58.8% or more of the cases.

Vector population varies from year to year and from locality to locality. Factors related to insect population are rice varieties, temperature and humidity and cultural practices (Suharni Siwi and Tantera, 1982). A distinct peak of population could be observed in relation to the planting time, in South Sulawesi and the northern coastal plain of West Java. However in West Java the population of the insects is rarely high.

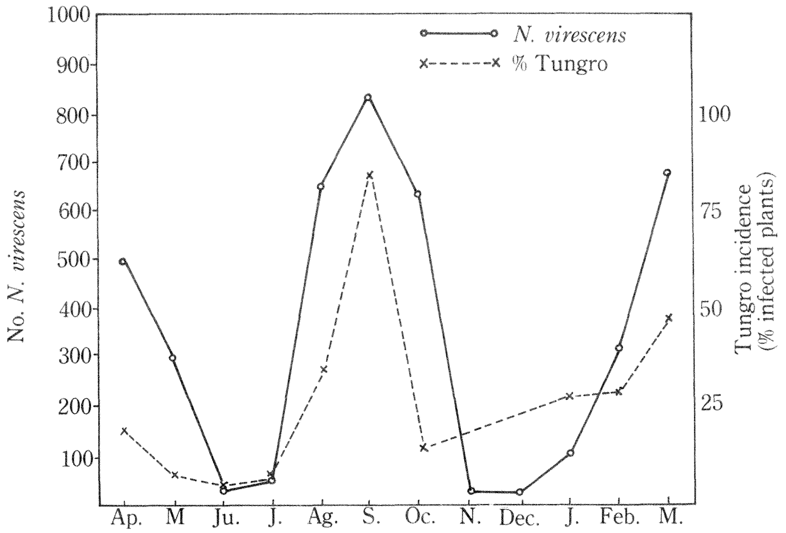


Fig. 1 Monthly average population of *N. virescens* and the corresponding tungro incidence at Lanrang (average 6 years).
Source: Shagir Sama *et al.* (1983)

In South Sulawesi, Shagir Sama *et al.* indicated that tungro indidence is colosely related to the *Nephotettix* population. In Fig. 1, each yearly cycle of tungro (1975–1981) is indicated showing that *N. virescens* monthly population was closely related to the monthly tungro incidence at Lanrang. Lanrang substation is probably the best place in the world for tungro field testing. In Fig. 2 a similar pattern was observed in the Maros area. Each location is a center of rice production in South Sulawesi. Tungro is known to be a disease which can be quickly disseminated by insect vectors. There is no other means of transmission known at present.

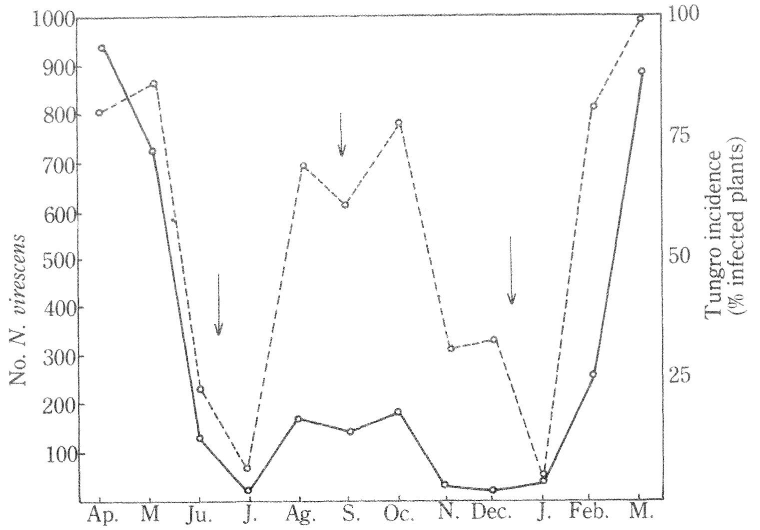


Fig. 2 Monthly average population of *N. virescens* and the corresponding tungro incidence at Maros (average 6 years).
Source: Shagir Sama *et al.* (1983)

In a susceptible variety, tungro may spread from a few hundred ha to ten thousand ha in 2-3 week time (Tantera, 1982, Suharni Siwi and Tantera, 1982). The warm tropical weather with high humidity is conducive to the insect propagation and activities.

Tungro incidence could also be predicted to a certain extent through assessing the field population of the insect, not only by the number but also by the species composition. Suharni Siwi and Tantera (1982) assessed the shift in the species ratio of *N. virescens* to *N. nigropictus* in many regions before and after tungro incidence.

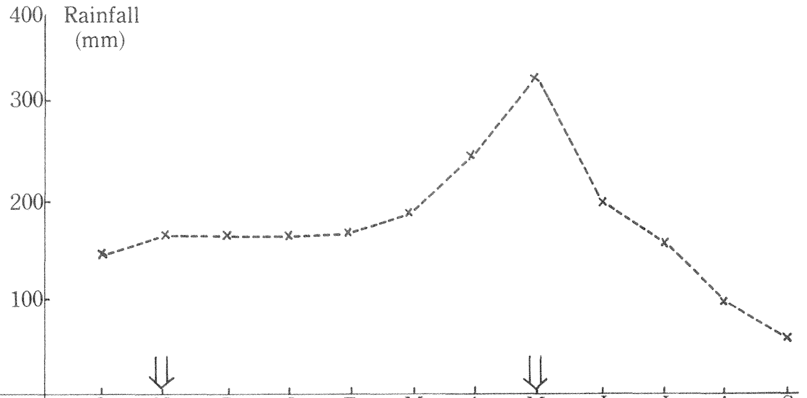
In 1977 *N. virescens* was dominant in South Sulawesi, where epidemics of tungro occurred, while in Java *N. nigropictus* was dominant. In our survey of 1981-1982 it was apparent that in most areas of Java, such as Central and East Java, most areas of West Sumatera, South Sulawesi, Bali and North Sumatera, there was a shift in dominance in favor of *N. virescens* in 60% to 100% of the population. This shift occurred in 2-3 year periods probably due to a shift in varietal preference by the farmer and also the introduction of more intensive cultivation (Suharni Siwi and Tantera, 1982).

These areas are at present closely monitored for tungro. From the above discussions it seems that for endemic areas such as Pekalongan, Banyumas (Central Java), Banyuwangi (East Java), Bali, South Sulawesi (Lanrang and Maros), Tanah Datar (West Sumatera) Simalungun (North Sumatera) in which *N. virescens* is dominant, monitoring the population is essential.

By monitoring the peak population each year one can decide the planting time. In such a case, for the South Sulawesi area appropriate planting time is indicated in Fig.3 and 4 (Shagir Sama, 1984). For the Lanrang area the appropriate planting time is in November and in May each year, while in the Maros area, the planting time is in January and July.

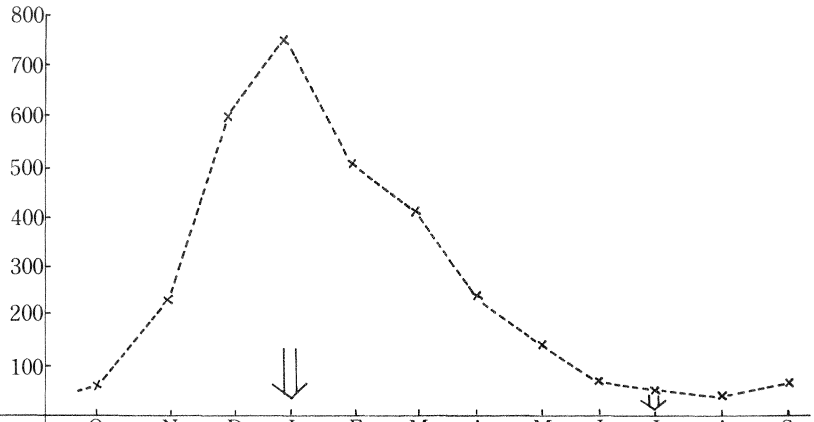
According to the above schedule, rice crop started to grow at the peak of monthly rainfall which coincides with the lowest level of insect population. As a result, high yield was obtained with the lowest tungro incidence for the entire crop duration, mainly because the highest level of insect population coincides with the flowering stage of the rice. At this stage the crop is tolerant to tungro and not so easily damaged by the feeding of the green leafhopper.

The second planting time came 5 months after the first planting. At this time, the insect population was the lowest, because most of the crop was already harvested some 3-4 weeks earlier, so that all the green leafhopper eggs and newly hatched nymphs were running out of food.



Time of planting	O	N	D	J	F	M	A	M	J	J	A	S
Rainfall	153	163	163	168	168	193	268	322	212	162	113	80
Green leafhopper population	60	10	10	162	626	826	43	3	5	146	1,726	2,525
Tungro (%)	10	5	15	45	95	55	15	0	15	35	95	95
Yield (t/ha)	4,9	6,1	4,5	1,2	0,3	0,0	3,5	5,4	4,2	2,4	1,3	0

Fig. 3 Rainfall pattern, green leafhopper population and tungro incidence on rice crop for each planting month at Lanrang Substation (average of 4 year data).
Source: Shagir Sama *et al.* (1983)



Time of planting	O	N	D	J	F	M	A	M	J	J	A	S
Rainfall	80	234	591	761	536	411	237	148	84	50	17	22
Green leafhopper population	825	10	0	0	50	1,585	6,581	5,875	562	46	140	525
Tungro (%)	100	50	5	0	15	75	100	55	5	0	10	90
Yield (t/ha)	0	0,4	3,5	5,2	2,9	0,4	0,0	0,1	2,8	5,6	1,8	0,0

Fig. 4 Rainfall pattern, green leafhopper population and tungro incidence in rice crop for each planting month at Maros Substation (averge of 4 year data).
Source: Shagir Sama *et al.* (1983)

The critical factor here is that there are about 30 days without crop between each cropping season, which enable to lower of level of the insect population.

3) Varietal resistance

Indonesia is one of the best places in the world for field testing of tungro resistance. The Lanrang Substation is particularly suitable for this purpose in which tungro naturally occurs throughout the year. Hundred thousands of varieties and lines from all over the world have been tested in this location.

Varieties found to be resistant to *N. virescens* are: Gampai, Pankhari 203 and Ptb18. On these varieties the life span of the insect is much shorter. Varieties found to be resistant to tungro virus are: Ambemolar 159, Habiganj Dw8, Katharibong. Resistance to the insect vectors seems to be independent of the resistance to the virus. Therefore most of the so-called field resistance to tungro is actually a resistance to the insect vectors.

Reaction of rice varieties to *Nephotettix virescens* seems to be erratic. An insect colony could easily adapt to a resistant variety if grown successively for several generations on such a variety. Therefore, resistance to the insect vector is temporarily maintained. When the insect population is selected toward that particularly variety then the resistance breaks down.

4) Tungro and its control

In our case, the strategy to control tungro is straighforward.

1 Susceptible period of rice crop to tungro is from germination to 45 days. After this period tungro infection will not seriously damage the crop.

2 Most of the varietal resistance in the high-yielding varieties is represented by the resistance to the insect vector. Therefore this resistance will break down if insect pressure is high.

3 In view of the above, for tungro control the control measures, should be integrated including varietal rotation, cultural practices, seedbed treatment, and insect monitoring to avoid the breakdown of resistance.

4 Use of resistant varieties whenever available is strongly recommended with synchronized planting time, two rice crops a year plus one palawija, seedbed treatment with carbofuran, adjustment of planting time so that peak population of insect coincides with flowering of rice.

5) Tungro virus

In the South and Southeast Asian Countries, such as Pakistan, India, Ceylon, Thailand, Malaysia, Indonesia, Philippines and China, tungro has a wide distribution. "Waika" disease which is related serologically to the spherical virus of RTV has been reported to occur in the Kyushu district of Japan.

The association of two types of particles in tungro disease was demonstrated by Saito *et al.* (1975) for the first time. This new finding illustrated the fact that tungro is due to a complex phenomenon. Hibino *et al.* (1977) illustrated the relationship between s and b particles in tungro, but still more research is needed to elucidate further the various phenomena in tungro, particularly those relating to the mechanism of varietal reaction to the disease. In this mechanism, about 6 factors interact with each other i.e. insect (possibly many biotypes) × virus (s and b types) × varieties (genes?) × environment.

In relation to the identification of the virus particles one should consider the use of serological techniques. With new developments in methodology the presence of the virus in the plants or in insect vectors could be quickly identified. The technique should contribute to further research in the epidemiology of the disease.

2 Grassy stunt and ragged stunt virus (GSV and RSV)

The brown planthopper (BPH) problem started in 1969/1970 in Central Java (Tegal) and East Java (Banyuwangi). About 10,000 ha were affected in that year. It was also noted that both infected areas were irrigated and rice crop was grown continuously throughout the year.

Direct damage due to brown planthopper attack is a well noted phenomenon called "hopperburn" in rice fields. In addition to the brown planthopper attack, two viruses transmitted by this insect produce additional damage, namely grassy stunt virus and ragged stunt virus. Ragged stunt virus which appeared in 1976, is distinct from grassy stunt. It occurred almost simultaneously in the Philippines and in Indonesia. It was associated with the introduction of IR26 and IR28 to Indonesia which were resistant BPH but susceptible to ragged stunt/grassy stunt.

Grassy stunt and ragged stunt also caused significant damage to rice crops (Table 2). An estimate of yield loss was made by Mochida (1976).

Table 2 Total rice area infected, estimated loss due to BPH, grassy stunt/ragged stunt diseases in Indonesia (O. Mochida (1979) and Tantera (1985)[1])

Year	Total area harvested (× 1,000 ha)	Area infected (× 1,000 ha)	Estimated loss* (× 1,000 ton paddy)	Estimated loss* (US$1,000)	Total rice production (× 1,000 ton)	Average yield (t/ha)
1972	6.611,524	35.5	71.6	17.900	17.785	2.69
1973	7.035,125	25.7	53.8	13.450	19.685	2.79
1974	7.342,105	51.9	110.9	27.725	20.923	2.85
1975	7.321,908	352.1	747.3	186.825	20.721	2.83
1976	7.239	317.0	713.3	178.325	21.717	3.00
1977	7.202,360	713.2	1.615,4	403.850	21.808	3.02
1978	7.698,409	319.1	749.1	187.275	24.172	3.13
1979	7.675,118	744.5	1.798,0	449.500	24.731	3.22
1980	7.824,046	79.388	212.56	53.140	27.993	3.57
1981	8.191,020	58.729	165.22	41.305	30.988	3.78
1982	7.872,600	61.599	186.19	46.547	31.775	4.03
1983	7.940,691	116.295	364.58	91.146	33.209	4.18
	Total:	2.880,142	6.787,95	1.696,988		

* As rice plant damage by BPH, GSV and RSV was mainly found in lowland rice cropping areas with high productivity, the loss was estimated for lowland rice as follows: (average yield × 3/2) × area infested × intensity of damage (50/100). Price of rice paddy (unhusked) = US$250/t.

1) O. Mochida, 1972-1976.
D.M. Tantera, 1976-1985 (Source: Directorate of Plant Protection).

GSV was identified in 1972 at Tegal (Cental Java). Later it appeared in Banyuwangi (East Java) from 1974-1980 and in North Sumatera from 1976 up to the present. At present only a few hundred ha are infested. Ragged stunt virus was identified in 1976.

GSV particles are flexuous rods. The antiserum reacts readily in latex flocculation tests with the virus taken from a single insect (Jumanto, personal communication). RSV is more readily purified but is less reactive to the antiserum.

1) Varietal reaction to GSV and RSV

In the early 1970s effort was mainly directed toward the incorporation of resistance genes to GSV. Test sites such as Banyuwangi and Tegal and North Sumatera are fully utilized for field testing. Varieties are tested, and some are released as being resistant to BPH and GSV.

However the single source of resistance derived from *O. nivara* is not sufficient for obtaining resistance to GSV strain 2 which at present occurs in the Philippines. RSV resistance is available in some local varieties such as Lemo, Kencana, Pulutnangka. The resistance is moderate, which is suitable only for a low population of insect vectors. More work is being done for the evaluation of resistance to RSV.

2) Control measures for GSV and RSV

For almost 15 years efforts have been concentrated on the control of BPH, GSV and RSV. An integrated Pest Management Program was used by combining:

(1) Use of resistant varieties:

(For bph 1 gene)	:	IR26, 28, 30, 34, Asahan, Brantas, Citaraum, Serayu.
(For bph 2)	:	IR32, 36, 38, 40, 42, Semeru, Cisadane, Ayung, Cipunegara, Sadang, Bahbolon, Parang, Klara.
(For bph 3)	:	IR50, IR52, IR54, IR56, IR46, Cimandiri, Krueng Aceh, Singkarak.

(2) Cultural practices:

They are mainly aimed to: (a) decrease BPH, RSV, GSV populations through eradication of infested crops; (b) synchronous planting time followed by fallows or planting of 1 crop of legume to interrupt the life cycle of the insect; (c) timely application of suitable insecticides to decrease BPH population. Insecticide application is the last alternative because it does not always give good control of BPH. In some cases resurgence effect was noticed when insecticides were applied continuously in two-three crop seasons.

Virus diseases of legume crops

Leguminous crops are essential as additional sources of food for human consumption or cattle feeding. Their relative importance for Indonesia is as follows: soybean, peanut, mungbean, cowpea, etc. The legumes are planted in the dry season, after one/two rice crops, if the area is fully irrigated, or otherwise in case of a rainfed area, during the wet monsoon season. A large rainfed area under upland crops is found in Sumatera, Kalimantan and Sulawesi Islands. Leguminous crops are also frequently planted in a multiple cropping pattern with upland rice (padi gogo).

1 Soybean

Many viruses have been identified in soybean fields namely soybean stunt (SSV), Indonesian soybean dwarf (ISDW), bean yellow mosaic (BYMV), soybean yellow mosaic (SYMV), soybean mosaic (SMV), cowpea mild mottle virus (CMMV) and peanut mottle R-type (RMVR) (Iwaki, 1979; Iizuka, 1985; Roechan, 1985).

1) Soybean stunt virus (SSV)

SSV which was first isolated from Bogor in 1973 shows a spotty distribution in Java (West, Central, East), South Sulawesi, West Sumatera and Lampung. As the symptoms consist of mild stunting and mottling in some varieties of soybean, the virus is frequently overlooked in the field.

The disease is transmitted through seed, sap, aphids (*A. craccivora, A. glycines*) in a non persistent manner. Seed infection causes brown mottle symptoms on the seed coat and the seed infection rate is quite significant (80-100%). The virus particles are spherical (30 nm) and react positively with CMVY strain antiserum (Roechan *et al.*, 1975). As varieties such as Taichung Bonus and No. 1592 are highly resistant to the disease, this aspect is to be considered in the future for the effective control of the disease.

2) Bean yellow mosaic virus (BYNV)

BYNV was isolated in 1973 from Muneng (East Java) by Iwaki (Roechan *et al.*, 1978).The virus was transmitted easily by juice and aphids (*A craccivora, A. glycines* in a non persistent manner but not by seeds. This virus has a wider host range compared to SSV. Its thermal inactivation point is 60° (for 1 min); it can be preserved at room temperature (25 — 30°C) for 7 days. The particles are elongated flexuous rods 700 — 750 nm in size.

The virus causes mosaic and malformation on soybean leaf such as curving of leaf edge and uneven leaf surface. Among about 50 varieties tested, varieties Adelphia and Harder showed a resistant reaction (Roechan *et al.*, 1978).

3) Indonesian soybean dwarf virus (ISDV)

ISDV was isolated from Cikeumeuh Substation, Bogor in 1974. At the beginning it was considered to be similar to soybean dwarf virus (SDV) in Japan, but thereafter it was found to be somewhat different. Under the combined effort of the Indonesia-Japan Joint Research Program the virus was named ISDV.

This virus is significant because it is transmitted by *A. glycines* in a persistent manner but not by *A, craccivora* or *Anlacortum solani*. The virus is not transmitted through seed or by sap inoculation, has a limited host range, since almost all the test plants inoculated were not susceptible except for the varieties of soybean plants (*Glycine max*). Cross-protection test with SDV of Japan and serological tests showed that the two viruses are distinctly different. However due to the symptoms of dwarfing, the presence of unproductive pods and the similarity in virus vector relationships, the virus was designated as listed above.

The distribution of the virus is widespread in Java and Sumatera, and yield loss due to this virus has been very severe. Means of controlling the disease have been possible through the development of resistant varieties. Shakti, one of the leading soybean varieties in Indonesia which is resistant to this virus, has been widely planted in recent years.

4) Soybean yellow mosaic virus (SYMV)

SYMV recently became important in Sukamandi and Indramayu (West Java). It is also transmitted in a persistent manner by *A. glycines*. Host plants are limited to peanut and soybean only. If transmitted through mechanical inoculation to soybean plant or peanuts, subsequent transmission by using insects usually failed (Iwaki, 1979).

Research on SYMV should be continued and effort to purify the virus and to obtain antiserum so far has not been successful.

5) Soybean mosaic virus (SMV)

SMV has only been recently identified by Roechan (1985). However this virus may have been present for some time already in view of its side distribution in West Java and West Sumatera.

The virus particles which are flexuous rods 750 nm in length are transmitted through sap, grafting and seed. The insect vector *Aphis glycines* is able to transmit the virus rather easily in a non persistent manner. Seed transmission affects about 30% of seeds. This virus is likely to become very important in the near future, due to seed infection. In recent years the demand for soybean seeds has increased in the newly opened lands located in remote areas of Sumatera, Kalimantan and Irian Jaya. It is a concern to all of us that sooner or later the virus may reach such areas as well.

6) Cowpea mild mottle virus (CMMV)

CMMV has a wide selection of host plants, and it can infect soybean. This virus was identified in 1983 as a whitefly-transmitted virus. Particles 650 nm in length are flexuous rods which are transmitted by *Bemisia tabaci* in a semi-persistent manner. Seed, sap and grafting transmission is also possible. CMMV is distributed over West, Central and East Java, and this year it was detected in Lampung (Iizuka, 1984). The significant role of this virus is only partially known. Whitefly populations are increasing in some areas in West and East Java. The fact that seed transmission is also possible is likely to enhance the spread of this virus if necessary steps are not taken to prevent such a case.

7) Peanut mottle virus (R-type)

PMV-R infects soybean in West Sumatera according to Iizuka. The virus can be transmitted quite easily from peanut to soybean and vice versa.

Both *A. craccivora* and *A. glycines* transmit it in a non persistent manner. Means of spread are sap, seed and also grafting. The distribution of the virus requires more studies. As the virus was isolated last year, the role of such disease in the field cannot be fully assessed. It seems that PMV-R spread from soybean to peanut crop vice versa, causing damage mainly in peanuts.

2 Peanut

1) Peanut mottle virus (Pn MV)

Pn MV is the most serious virus disease on groundnut. It may cause a serious yield loss of around 15–255. It is widespread over all the peanut-growing areas of Indonesia. To a certian extent it reduces seed quality due to the decrease in seed size produced by infected plants.

Pn MV isolated from the field in different localities may differ in host range, though the virus-vector relations and other characters are identical (Iwaki, 1977). Pn MV is transmitted by *A. craccivora* and *A. Glycines* in a non persistent manner.

Particle morphology is characterized by the presence of elongated flexuous rods 700–750nm long. In some preparations the virus aggregates into inclusion bodies in the epidermal cells of peanut leaf. The virus is easily transmissible through juice. Seed transmission was frequently reported. About 25 of the seeds may be infested. The role of seed infection in the long range spread of Pn MV and measures to be taken to prevent or limit it are being studied intensively.

Testing of more than 27 lines/virus by Iwaki (1977) indicated that all are susceptible to the virus. This fact supports the observation that in many areas severe disease attacks were frequently observed. Peanut mottle disease was found in Sumatera and in restricted areas of Java in 1975. Later the disease was observed throughout Java Island in 1978 and it was first reported by Triharso in 1977 (Triharso, 1977).

2) Peanut mosaic virus (PMV)

PMV is the first virus disease studied by Thung in 1947 and later on Bergman (1955) found that it was transmitted by a leafhopper, *Orosius argentatus* Evans in a persistent manner.

The leafhopper vector retains the virus for 77 days. Although PMV had been known for such a long time, its role has been quickly overtaken by PMVT in recent years. this phenomenon is thought to be due to the fact that the PMV does not spread through seed, and the fact that its host range is limited to peanut plants.

Peanut mosaic induces vein-clearing and leaf curling on young leaf which later turn into mosaic pattern. The infected plant becomes severely stunted and the yield is practically nil. The virus particles have not been studied in detail.

3) Peanut crinkle leaf (PCLV)

This disease was first studied by Thung and Tojib in 1953. Infected plant showed slight dark green color and leaves were thickened, and curled upward. The infected plants were severely stunted, enations were produced along the vein on the underside of leaves and protruding ridges were observed on seed of infected plants.

PCLV can only be transmitted through grafting and vector. Other modes of transmission as well as the causal agent, presumably a virus have not been studied in detail.

3 Mungbean

Mungbean (*Vigna mungo*), and green gram (*Vigna radiata*) are also important as additional food crops. The crop has several advantages over the other legumes such as soybean, particularly because it can tolerate drought conditions compared to the other crops. Viruses affecting mungbean are black gram mottle virus (BGMV), mungbean mosaic virus (MMV) and bean yellow mosaic virus (BYMV). these viruses are distributed all over Java.

1) Black gram mottle virus (BGMV)

Nasir Saleh (1985) studied this virus with particular emphasis on its seed transmissibility. BGMV causes systemic mosaic symptoms on green gram (*Vigna radiata*), common bean, 'Master Peace' and 'Kurosando' but it did not infect cucumber, pea, tomato, *N. glutinosa,* tabacco, petunia and eggplant.

The virus survives heating for 10 min, at 40–100°C, dilution end point is 10^{-9}, and it can withstand 7 week storage at 20°C. Transmission of the virus is obtained through sap, seed and insect vector, *Pagria signata* Motch in a semi-persistent manner.

The virus can be detected in seeds, with the highest concentration of virus particles being found in the seed coat, and to a lesser extent in the embryo. Seed transmission to the next crop mainly occurs with *Vigna radiata,* but not with *Vigna mungo.* Seed obtained from plants infected early (less than 2 weeks old) can easily produce diseased plants in the next crop. About 90–98% of the seeds from infected plants are infected with the virus. Most sensitive reaction for virus infection in seeds is the ELISA test followed by infectivity tests (Table 3). However if seeds are sown or grown in the field, only about 1–2% produce disease symptoms (Nasir Saleh, 1985).

Table 3 Sensitivity of ELISA, infectivity test and growth in test for detection of BGMV in *V. radiata*

Variety	Percentage of seeds infected			Observed value at 405nm	
	ELISA	Infectivity	Growing	Infected	Healthy
M7A	98.96	90	1.5	2.73	0.24
MB129	66.6	50	1.0	2.16	0.29
MB436	25	25	0.0	0.75	0.06
TM108	10.42	10	1.0	1.08	0.08

Source: Nasir Saleh (1985).

Studies on BGMV elucidated several points relating to the transmission of this virus through seed; 1) The virus could produce infection in the next crop only on *Vigna radiata;* 2) Rate of infection is about 1–2%; 3) A high concentration of virus could be detected in the seed coat (90–98%), which does not imply that the virus will be transferred to the next generation of crop.

2) Mungbean mosaic virus (MMV)

MMV has a wider host range than BGMV. It is considered to be an important virus on mungbean because of its wide distribution all over Java.

Infected plants show mosaic symptoms and malformations. According to Iwaki (1979), MMV in Indonesia is different from the virus reported from other countries because, on *C. amaranticolor* it produced local lesions. It seems to be related more to a azuki mosaic virus because of the similarity in the seed transmissibility.

This virus is transmitted by sap, seed of mungbean and azuki bean and by the insect vectors *A. craccivora* and *A. glycines* in a non persistent manner. Infected plants produce smaller seeds than the healthy ones, the number of pods is reduced by 65%, the number of seeds by 70% and the dry seed weight by 80%.

The virus particles are flexuous rods 750nm in diameter.

3) Bean yellow mosaic virus (BYMV)

This virus, as illustrated previously in soybean, can also infect mungbean. The wide host range of this virus on legumes indicates its potential of persisting on legumes by continuously infecting crop to crop almost all the year round.

4 Cowpea

Cowpea plants under the conditions prevailing in Indonesia are almost always present throughout the year. These vine beans are cropped along the levees, on elevated bunds of rice fields (sawah) or in a multiple cropping pattern with other palawija.

1) Cowpea aphid-borne mosaic virus (CAMV)

This virus was first identified in 1975 from a virus first reported by Haryono Semangun (1958). It produced distinct mosaic on cowpea, as well as on *P. sativum, V. sesquipedalis, P. vulgaris* (Honkintonki).

The virus particles consist of flexuous rods 700-750nm long which are easily transmitted through sap, insect vector (*A. crassivora* Koch) in a non persistent manner but not through seeds.

2) Cowpea stunt virus (CSV)

Iwaki (1979) observed another virus which infected cowpea, but was transmitted by aphids (*A. craccivora* Koch) in a persistent manner. The symptoms produced on cowpea included small leaves, severely stunted plant with a bunchy top appearance. this disease is widely distributed in Java, Sumatera, Bali and Sulawesi Islands.

The virus was first reported by Haryono Semangun as witches' broom of cowpea in 1958 but later on was renamed because it does not cause witches' broom disease which has been found to be caused by a mycoplasma. CSV could also infect a number of different crops such as soybean, *V. sesquipedalis, P. vulgaris, Pisum sativum, Vicia faba.* Identification of this disease is still incomplete.

5 Witches' broom disease of legumes

On many kinds of leguminous crop plants one often finds witches' broom symptoms, consisting of phyllody, enation and leaf proliferation. The plants are stunted with a severely reduced leaf area. This disease was first reported by Thung in 1947. Bergman and Bos (1955, 1957) further studied the symptoms of the disease which is transmitted by grafting and by a leafhopper vector *Orosius argentatus* Evans in a persistent manner.

Electron microscopic observations of leaf materials indicate that the disease is caused by mycoplasma.

The disease appears frequently in the fields, infecting peanuts, soybeans, cowpea, mungbean, *Crotalaria* sp. and sweet potatoes. Incidence of the disease is minor, and it only appears unfrequently.

References

1) Hibino, H., Roechan, M., Sudarisman, S. and Tantera, D. M. (1977): A virus disease of rice (kerdil hampa) transmitted by brown planthopper *N. lugens* Stal in Indonesia. Contrib. Centr. Res. Inst. Agric. Bogor, No. 35. 15pp.

2) Iwaki, M., Roechan, M. and Tantera, D. M. (1975): Virus diseases of legume plants in Indonesia. 1. Cowpea aphid born mosaic virus. Contrib. Centr. Res. Inst. Agric. Bogor No. 13. 14pp.

3) Iwaki, M. (1979): Virus and mycoplasma disease of legume crops in Indonesia. Rev. Pl. Prot. Res. Japan, 12 88-97.

4) Iwaki, M., Roechan, M., Hibino, H., Tochihara, H. and Tantera, D. M. (1980): A persistent Aphidborne virus of soybean, Indonesian soybean dwarf virus. Pl. Disease vol. 64, No. 11. P.1027-1029.

5) Mochida, O. (1976): Brown planthoppers reduce rice production. Indonesia Agric. Research and Dev. Journal. Vol. 1, No. 1 and 2. p.3-7.

6) Nasir, Saleh (1985): Studies on virus diseases of mungbean in Indonesia. A. Ph. D. Dissertation, Univ. of Gajah Mada Yogyakarta, Indonesia.

7) Rivera, C. T., Ou, S. H. and Tantera, D. M. (1969): Tungro disease of rice in Indonesia. Plant Dis. Reporter, 52, 122-124.

8) Roechan, M., Iwaki, M. and Tantera, D. M. (1975): Virus diseases of legume plants in Indonesia. 2. Soybean Stunt Virus. Contrib. Centr. Res. Inst. Agric. Bogor No. 15. 16pp.

9) Saito, Y., Roechan, M., Iwaki, M. and Tantera D. M. (1975): Electron microscopic investigation on Penyakit Habang and similar diseases in Asia. Seminar Paper, March 1975. Central Research Institute for Agriculture Bogor, Indonesia.

10) Saito, Y., Roechan, M., Iwaki, M. and Tantera, D. M. (1975): Bacilliform virus particles associated with Penyakit Habang of rice in Indonesia. Phytopathology, 65, 793-796.

11) Shagir, Sama, Hasanuddin, A. and Suprihatno, B. (1983): Risalah Lokakarya Penelitian Padi, Cibogo, Bogor. 22-24 Maret 1983. p.111-129.
12) Sri Suharni Siwi and Tantera, D. M. (1982): Shifting in dominance of green leafhopper species in Indonesia. Jurnal Penelitian dan Pengembangan Pertanian. Vol. 1, No.2. p.57-67. (In Indonesian).
13) Tantera, D. M. (1973): On an outbreak of Penyakit Habang (tungro) in rice in Central and South Sulawesi. Rice Pathology Newsletter, 2/73, IRRI, Los Banos.
14) Tantera, D. M., Satomi, H. and Roechan, M. (1973): Grassy stunt disease of rice in Indonesia. Contrib. Centr. Res. Inst. Agric. Bogor, No. 2. 8pp.
15) Tantera, D. M., Roechan, M. and Rachmadi (1975): Virus-vector relationship on Penyakit habang of rice. Proc. Third Congress, Indonesia Phytopathological Society, Bogor, Febr. 1975. p.52-58.
16) Tantera, D. M. (1982): Rice tungro disease outbreak in Bali. Jurnal Penelitian dan Pengembangan Pertanian Vol. 1, No.1. 1982. p.2-5. (In Indonesian).

Discussion

Ishikura, H. (Japan): 1. What is the total area planted to rice in Indonesia? 2. You reported that the total area infected with tungro and grassy stunt involved 126,000 ha and 200,000 ha, respectively. Is it the total area for the period 1975-1985 or the annual average of the 10-year period?

Answer: 1. The total area planted to rice, including upland rice amounts to 7.5 million ha per year. 2. It is an average of 10 years. In the manuscript I indicate that for a period of 15 years (1970-1985) 180,000 ha were infected with tungro, with the peak being observed in 1972. Presently in central Java only 2,000-3,000 ha are affected by tungro. In Indonesia, for rice, the major diseases and pests are tungro, grassy stunt and the brown planthopper.

Green, S. K. (AVRDC): Among the virus diseases of soybean you mentioned, namely bean yellow mosaic and soybean yellow mosaic diseases, did you identify the virus causing soybean yellow mosaic?

Answer: Yes we we did identify the virus based on the host range and morphological characteristics, including the particle size.

Mochida, O. (IRRI): I heard that in South Sulawesi the government recommends gene rotation to control tungro. Is it implemented?

Answer: Actually one deals with varietal rotation as gene identification is difficult to achieve. The population of the green leafhopper is well regulated and the peak of the population is being monitored. Control of tungro is mainly achieved by synchronous planting and the introduction of a one month fallow peirod. Since the green leafhopper becomes easily adapted to the varieties resistant to the insect after 3-4 years of cultivation of the same variety, rotation of varieties is being promoted to alleviate the breakdown of resistance. In Java, due to problems related with seed availability, rotation of varieties is more difficult to implement.