Legume pathology at Maha Illuppallama

P. SHIVANATHAN

Central Agricultural Research Institute Gannoruwa, Peradeniya

INTRODUCTION

The important leguminous crops grown in the dry regions of Sri Lanka for consumption as green and grain include the cowpea (*Vigna unguiculata* (L.) Walp.), green gram (*Vigna radiata* (L.) Wilczek), black gram (*Vigna mungo* (L.) Wilczek.) groundnut (*Aracuis hypogea* L.) and to a lesser extent soybeans (*Glycine max* (L.) Merr.) and tur dhal (*Cajanus cajan* (L.) Millsp.). Green gram, cowpea, groundnut and black gram provide the major source of vegetable protein intake of the rural and the poor sections of the urban population of Sri Lanka. These legumes are cultivated mainly as a rainfed crop in the maha season (October to March). The cultivation of legumes in the yala season (April to September) though negligible at present could expand as irrigation facilities become available to extensive areas in the dry zone. A complex of pests and diseases is a major constraint to more intensive and increased production of legumes: Abeygunewardene, 1969: Fellows, 1977 and Shivanathan, 1975. The more important and potentially important legume diseases together with the control measures are discussed in this paper.

VIRAL DISEASES

Viral diseases constitute a very serious problem to the profitable cultivation of several legumes. In comparison with other diseases research on virus diseases affecting crops in the dry zone was started recently (Shivanathan, 1977(a). In the past the virological dangers inherent in the importation of seed and vegetative parts of plants were not given serious attention. Several diseases particular to specific areas of the world were thus introduced and have become well established adding enormously to the costs of production of certain crops. The effects of Mung bean Yellow Mosaic Virus (MYMV) on greengram crops are extremely devastating and this disease was given considerable attention in recent years: Shivanathan, 1976: 1977, Shivanathan *et. al.* 1979.

Mung Bean Yellow Mosaic Virus

Mung bean Yellow Mosaic Virus (MYMV) causes severe yield reduction in green gram and other potentially important legumes. It is regarded as the most devastating virus disease of the dry zone. A similar yellow mosaic virus, causing severe yield reductions in green gram, black gram and several other legumes was reported in India by Nariani, 1960: Nair, 1970: and Nene, 1975. The virus reported in this paper differs from the MYMV of India in host range and transmission characteristics.

Symptoms and hosts in nature. The symptoms produced by MYMV vary with the species and cultivar affected. The infected plants show mosaic symptoms, where bright yellow patches predominate giving a yellow colour to the affected crop. In highly susceptible cultivars of green gram, soybeans etc. besides the green and yellow areas, extensive necrotic lesions appear on the leaf lamina. The pods are often malformed, yellow and the seeds shrunken, often fail to develop. The affected plants are stunted and chlorotic.

In nature the virus was recovered from *Phaseolus lathyroides* L., *Phaseolus atropurpura* L., *Alysicarpus vaginalis* (L.) DC., *Vagina radiata* (L.) Wilczek, and *Xanthium strumarium* L.

Mechanical transmission. When infected tissue from leaves of green gram were ground with equal weight for volume of 0.01 molar potassium phosphate buffer at neutral pH and mechanically inoculated to test seedlings of green gram cv. H 101 successful transmission of this disease was not obtained. The experiment was repeated with tris — HCl buffer at varying pH levels with unsuccessful results.

Seed transmission. High rates of seed transmission were reported in several leguminous plants: Fulton, 1964: Bennett, 1968: Shivanathan, 1977 (b). The early infection of yellow mosaic in the field strongly suggested the possibility of seed transmission. Over 5000 seeds collected from infected plants were sown in autoclaved soil, and the seedlings were raised in insect proof screen house. In observations lasting a period of 1 month from sowing no symptoms were observed in the seedlings.

Pollen transmission. In recent years, increasing number of viruses particularly those of the viroid group were shown to be pollen transmitted. Pollen from infected green gram cv. H. 101 was tested for the ability to transfer the virus to healthy green gram cv. H. 101 In over 300 crosses only 4 pods with viable seeds were obtained. None of the female parents was infected and the F1 progency was free of yellow mosaic. Artificial hybridization in mung cultivars gave less than 1 percent seed set: Shivanathan, 1977 (b). The importance of pollen transmission in green gram is of little significance in MYMV spread in the field.

Insect transmission. Aphids, mites and whiteflies found in abundance in MYMV infected fields were tested for their ability to transmit MYMV.

Aphid transmission. Four aphid species common on legume crops were tested for their ability to transmit MYMV. Non viruliferous aphid colonies of *Aphis gossypii* Glov. and *Myzus persicae* Sulz. were produced on *Gossyptum herbacium* L. cv. H.C. 101, while *Aphis caraccivora* Koch. and *Aphis malvoides* were multiplied on cowpea (*Vigna unguiculata* (L.) Walp.) cv. M.I. 35. Non alate forms of the insects were used in transmission experiments. The nymphs were collected with a fine camel hair brush and starved for 2 hours on 'blotter paper' in petri plates before being given acquisition feeding periods ranging from 15 minutes to 4 hours on detached infected leaves of green gram cv. M.I. 1. After acquisition feeding the nymphs were transferred to a healthy 2 weeks old green

gram test seedling of cv. H. 101 at the rate of 10 nymphs per plant for a 12 hour inoculation feeding. The inoculated seedlings were treated with 0.2 percent Azodrin and placed in the insect-proof screen-house for development of symptoms. None of the test seedlings developed symptoms of yellow mosaic.

Mite transmission. In the warmer months mite infestations were common on many legume crops. The red spider mite was tested for the ability to transmit MYMV to green gram. Non viruliferous red spider mites were collected by the funnel technique and reared on groundnut (*Arachis hypogea* L.), an immune host for MYMV. The mites were transferred to diseased green gram plants for multiplication. The mite infested leaflets from diseased plants were stapled to leaves of 2-3 weeks old green gram test seedlings. None of the test plants developed symptoms of yellow mosaic.

Whitefly transmission. Whitefly (*Bemisia tabaci* Genn.) is an important vector of several viral diseases in Sri Lanka (Shivanathan, 1977 (a), and Mishra, 1977). Costa, 1969 recognizes two groups of whitefly virus according to whether they produce mosaics or leaf curls. Symptoms of MYMV resembled other yellow mosaics caused by whiteflies in Sri Lanka. Non viruliferous whitefly colonies for experiments were produced on *Gossypium herbacium* L. cv. H. C. 101 and on *Abutilon indicum* (L.) G. Don. as these were favoured hosts of whiteflies for major part of the year at Maha Illuppallama immune to the whitefly viruses in Sri Lanka. In transmission studies 15 to 20 whiteflies were given acquisition feeding of 24 hours on MYMV infected green gram cv. M.I. 1 and transfered to healthy 2 weeks old seedlings of green gram cv. M.I. 1 for inoculation feeding of 24 hours. The inoculated seedlings were treated with 0.2 percent Azodrin and placed in insect proof screen house for development of symptoms. Six of the 10 inoculated seedlings developed symptoms of yellow mosaic in 9 days indicating that the whitefly was a vector for mung yellow mosaic virus.

Vector-virus relationship. Although several whitefly transmitted viral diseases are a serious problem in Sri Lanka, with the possible exception of the leaf curl virus, none of the others were studied systematically and in detail. Information on virus vector relationship and host range of MYMV is presented in this paper.

(i) *Number of whiteflies required for optimum infection.*

Different numbers of whiteflies ranging from one to 30 were given 24 hours acquisition feeding on infected green gram cv. H. 101. The viruliferous insects were transfered to 2 week old test seedlings of cv. H. 101 for 24 hours inoculation feeding. The inoculated seedlings were treated with 0.2 percent Azodrin and transfered to the insect proof screen house for development of symptoms. While a single insect could transmit the virus, more than 15 adult whiteflies were required to obtain over 75 percent infection. The results are given in Table 1.

Table 1: Transmission of MYMV as a function of the number of whiteflies used for inoculation

No. of insects per plant	No. of plants inoculated (a)	No. of plants infected (b)	Percentage transmission
1	18	2	11.1
2	20	2	10.0
4	24	7	29.2
8	22	12	54.5
15	24	18	75.0
20	24	21	87.5
30	18	15	83.3

(a) The green gram cv. H. 101 used in these tests was highly susceptible to MYMV.

(b) Observations on inoculated seedlings were up to 3 weeks from inoculation.

(ii) *Minimum time required by whiteflies to acquire the virus from an infected plant.*

To obtain optimum infection it was necessary to use a minimum of 20 whiteflies (Table 1). In tests to determine the minimum acquisition feeding period, groups of 20 whiteflies were caged on infected green gram plants cv. H. 101 for different periods of time and were transfered to 2 week old healthy test seedlings of green gram cv. H. 101 for inoculation feeding for 24 hours. At the end of the inoculation feeding period the plants were treated with 0.2 percent Azodrin and placed in the insect proof screen house for the development of symptoms. As a control an equivalent number of non viruliferous whiteflies were given inoculation feeding for 24 hours on test seedlings of similar age to differentiate between symptoms caused by feeding injury from that due to MYMV. The results in Table 2 indicated that a minimum acquisition feeding period of 30 minutes was required by the whiteflies to become viruliferous.

Table 2: Transmission efficiency of MYMV by whiteflies as a function of different acquisition feeding periods

Acquisition feeding period (a)	No. of plants inoculated	No. of plants infected (b)	Percentage transmission
10 min.	28	0	0
15 min.	30	0	0
30 min.	30	1	3.3
1 hr.	30	4	13.3
2 hr.	26	2	7.7
4 hr.	18	10	55.5
8 hr.	22	14	63.3
1 day	20	16	80.0
2 day	20	15	75.0

(a) Whiteflies were starved for 2 hours prior to acquisition feeding.

(b) Observations on test plants lasted 3 weeks from inoculation.

The data in table 2 indicates that acquisition feeding periods between 30 minutes and two hours resulted in no significant increase in the transmission efficiency, while a significant increase in transmission efficiency was obtained when the acquisition feeding time was increased from 2 hours to 4 and 8 hours. The data suggest that the process of acquisition of MYMV by the whiteflies is a slow process. Nair, 1971 reported a minimum acquisition period of 30 minutes for MYMV while Bird, 1958 reported a minimum acquisition period of 15 minutes for infectious chlorosis in *Sida carpinifolia*. Whiteflies require a minimum acquisition feeding perod of 30 mnutes to 8 hours for many other viruses, Kirpatrick, 1931: Pruthi and Samuel, 1939: Costa and Bennett, 1950: Varma, 1952: Bird, 1957: Chant, 1958: Laird and Dickson, 1959: Cohen and Nitzany, 1966 and Duffus, 1965.

(iii) *Minimum inoculation feeding time required by whiteflies to transmit MYMV.*

Groups of 20 non viruliferous whiteflies were caged on MYMV infected green gram cv. M.I. 1, for acquisition feeding for 24 hours. The viruliferous insects were caged on 2 weeks old healthy seedlings of green gram cv. H. 101 for different periods ranging from 5 minutes to 8 hours for inoculation feeding. The inoculated seedlings were treated with 0.2 percent Azodrin and kept in the screen house for development of symptoms. The results are given in Table 3.

Table 3: The efficiency of transmission of MYMV by whiteflies as a function of the inoculation feeding period

Inoculation feeding period on test plant (a)	No. of plants inoculated	No. of plants infected (b)	Percentage transmission
5 min.	20	0	0
10 min.	20	0	0
20 min.	20	4	20
30 min.	20	3	15
1 hr.	20	11	55
2 hr.	20	18	90
4 hr.	20	20	100
8 hr.	20	17	85

(a) The whiteflies were starved for 2 hours prior to inoculation feeding.
(b) Observation on test plants lasted 3 weeks from inoculation feeding.

Whiteflies were not able to transmit MYMV in periods shorter than 20 minutes. The minimum time required by whiteflies to transmit MYMV was 20 minutes and the transmission efficiency increased as the inoculation feeding period on test plants was increased. A high rate of transmission was achieved in 2 to 4 hours of inoculation feeding. In comparison with acquisition, inoculation of MYMV by whiteflies is a more efficient process. Nair, 1971 and Nene, 1975 reported a minimum inoculation period of 15 minutes for MYMV in *Vigna Mungo* (L.) Wilczek cv.

Maha Illuppallama. Inoculation periods ranging from 15 to 30 minutes were reported for different viruses transmitted by whiteflies. Costa and Bennett, 1950: Varma, 1963: Harpaz and Cohen, 1965: Cohen and Nitzany, 1966: Bird and Maramorosch, 1975 etc.

(iv) *Indentification of an incubation period for MYMV in whiteflies.*

Incubation periods of 4 to 8 hours in *Bemisia tabaci* Genn. were reported for several whitefly transmitted viruses, Storey, 1935: Capoor and Varma, 1948: Costa and Bennett, 1950: Varma, 1955: Costa and Carvalha, 1950: Varma, 1963: Duffus, 1965 etc. Incubation periods of 20 hours or more were reported for two whitefly transmitted viruses Laird and Dickson, 1959 and Cohen and Nitzany, 1966. Nair, 1971 obtained an incubation period in whiteflies of 4 hours for MYMV in *Vigna mungo* (L.) Wilczek. cv. Maha Illuppallama 1.

In the present study single whiteflies were used in inoculations. The whiteflies were starved for 3 hours prior to an acquisition feeding of 1 hour on MYMV infected green gram cv. M.I. 1. At various intervals of time after 1 hour acquisition feeding period the insects were transfered to healthy 2 weeks old seedlings of green gram cv. H. 101. Each viruliferous whitefly was allowed an inoculation feeding period of 1 hour on test seedlings. The inoculated seedlings were treated with 0.2 percent Thiodan and placed in the insect proof screen house for development of symptoms. The results are indicated in Table 4.

Table 4: Incubation period for MYMV in whitefly adults

Interval after acquisition feeding	No. of plants inoculated	No. of plants infected (a)	Percentage transmission
0 (control)	8	0	0
30 min.	8	0	0
1 hr.	8	0	0
2 hr.	8	0	0
4 hr.	8	0	0
8 hr.	8	2	25
15 hr.	8	5	62
30 hr.	8	5	62

(a) Observations on test seedlings lasted 1 month from inoculation feeding.

The data in Table 4 suggests that the virus was persistent in the insect and the incubation period of MYMV in the vector was more than 4 hours but less than 8 hours excluding the acquisition and inoculation feeding periods.

(v) *Serial transmission and efficiency of the sexes of whiteflies in the transmission of MYMV.*

The whitefly transmitted viruses with the exception of cucumber vein yellowing virus CVYV, Harpaz and Cohen, 1965, showed a persistent relationship with the vector *Bemisia tabachi* Genn. In virus retention studies evidence for retention of whitefly borne viruses for long periods ranging from 4 hours to 20 days in the vector was obtained, Costa and Bennett, 1950: Bird, 1957: 1958: Cohen and Nitzani, 1966: Duffus, 1965, Nair, 1971: and Nene, 1975. Although the virus was persistent in the adult insect it was not retained for the entire life period. Varma, 1952 however reported that the virus of bhendi yellow vein mosaic was retained for the entire life time of the insect.

The non viruliferous whiteflies for these experiments were raised on cotton culivar H.C. 101. The whiteflies were removed singly into the aspirator tubes and their sex determined under a hand lens on the basis that the bigger bodied, pure white coloured insects were females and the smaller sized yellowish white insects were males. The non viruliferous insects were given different acquisition feeding periods ranging from 30 minutes to 3 days by cageing them individually on infected plants of *Vigna radiata* cv. H. 101. At the end of the pre determined acquisition feeding period the insects were transfered serially at intervals of 24 hours to fresh healthy test seedlings of green gram cv. H. 101 to detect virus retention. The inoculated seedlings were treated with 0.2 percent Azodrin and removed to an insect proof screen house for development of symptoms. The results are given in Table 5.

The results in Table 5 indicate that significant differences in the efficiency of transmission of MYMV exist between the sexes of whiteflies. Given an acquisition period of over 4 hours, less than 30 percent of the male whiteflies retained infectivity at the end of 24 hours as compared to over 80 percent for the female insects. At the end of the second and the third day not more than a tenth of the male whiteflies retained infectivity as compared to 70 to 80 percent in the female insects up to the sixth day. The female insects retained infectivity of 20 to 30 percent up to the 10th day and an occasional insect even up to the 12th day. The life expectancy of the male whiteflies was less than half of the female flies. A few insects did not become viruliferous while a few others could not transmit the virus for the first one or two days after acquisition but became viruliferous on the third day and consequently transmitted the virus. The data in Table 5 suggest that the virus was persistent in the vector but was not retained for the entire life time of the insect.

Table 5: Serial transmission and efficiency of the sexes in the transmission of MYMV

Acquisition feeding period	Sex of insect	Days after acquisition feeding													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
0 (control)	M	—	—	—	—	D									
	F	—	—	—	—	—	—	—	—	—	D				
30 minutes	M	—	—	—	D										
	F	+	+	+	+	+	+	+	+	+	+	—	D		
	M	—	—	—	D										
	F	—	—	—	—	—	+	+	—	D					
3 hours	M	—	—	D											
	F	+	+	+	+	+	+	+	+	D					
	M	+	D												
	F	+	+	+	+	+	+	+	—	—	D				
6 hours	M	+	+	—	D										
	F	+	+	+	+	+	+	D							
	M	—	—	—	—	—	D								
	F	+	+	+	+	+	+	+	+	+	—	—	—	D	
12 hours	M	—	—	D											
	F	+	+	+	+	+	+	+	D						
	M	+	+	—	D										
	F	+	+	+	+	+	—	—	—	—	D				
	M	—	—	—	D										
	F	+	+	+	+	+	—	—	D						
24 hours	M	+	+	—	—	—	D								
	F	+	+	+	+	+	+	+	+	—	D				
	M	+	—	D											
	F	+	+	+	+	+	+	+	+	—	—	D			
	M	+	—	D											
	F	+	+	+	+	+	—	—	—	D					
	M	—	—	—	D										
	F	—	—	+	+	+	+	+	+	+	D				
48 hours	M		—	D											
	F		+	+	+	+	+	+	+	+	+	—	—	—	D
	M		—	—	—	D									
	F		+	+	+	+	+	+	D						
	M		+	—	D										
	F		+	+	+	+	+	+	+	D					
	M		+	D											
	F		—	+	+	+	+	+	+	—	D				
72 hours	M			—	D										
	F			+	+	+	+	+	+	D					
	M			+	+	+	D								
	F			—	—	—	+	+	D						
	M			+	D										
	F			+	+	+	+	+	+	D					
	M			D											
	F			+	+	+	+	+	+	+	D				

M Male whiteflies. F Female whiteflies. D Death of whitefly. — Test seedling infected. + Test seedling not infected.

(vi) *Tests for transovarian transmission and the minimum age at which whiteflies become infective.*

Although the virus was persistent in the vector there was no data to support that the virus multiplied in the tissues of the vector. Transovarian transmission was seldom reported for plant viruses and was not recorded for any of the whitefly borne viruses (Bird and Maramorosch, 1975: Harris and Maramarosch, 1980). In experiments to test the ability of female whiteflies to transmit the virus to the progeny, viruliferous female white flies were collected from MYMV infected green gram plants

and transfered to *Gossypium herbaceum* L. and *Abutilon indicum* (L.) G. Don. which are immune hosts of MYMV. The viruliferous female insects were allowed to oviposit on the leaves of the two immune hosts and the plants were treated with 0.1 percent Thiodan and caged in a screen house. The adult insects that developed from the eggs of viruliferous whiteflies were caged at the rate of 20 adult whiteflies per plant on 8 two weeks old test seedlings of green gram cv. H. 101. None of the test seedlings was infected indicating that the virus was not transmitted through eggs of viruliferous females.

When non-viruliferous whiteflies were allowed to oviposit on diseased seedlings of green gram cv. M.I. 1 infected with MYMV and the adults killed by a spray of 0.1 percent Thiodan, the adults that developed on the infected green gram leaves though originally from a non-viruliferous vector were found to be viruliferous when inoculated to healthy 2 weeks old seedlings of green gram cv. H. 101. The results suggested that the insects acquired the virus in the nymphal stages or at the time of first feeding on the infected leaf as adult insects.

To test the ability of the nymphs of *Bemisia tabaci* Genn. to transmit the virus, viruliferous insects were allowed to oviposit on 3 to 4 weeks old MYMV infected green gram cv. H. 101 . The host plants were treated with 0.1 percent Thiodan and caged in a screen house. The larvae that developed in 3 to 4 days were removed with a fine writing brush at the time the larvae were motile and transferred at the rate of 50 to 100 larvae per each 2 weeks old seedlings of green gram cv. H. 101. None of the 12 seedlings inoculated with the larvae developed symptoms of MYMV. Similarly, the nymphs (a stage between 5 and 15 from oviposition) were tested for the ability to transmit the virus to transplant host and to the next stage (adult) of development (transstadial passage, Ling, 1972: 1977). None of the 12 healthy test seedlings of green gram cv. H. 101 inoculated with between 50 and 100 nymphs were infected with MYMV. A total of 23 adult insects developed from 840 nymphs collected from MYMV infected green gram. When the 23 adult insects were caged individually on healthy 2 weeks old test seedlings of green gram cv. H. 101 only 2 of the 23 insects were found to be viruliferous. Transstadial passage of MYMV in whiteflies to an extent of ten percent was possible.

Host susceptibility to mung yellow mosaic virus. A wide range of host plants belonging to many families that include Compositae, Convolvulaceae, Cruciferae, Cucurbitaceae, Euphorbiaceae, Geraniaceae, Graminaceae, Leguminoseae, Linaceae, Malvaceae, Pedaliaceae, Solanaceae, Sorophulariaceae, Urticaceae, Verbanaceae etc. were found to be susceptible to whitefly borne viruses, Costa, 1969.

A large number of weed species and cultivated plants showed symptoms of yellow mosaic that were similar to that caused by MYMV on *Vigna radiata* (L.) Wilezek. To determine host susceptibility to MYMV a range of cultivated and weed plants were artificially inoculated with viruliferous whiteflies in an insect proof screen house. A total of 20 to 25 whiteflies were used per inoculation. The non viruliferous whiteflies were starved for 3 hours prior to acquisition feeding for 24 hours on a MYMV infected green gram cv. M.I. 1. The viruliferous insects were caged on test seedlings for 24 hours of inoculation feeding. The inoculated plants were sprayed with 0.2 percent Azodrin and transferred to an insect proof screen house for development of symptoms. To avoid

confusion of virus symptoms with injury caused by insect feeding, an equivalent number of non viruliferous whiteflies were fed on control plants of the same species and age for the duration of inoculation feeding. Observations on the test plants were continued for 2 months. To detect the presence of virus in symptomless carriers attempts were made to recover the virus by allowing non viruliferous whiteflies an acquisition feeding of 24 hours and transferring them to 2 weeks old test seedlings of green gram cv. H. 101. Attempts at virus recovery was made one month after the inoculation of the host plant where a test plant showed symptoms of yellow mosaic but attempts at virus recovery through whiteflies failed. Attempts were made to recover the virus by allowing an acquisition feeding time of a maximum of 48 hours. The results are shown in Table 6.

Table 6: Host susceptibility to mung yellow mosaic virus.

Scientific name of host inoculated	*No. of plants inoculated*	*No. of plants infected (a)*	*Percentage transmission*	*Symptoms (b)*	*Virus recovery* 1	2
Plants found susceptible to MYMV						
Vigna radiata (L.) Wilczek cv.M.I.I.	10	10	100	ym/ns	—	
Phaseolus lathyroides L.	10	8	80	ym.	—	
Phaseolus atropurpura L.	10	6	60	ym	—	
Glycine max (L.) Merr. cv. Bragg	7	3	42	ym/ns	—	
Cajanus cojan (L.) Millep. cv. TK. 5	20	2	10	ym		
Xanthium strumarium L.	10	1	10	ym		
Alysicarpis vaginalis L.	12	1	8	ym		
Plants found non susceptible to MYMV						
Amaranthus (Hort. cv.)						
Emila ponchifolia (L.) DC.						
Comphrena globota L.						
Beta vulgaris L.						
Chenonpodium amaranticolor L.						
Zinnia elegans Jacq.						
Ageratum conizoides L.						
Bolianthus annus L.						
Cucumis melo L.						
Cucurbita maxima Duchese						
Acalypha indica L.						
Casia tora L.						
Vigna mungo (L.) Wilczek						
Vigna unguiculata (L.) Walp.						
Tephrosia purpurea (L.) Pers.						
Phaeolus vulgaris L.						
Psophocarpus tetragonalobus DC. (L.) DC.						
Abelmoschus esculentus Meend.						
Gossypium hirsutum L.						
Hibiscus esculentus L.						
Sesamum indicum L.						
Capsicum annum L.						
Lycopersicum esculentum L.						
Nicotiana tabacum L.						
Nicotiana glutinosa L.						
Solanum melongena L.						
Solanum nigra L.						
Solanum tuberosum L.						

(a) Observations on most plants lasted for 2 months.
(b) ym yellow mosaic symptoms
ns—necrotic spots
(c) Virus recovery at the end of 1 month by 1. insects given acquisition feeding of 24 hours.
2. Insects given acquisiion feeding of 48 hours.

Phaseolus vulgaris L. and *Vigna mungo* (L.) Wilczek were reported to be susceptible to MYMV by Nair, 1971 and Nene, 1975. In the present study these two hosts were found to be immune to the MYMV of Sri Lanka. *Phaseolus lathyroides* L., *Phaseolus atropurpurea* L., *Xanthium strumarium* L. and *Alysicarpus vaginalis* L. were susceptible to MYMV and are important alternative hosts for this virus. The virus was easily recoverable by the whiteflies from *Phaseolus lathyroides* and *Phaseolus atropurpurea* after an acquisition feeding of 24 hours but in *Cajanus cajan*, *Xanthium strumarium* and *Alysicarpus vaginalis* the whiteflies could not recover the virus at the end of 48 hours acquisition feeding. The F 1 hybrids from reciprocal crosses between *Vigna mungo* and *Vigna radiata* when tested for susceptibility to MYMV were found to be immune, indicating the immunity to be a dominant factor.

Geographical distribution and strains of MYMV. The type strain of Mung Yellow Mosaic Virus MYMV (t) reported in this paper was an isolate obtained from naturally infected green gram cv. M.I. 1 found in the plant pathology field plots at the Agricultural Research Station, Maha Illuppallama. This isolate was similar in host range and transmission characteristics to isolates obtained from weed hosts and cultivated plants in and around the Agricultural Research Station, Maha Illuppallama.

In the yala season of 1974 a naturally occurring strain of yellow mosaic virus was detected in black gram cultivars in the Vavuniya and Amparai districts. This isolate when tested in insect proof screen house with the laboratory strain of whiteflies used for the transmission of the MYMV (t) strain was found to infect all the hosts species of the type strain besides *Vigna mungo* and *Phaseolus vulgaris* cv. Top crop. This isolate may be referred to as the black gram strain of Mung Bean Yellow Mosaic Virus MYMV (bg.).

The MYMV (bg) strain was not isolated from any of the naturally infected weed species. Samples of yellow mosaic infected plants from the different agro-ecological regions of the dry zone indicated that the MYMV (t) strain was dominant and was prevalent in all weeds and crop plants in all regions with the exception of black gram in the Vavuniya and Amparai districts where the MYMV (bg) strain was found. The spread of the MYMV (bg) strain exclusively in the black gram crops may be due to the presence of a different vector or to the existence of different 'biotypes' of the same vector. The existence of biotypes of whiteflies different from the whiteflies used in this study was however not established. The results of the geographical distribution of the two strains of MYMV as occurring in two crop plants and a dominant weed are shown in Table 7.

Table 7: The geographical distribution of the two strains of MYMV in two crop plants and a dominant weed host. (a)

Samples from Districts (b)	Strain of virus detected on *Vigna radiata*	*Vigna mungo*	*Phaseolus lathyroides*
Amparai	t (c)	bg (d)	t
Anuradhapura	t	— (e)	t
Batticaloa	t	bg	t
Jaffna	t	—	0 (f)
Killinochchi	t	—	t
Mannar	t	—	0
Vavuniya	t	bg	t
Trincomalee	t	0	0

(a) The evidence for the existence of strains was based on differential host reaction, which by itself is not adequate. The relationship between the two strains was also not well established. It is possible that these strains are one and the same virus or variants of a single virus complex that become better adapted to certain hosts vector or both.

(b) No tests were made to identify the isolates in Moneragala and Hambantota districts.

(c) (t) refers to the type strain of Mung bean Yellow Mosaic Virus.

(d) (bg) refers to the strain infecting black gram.

(e) — indicates absence of virus in crop.

(f) 0 indicates no tests were made.

Control. The possible strategies for the control of Mung Yellow Mosaic Virus infections in green gram crops may be examined under two criteria. The first is to examine host resistance with a view to adaption of immune cultivars. The second is to identify the factors that prevent, delay or postpone epidemics of yellow mosaics, and combine these factors to obtain optimal results. The use of insecticides for vector control was examined in a series of field experiments at the Agricultural Research Station, Maha Illuppallama. In these experiments low levels of spread of MYMV were obtained in early maturing green gram cultivars like M.I. 4 and H. 101 by the application of systemic insecticides at regular intervals. The complete control of spread of the yellow mosaic was not obtained by insecticidal sprays. The insecticides were ineffective for the control of yellow mosaic in the late maturing cultivars like M.I. 1 and M.I. 3. Insecticidal control of MYMV even in the early maturing cultivars does not appear to be technically and economically feasible at the present farmer level.

Crop sanitation procedures such as clean weeding, barrier cropping, systematic roguing of infected seedlings etc. reduced the incidence and spread of the virus in the rainfed early maha season crops to about the

same extent as the insecticides. This method was of little benefit in the yala season. The incidence and spread of whitefly borne virus diseases is lowest during the intermonsoonal rainy months and highest in the warm dry weeks that follow, Shivanathan, 1976. The adjustment of the planting time to fit the crop establishment and growing phases within the intermonsoonal period resulted in the prevention of yield loss due to MYMV.

Agricultural 'cropping systems' such as inter cropping, mixed cropping, relay cropping, etc. of green gram with other non susceptible crops such as *Vigna mungo* (L.) Wilczek, *Phaseolus vulgaris* L., *Vigna unguiculata* (L.) Walp., *Allium ascalonicum* L., *Arachis hypogea* L., *Capsicum annum* L., *Capsicum frutescens* L. *Manihot utilissima* Pohl etc. were tested as additional methods of control. Although the incidence of disease in the inter cropping experiments and other cropping systems experiments was numerically less than in the monocrops of green gram there was no significant yield increase or economic advantage by the adoption of mixed cropping systems as a cultural practice for the control of MYMV in green gram.

The ultimate solution to the problem of MYMV disease control appears to rest on the use of immune or tolerant green gram cultivars. In a total of 734 green gram cultivars obtained globally and locally, only 12 hybrid lines had stable and good resistance to MYMV while 6 others rated a tolerant reaction when screened at the Agricultural Research Station, Maha Illuppallama for their reaction to the type strain of MYMV. In the 716 cultivars found susceptible to the type strain of the virus were all the commercial cultivars with acceptable seed quality and other agronomic traits. The 6 tolerant cultivars were susceptible to MYMV but their susceptibility did not affect the yield. Table 8 summarises the results of inoculation tests to determine yield loss between a susceptible commercial cultivar and one of the 6 cultivars that showed a tolerant reaction to MYMV.

Table 8. Comparison of loss in yield between a susceptible and a tolerant cultivar of green gram to MYMV

Cultivar of Green gram	Age at inoculation in weeks	Weight in grams		No. of pods per plant	No. of seeds per pod
		Normal	Shrunken		
H 101	2	0	0.49	3.8	4.2
VR/MI/LM/124	2	3.7	0.14	15.4	9.8
H. 101	4	1.82	0.42	7.6	6.3
VR/MI/LM/124	4	3.53	0.31	14.2	12.1
H. 101	6	3.11	0.26	7.1	6.9
VR/MI/LM/124	6	3.94	0.28	15.9	13.2
H. 101 (control)	healthy	4.23	0.08	9.0	11.4
VR/MI/LM/124 (control)	healthy	3.81	0.12	16.3	12.6

The data in table 8 indicates a negligible yield loss in the tolerant cultivar VR/MI/LM/124 due to MYMV. The adoption of tolerant cultivars until such time as breeders incorporate good and stable resistance

into commercial cultivars will be a partial solution to the disease constraint of MYMV. These cultivars require careful testing for stability of resistance to several different populations of vectors and pathogens under widely differing environments.

Stable and good resistance was identified in crosses involving *Vigna radiata* (L.) Wilczek and *Vigna mungo* (L.) Wilczek and also in reciprocal crosses between commercial cultivars of *Vigna radiata* (L.) Wilczek and wild species of *Vigna radiata* (L.) Wilczek native to the Himalayan regions*. The hybrids were found to be immune to MYMV (t) in test at the Agricultural Research Station, Maha Illuppallama. In a further test at 3 agro-ecological regions in the dry zone these hybrids were found to be resistant to the naturally occurring strains of the virus. The identification of resistance to MYMV in green gram cultivars represents a potential solution to the disease constraint in production. A concerted and co-ordinated effort by the plant pathologists and plant breeders would be required to select the most suitable and stable resistance in the immune cultivars and incorporate them into commercial cultivars with acceptable seed quality and other agronomic traits.

The detection of the bg strain of MYMV in black gram cultivars has complicated the task of identification of host resistance to the composite of 2 strains. The cultivars were screened in areas where the MYMV (t) strain predominants. The natural epidemic of MYMV (bg) strain was detected only in black gram crops in the two districts. These resistant cultivars will require careful evaluation for stability of the resistance to several different populations of pathogens and vectors under widely different environmental conditions before stable resistance to this disease can be logically developed.

Cowpea Mosaic Virus

The cowpea mosaic virus was found in nature in many commercial cultivars of *Vigna unguiculata* (L.) Walp., *Crotalaria* spp. and *Euphorbia geniculata.* The latter two hosts appear to be the alternative hosts in nature for this virus. In many commercial cultivars of cowpea the virus caused a mild mosaic and was seldom a problem particularly in the maha season. The aphid vectors *Aphis gossypii* Glov., *Myzus persicae* Sulz. *Aphis craccivora* Koch. and *Aphis malvoides* were capable of transmitting the virus in the field. The virus was easily sap transmissible but seed transmission was not detected in the commercial cultivars Pellon, Hawari, Bush-sitavo, M.I. 35 and M.I. 625. The humid and wet conditions resulting from the intense intermonsoonal rains prevent the rapid multiplication of the aphid vector and hence the disease seldom assumes epiphytotic proportions in the maha season. The late maturing indeterminate, non dwarf cultivars grown in the yala season under irrigation suffer considerable yield loss due to severe incidence of cowpea mosaic virus. A fortnightly spray of Thiodan or Actellic checks the spread of this virus in the early maturing dwarf cultivars.

---

* Seeds of wild species of green gram and hybrid seeds with the wild species as a parent were given to the author by Professor S. P. Biniwal, Professor of Plant Pathology, University of Pantnagar, Uttar Pradesh, India.

Common Bean Mosaic Virus

The common bean mosaic virus was isolated from field plants of *Phaseolus vulgaris, Vigna mungo, Vigna radiata* and *Vigna unguiculata.* The affected plants showed mosaic symptoms, clearing of veins and leaf distortion. This disease was recorded in and around the Agricultural Research Station, Maha Illuppallama. This virus was not recorded from other parts of the dry zone, and its importance remains to be assessed. It is a likely introduction with imported seeds.

Southern Bean Mosaic Virus

A virus similar to southern bean mosaic virus was isolated from *Vigna radiata, Vigna mungo, Phaseolus vulgaris, Vigna unguiculata* and *Glycine max.* The incidence of this virus in the farmer's field was negligible. In seed packets imported for scientific work this virus was detected to a maximum of 8 percent in some cultivars of *Vigna mungo* and to about 12 percent of the seeds of *Vigna radiata,* This virus is an unwelcome introduction with seeds and the procedures for the importation of seed need revision in the light of risks of importing diseases which may be extremely costly to erradicate or may add enormously to the costs of production.

Leaf Curl Virus

The leaf curl virus transmitted by whiteflies *(Bemisia tabaci* Genn.) causes severe economic losses annually in a wide range of crops in the dry zone. This virus was studied in detail by Fernando, 1953: Pieris, 1953: Fernando and Pieris, 1957: Shivanathan and Abeygunewardene, 1964: Shivanathan 1978. This virus was not isolated in nature from *Vigna mungo, Vigna radiata, Vigna unguiculata* and *Phaseolus vulgaris.* The leaf curl virus was frequently isolated in the yala season from field infected green gram cultivars. This virus was always found in green gram cultivars as a mixed infection in association with the type strain of MYMV. The leaf curl virus comprises of two strains — the type strain of the virus was studied in detail and is widely distributed while the enation strain LCV (e) was isolated mainly from tobacco crops in the North Central Province on which it causes pronounced enations rather than the upward curling of leaves. In all samples of infected green gram plants tested the (t) strain of the leaf curl virus was found associated with the MYMV(t) strain. The leaf curl virus was never isolated independent of MYMV(t). Similarly the LCV (e) was not detected alone or in association with either MYMV(t) or MYMV (bg) strain. Varma, 1955 reported that the whiteflies were capable of carrying more than one virus simultaneously. The dual infection of MYMV and LCV in green gram was produced either by individual inoculation or simultaneously by a whitefly carrying both viruses in its system. In the Yala season a maximum of 20 percent dual infection was recorded for green gram in certain years. The early dual infection of green gram by MYMV and LCV results in complete sterility, leaf curl, vein clearing chlorosis and dwarfing of plants.

Soybean Mosaic Virus

The soybean mosaic virus was isolated in nature only from soybeans *(Glycine max* (L.) Merr.) It was not recorded in any of the important grain legumes in Sri Lanka. The virus is highly seed borne

in some cultivars. It was easily sap transmitted but the field spread appears to be by means of aphid vectors *Aphis gossypii* and *Myzus persicae*. The spread of this virus could be controlled by proper seed certification procedures and by strict quarantine control of all seed imports from abroad where at least 7 strains of this virus, varying in their ability to pass through seed, were reported, Goodman, 1980.

Leaf Crinkle Virus

The leaf crinkle virus was first observed in the genetic evaluation plots at the Agricultural Research Station, Maha Illuppallama on introduced cultivars of *Vigna radiata* and *Vigna mungo*, Plant disease surveys indicated that this virus was widely distributed in all areas where green gram and black gram were grown extensively. The maha season crops generally showed higher incidence of leaf crinkle virus infection than the yala season cultivations. This virus was sap transmissible and was seed borne to a low percentage in a number of cultivars of green gram and black gram. The vector for this virus, if any, was not identified. The virus was not observed to spread within the field. The following insects were tested for vector transmission of this virus in the screen house with unsuccessful results:

(i) Whitefly (*Bemisia tabaci* Genn.)
(ii) *Aphis gossypii* Glov
(iii) *Aphis malvoides*
(iv) *Aphis craccivora* Koch.

The extent of seed transmission in five cultivars of *Vigna mungo* was determined by inoculating the cotyledonary leaves of 10 day old seedlings of these cultivars with infectious sap from leaf crinkle infected plants. The seeds were harvested from the artificially inoculated plants and sown in autoclaved soil in the insect proof screen house. The tests were done only in the maha season to avoid the effects of temperature and other factors on seed transmission. Shivanathan, 1970. The results are summarised in Table 9.

Table 9: Transmission of leaf crinkle virus in five cultivars of *Vigna mungo* (L.) Wilczek

Name of culivar	No of plants inoculated(a)	No. of seeds harvested	No. of seeds garminated	No. of seedlings with symptoms(b)	Percantage seed tramission
M.I. 1	10	316	284	4	1.4
Uffani 16	10	263	194	11	5.6
Wooly Purol	10	296	283	9	3.2
Gualior 18	10	339	306	0	0
Pant U 30	10	276	266	12	4.5
M.I. 1 (healthy) (control)	10	2716	294 (c)	0	0

(a) Seedlings sap inoculated at cotyledonary stage.
(b) Observations lasted till flowering (32 to 46 days from sowing)
(c) Only 300 of 2716 seeds in control were germinated.

The results in table 9 indicate very low rates of seed transmission for the five black gram cultivars. The virus induces high percentage of sterility in the infected plants. Selection of cultivars showing no seed passage would be a possible control measure for this virus.

Tobacco Ringspot Virus

This virus was isolated from a wide range of host species that includes many of the cultivated plants and the more dominant weed flora representing several families, Shivanathan, 1977 b. This virus is probably an introduction with fodder and crop seeds. It has the tendency to be highly seed borne and could thus be distributed with infected crop seeds to all parts of the country.

Sterility Mosaic

Sterility mosaic was observed in nature only on *Cajanus cajan*. This is the only mite transmitted virus known in this country, Shivanathan 1977 a. The virus was not transmitted by sap, seed or soil. Successful transmissions were achieved by graft and by the Eriophyd mite *Aceria cajani*. The characteristic symptoms of the disease include stunting, bushy and pale green appearance, and complete cessation of reproductive structures. The disease resembles mycoplasma type diseases and regular application of sulphur to control the vector provides acceptable control of this disease.

FUNGAL DISEASES

The fungal diseases affecting leguminous crops in Sri Lanka were described by Abeygunewardene, 1969. In this section additional information on some important disease problems in the dry zone are presented.

Seedling Mortality

The legume crops are vulnerable to attack by soil borne pathogens in the wet maha season. Seedling mortality due to pathogenic fungi in the irrigated yala crops was negligible. In the maha season a seedling mortality rate of 75 percent in 20 days was frequently reported in soybeans, cowpea and green gram. Two pathogenic fungi, *Pythium aphanidermatum* (Edison) Fitzp. and *Corticium solani* (Prill. & Delact) Bourd and Galz. or *Thanatephorus cucumeris* (Frank) Donk. were constantly isolated from diseased seedlings.

Pythium aphanidermatum causes pre and post emmergence seedling mortality. The fungus invades the collar region and moves rapidly up the hypocotyls. The affected portion assumes a water soaked greyish appearance and the seedlings collapse at the water soaked region. The disease first appears with the intermonsoonal rains at the beginning of the season, when the hot dry spell is broken by a few thunder showers. The highest incidence of seedling mortality due to *Pythium aphanidermatum* occurs in November and December when the rains and cool wet conditions with the overcast sky favour the rapid spread of this fungus. This disease tapers off in February and March and is seldom recorded on legumes in the dry months.

Corticium solani — *Thanatephorus cucumeris* was identified as a component of seedling mortality in many crops. It causes brownish to brownish grey lesions at the collar region. Although a higher incidence of seedling mortality due to Corticium was recorded for the maha seasons the fungus causes damage in both seasons and in the intermonsoonal periods.

Control. Agro-chemicals are not used in the dry zone for control of seedling mortality. The practice of slightly increasing the seed rate to cover losses due to seedling mortality has been rewarding particularly in the early season plantings with the more traditional cultivars. It is unlikely that stable resistance can be found for unspecialized soil fungi such as *Pythium aphanidermatum* and *Corticium solani*. In late season plantings with improved cultivars seedling mortality can be controlled by the application of a chemical seed protectant such as Captan at 3—5 grams active ingredient per kilogram of seed. Coating the seed with Captan 50 WP and Actellic 5 percent dust gave good control of seedling mortality over several seasons at the Agricultural Research Station, Maha Illuppallama.

Cercospora Leaf Spot

Among the funal diseases Cercospora leaf spots and rusts cause significant yield loss annually in many legumes. Economic losses due to Cercospora leaf spot on groundnut range from 10 to 30 percent while damage on the maha season susceptible cultivars of green gram and cowpea amounts to 20 to 50 percent in most years.

Cercospora leaf spot on groundnut caused by *Cercospora personata* (Berk. & Cprt.) Ellis & Everh. does severe damage to late-maturing cultivars in the maha season. The fungus propagates through conidia and ascospores produced on groundnut debris in the field. None of the cultivars screened at the Agricultural Research Station had good resistance to this disease. Adoption of early maturing cultivars together with four sprays of Dithane M 45 or Manzate D at 2 kilograms per hectare starting from the second week of January at intervals of 10 to 15 days gave acceptable control.

In cowpea and green gram two species of Cercospora were identified. *Cercospora cruenta* Sacc. was common and caused more damage than *Cerocospora canescens* Ellis & Martin. The spots of *Cercospora cruenta* often appear on the lower surface of the leaves as circular reddish brown lesions that turn brown with maturity. The lesions become necrotic and drop fall off leaving large circular holes on the lamina of the leaves. Most leaves abscise prematurely. The lesions can develop on stems, pods, petioles and all aerial parts of the plant.

Control. All cultivars of green gram and cowpea screened for resistance at the Agricultural Research Station, Maha Illuppallama were found to be susceptible to the dominant fungal species *Cercospora cruenta*. Foliar applications of systemic fungicides such as Benlate at 0.2 percent active ingredient gave good control but could not be recommended due to costs and other factors. Dithane M. 45 and Manzate D at 2 kilogram per hectare gave acceptable control in green gram and cowpea crops.

Rusts. *Uromyces appendiculatus* (Pers.) Unger.

Rusts cause considerable damage to many legume crops. Highly susceptible cultivars of groundnut, green gram and black gram can be entirely wiped out or completely defoliated by mid flowering stage resulting in severe yield reductions. The disease develops during the dry

weather starting in January and reaches epidemic proportions by February and March. Early season plantings reduce rust incidence in the pre flowering periods. It is not economically feasible or technically possible to control rusts by fungicidal sprays on a low value crop of the low income farmer. In the numerous cultivars and breeding lines evaluated at the Agricultural Research Station, Maha Illuppallama suitable resistance to rust was not identified. In India and at IITA sources of immunity and low susceptibility has been identified: Williams, 1975. The best solution for the rust disease is to develop resistant cultivars.

Wilts

Wilt diseases caused by several fungi are of increasing significance particularly in the irrigated area with intensive farming. Incidence of hydro-mycotic wilts in soils of reddish brown earth group ranged between 0.2 and 3 percent. In the intensively cultivated latersols and the sandy loams wilt incidence up to 20 percent was frequent. Several pathogenic fungi were found associated with wilt diseases and soil moisture levels, resulting from improper irrigation and drainage practices was identified as a predisposing factor, Shivanathan, 1976.

Fusarial wilts. *Fusarium solani* (Mart) Sacc. was isolated from most samples and is the dominant fusarial species causing wilt in the dry zone. *Fusarium oxysporium* (E. F. Smith) Snyder & Hansen. was isolated infrequently in green gram and toor dhal grown in the reddish brown earth type of soils.

Sclerotial wilts. The fungus *Sclerotium rolfsii* Sacc. *Corticium rolfsii* Curzi.) was isolated in several samples of leguminous plants. The base of the stem is often girdled by the fungus. The sclerotia are produced on cottony mycelial growth near the outer margin of the stem and sometimes on the ground around the stem. The sclerotia are large globose and white to brown in colour. The fungus is soil borne and attacks a wide range of plants. The disease is favoured by high temperature and dry weather. Intensive cropping with susceptible crops results in the build up of the pathogen. Deep ploughing to bury the infected debris and crop rotation with non susceptible hosts are the recommended control measures.

Charcoal rot. Charcoal rot is caused by the fungus *Macrophomina phaseolina* (Tassi) Goid. *Rhizoctonia pataticola* (Taulb) Butler. The fungus is favoured by high temperatures (above 35°C.) and is the dominant fungus causing wilt in all of the dry zone in the warmer months (Yala season) especially in the sandy loams and the lateritic type of soils. The fungus attacks the root and stem bases of the plants. When the barks of affected plants are peeled numerous small black spore bearing pyenidia giving a greyish black appearance to the tissues can be seen. The fungus is non specific and attacks a wide range of host plants. It is devastrating in hot dry weather. The disease is seed and soil borne. Systematic studies to find possible resistance were not made and the treatment of seeds with Agrozan is recommended.

Other Fungal Diseases

Several other fungal diseases of legumes were identified but their importance in the field was not determined. In very wet maha season crops of cowpea *Corynespora casaicola* (Berk. & Curt.) Wei was observed to be a problem. Powdery mildews caused by *Erysiphe polygoni* DC. appear in field crops generally during dry spells that immediately follow a rainy period. In case of severe infection by powdery mildews complete defoliation could result. Host resistance of a stable nature was not detected. In the maha season the zonate leaf spots caused by *Batuliphora tarri* Leakey, appears about the same time as *Cheanephora infundibulifera* (Curry) Sacc, appears on pods of green gram and cowpea damaged by insect borer Heliothes spp.

BACTERIAL DISEASES

Bacterial diseases of legumes are very few and do not cause significant yield losses in any of the legumes. The bacterial pustule appears during the rainy months. The symptoms appear as tiny dark water soaked dots on the under side of the leaves. On the upper side these appear like dark brown necrotic spots. The symptoms of this disease are similar to those described by Patel and Jindal, 1973 for bacterial leaf spot of mung beans in India. A *Xanthomonas* species of bacteria similar to *Xanthomonas vignicola* has been regarded as the causal agent.

Xanthomonas vignicola Burkholder was isolated from cowpea plants in the maha season. It causes bacterial blight on cowpeas and its importance is yet to be determined. The practice of collecting the yala season seeds to be sown in the maha season effectively prevents the spread of many fungal and bacterial pathogens such as *Collectotrichum lindemuthianum* (Sacc. & Magn.) Bri. & Cav. and *Xanthomonas vignicola* Burkholder.

LEGUME SEED PATHOLOGY

In view of the substantial risks and severe consequences associated with the carriage of pest and diseases on seed material, preliminary studies were conducted to identify some of the myco-micro flora in and on seeds of legumes cultivated at the Agricultural Research Station, Maha Illuppallama. The legume seeds were found to be highly susceptible to seed rot and seedling blights. The methods of processing of legume seeds in the dry zone entails high risks of contamination with infected debris and with soil. The high incidence of seed rot and seedling mortality in the new improved varieties as compared to the traditional varieties may partly be related to seed borne organisms.

To determine the nature and extent of microflora on legume seeds, samples of 400 seeds each were drawn from the breeders seeds of five legume cultivars. These seeds were subjected to the 'blotter test' (ISTA). The fungal isolates from the seeds were identified by the C.M.I. The results are shown in Table 10.

Table 10: The microflora associated with seeds of five legume varieties.

Organism isolated	Percent seeds affected in legume varieties				
	Cowpea	Green gram	Ground-nut	Toor dhal	Soybean
Alternaria tenuissima	0.5	0	0.75	0	0.25
Aspergillus niger van Tiegh	0.25	0	0	6.5	0
Curvularia senagalensis (Speg) Subram & other spp.	0	0.5	0.5	0.25	0
Fusarium solani (Mart.) Sacc.					
Fusarium semitectum Berk & Rav.					
Fusarium equiseti (Corda) Sacc.					
Fusarium moniliforme var anthiophilum (Wollen & Reink)					
Fusarium fusaroides (Frag & Cifi) Booth	1.25	0.75	0.75	0.5	0.5
Drechslera halodes (Drechsler) Subram & Jain					
Phoma sorghina (Sacc)	1.0	1.25	2.0	0.75	0.25
Boerema Dorenbosch & van kest.	0.25	0	0.25	0	0.25
Rhizoctonia bataticola (Taulb) Butler	0.5	0	0	0.25	0
Sterile dematiaceous mycelium	0	0	0.5	0.25	0
Sterile with chlamydospores	0	0.25	0.25	0	0.25
Unidentified bacterial colony	0.5	0.25	0.75	0.5	0.5

In the grain legume improvement programmes the early maturing high yielding cultivars with determinate growth are being increasingly recommended to replace the hardy drought resistant traditional cultivars. A comparative study on the microflora of the seeds of the traditional cultivars was not made. However, the data in table 10 suggests that the legume seeds released from the Research Station should mandatorily be treated with a seed protectant so as to exclude the possibility of pathogen and pest dispersal through seed.

SUMMARY AND CONCLUSIONS

The more important viral, fungal and bacterial diseases of legumes are discussed together with their control measures. Mung Yellow Mosaic Virus MYMV transmitted by whitefly *(Bemisia tabaci* Genn.) is a serious constraint in the production of several legume crops. This disease has been discussed in detail. Chemical control measures have been found for some diseases. Although good control could be achieved by these measures, with the possible exception of chemical seed protectants they are unlikely to be popular, technically viable or economically feasible for

a farming community that depends on the monsoonal rains for their agriculture. In addition adequate chemical or other control measures do not exist for several diseases that are a persistent problem in the dry zone. The use of host plant resistance appears to provide the best solution to many of the important disease problems of legumes. The identification of resistance to Mung Yellow Mosaic Virus in *Vigna radiata* (L.) Wilczek represents a potential solution to a difficult and complex disease problem. A massive co-ordinated national effort between plant pathologists and plant breeders is essential to select the most suitable and stable resistance and incorporate these into cultivars with acceptable seed quality and other agronomic traits. The successful and intensive cultivation of legume crops in the yala season with irrigation that would in the future be available to extensive areas in the dry zone will largely depend on finding economically and technically feasible control measures for the serious pest-disease complex of the dry zone.

REFERENCES CITED

1. Abeygunewardene, D. V. W. (1969) Diseases of cultivated plants. The Colombo Apothecaries' Co. Ltd.
2. Bennet, C. W. (1969). Seed transmission of plant viruses. *Adv. Virus Res.* 14:221-261.
3. Bird, J. (1957). A whitefly transmitted mosaic of *Jatropha gossypfolia*. *Agr. Exp. Sta. Univ, Puerto Rico. Tech. paper* **22:** 1-35 RAM 37: 421.
4. Bird, J. (1958). Infectious chlorosis in *Sida carpinifolia*. in Puerto Rico. *Agr. Exp. Sta. Univ. Puerto Rico. Tech paper* **26:** 1-23.
5. Capoor, S. P. and P. M. Varma (1948). Yellow mosaic of *Phaseolus lunatus* L. Curr. *Sci.* 18: 82-83 RAM 27: 549-550.
6. Chant, S. R. (1959) Studies on the transmission of cassava mosaic by *Bemisia* spp. (Aleyrodidae) *Ann. Appl. Biol.* 46: 210-215.
7. Cohen, S. and F. E. Nitzany (1966) Transmission and host range of tomato yellow leaf curl virus. *Phytopathology.* **56:** 1127-1131.
8. Costa, A. S. and C. W. Bennett (1950) Whitefly transmitted mosaic of *Euphorbia prunifolia. Phytopathology.* 40: 266-283
9. Costa, A. S. Ana Maria Carvalho (1960) Comparative studies between Abutilon and Euphorbia mosaic viruses. *Phytopathology* Z. 38: 129-125.
10. Costa, A. S. (1969) Whiteflies as virus vectors. In 'Viruses, Vectors and Vegetation' (K. Maramorosch ed.) 95-119. John Wiely & Sons.
11. Duffes, J. E. (1965) Beet pseudo-yellows virus transmitted by greenhouse whitefly *(Trialeurodes vaporariorum). Phytopathology* 55: 450-453.
12. Fellows, R. W. (1977) Entomology. Yala-Maha Reports 1977 Agr. Res. Sta. Maha Illuppallama.
13. Fernando, H. E. (1953) Insect transmission of chilli viruses. *Trop. Agric.* CIX: 216.

14. Fernando, H. E. and J. W. L. Peiris (1957) Investigation of the chilli leaf curl complex and its control. *Trop. Agric.* CHIII: 305-323.

15. Fulton, R. W. (1964) Transmission of plant viruses by grafting, dodder seed and mechanical inoculation. In *'Plant Pathology'* (M. K. Corbett and H. D. Sisler. eds.). 39-67. Uni. Flor. Press. Gainsville, Florida.

16. Harpaz, I. and S. Cohen (1965) Semipermanent relationship between Cucumber Vein Yellowing (CVYV) and its vector tobacco whitefly *(Bemisia tabaci* Gennadius) *Phytopathology.* Z. 54: 240-248.

17. Harris, K. F. and K. Maramorosch (1980) Vectors of Plant Pathogens. Acdem. Press.

18. Kirkpatrick, T. K. (1931) Further studies on the leaf curl of cotton in the Sudan. *Bull. Entomolo, Res.* 22: 323-363.

19. Laird, E. F. and R. C. Dickson (1959) Insect transmission of leaf crumple virus of cotton. *Phytopathology.* 49: 324:327.

20. Ling, K. C. (1972) Rice Virus Diseases. International Rice Research Institute, Los Banos. Philippines.

21. Mishra, M. D. (1977) Progress and trends in virus research in India. *Trop. Agr. Res. Ser.* 10

22. Nair, N. G. (1971) Studies on yellow mosaic of urd bean caused by mung bean yellow mosaic virus. Ph.D. thesis. UPAU. Pantnagar, India.

23. Nariani, T. K. (1960) Yellow mosaic of mung *(Phaseolus lunatus L.) Indian Phytopathology* 13: 24-29.

24. Nene, Y. L. (1975) A survey of virus diseases of pulse crops in Uttar Pradesh. *Res. Bull.* 4. *UPAU. Panthagar, India.*

25. Patel, P. N. and J. K. Jindal (1972) Bacterial leaf blight and halo blight diseases of mung beans (*Phaseolus aureus* L.) and other legumes in India. *Indian Phytopathology,* 25: 517-525.

26. Peiris, J. W. L. (1953) Chilli leaf curl complex, *Trop. Agric.* CIX:210.

27. Pruthi, H. S. and C. K. Samuel (1939) Entomological investigation on the leaf curl disease in Northern India. III. The transmission of leaf curl virus by whitefly *Bemisia gossypiperda* to tobacco, sunhemp and a new alternative host of leaf curl virus. *Indian J. Agr. Sci.* 9: 223-275.

28. Shivanathan, P. and D. V. W. Abeygunewardene (1964) Recent advances on the control of chilli virus diseases. *Proc. Ceylon Ass. Advmt. Sci.*

29. Shivanathan, P. (1970) Seed transmission of N. S. P. strain of BSMV in barley. Ph.D. thesis. McGill Univ. Canada.

30. Shivanathan, P. (1974) Plant Pathology. Yala-Maha Reports 1974 Agr. Res. Sta. Maha Illuppallama.

31. Shivanathan, P. (1975) Diseases of rainfed crops in Sri Lanka. F.A.O. Bangkok. RAFE: 23.

32. Shivanathan, P. (1976) Plant Pathology Yala-Maha Reports 1976 Agr. Res. Sta. Maha Illuppallama.

33. Shivanathan, P. (1977 a) Virus diseases of crops in Sri Lanka. *Trop. Agr. Res. Ser:* 10: 65-71.

34. Shivanathan, P. (1977 b) A seed borne virus of *Phaseolus aureus* Roxb. *Trop. Agr. Res. Ser:* 10: 143-150.

35. Shivanathan, P. (1977 c) Plant Pathology. Yala-Maha Reports 1977 Agr. Res. Sta. Maha Illuppallama.

36. Shivanathan, P. (1979 a) Virus diseases of the chilli crop in the dry zone of Sri Lanka *Proc. Sri Lanka Ass. Advmt. Sci.* 35: (1) 22.

37. Shivanathan, P. P., A. T. Wickremasinghe and T. Jayaratne (1979 b) Studies on soybean yellow mosaic virus in Sri Lanka. *Proc. Sri Lanka Ass. Advmt. Sci.* 35: (1) 23.

38. Storey, H. H. (1935) Virus diseases of East Africa plants. II. Leaf curl disease of tobacco. *E. Afr. Agr. J* 2: 148–153. RAM 15: 118 (1936).

39. Varma, P. M. (1952) Studies on the relationship of bhendi yellow mosaic virus and its vector whitefly *(Bemisia tabaci* Genn.) Indian *J. Agr. Sci.* 22: 79-91.

40. Varma, P. M. (1955 a) Persistence of yellow vein mosaic virus of *Abelmoschus esculentus* L. Moench. in its vector *(Bemisia tabaci* Genn) *Indian J. Agr. Sci.* 24: 293-302.

41. Varma, P. M. (1955 b) Ability of whitefly to carry more than one virus simultaneously. *Curr. Sci.* 24: (9) 317-318. RAM 35: 69. (1956).

42. Varma, P. M. (1963) Transmission of plant viruses by whiteflies. *Bull. Nst. Inst. Sci. India.* 24: 11-23.

43. Williams, R. J. (1975) Diseases of cowpea *Vigna unguiculata* (L.) Walp. in Nigeria. Pans. 21: (3) 253-267.

National Digitization Project

National Science Foundation

Institute : Department of Agriculture

1. Place of Scanning : Department of Agriculture, Peradeniya
2. Date Scanned : 2018/01/23
3. Name of Digitizing Company : Sanje (Private) Ltd, No 435/16, Kottawa Rd, Hokandara North, Arangala, Hokandara
4. Scanning Officer

Name : N.S. Karunarathna

Signature : Sithara

Certification of Scanning

I hereby certify that the scanning of this document was carried out under my supervision, according to the norms and standards of digital scanning accurately, also keeping with the originality of the original document to be accepted in a court of law.

Certifying Officer

Designation : Chief Librarian

Name : Saumya Upamalika

Signature :

Date : 2018/01/23

"This document/publication was digitized under National Digitization Project of the National Science Foundation, Sri Lanka"