Virus Diseases of Cowpeas.

By

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Virus infections of cowpea, *Vigna unguiculata*, are common in South Africa. There are three types of symptom found in the field viz. a vivid yellow mosaic with dark green blisters; dark green veinbands with necrosis and severe malformation, and a mild veinbanding or mosaic. There is no evidence of seed transmission but *Aphis* species are efficient vectors.

REVIEW OF LITERATURE.

The first reports of mosaic diseases of *Vigna* species were by McClintock (1917), Elliot (1921) and Elmer (1925). Smith (1924) established that a virus causing mosaic symptoms on cowpea was transmissible by a leaf-beetle, *Ceratoma trifurcata*. In 1929, Briant & Martyn recorded the transmission of a mosaic of *V. catjang* in Trinidad; and the following year Smith & Barker described a virus causing severe stunt and chlorosis on cowpeas in Haiti. Yu reported a mosaic of cowpea in China in 1939.

Detailed descriptions of viroses of *Vigna* spp. are given by McLean—a seed-borne mosaic of cowpea (19); Snyder—a seed-borne mosaic of asparagus bean (31); Vasuveda—a mosaic of *V. catjang* in India (32); Yu—cowpea mosaic in China (41); d'Oliviera—cowpea mosaic viruses 1, 2 and 3 (11); Dale—a cowpea mosaic transmitted by a leaf-beetle (8 and 9); Warid & Plakidas—cowpea mosaic viruses with extremely high thermal inactivation points (35) and Anderson (3b). Capoor *et al* described mosaic diseases of *V. catjang* (6) and *V. cylindrica* (7).

Price (21) was the first to report a strain of cucumber mosaic virus (strain Y) which caused a systemic reaction as well as the usual local lesions on cowpea. Later Whipple & Walker (38) described strains 14 and 17, and Fulton found strains A–F on spinach (14). Anderson (3a) recorded yet another strain, also systemic on cowpea.

Sill & Walker (26a and b) when working on the optimum conditions for local lesion production on cowpea with cucumber mosaic virus, found that some lines of cowpeas became systemically infected. Sinclair & Walker (25) determined that this factor was controlled by the mutation of a single gene pair.

Other legumes which can be naturally infected with strains of cucumber mosaic virus are peas and beans, Whipple & Walker (38), and Hagedorn (15), sweet peas, Ainsworth (2) and lima bean, Harter (16).

Several viruses, when inoculated artificially induce local lesions only on cowpea, viz. tobacco ringspot, Wingard (39); tobacco necrosis, Smith & Bald (30); potato calico, Black & Price (4); tomato bushy stunt, Smith (28); alfalfa mosaic 1, Zaumeyer (43) and Black & Price (4); alfalfa mosaic 1A, 1B and 2, Zaumeyer (43) and pea wilt, Johnson (17).

The curly top virus causes severe stunt of the plant and proliferation of the leaves of cowpea, Severin & Henderson (24).

METHODS AND MATERIALS.

The following three viruses were isolated from naturally infected cowpeas found in several districts of the Transvaal.

The standard test plants used were: *Phaseolus vulgaris* var. Canadian Wonder, *Vicia faba* and *Pisum sativum* var. Greenfeast; also *Nicotiana tabacum* var. White Burley, *N. glutinosa*, *Cucumis sativus*, and *Zinnia elegans* as so many cowpea viruses are related to the cucumber mosaic virus group. In addition, about 30 other legumes were included in the susceptibility tests.

Carborundum powder was used for the mechanical sap inoculations, and *Aphis craccivora* for the insect transmissions. (This aphis was used solely as a criterion of whether or not the viruses were indeed aphis transmissible.)

In this report three virus diseases found naturally on cowpea are described and compared with those already recorded in the literature.

During this survey of legume virus diseases, cowpea was found to be susceptible to many other legume virus when inoculated artificially. It also produced local necrotic lesions with the tomato spotted wilt virus.

1. **Cowpea Mosaic Virus A.**

Physical properties: Thermal inactivation point, 62–65°C. Longevity *in vitro*, 2–4 days. Dilution end point, 1: 2000.

Transmission: Mechanical sap inoculation. *Aphis craccivora.*

Host range: *Arachis hypogaea* L., *Crotalaria juncea* L., *C. spectabilis* Roth., *Dolichos lablab* L., *Glycine javanica* L., *G. max* (L.) Merr., *Lathyrus odoratus* L., *Lupinus albus* L., vars. sweet and bitter, *L. luteus* L., *L. mutabilis* Sweet., *Medicago lupulina* L., *M. sativa* L., *Melilotus officinalis* Willd., *Phaseolus acutifolius* Gray var. *latifolius* Freem., *P. lunatus* L., *P. mungo* L., *P. vulgaris* L., *Pisum sativum* L., *Trifolium fragiferum* L., *T. hybridum* L., *T. incarnatum* L., *T. pratense* L., *T. repens* L., *Vicia faba* L., *Vigna sesquipedalis* (L.) Wight., *V. unguiculata* (L.) Walp., *Voandzeia subterranea* Thouars.

Reaction of Susceptible Species.

Arachis hypogaea.

Local. No reaction.

Systemic. The leaves are crinkled, and chlorotic with dark green veinbands.

Crotalaria juncea.

Local. There are necrotic specks with chlorotic rings. The leaves drop.

Systemic. After a vein clearing and spotting in 10 days, the leaves develop a mottle with dark green blisters and veinbands. There are also necrotic specks. These leaves are crinkled and malformed with constrictions of the laminae. The plant is rosetted.

C. spectabilis.

Local. No reaction.

Systemic. After 13 days there is a vein clearing and chlorotic spotting and flecking of the young leaves. The next leaves develop irregular chlorotic areas with dark green veinbands and islands. These leaves are rolled, crinkled and slightly malformed.

Dolichos lablab.

Local. No reaction.

Systemic. There are diffuse chlorotic areas.

Glycina javanica.

Local. There are necrotic spots with chlorotic rings in 4 days.

Systemic. The leaves may have chlorotic areas or, if symptomless, the virus can be recovered.

G. max.

Local. Chlorotic spots may develop.

Systemic. There is a chlorotic spotting and vein flecking in 9 days. The next leaves develop a mottle with dark green blisters and irregular yellow areas. They are elongated and malformed with a crinkled surface. The older leaves have necrotic specks.

Lathyrus odoratus.

Local. No reaction.

Systemic. There are dark green veinbands on most leaves, which are also rolled. The plant is stunted.

Lupinus albus var. Sweet.

Local. There are dark green lesions on chlorotic leaves in 9 days and the leaves drop.

Systemic. At the same time the young leaves remain folded and have wavy margins, with a vein clearing and later spotting. The plant remains stunted. Necrotic specks develop later and the plant collapses.

L. albus var. Bitter.

Local. No reaction.

Systemic. The young leaves remain small and are chlorotic with dark green blisters. They are rosetted and have twisted tips. Necrosis sets in and many leaves drop.

L. luteus.

Local. Necrotic specks develop in 10 days.

Systemic. The young leaves remain folded and have twisted tips and chlorotic spots. Later leaves are mottled with dark green veinbands. They are small, rolled and malformed. Necrosis may set in and the leaves drop. The plant is stunted.

L. mutabilis.

Local. No reaction.

Systemic. The leaves are mottled with dark green blisters. The plant is rosetted and stunted.

Medicago lupulina.

A symptomless carrier.

M. sativa.

Local. No reaction.

Systemic. There is a chlorotic spotting with necrotic specks.

Melilotus officinalis.

A symptomless carrier.

Phaseolus acutifolius.

Local. There are chlorotic spots in 6 days.

Systemic. After a vein clearing of the young leaves in 9 to 10 days, most later leaves have a speck mottle.

P. lunatus.

Local. Large chlorotic blotches develop.

Systemic. The young leaves develop a vein clearing in 6 to 7 days (Fig. 1f). Later leaves have chlorotic vein flecks or irregular areas which become necrotic (Fig. 1e). These leaves may be crinkled.

P. mungo.

Local. There are necrotic spots, ringspots and veins in 7 days.

Systemic. In 3 weeks the young leaves may develop chlorotic specks which soon become necrotic.

P. vulgaris var. Canadian Wonder.

Local. In 4 days there are chlorotic spots which later have necrotic rings.

Systemic. The young leaves develop a vein clearing and chlorotic spotting in 6 days. Later leaves are mottled.

var. Haricot.

Local. In 4 days there are chlorotic spots which spread and fuse. There are also necrotic ringspots and veins.

Systemic. In 10 days the young leaves curl down and develop a vein clearing. These veins become necrotic and there are necrotic stem streaks. The plant is stunted and usually collapses.

Pisum sativum.

Local. No reaction.

Systemic. After a vein clearing and spotting there is a chlorotic mottle. The leaves may be slightly malformed and rosetted and the tendrils abnormally curled.

Trifolium fragiferum.

Local. There are necrotic rings on chlorotic leaves.

Systemic. No reaction.

T. hybridum.

Local. No reaction.

Systemic. Many leaves develop chlorotic streaks and spots.

T. incarnatum.

Local. The veins become necrotic and there are necrotic spots.

Systemic. The young leaves develop a vein clearing in 10 days, and later leaves have a chlorotic spotting, streaking, or mosaic with necrosis setting in, in the chlorosis. These leaves are crinkled, puckered and small. The plant is stunted and may later collapse.

T. pratense.

Local. No reaction.

Systemic. After a vein clearing of the young leaves in 18 to 19 days, later ones show a broad dark green midrib with chlorotic leaf margins. Some plants were symtomless carriers.

T. repens.

A symptomless carrier.

Vicia faba.

Local. There are necrotic ringspots on chlorotic leaves.

Systemic. In 3 weeks there is a chlorotic mottle.

Vigna sesquipedalis.

Local. There are chlorotic spots in 6 days.

Systemic. The young leaves show a vein clearing and spotting in 10 to 11 days. The next formed leaves are mottled with dark green veinbands and they are malformed. The old leaves become necrotic and drop.

V. unguiculata.

Local. There are necrotic spots in 5 days and there may be a slight veinal necrosis (Fig. 1a). The leaves show a marked epinasty and soon drop.

Systemic. The young leaves develop a vein clearing and flecking in 12 days. The next formed leaves have chlorotic spots and veinbands becoming a mosaic (Fig. 1b). Necrotic specks develop causing malformation and later these leaves drop (Fig. 1d). The plant is stunted and there are necrotic stem streaks (Fig. 1c).

Voandzeia subterranea.

Local. There are chlorotic spots in 6 days.

Systemic. After 13 days the young leaves develop a chlorotic network and spotting. Later leaves are mottled with dark green blisters and are contorted. The old leaves may develop a necrotic sheen.

Natural source of virus: *Vigna unguiculata.*

The plants were stunted. The younger leaves had chlorotic spots, dark green veinbands or a mosaic; and they were small and malformed. Older leaves showed varying amounts of necrosis in the chlorotic areas.

Identification.

According to Anderson (3b) in a classification of the known cowpea viruses, most are seed-borne. Exceptions are the mosaics described by d'Oliviera (11) and Dale (9) and the cucumber mosaic virus strains.

Cowpea mosaic viruses 2 and 3 d'Oliviera cause only systemic symptoms on cowpea, whereas this virus induces a marked local reaction as well. The thermal inactivation point is about 70°C but this virus withstood 62–65°C only.

d'Oliviera's cowpea mosaic virus 1 has a lower deathpoint (about 60°C) and causes both local and systemic symptoms on cowpea, but too few details are available for a complete comparison.

The cowpea mosaic of Dale is not transmissible by aphis, but by a leaf-beetle; and it withstands a much longer ageing period (20 days) and higher dilution (1: 100,000) than the virus described here.

In summing up the five groups of cowpea viruses, Anderson reports that none are able to infect *Medicago sativa*, *Trifolium incarnatum* or *Lathyrus odoratus*, all of which are susceptible to this virus. Further, the viruses of Yu (41), McLean (19) and Anderson (3b) are unable to infect the bean, and Snyder's (31) virus appears to be confined to *Vigna* spp.

The extremely high thermal inactivation points (98–104°C.) of Warid's *Vigna* viruses 1, 2, 3 and 3A and complexes 1, 2 and 3 exclude them from this comparison (35).

The virus described here is therefore considered to be a new entity belonging to the cowpea mosaic group, and is named cowpea mosaic virus A.

2. **Cowpea Mosaic Virus B.**

Physical properties: Thermal inactivation point, 60–62°C. Longevity *in vitro*, 2–3 days. Dilution end point, 1: 1000.

Transmission: Mechanical sap inoculation. Insect vector—probably an aphid but results were inconclusive.

Host range: *Crotalaria juncea* L., *C. spectabilis* Roth., *Dolichos lablab* L., *Glycine javanica* L., *G. max* (L.) Merr., *Lathyrus odoratus* L., *Lupinus albus* L., vars. sweet and bitter, *L. luteus* L., *L. mutabilis* Sweet., *Medicago lupulina* L., *Melilotus officinalis* Willd., *Phaseolus acutifolius* Gray var. *latifolius* Freem., *P. lunatus* L., *P. mungo* L., *P. vulgaris* L., *Pisum sativum* L., *Trifolium incarnatum* L., *T. pratense* L., *Vicia faba* L., *Vigna sesquipedalis* (L.) Wight., *V. unguiculata* (L.) Walp., *Voandzeia subterranea* Thouars.

Reaction of Susceptible Species.

Crotalaria juncea.

Local. No reaction.

Systemic. There are chlorotic spots on the young leaves which have wavy margins. The next leaves have a mottle with irregular chlorotic areas which result in malformation.

C. spectabilis.

Local. No reaction.

Systemic. After a vein clearing and spotting in 13 days, later leaves are rolled and have dark green veinbands.

Dolichos lablab.

Local. No reaction.

Systemic. There are scattered irregular chlorotic areas.

Glycine javanica.

Local. Necrotic lesions develop in 8 days.

Systemic. Some leaves have large chlorotic blotches on a puckered surface.

G. max.

Local. Chlorotic rings develop in 10 days and the leaves drop.

Systemic. There are chlorotic specks and irregular areas which cause a distortion of the leaf surface. The old leaves have necrotic specks.

Lathyrus odoratus.

Local. No reaction.

Systemic. The leaves curl down and have chlorotic spots and a dark green midrib.

Lupinus albus var. Sweet.

Local. No reaction.

Systemic. The leaves have wavy margins and a chlorotic network. Later ones develop a dark green veinbanding.

L. albus var. Bitter.

Local. No reaction.

Systemic. The leaves are small with twisted tips. They have a chlorotic mottle with a necrotic sheen. Many leaves drop and the plant is rosetted.

L. luteus.

Local. There are necrotic ringspots.

Systemic. Necrosis may spread rapidly into the growing point which curls to one side, before a total collapse of the plant. If not, the leaves remain folded, with wavy margins, and are mottled and small. The plant is stunted and rosetted.

L. mutabilis.

Local. No reaction.

Systemic. The leaves are malformed and stringlike and are chlorotic with dark green marginal blisters. The plant is rosetted.

Medicago lupulina.

A symptomless carrier.

Melilotus officinalis.

Local. No reaction.

Systemic. After a chlorotic spotting there is a dark green mottle.

Phaseolus acutifolius.

Local. In 10 days there are chlorotic spots with necrotic rings and veins.

Systemic. The plant collapses in 12 days after a severe necrosis.

P. lunatus.

Local. There are chlorotic spots in 10 days. These fuse to a general chlorosis.

Systemic. Diffuse vein flecks develop.

P. mungo.

Local. There are chlorotic spots in 7 days.

Systemic. The young leaves develop chlorotic then necrotic specks and veins in 11 days (Fig. 2c).

P. vulgaris var. Canadian Wonder.

Local. There are chlorotic spots in 4 days with a slight necrosis.

Systemic. The young leaves develop a vein clearing in 10 days and later ones have a mottle with dark green blisters.

var. Haricot.

Local. There are chlorotic and necrotic spots, and the leaves drop.

Systemic. Chlorotic spots develop on the young leaves. Later ones are mottled and reduced in size.

Pisum sativum.

Local. No reaction.

Systemic. The young leaves develop chlorotic spots and later ones a mottle. The tendrils are abnormally curled.

Trifolium incarnatum.

Local. There are chlorotic spots with necrotic rings and veins in 10 days.

Systemic. In 14 days there is a vein clearing followed by a veinbanding or mosaic on most leaves. They are crinkled and the plant is stunted.

T. pratense.

Local. No reaction.

Systemic. There are diffuse dark green veinbands.

Vicia faba.

Local. There are necrotic lesions in 10 days which fuse and the leaves drop.

Systemic. There is a chlorotic mottle.

Vigna sesquipedalis.

Local. Chlorotic spots develop in 10 days.

Systemic. The young leaves develop a vein clearing which may become necrotic. The next leaves are mottled and slightly malformed. (Fig. 2b.).

V. unguiculata.

Local. There are necrotic specks and a necrotic sheen in 3 days.

Systemic. The young leaves develop a vein clearing and chlorotic spotting while later ones are mottled with veinbands (Fig. 2d). There may be necrotic stem streaks. The plant is stunted (Fig. 2a).

Voandzeia subterranea.

Local. There is a necrotic sheen in 10 days.

Systemic. The young leaves develop a chlorotic spotting and veinbanding, and later leaves are malformed and have a mottle with necrotic specks.

Natural source of virus: *Vigna unguiculata.*

There was a mosaic or dark green veinbanding on the leaves, which were normal in size and shape. On the old leaves there was a slight necrosis in the chlorosis. The plants were not stunted or rosetted.

Identification.

Like cowpea mosaic virus A this virus cannot be identified with any of the described cowpea mosaics, nor with the cucumber mosaic strains. It further differs from cowpea mosaic virus A in host range, physical properties and symptoms on many hosts. See tables. Generally, the symptoms caused by the B virus are milder than those caused by the A virus.

This virus is therefore named cowpea mosaic virus B.

3. Cucumber Mosaic Virus Strain.

Physical properties: Thermal inactivation point, 62–64°C. Longevity *in vitro*, 4–5 days. Dilution end point, 1: 5000.

Transmission: Mechanical sap inoculation. *Aphis craccivora.*

Host range: *Arachis hypogaea* L., *Crotalaria juncea* L., *C. spectabilis* Roth., *Dolichos lablab* L., *Glycine max* (L.) Merr., *Lupinus albus* L., vars. sweet and bitter, *L. luteus* L., *L. mutabilis* Sweet., *Medicago lupulina* L., *M. sativa* L., *Melilotus officinalis* Willd., *Phaseolus acutifolius* Gray var. *latifolius* Freem., *P. mungo* L., *P. vulgaris* L., *Trifolium hybridum* L., *T. incarnatum* L., *T. medium* L., *T. pratense* L., *Vicia faba* L., *Vigna sesquipedalis* (L.) Wight., *V. unguiculata* (L.) Walp., *Voandzeia subterranea* Thouars.

Cucumis sativus L., *Nicotiana glutinosa* L., *N. tabacum* L., *Solanum capsicum* L., *Zinnia elegans* Jacq.

Reaction of Susceptible Species.

Arachis hypogaea.

Local. No reaction.

Systemic. There is first a chlorotic spotting and then a mottle on later formed leaves.

Crotolaria juncea.

Local. No reaction.

Systemic. Most leaves develop a mottle with dark green islands. They are slightly malformed.

C. spectabilis.

Local. Necrotic lesions develop in 7 days.

Systemic. The young leaves show a chlorotic spotting and flecking. Later ones have chlorotic interveinal areas or a diffuse speck mottle.

Dolichos lablab.

Local. No reaction.

Systemic. In 3 weeks the older trifoliates show marked chlorotic line patterns and some chlorotic spotting. The young leaves are slightly ruffled and have irregular chlorotic blotches.

Glycine max.

Local. There may be a general chlorosis in 4 days.

Systemic. After 11 days there is a vein clearing of the young leaves. Later ones are mottled with dark green blisters and are severely malformed.

Lupinus albus var. Sweet.

Local. No reaction.

Systemic. The young leaves remain folded and have wavy margins. Later ones are mottled with dark green blisters and are malformed. The plant is rosetted.

var. Bitter.

Local. No reaction.

Systemic. The leaves become elongated and chlorotic with dark green areas. The plant may collapse.

L. luteus.

Local. No reaction.

Systemic. In 3 weeks the young leaves develop small chlorotic spots. Later leaves are very small and rosetted and the plant is very stunted.

L. mutabilis.

Local. No reaction.

Systemic. Most leaves are chlorotic with dark green marginal blisters. The plant is stunted and rosetted.

Medicago lupulina.

Local. No reaction.

Systemic. Most leaves develop diffuse chlorotic vein slashes.

M. sativa.

Local. There are small chlorotic spots.

Systemic. The young leaves show a vein clearing and later leaves may develop small dark green blisters. These are puckered and crinkled.

Melilotus officinalis.

Local. No reaction.

Systemic. In 3 weeks the young leaves show chlorotic streaks following the veins. On the old leaves there are occasional chlorotic ringspots.

Phaseolus acutifolius.

Local. No reaction.

Systemic. The young leaves show a vein clearing then a mottle with yellow specks.

P. mungo.

Local. No reaction.

Systemic. The first trifoliates show a spotting, and later formed leaves have a general chlorosis with slight necrosis. The necrosis may spread until the growing point collapses.

P. vulgaris var. Canadian Wonder.

Local. No reaction.

Systemic. In 13 days there is a mottle followed by vivid yellow spots and vein flecks on the second and third trifoliates (Fig. 3b). The young leaves may be symptomless and when subinoculated there is no virus present.

var. Haricot.

Local. No reaction.

Systemic. The young leaves develop chlorotic spots and then a mottle. Later leaves may be malformed and have yellow areas. The old leaves have large almost white chlorotic blotches.

Trifolium hybridum.

Local. No reaction.

Systemic. There are chlorotic streaks.

T. incarnatum.

Local. After 2 weeks dark green rings with chlorotic centres appear.

Systemic. The young leaves develop a chlorotic mosaic with necrotic specks and a slight crinkle.

T. medium.

Local. No reaction.

Systemic. In 3 weeks there are chlorotic streaks along the veins.

T. pratense.

Local. No reaction.

Systemic. There is first a vein clearing and later some veins become necrotic. This leads to a distortion of the leaves. The plant is stunted.

Vicia faba.

Local. There are necrotic rings in 6 days.

Systemic. In 11 days chlorotic spots develop on the young leaves and then necrotic specks. Later leaves are mottled with raised dark green areas and necrotic ring and line patterns. The petioles and stem may have superficial necrotic streaks.

Vigna sesquipedalis.

Local. In 7 to 8 days there are chlorotic spots with necrotic specks. These leaves drop.

Systemic. In 11 days the young leaves show a vein clearing, and later ones are vividly mottled, and rolled, curled and crinkled (Figs. 3d and f). The symptoms are similar to, but not as severe as, those on *V. unguiculata.*

V. unguiculata.

Local. In 4 to 5 days there are chlorotic spots which become necrotic. The leaves bend down and later drop.

Systemic. A week later chlorotic flecks develop on the older trifoliates which may be slightly puckered. Young leaves become progressively more crinkled and also malformed. They are a bright yellow and have dark green blisters and necrotic specks (Fig. 3e). These leaves are small and the plant is stunted and may collapse completely (Fig. 3a).

Voandzeia subterranea.

Local. No reaction.

Systemic. After 3 weeks the young leaves develop dark green blisters on a chlorotic background. Later leaves have vivid yellow spots and are curled and contorted.

Cucumis sativus.

Local. In 14 days small chlorotic spots develop (Fig. 2g).

Systemic. At the same time the young leaves show a clearing of the veins with dark green blisters. The plant remains stunted (Fig. 2g).

Nicotiana glutinosa.

Local. In 4 days necrotic lesions develop.

Systemic. Some leaves have chlorotic ring and line patterns which cause a distortion of the surface (Figs. 2e and f.)

N. tabacum.

Local. No reaction.

Systemic. Small chlorotic spots develop in 11 days and on later leaves there are chlorotic ring and line patterns, which distort the leaf surface.

Solanum capsicum.

Local. There are necrotic lesions in 4 days and the leaves drop.

Systemic. In 13 days there is a vein clearing followed by a mottle with necrotic specks which cause a malformation of the leaf.

Zinnia elegans.

Local. No reaction.

Systemic. After a vein clearing there is a mottle (Fig. 3c).

Natural source of virus: *Vigna unguiculata.*

The leaves had a vivid yellow mottle, and they were puckered and blistered. The plants were severely stunted.

Identification.

The very marked yellow mottle and severe stunt on cowpea can be compared with only one other virus. Smith & Barker (29) in their report on the bean yellows virus, mention the severe stunt and extreme chlorosis that virus causes on cowpea.

However, the symptoms on the bean are not similar, the host range is very limited and that virus is transmissible by *Empoasca fabalis.*

Apart from this characteristic yellow mottle on cowpea, there are similarities with several of the strains of cucumber mosaic virus, in respect of both physical properties and host range. The host range includes non-leguminous species.

On the cowpea there is some resemblance to the Y strain of Price (21), the yellow isolate of strain 14 of Whipple & Walker (38) and strain C of Fulton (14).

However, Price does not describe the symptoms on other legume hosts, so a comparison can not be made.

Both the Y isolate of strain 14 and strain C cause systemic necrosis and ultimate collapse of beans and peas, while this virus either induces a yellow fleck on beans or is latent; and it is unable to infect peas.

Whipple & Walker report that their strain 17, the celery virus 1 strain and the type cucumber mosaic virus all result in local lesions on cowpea, and systemic necrosis on pea. They are unable to infect beans. Peas are susceptible to all the other strains described by Fulton.

Harter's lima bean mosaic (16), also considered a strain of cucumber mosaic virus, causes only local lesions on cowpea, and is non-infectious to bean, lupin, soybean, alsike etc., all of which are hosts of this virus.

The strain of cucumber mosaic virus described by Anderson (3a), may cause both local and systemic symptoms on cowpeas, but on most varieties they are masked—in contrast to the severe effect of this virus. Furthermore the symptoms of Anderson's strain on tobacco and cucumber are transient only, whereas with this virus they are definite and lasting. Anderson's strain withstands only 6–24 hours ageing, and this one lasts 4–5 days.

To sum up—although this virus shows many links with the cucumber mosaic virus group, it can not be fully identified with any of the strains already described. It is therefore considered a new strain of the cucumber mosaic virus.

COMPARISON OF SYMPTOMS CAUSED BY COWPEA MOSAIC VIRUSES A AND B ON SOME HOST PLANTS.

Host Plant.	Cowpea Mosaic Virus A.	Cowpea Mosaic Virus B.
1. *Crotalaria juncea*.....	Local—necr. specks and chl. O. Syst.—mot., dgr. blisters and veinb., necr. specks.	Local—no reaction. Syst.—irreg. chl. areas, malformation.
2. *Lupinus albus*.....	Local—dark green spots. Syst.—chl. sp., necr. specks, collapse.	Local—no reaction. Syst.—chl. network, dgr. veinbands.
3. *Melilotus officinalis*.....	Symptomless carrier.	Local—no reaction. Syst.—dgr. mottle.
4. *Phaseolus acutifolius*....	Local—chl. spots. Syst.—speck mottle.	Local—chl. spots, necr. O and veins. Syst.—necrosis and collapse.
5. *Trifolium incarnatum*....	Local—necr. spots and veins. Syst.—chl. streaks, mosaic, necr., crinkle, ros., collapse.	Local—chl. spots, necr. O and veins. Syst.—mosaic, crinkle.
6. *Vigna sesquipedalis*.....	Local—chl. spots. Syst.—mot., dgr. veinbands, necrosis, malformation.	Local—chl. spots. Syst.—mottle.
7. *Vigna unguiculata*.....	Local—reflex., necr. sp. and veins. Syst.—mosaic, necr. specks, malformation, necr. stem streaks.	Local—necr. sheen. Syst.—mottle, dark green veinbands.

ABBREVIATIONS USED:—

chl.—chlorosis/chlorotic.
dgr.—dark green.
irreg.—irregular.
mot.—mottle.
necr.—necrosis/necrotic.
ros.—rosette.
sp.—spots.
veinb.—veinbands.
O—rings.

COMPARISON OF PHYSICAL PROPERTIES AND METHODS OF TRANSMISSION.

Virus.	Thermal inactivation point.	Longevity *in vitro*.	Dilution end point.	Transmission.		
				Sap.	Seed.	Aphid.
Cowpea mosaic virus A.....	62–65°C	2–4 days	1 : 2000	+	–	+
Cowpea mosaic virus B.....	60–62°C	2–3 days	1 : 1000	+	–	?
Cucumber mosaic virus strain	62–64°C	4–5 days	1 : 5000	+	–	+

HOST RANGES.

	Cowpea Mosaic Virus A.	Cowpea Mosaic Virus B.	Cucumber Mosaic Virus Strain.
Arachis hypogaea	+	−	+
Crotalaria juncea	+	+	+
C. spectabilis	+	+	+
Dolichos lablab	+	+	+
Glycine javanica	+	+	
G. max	+	+	+
Lathyrus odoratus	+	+	−
Lupinus albus—sweet	+	+	+
Lupinus albus—bitter	+	+	+
L. luteus	+	+	+
L. mutabilis	+	+	+
Medicago lupulina	+	+	+
M. sativa	+	−	+
Melilotus officinalis	+	+	+
Phaseolus acutifolius	+	+	+
P. lunatus	+	+	
P. mungo	+	+	+
P. vulgaris	+	+	+
Pisum sativum	+	+	−
Trifolium fragiferum	+	−	−
T. hybridum	+	−	+
T. incarnatum	+	+	+
T. pratense	+	+	+
T. repens	+	−	−
Vicia faba	+	+	+
Vigna sesquipedalis	+	+	+
V. unguiculata	+	+	+
Voandzeia subterranea	+	+	+
Cucumis sativus	−	−	+
Nicotiana glutinosa	−	−	+
N. tabacum	−	−	+
Solanum capsicum	−	−	+
Zinnia elegans	−	−	+

SUMMARY.

Three virus diseases of naturally infected cowpeas are described in detail—their physical properties, methods of transmission, host ranges and symptoms. None could be fully identified with any previously recorded virus or strain.

1. Cowpea mosaic virus A. In the field the plants are stunted and the leaves are small and malformed. They have dark green veinbands or a mosaic with necrosis. The virus is inactivated at temperatures of 62–65°C., at a dilution of 1:2,000 and after 2–4 days ageing *in vitro*. It is sap and aphid transmissible and the host range is confined to the *Leguminosae*.

2. Cowpea mosaic virus B. The only symptom in the field is a dark green veinbanding. The thermal inactivation point of the virus is 60–62°C. The longevity *in vitro* is 2–3 days and the dilution end point, 1: 1,000. It is sap transmissible, but results from insect transmissions were inconclusive. The host range is confined to the legumes, and the symptoms are generally milder than for the A virus.

3. Cucumber mosaic virus strain. The field symptoms are severe—the plants are very stunted and the leaves show a vivid yellow mottle. Similarities in physical properties, host range (which includes the non-legumes) and symptoms, indicate a relationship with the cucumber mosaic virus group.

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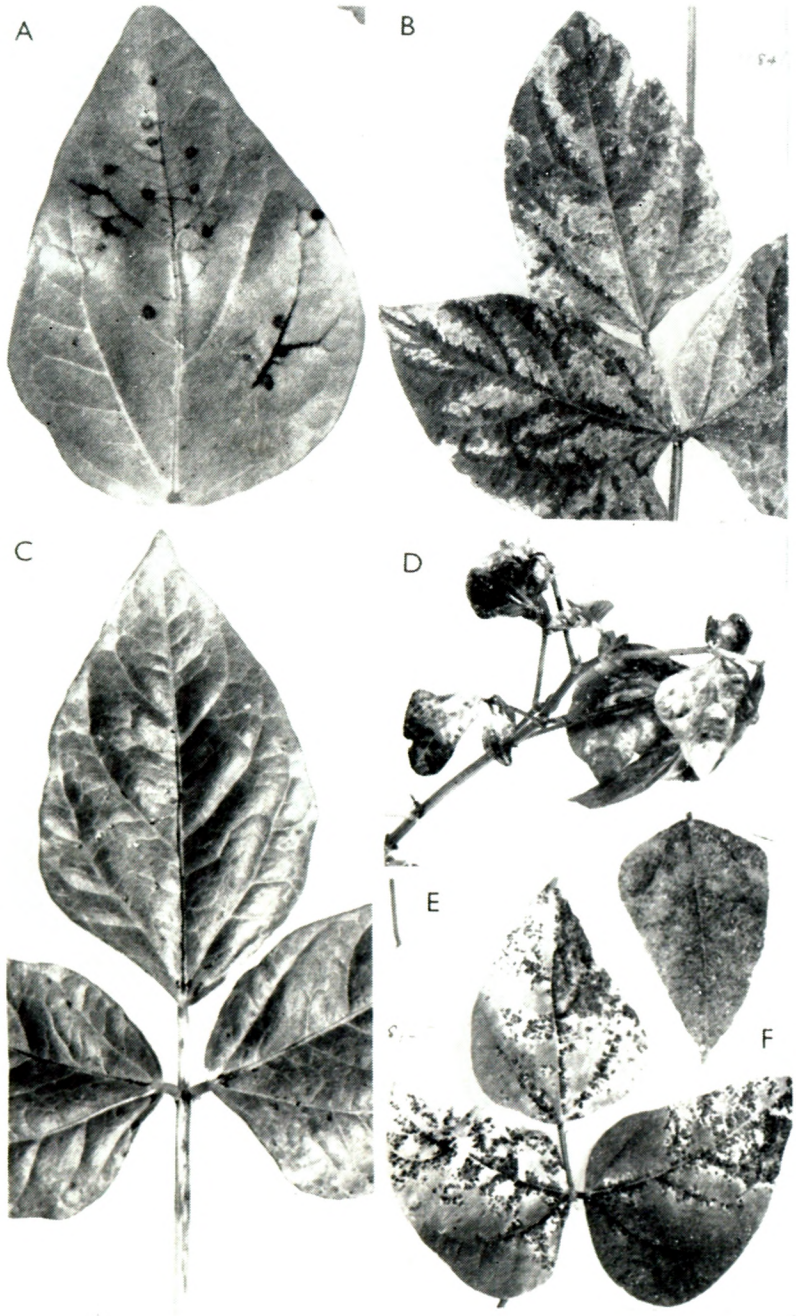

FIG. 1.—COWPEA MOSAIC VIRUS A.

A–D *Vigna unguiculata*. A. Local necrotic lesions. B. Systemic veinbanding and mosaic. C. Systemic necrotic specks. D. Malformation of young leaves.

E–F *Phaseolus lunatus*. E. Necrosis and chlorosis on older leaf. F. Fine chlorotic network on young leaf.

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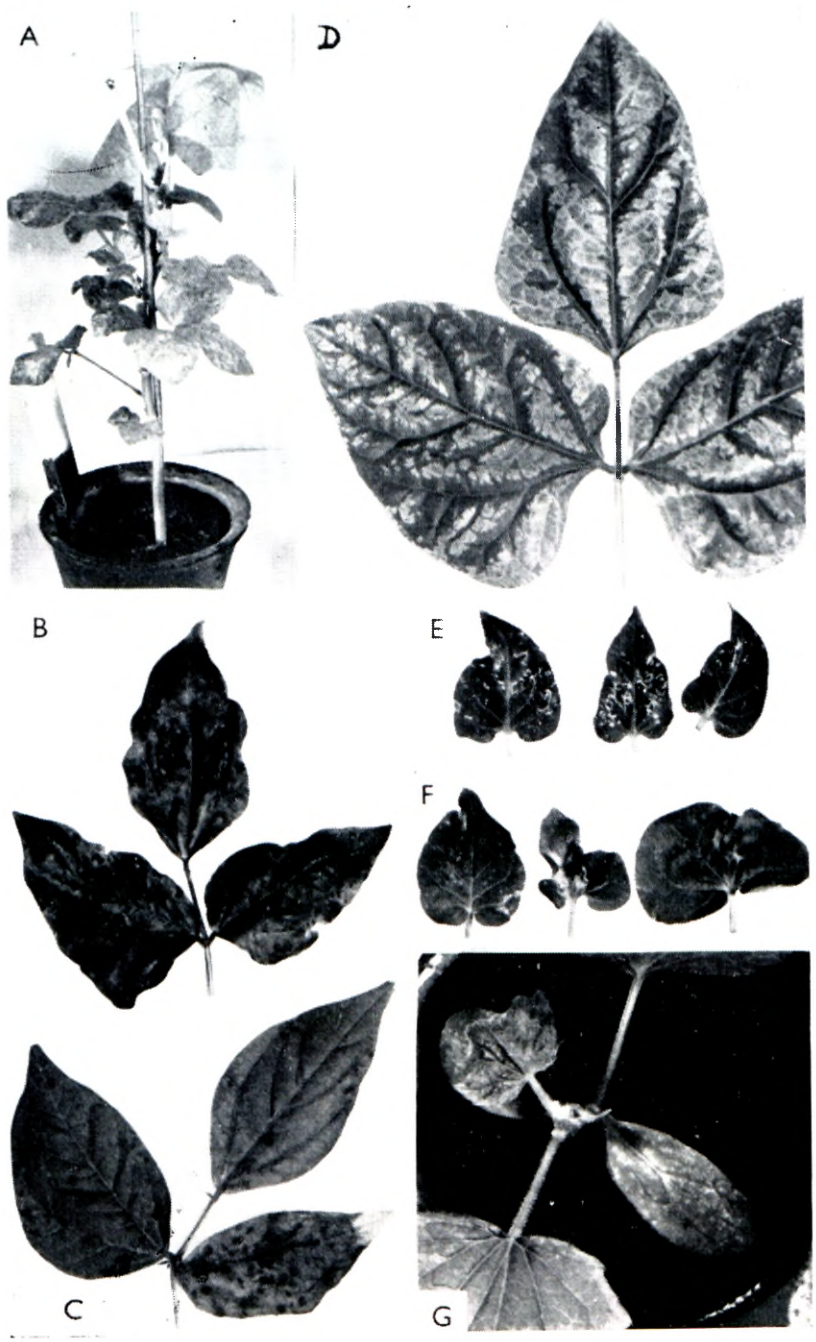

FIG. 2.—A–D COWPEA MOSAIC VIRUS B.
A and D *Vigna unguiculata*. B. *V. sesquipedalis*. C. *Phaseolus mungo*.
E–G CUCUMBER MOSAIC VIRUS STRAIN.
E and F *Nicotiana glutinosa*. G. *Cucumis sativus*.

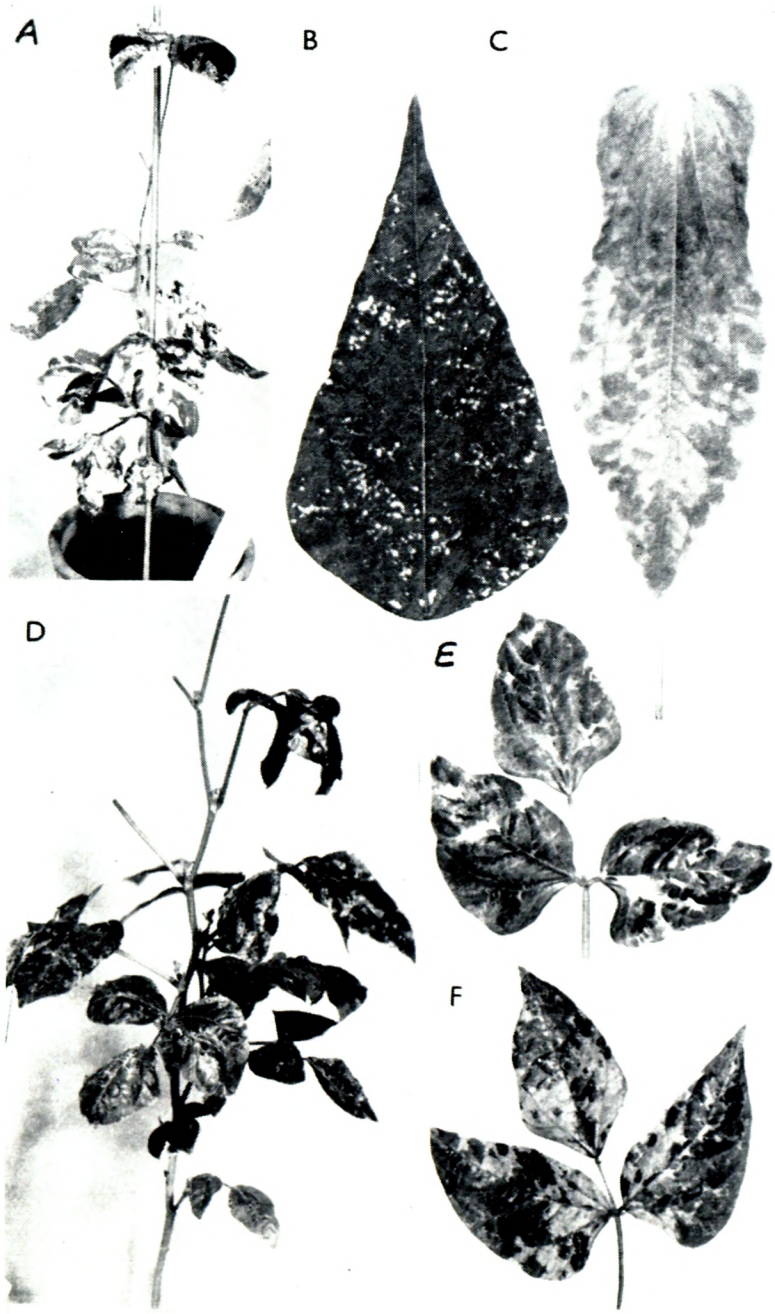

FIG. 3.—CUCUMBER MOSAIC VIRUS STRAIN.

A and E. *Vigna unguiculata.* D. and F. *V. sesquipedalis.* B. *Phaseolus vulgaris.* C. *Zinnia elegans.*