Virus Diseases of Lupins.

By

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Although virus infections of lupins have been known in South Africa for several years, no previous attempt has been made to identify the causal organisms. A preliminary report was published in 1953 (3).

REVIEW OF LITERATURE.

The first record of viroses of lupins came from Germany in 1929 when Merkel (6) reported a pock mosaic and a speckle mosaic of yellow lupins.

Mastenbroek (5) described in detail what he considered to be the same virus. It was found to be seedborne in yellow lupin and only rarely transmissible to beans. He named it *Lupinus* virus 1.

In 1934, Neill, Brien and Chamberlain (7) described " Sore-shin " in New Zealand, and Richter (9) found an unidentified disease in Germany, both of which were later proved to be caused by the pea mosaic virus (1). Further work on this virus in lupins was done by Norris (8).

Kohler (4) reported the Lupinenbraüne virus, later found to be the cucumber mosaic virus. In 1936 Spierenberg (10) in Holland, described a disorder, also later proved to be cucumber mosaic.

Weimer (11) described two viruses found in *L. angustifolius*, but does not confirm their identity. Neither of them is sap transmissible to lupins.

METHODS AND MATERIALS.

Plants with suspected virus infections were collected from different parts of the Union.

The standard test plants used were: *Phaseolus vulgaris* var. Canadian Wonder, *Vicia faba* and *Pisum sativum* var. Greenfeast. In addition, about 30 other legumes, and some plants belonging to the *Solanaceae* were used in susceptibility tests.

Aphis craccivora was used for the insect transmission tests, but it is not necessarily the natural vector.

Mechanical sap transmission was aided by the use of carborundum powder, and the methods of Johnson and Grant (2) were used for the physical property tests.

This report deals with five viruses, and at the end of each section, there is a discussion on the relationship of the viruses concerned, and names are suggested for the new ones. These names are only tentatively proposed as no proof of virus identity is available beyond that of symptom and physical property resemblances.

VIRUSES FOUND OCCURRING NATURALLY ON LUPINS.

Host Plant.	*Virus.*
Lupinus affinis	Lupin virus A. Pea mosaic virus 4.
L. albus	Lupin virus A. Lupin virus B. Lupin virus C. Bean yellow mosaic virus. Pea mosaic virus 4.
L. angustifolius	Lupin virus A. Lupin virus B. Lupin virus C. Bean yellow mosaic virus. Pea mosaic virus 4.
L. luteus	Lupin virus A. Pea mosaic virus 4.
L. mutabilis	Lupin virus A.

Lupins are also susceptible to most other legume viruses when inoculated artificially. With the spotted wilt virus they develop a local necrotic reaction. (See report on pea virus diseases.)

SYMPTOMS FOUND ON LUPINS WHEN NATURALLY INFECTED.

Lupinus affinis with:

1. Lupin virus A.

   The leaves are chlorotic and malformed, and rosetted. The plant is stunted.

2. Pea mosaic virus 4.

   The leaves are chlorotic with necrosis setting in, and they are much reduced in size. There are necrotic stem streaks. The plant is stunted.

Lupinus albus with:

1. Lupin virus A.

   A top necrosis usually causes the collapse of the growing point. Secondary shoots have chlorotic, malformed leaves and they are rosetted and stunted.

2. Lupin virus B.

   Most leaves are small, malformed and chlorotic. Many drop and there may be a complete defoliation. There are necrotic stem streaks.

3. Lupin virus C.

   The leaves have chlorotic spots and possibly necrotic specks. They remain folded and have wavy margins. The plant is stunted.

4. Bean yellow mosaic virus.

   The leaves are mottled, they remain folded, and have wavy margins and a general puckering. There is a severe rosette and the plant is stunted. (Fig. 4a).

5. Pea mosaic virus 4.

   There is a vein clearing, chlorotic ringspotting or mottle. The plant may be rosetted.

Lupinus angustifolius with:

1. Lupin virus A.

   The leaves are chlorotic and malformed, and the plant is stunted and rosetted.

2. Lupin virus B.

   The leaves are small and have necrotic specks. Most leaves drop. There are necrotic stem streaks.

3. Lupin virus C.

   The leaves have a chlorotic speck mosaic and they are very small and crinkled. The plant is extremely rosetted and stunted. (Fig. 3a).

4. Bean yellow mosaic virus.

   The leaves are mottled and there may be necrotic stem streaks which cause the collapse of the growing point. The leaves of the secondary shoots are vividly mottled, rolled and malformed.

5. Pea mosaic virus 4.

   There is a mottle on the leaves with possibly a veinal necrosis which results in the collapse of the plant.

Lupinus luteus with:

1. Lupin virus A.

   The leaves are chlorotic and malformed and the plant is rosetted and stunted.

2. Lupin virus B.

   The leaves are mottled and puckered and the plant is rosetted.

Lupinus mutabilis with:

1. Lupin virus A.

   There is a general chlorosis of the leaves which are also malformed, and rosetted. The plant is stunted.

I. Lupin Virus A.

Physical properties: Thermal inactivation point, 58–60°C. Longevity *in vitro*, 2–3 days. Dilution end point, 1 : 1000.

Transmission: Mechanical sap inoculation. *Aphis craccivora.*

Host range: *Cicer arietinum* L., *Crotalaria juncea* L., *C. spectabilis* Roth., *Glycine max* (L.) Merr., *Lathyrus odoratus* L., *Lupinus albus* L. var. Sweet, *L. albus* L. var. Bitter, *L. angustifolius* L., *L. luteus* L., *L. mutabilis* L., *Medicago lupulina* L., *Melilotus officinalis* Willd., *Phaseolus acutifolius* Gray var. *latifolius* Freem., *P. lunatus* L., *P. vulgaris* L., *Pisum sativum* L., *Trifolium hybridum* L., *T. incarnatum* L., *T. pratense* L., *T. repens* L., *Vicia faba* L., *Vigna unguiculata* (L.) Walp., *Voandzeia subterranea* Thouars.

Reaction of Susceptible Species.

Cicer arietinum.

Local. No reaction.

Systemic. The young leaves develop a few small chlorotic spots.

Crotalaria juncea.

Local. Small necrotic specks develop.

Systemic. After a vein clearing in 24 days the leaves show an irregular chlorosis with dark green islands. The plant is stunted. Several young plants collapsed after a severe necrosis.

C. spectabilis.

Local. In 11 days chlorotic spots with a small central necrotic speck develop. These leaves drop.

Glycine max.

Local. No reaction.

Systemic. A diffuse chlorotic mottle develops.

Lathyrus odoratus.

Local. No reaction.

Systemic. In 21 days there is a vein clearing of the young leaves followed by a streak mottle of leaves which are small and puckered.

Lupinus albus var. Sweet.

Local. There are chlorotic spots in 11 days and the veins may be necrotic in 18 days.

Systemic. There may be a vein clearing soon followed by a necrotic speckling which spreads and results in the collapse of the growing point. Secondary shoots have small leaves which are malformed with crinkled blistered dark green margins and a long narrow base (Fig. 1b.)

L. albus var. Bitter.

Local. No reaction.

Systemic. Necrosis sets in, in 11 days and the plant collapses.

L. angustifolius.

Local. No reaction.

Systemic. The young leaves may show a chlorotic spot mottle and there is a slight malformation with irregular margins. Later necrosis sets in, in the growing point and the plant collapses within three weeks (Fig. 1c).

L. luteus.

Local. No reaction.

Systemic. After 10 days the young leaves develop a chlorotic spotting and later a chlorotic mottle. The leaves remain folded and are almost stringlike and malformed. New leaves are small and rosetted (Fig. 1a).

Medicago lupulina.

Local. No reaction.

Systemic. After a vein clearing there is a chlorotic spot mottle and slight puckering.

Melilotus officinalis.

Local. No reaction.

Systemic. There are streaks which are almost yellow and ringspots which may become necrotic and cause a malformation.

Phaseolus acutifolius.

Local. In 7 days the leaves have chlorotic veins.

Systemic. In 12 days there is a vein clearing of the young leaves. The next leaves to develop are mottled, and still later ones have yellow specks.

P. lunatus.

A symptomless carrier.

P. vulgaris var. Canadian Wonder.

Local. No reaction.

Systemic. The first and second trifoliates have large chlorotic blotches and are reflexed. After 14 days a chlorotic spotting develops on the young leaves which are also rolled. Later leaves develop a mottle with short dark green veinbands. There may be a slight malformation and puckering.

var. Haricot.

Local. In seven to eight days there is a reflexing and the leaves are generally chlorotic.

Systemic. Similar to Canadian Wonder.

vars. Long Tom, Tendergreen and Victor show a reaction similar to Canadian Wonder.

vars. Black Wonder, Idaho Refugee and S.A. Black and White develop large local chlorotic blotches. There is also a severe puckering of the leaves and the plant is stunted.

Pisum sativum.

Local. No reaction.

Systemic. A chlorotic spotting of the young leaves is followed by a mosaic with short dark green veinbands. Later leaves show a marked white vein etching, and they are small. The tendrils are abnormally curled.

Trifolium hybridum.

Local. No reaction.

Systemic. After three weeks a vein clearing develops into alternate chlorotic and green streaks following the veins.

T. incarnatum.

Local. Small chlorotic spots develop.

Systemic. In 18 to 19 days the young leaves develop chlorotic spots. Later leaves have a chlorotic mosaic and are crinkled.

T. pratense.

A symptomless carrier.

T. repens.

A symptomless carrier.

Vicia faba.

Local. No reaction.

Systemic. In 14 days there are chlorotic spots, and a clearing of the veins. Later leaves are mottled.

Vigna unguiculata.

Local. No reaction.

Systemic. A diffuse chlorotic network may develop. The virus can be recovered if symptomless.

Voandzeia subterranea.

Local. No reaction.

Systemic. There may be a diffuse chlorotic spotting, but the virus can be recovered if symptomless.

Natural source of virus: *Lupinus affinis* (Pretoria district), *L. albus*, *L. angustifolius*, *L. luteus*, and *L. mutabilis* (Stellenbosch district).

IDENTIFICATION.

Because of the characteristic reflexing of the bean leaves, this virus is compared with others showing this symptom.

Bean yellow mosaic virus Pierce causes a local necrosis on pea, is non-infectious to cowpea and has a shorter ageing period. Other details are similar, although the host range differs.

A necrotic strain of bean yellow mosaic virus Klesser, has similar physical properties, but induces a local and systemic necrosis of the pea and local necrosis on the cowpea.

Alsike clover mosaic virus 2 Zaumeyer gives a similar reaction on pea, but differs on other hosts.

Osborn's pea virus 2 differs in physical properties, host range and some symptoms.

As no complete correlation can be found, this is considered a new virus, related to the bean yellow mosaic group.

It is named lupin virus A.

2. **Lupin Virus B.**

Physical properties: Thermal inactivation point, 62–65°C. Longevity *in vitro*, 2–3 days. Dilution end point, 1: 100.

Transmission: Mechanical sap inoculation. *Aphis craccivora.*

Host range: *Cicer arietinum* L., *Crotalaria juncea* L., *C. spectabilis* Roth., *Glycine max* (L.) *Merr.*, *Lupinus albus* L. var. Sweet, *L. albus* L. var. Bitter, *L. angustifolius* L., *L. luteus* L., *L. mutabilis* L., *Medicago lupulina* L., M. *sativa* L., *Melilotus officinalis* Willd., *Phaseolus acutifolius* Gray var. *latifolius* Freem., *P. lunatus* L., *P. vulgaris* L., *Pisum sativum* L., *Trifolium hybridum* L., *T. incarnatum* L., *T. pratense* L., *T. repens* L., *Vicia faba* L., *Vigna unguiculata* (L.) Walp.

Nicotiana glutinosa L., *N. tabacum* L., *Solanum capsicum* L.

REACTION OF SUSCEPTIBLE SPECIES.

Cicer arietinum.

Local. Chlorotic spots with necrotic rings develop.

Systemic. After a vein clearing of the young leaves, later ones are long, narrow and malformed.

Crotalaria juncea.

Local. There are necrotic spots and veins.

Systemic. No reaction.

C. spectabilis.

Local. No reaction.

Systemic. In 11 days there is a clearing of the veins followed by small chlorotic spots, and later, a mottle. Necrosis sets in along the veins causing a puckering of the midrib and malformation. The plant may be severely stunted.

Glycine max.

Local. No reaction.

Systemic. There are chlorotic flecks on the younger leaves.

Lupinus albus var. Sweet.

Local. In nine days there are chlorotic spots and the leaflets collapse.

Systemic. At the same time chlorotic specks develop. On later leaves there is a general chlorosis leaving dark green blisters. The leaflets remain folded and are malformed (Fig. 2b). After a speck necrosis the plant is almost completely defoliated.

L. albus var. Bitter.

Local. No reaction.

Systemic. In 14 days there are chlorotic spots on the young leaves. Later leaves are mottled and stringlike. There is a slight necrosis and the leaves drop.

L. angustifolius.

Local. After a general necrosis the leaves collapse.

Systemic. There is a veinal necrosis of the young leaves, soon followed by necrotic stem streaks, and collapse of the plant (Fig. 2d).

L. luteus.

Local. No reaction.

Systemic. After 10 days there is a vein clearing of the young leaves, which remain folded, with wavy margins. Later leaves are stringlike and chlorotic and the plant is rosetted and stunted (Fig. 2a).

L. mutabilis.

Local. No reaction.

Systemic. Most leaves have irregular chlorotic areas.

Medicago lupulina.

Local. No reaction.

Systemic. A veinal chlorosis of the young leaves develops in 14 days. This becomes general, leaving dark green veinbands. The leaves are reduced, crinkled and puckered along the midrib.

M. sativa.

Local. No reaction.

Systemic. There are isolated chlorotic spots.

Melilotus officinalis.

Local. No reaction.

Systemic. Only a diffuse chlorotic mottle develops.

Phaseolus acutifolius.

Local. In seven days there are necrotic spots and veins on chlorotic leaves.

Systemic. After 12 days there is a vein clearing of the young leaves, and a yellow mottle and malformation of those formed later.

P. lunatus.

Local. No reaction.

Systemic. In 10 days there is a chlorotic network and later a speck mottle. Necrosis may set in, and the leaves become malformed.

P. vulgaris var. Canadian Wonder.

Local. Chlorotic spots with necrotic rings develop in 11 days (Fig. 2c.)

Systemic. There are only isolated chlorotic spots which become a diffuse mottle on later formed leaves. The pods are mottled.

var. Haricot.

Local. There are necrotic specks on chlorotic leaves in seven days.

Systemic. The leaves show a chlorotic mottle and they are elongated. The pods are mottled.

Pisum sativum.

Local. After a general necrosis the leaves collapse.

Systemic. There is a vein chlorosis in six days followed by a mottle and sometimes a marked vein etching. The leaves are crinkled and rosetted. The plant is stunted and collapses from necrosis. The tendrils are tightly curled and twisted.

Trifolium hybridum.

Local. No reaction.

Systemic. In nine days there are chlorotic vein streaks and later a mild streak mottle on all leaves.

T. incarnatum.

Local. There may be necrotic specks.

Systemic. In two weeks the young leaves show a vein clearing. Later leaves have an almost white mosaic and are crinkled and rolled.

T. pratense.

Local. No reaction.

Systemic. After a month most leaves show vivid yellow spots and a mosaic.

T. repens.

A symptomless carrier.

Vicia faba.

Local. No reaction.

Systemic. The young leaves develop small chlorotic spots in seven days and those formed later are mottled. Some malformation occurs, leaving an uneven surface.

Vigna unguiculata.

Local. No reaction.

Systemic. There may be vein clearing and a chlorotic speckle. If symptomless, the virus can still be recovered.

Nicotiana glutinosa.

Local. Chlorotic spots and rings appear in seven days.

Systemic. A week later the young leaves develop chlorotic spots and then a mottle. The leaves are puckered and the plant is stunted.

N. tabacum.

Local. No reaction.

Systemic. The young leaves first develop chlorotic spots and then a mottle.

Solanum capsicum.

Local. No reaction.

Systemic. A chlorotic mottle concentrated at the base of the leaves appears after a month.

Natural source of virus: *Lupinus albus* (Pretoria and Stellenbosch), *L. angustifolius* (Stellenbosch).

IDENTIFICATION.

Apart from the local reaction on the bean this virus shows some resemblance to several others.

Lupin virus B resembles the white clover mosaic virus complex Pierce, in that both cause a systemic chlorosis on the bean with a local and systemic necrosis on the pea. It differs from it in the reaction on the broad bean, and the type of local lesion on the French bean. Physical properties are also different.

Lupin virus B also resembles alsike clover mosaic virus 2 Zaumeyer as both cause a necrotic speckling and severe stunting of the pea, but differs from it in that the latter induces a marked reflexing of the leaves of the bean and there is no local reaction.

In his report on the sweet pea streak viruses Ainsworth mentions one which caused an identical local reaction on the bean viz. chlorotic spots with necrotic rings. Unlike lupin virus B, it also induced a reflexing of the bean leaves and eventual collapse of the plant. It also caused a local and systemic necrosis of the broad bean, and only a chlorosis of the pea.

The two types of bean yellow mosaic virus, viz. the local lesion and severe yellow strains of Zaumeyer, are similar in some respects, too.

The local lesion strain also causes a local reaction followed by a systemic mottle, on the bean, but only local lesions develop on the broad bean and cowpea, whereas the lupin virus B induces a systemic mottle on these hosts. Further, the host range and physical properties are dissimilar.

Like lupin virus B, the severe yellow strain causes a mottle on broad bean, and a mottle and necrosis on some varieties of pea, but unlike it, a systemic necrosis usually develops on the bean. Symptoms on other plants and the physical properties also differ.

The systemic symptoms on *Nicotiana glutinosa* are not unlike those of cucumber mosaic virus but further details are not similar.

Therefore, as there appears to be no complete correlation with any other virus, this is considered a new one. The name suggested is lupin virus B.

3. **Lupin Virus C.**

Physical properties: Thermal inactivation point, 56–58°C. Longevity *in vitro*, 1–2 days. Dilution end point, 1: 100.

Transmission: Mechanical sap inoculation. *Aphis craccivora.*

Host range: *Crotalaria spectabilis* Roth., *Glycine max* (L.) Merr., *Lathyrus odoratus* L., *Lupinus albus* L. var. Sweet, *L. albus* L. var. Bitter, *L. angustifolius* L., *L. luteus* L., *Melilotus officinalis* Willd., *Phaseolus acutifolius* Gray var. *latifolius* Freem., *P. lunatus* L., *P. vulgaris* L., *Trifolium hybridum* L., *T. incarnatum* L., *T. pratense* L., *Vigna unguiculata* (L.) Walp.

Nicotiana glutinosa L., *N. tabacum* L.

Reaction of Susceptible Species.

Crotalaria spectabilis.

Local. No reaction.

Systemic. The young leaves show chlorotic spots, each with a necrotic centre. Later this becomes a mosaic with dark green veinbands and necrosis setting in in the chlorotic areas. The leaves are slightly reduced in size, and puckered and curled.

Glycine max.

Local. There are necrotic lesions in 12 days.

Systemic. The first trifoliates develop chlorotic flecks with necrotic rings, and soon drop. Most other leaves have vivid chlorotic flecks and later a mosaic with necrotic specks.

Lathyrus odoratus.

Local. No reaction.

Systemic. There is a chlorotic streak mottle.

Lupinus albus var. Sweet.

Local. In nine days chlorotic spots with necrotic centres develop.

Systemic. In twelve days the young leaves show a vein clearing and chlorotic spotting. These leaves are rolled upwards but bent down from the pulvinus like an umbrella (Fig. 3b). They have dark green bands or raised blisters, and are rosetted at the top of the plant. Later necrosis sets in from the growing point, and extends down the stem until the plant collapses.

L. albus var. Bitter.

Local. No reaction.

Systemic. Within 15 days necrosis has caused the collapse of the plant.

L. angustifolius.

Local. No reaction.

Systemic. The leaves show only a diffuse mottling, but they are severely curled and folded. Later necrosis causes the leaves to drop.

L. luteus.

Local. No reaction.

Systemic. There is a vein clearing and spotting of the young leaves in 15 days. Later leaves are small with dark green blisters, and they remain folded. The plant is stunted.

Melilotus officinalis.

Local. No reaction.

Systemic. Chlorotic streaks and rings develop.

Phaseolus acutifolius.

Local. Chlorotic spots with necrotic rings develop.

Systemic. There is a chlorotic spotting.

P. lunatus.

A symptomless carrier.

P. vulgaris var. Canadian Wonder.

Local. Chlorotic spots with a necrotic ring develop in 12 to 13 days.

Systemic. There is a chlorotic mottle.

var. Haricot.

Local. There is a chlorotic spotting in seven days and later the leaves drop.

Systemic. The older trifoliates become long and narrow while the young leaves are malformed with a mottle or broad dark green veinbands.

vars. Idaho Refugee, S.A. Black and White and Tendergreen develop symptoms similar to Canadian Wonder.

Trifolium hybridum.

Local. No reaction.

Systemic. After a vein clearing there are diffuse chlorotic blotches.

T. incarnatum.

Local. Small necrotic lesions develop in 12 days.

Systemic. After a vein clearing there are chlorotic veinbands and a mosaic on the crinkled leaves. The plant is stunted.

T. pratense.

Local. No reaction.

Systemic. There are chlorotic streaks with necrosis setting in, which results in a malformation of the leaves. Some leaves may collapse from the necrosis.

Vigna unguiculata.

Local. In 5 days there are small necrotic spots and the leaves drop.

Systemic. The young leaves also show necrotic spots, and the plant may be completely defoliated.

Nicotiana glutinosa.

Local. Chlorotic spots and patterns develop in 7 days, sometimes with necrotic rings.

Systemic. In 9 days there are chlorotic spots, becoming a mottle on later leaves which are crinkled. The plant is stunted.

N. tabacum.

Local. Necrotic lesions, which enlarge and fuse, appear in 7 days.

Systemic. No reaction.

Natural source of virus: *Lupinus albus* and *Lupinus angustifolius* from Stellenbosch.

IDENTIFICATION.

Like lupin virus B, this virus has similarities with, but cannot be related to, white clover mosaic virus complex Pierce, alsike clover mosaic virus 2 Zaumeyer, the two strains of bean yellow mosaic virus Zaumeyer and cucumber mosaic virus.

It has however, the same characteristic local reaction on the bean as lupin virus B, but differs from it, in its inability to infect either broad bean or pea. The symptoms on lupins are also dissimilar.

Despite the one link with lupin virus B, viz. the local reaction on bean, the virus seems distinct, and is named lupin virus C.

4. **Bean Yellow Mosaic Virus** Pierce.

Physical properties: Thermal inactivation point, 58–60°C. Longevity *in vitro*, 1–2 days. Dilution end point, 1: 1000–1: 2000.

Transmission: Mechanical sap inoculation. *Aphis craccivora.*

Host range: *Arachis hypogaea* L., *Crotalaria juncea* L., *C. spectabilis* Roth., *Glycine max* (L.) Merr., *Lathyrus odoratus* L., *Lupinus albus* L. var. Sweet, *L. albus* L. var. Bitter, *L. angustifolius* L., *L. luteus* L., *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 hybridum* L., *T. incarnatum* L., *T. pratense* L., *T. repens* L., *Vicia faba* L., *Voandzeia subterranea* Thouars.

REACTION OF SUSCEPTIBLE SPECIES.

Arachis hypogaea.

Local. Diffuse chlorotic blotches develop.

Systemic. Most leaves have chlorotic ringspots or patterns, and the plant is stunted.

Crotalaria juncea.

Local. No reaction.

Systemic. The young leaves develop a chlorotic network in 9 days. On later leaves there is a chlorotic mottle with dark green blisters. These leaves are slightly malformed and have wavy margins.

C. spectabilis.

Local. There may be chlorotic spots surrounded by necrotic rings.

Systemic. After a vein clearing of the young leaves in 13 days, later ones develop broad dark green veinbands. The next leaves are mottled.

Glycine max.

Local. Small necrotic lesions develop in 12 days.

Systemic. The young leaves show chlorotic spots or flecks, and on the later ones there is a diffuse mottle.

Lathyrus odoratus.

Local. No reaction.

Systemic. In 3 weeks the young leaves show a vein clearing and chlorotic spotting. The next leaves are rolled and have a mosaic. There is a colour break on the flowers.

Lupinus albus var. Sweet.

Local. There are isolated chlorotic spots in 9 days and the leaves become flaccid.

Systemic. The young leaves remain folded and develop a vein clearing and chlorotic spotting after 16 days. Later leaves are mottled with dark green blisters. They are elongated, malformed and the margins are rolled (Fig. 4b).

L. albus var. Bitter.

Local. No reaction.

Systemic. After a severe necrosis the plant collapses. If secondary shoots develop, they are rosetted with small malformed leaves.

L. angustifolius.

Local. No reaction.

Systemic. The young leaves have a diffuse chlorotic spotting. Later ones are mottled.

L. luteus.

Local. Diffuse chlorotic areas may develop.

Systemic. The young leaves remain folded and have wavy margins, and are chlorotic. Later leaves are stringlike and malformed. The plant is severely rosetted and stunted.

Medicago lupulina.

Local. No reaction.

Systemic. The leaves develop a vein clearing and later a mottle. They are puckered along the midrib.

Melilotus officinalis.

Local. No reaction.

Systemic. After 3–4 weeks most leaves show chlorotic spots, streaks, rings or concentric patterns (Fig. 4c). The old leaves have a chlorotic etching.

Phaseolus acutifolius.

Local. No reaction.

Systemic. The young leaves curl back and have a yellow network. Later leaves are mottled.

P. lunatus.

Local. No reaction.

Systemic. Chlorotic vein slashes may develop in 2–3 weeks or the plant is a symptomless carrier.

P. mungo.

Local. Necrotic veins develop.

Systemic. A limited amount of veinal necrosis may occur.

P. vulgaris var. Canadian Wonder.

Local. No reaction.

Systemic. The young leaves show a marked reflexing from the pulvini and they develop a vein clearing and flecking. Later formed leaves show a mottle and they are slightly malformed with an uneven surface. Most pods have dark green blisters.

var. Haricot.

Local. These leaves bend at right angles to the pulvini, and have diffuse chlorotic areas.

Systemic. The first trifoliates show a marked reflexing and have chlorotic spots. The young leaves are curled, small and mottled, and may have necrosis of the veins. The pods develop dark green blisters with necrosis.

vars. Black Wonder, Idaho Refugee, Long Tom, S.A. Black and White, Tendergreen and Victor develop the typical systemic reaction.

vars. Black Wonder, Idaho Refugee, Long Tom and Tendergreen also show a local chlorosis.

Pisum sativum.

Local. A spreading necrosis causes the leaves to collapse in 14 days.

Systemic. After a vein clearing in 7 days there is a chlorotic spotting followed by a mosaic. The leaves are small, the tendrils are abnormally curled and the plant is stunted.

Trifolium hybridum.

Local. No reaction.

Systemic. After a vein clearing in 15 days the leaves have chlorotic streaks.

T. incarnatum.

Local. No reaction.

Systemic. In 12 days there is a vein clearing and chlorotic spotting. Later leaves develop a mosaic.

T. pratense.

A symptomless carrier.

T. repens.

A symptomless carrier.

Vicia faba.

Local. The leaves may become flaccid and drop.

Systemic. Within 7 days the young leaves develop a spotting or mottle. Later ones are slightly malformed and have chlorotic patterns.

Voandzeia subterranea.

Local. No reaction.

Systemic. A diffuse mottle develops.

Natural source of virus: *Lupinus albus* (Pretoria) and *L. angustifolius* (Stellen bosch).

IDENTIFICATION.

The reflexing of the leaves of *Phaseolus vulgaris* is a characteristic of four viruses or strains.

Only with bean yellow mosaic virus is this reflexing also associated with similarity in physical properties, host range and symptoms on other hosts. This virus is therefore considered to be bean yellow mosaic virus.

5. **Pea Mosaic Virus 4** Zaumeyer.

Physical properties: Thermal inactivation point, 60°–65°C. Longevity *in vitro*, 3–4 days. Dilution end point, 1: 5000–1: 10000.

Transmission: Mechanical sap inoculation. *Aphis craccivora.*

Host range: *Crotalaria juncea* L., *C. spectabilis* Roth., *Glycine max* (L.) Merr., *Lathyrus odoratus* L., *Lupinus albus* L. var. Sweet, *L. albus* L. var. Bitter, *L. angustifolius* L., *L. luteus* L., *Medicago lupulina* L., *M. sativa* L., *Melilotus officinalis* Willd., *Phaseolus acutifolius* Gray var. *latifolius* Freem., *P. lunatus* 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 unguiculata* (L.) Walp., *Voandzeia subterranea* Thouars.

Reaction of Susceptible Species.

Crotalaria juncea.

Local. No reaction.

Systemic. After 2 weeks there is a mosaic with irregular chlorotic areas and dark green blisters. Later leaves are malformed and stringlike, and the plant is stunted.

C. spectabilis.

Local. Chlorotic spots with small necrotic centres develop in 10–11 days.

Systemic. The young leaves develop chlorotic spots. The next formed are chlorotic with almost white streaks and dark green blisters. There is a slight malformation.

Glycine max.

Local. Chlorotic spots develop in 4–5 days.

Systemic. After a month the leaves show a chlorotic spotting. The older ones also have necrotic specks. The plant is stunted.

Lathyrus odoratus.

Local. No reaction.

Systemic. After 3 weeks there are chlorotic veinbands followed by a streak mottle on later leaves.

Lupinus albus var. Sweet.

Local. After 11 days there is a general chlorosis leaving dark green veinbands. The leaves become flaccid and drop.

Systemic. The young leaves develop a vein clearing and remain folded (Fig. 5b). Later leaves show an irregular chlorosis with dark green blisters. They are malformed, elongated or even stringlike, and rolled (Fig. 5d).

L. albus var. Bitter.

Local. No reaction.

Systemic. The plant collapses after a necrosis.

L. *angustifolius*.

Local. No reaction.

Systemic. A diffuse chlorotic mottle develops in 18 days.

L. luteus.

Local. No reaction.

Systemic. In 14–15 days the young leaves show a vein clearing and spotting. Later leaves are small and malformed and have dark green blisters (Fig. 5c). The plant is stunted and rosetted (Fig.5a).

Medicago lupulina.

Local. No reaction.

Systemic. There is a vein clearing and spotting of the young leaves. Later ones have irregular chlorotic areas, and are slightly puckered along the midrib.

M. sativa.

Local. No reaction.

Systemic. The leaves develop diffuse chlorotic spots.

Melilotus officinalis.

Local. No reaction.

Systemic. There may be chlorotic spots or streaks, or the plant may be a symptomless carrier.

Phaseolus acutifolius.

Local. No reaction.

Systemic. The young leaves curl down severely. They are mottled and have dark green blisters. Later leaves have yellow specks.

P. lunatus.

A symptomless carrier.

P. vulgaris var. Canadian Wonder.

Local. No reaction.

Systemic. The centre leaflet of the first trifoliates shows a marked reflexing. Chlorotic spots develop in 12–13 days and on later leaves there is a mottle. The leaves are crinkled.

var. Haricot.

Local. The leaves bend at right angles to the petiole and may have necrotic specks.

Systemic. As for Canadian Wonder, but there is also a malformation of the leaves. There may be a necrosis of the growing point, which results in the collapse of the plant.

vars. Black Wonder, Long Tom, S.A. Black and White, Tendergreen and Victor show similar symptoms to those of Canadian Wonder.

vars. Long Tom and S.A. Black and White also develop a local chlorosis in 3 days.

Pisum sativum.

Local. No reaction.

Systemic. After a preliminary vein clearing and spotting, a diffuse mottle develops (Fig. 5e).

Trifolium fragiferum.

A symptomless carrier.

T. hybridum.

Local. No reaction.

Systemic. The vein clearing is vivid, and is followed by alternate chlorotic and green streaks, with occasional intervenal spots.

T. incarnatum.

Local. No reaction.

Systemic. There is a vein clearing of the young leaves in 14 days. Later leaves develop a mosaic and crinkling. The plant is stunted.

T. pratense.

Local. No reaction.

Systemic. There are chlorotic ringspots and streaks on most leaves. On the younger leaves a veinal necrosis may develop which causes a slight malformation.

T. repens.

Local. No reaction.

Systemic. There is vein clearing after 3 weeks which is followed by chlorotic streaks.

Vicia faba.

Local. No reaction.

Systemic. After 14 days the young leaves develop chlorotic spots, and later leaves have a mosaic. The old leaves show a chlorotic network.

Vigna unguiculata.

A symptomless carrier.

Voandzeia subterranea.

Local. No reaction.

Systemic. There may be a diffuse chlorotic spotting.

Natural source of virus: *Lupinus affinis* (Pretoria and district) *L. albus*, *L. angustifolius* and *L. luteus* (Stellenbosch).

Identification.

Of the viruses causing the characteristic reflexing of the leaves of the bean, most similarity is shown to the pea mosaic virus 4 Zaumeyer, and this virus is considered to be the same, or very closely related to it.

HOST RANGES.

Host Plant.	Lupin Virus A.	Lupin Virus B.	Lupin Virus C.	Bean Yellow Mosaic Virus.	Pea Mosaic Virus 4.
Arachis hypogaea	−	−	−	+	−
Cicer arietinum	+	+	−	−	−
Crotalaria juncea	+	+	−	+	+
C. spectabilis	+	+	+	+	+
Dolichos lablab	−	−	−	−	−
Glycine javanica	−	−	−	−	−
G. max	+	+	+	+	+
Lathyrus odoratus	+		+	+	+
Lupinus albus Sweet	+	+	+	+	+
Bitter	+	+	+	+	+
L. angustifolius	+	+	+	+	+
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	+	−	−	+	+
Nicotiana glutinosa	−	+	+	−	−
N. tabacum	−	+	+	−	−

PHYSICAL PROPERTIES AND METHODS OF TRANSMISSION.

Virus.	Thermal Inactivation Point.	Longevity *in vitro*.	Dilution End Point.	Transmission.		
				Sap.	Seed.	Aphis.
Lupin virus—						
A	58–60°C	2–3 days	1 : 1000	+	−	+
B	62–65°C	2–3 days	1 : 100	+	−	+
C	56–58°C	1–2 days	1 : 100	+	−	+
Bean yellow mosaic virus	58–60°C	1–2 days	1 : 1000	+	−	−
Pea mosaic virus 4	60–65°C	3–4 days	1 : 5000	+	−	+

SYMPTOMS ON THREE MAIN TEST PLANTS.

Virus.	*Phas. vulgaris.*	*Vicia faba.*	*Pisum sativum.*
Lupin Virus A.....	Local—neg. Syst.—reflex., chl. mot.	Local—neg. Syst.—c.sp., c. mot.	Local—neg. Syst.—c. mot.
Lupin Virus B.....	Local—chl. sp., necr. O. Syst.—chl. spots	Local—neg. Syst.—c. mot., malf.	Local—necrosis. Syst. c. mot., necr.
Lupin Virus C.....	Local—chl. sp., necr. O. Syst.—chl. mot.	Local—neg. Syst.—neg.	Local—neg. Syst.—neg.
Bean Yellow Mosaic Virus	Local—neg. Syst.—reflex., mot., malf.	Local—flaccid. Syst.—c. sp. mos.	Local—necrosis. Syst.—mos., stunt.
Pea Mosaic Virus 4.....	Local—neg. Syst.—reflex., mot.	Local—neg. Syst.—mos.	Local—neg. Syst.—c. mot.

SYMPTOMS ON THREE MAIN *LUPINUS* HOST PLANTS.

Virus.	*L. albus*—Sweet.	*L. angustifolius.*	*L. luteus.*
Lupin Virus A.....	Local—chl. and necr. Syst.—necr.	Local—neg. Syst.—c. mot., necr.	Local—neg. Syst.—c. mot., malf., ros.
Lupin Virus B.....	Local—chl. Syst.—c. mot., necr.	Local—necr. Syst.—necr.	Local—neg. Syst.—c. mot., stringlike.
Lupin Virus C.....	Local—chl. and necr. Syst.—c. mot., necr.	Local—neg. Syst.—c. mot., crinkle	Local—neg. Syst.—dgr. blist., stunt.
Bean Yellow Mosaic Virus	Local—chl. Syst.—c. mot., malf.	Local—neg. Syst.—chl. mot., esp.	Local—chl. Syst.—chl., malf., stunt.
Pea Mosaic Virus 4.....	Local—chl., veinb. Syst.—c. mot., stringlike	Local—neg. Syst.—chl. mot.	Local—neg. Syst.—dgr. blist., stunt.

ABBREVIATIONS USED:—

chl.—chlorosis, chlorotic.
c. mot.—chlorotic mottle.
c. sp.—chlorotic spots.
dgr. blist.—dark green blisters.
malf.—malformation.
mos.—mosaic.
neg.—negative.
necr.—necrosis or necrotic.
reflex.—reflexing.
ros.—rosette.
veinb.—veinbands.
O.—rings.

SUMMARY.

Lupins in South Africa are naturally infected by five viruses:

1. Bean yellow mosaic virus was found on *Lupinus albus* and *L. angustifolius* at Pretoria and Stellenbosch. This is the first report of the presence of this virus in South Africa.

2. Pea mosaic virus 4 was found on *L. affinis*, *L. albus*, *L. angustifolius* and *L. luteus* in the Pretoria district and Stellenbosch. It is also reported for the first time.

3. Lupin virus A was found on *L. affinis*, *L. albus*, *L. angustifolius*, *L. luteus* and *L. mutabilis*. It is possibly related to the bean yellow mosaic virus group.
4. Lupin virus B was found on *L. albus* and *L. angustifolius*. This is apparently a new virus.
5. Lupin virus C was found on *L. albus* and *L. angustifolius*, and also seems to be a distinct entity, possibly related to lupin virus B.

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FIG. 1.—LUPIN VIRUS A.
A. *Lupinus luteus*. B. *L. albus*. C. *L. angustifolius*. Artificial infections.

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FIG. 2.—LUPIN VIRUS B.
A. *Lupinus luteus*. B. *L. albus*. C. *Phaseolus vulgaris*. Artificial infections.
D. *L. angustifolius*—natural infection.

FIG. 3.—LUPIN VIRUS C.

A. *Lupinus angustifolius*—natural infection.

B. *L. albus*—artificial infection.

FIG. 4.—BEAN YELLOW MOSAIC VIRUS.
A. *Lupinus albus*—natural infection.
B. *L. albus*—artificial infection.
C. *Melilotus officinalis*—artificial infection.

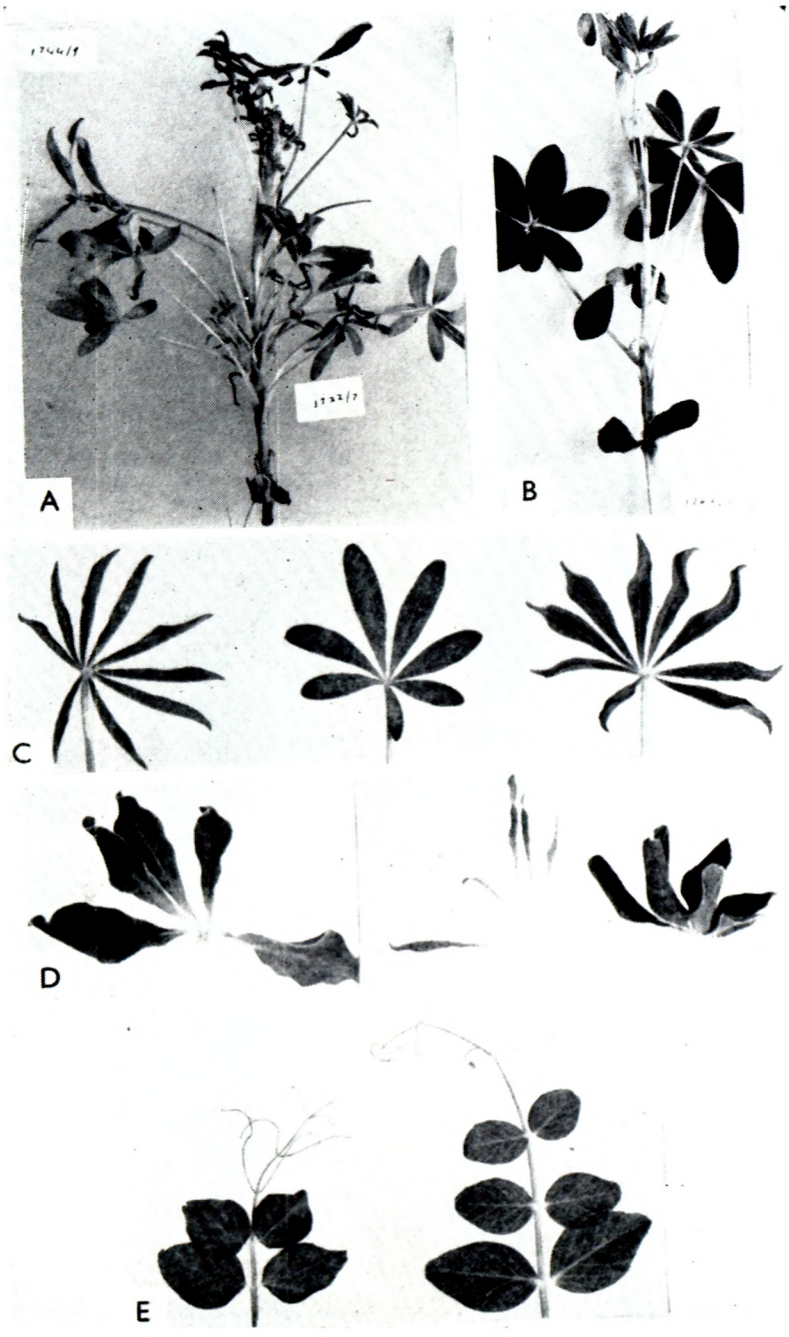

FIG. 5.—PEA MOSAIC VIRUS 4.
A. and C. *Lupinus luteus*. B. and D. *L. albus*.
E. *Pisum sativum*. Artificial infections.