

VIRUS DISEASES OF ANNUAL LEGUME CROPS

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ABSTRACT

An increase in incidence and diversity of virus diseases of peas (*Pisum sativum* L.) dwarf beans (*Phaseolus vulgaris* L.) broad beans (*Vicia faba* L.) and field beans (*V. faba* L. *minor*) has followed the arrival in New Zealand of blue-green lucerne aphid (BGLA) (*Acyrtosiphon kondoi* Shinji) and pea aphid (*A. pisum* Harris). Crop surveys showed that alfalfa mosaic virus (AMV) has become prevalent and damaging in peas. Bean yellow mosaic (BYMV), cucumber mosaic and pea seed-borne mosaic viruses were also isolated from pea crops. Bean common mosaic virus was detected in dwarf bean crops for the first time in many years. BYMV and AMV were also isolated from this crop, from field beans and from broad beans. The incidence of subterranean clover red leaf virus (SCRLV) was low probably due to use of resistant peas and the manipulation of sowing dates of beans to avoid aphid flights.

A bait plant study showed that lucerne and white clover were good sources of AMV and the period during which this virus was most frequently isolated corresponded with the peak flight activity of BGLA but not with that of pea aphid.

The bait-plant study also showed that although not a problem in the legume, crops, SCRLV was prevalent and that white clover was the main source of this virus and of its vector *Aulacorthum solani* Kltb. BGLA is a nonvector of SCRLV and pea aphid appeared to be of only minor importance as a vector of this virus.

THE CROPS

Annual legume crops widely grown in New Zealand are peas (*Pisum sativum* L.) dwarf beans (*Phaseolus vulgaris* L.) and faba beans, i.e. broad beans (*Vicia faba* L.) and field beans (*V. faba* L. *minor*).

THE VIRUSES AND THEIR SYMPTOMS

Top yellows and subterranean clover red leaf virus (SCRLV)

'Top yellows' is a disease caused by SCRLV and bean leafroll virus (BLRV) (Synonym: pea leaf roll virus) either singly or in combination (Wilson and Close, 1973). Since 1972 most of the top yellows of annual legumes has been caused by SCRLV alone (Ashby *et al.*, 1979). In susceptible peas this virus causes a marked stunting and yellowing and the plants become rigid and brittle. There is frequently a proliferation of shoots from nodal buds at the base of the plant and infected plants often succumb to secondary fungal root rot. In dwarf beans SCRLV causes a yellowing and thickening of leaves with downward leaf curling and premature leaf fall. Plants are stunted and few pods are set. In broad beans the most characteristic symptom of SCRLV infection is upward rolling and interveinal chlorosis of lower leaves. Early infection reduces the numbers of pods set.

Many of the pea cultivars currently in use are resistant to top yellows (Crampton and Goulden, 1974) and the growing of dwarf beans in Canterbury is normally delayed until the main flights of the aphid vector, *Aulacorthum solani* Kltb have finished. Faba beans are normally autumn sown and hence reasonably mature and tolerant of virus infection before spring flights of *A. solani* commence. Despite these precautions, in some seasons heavy losses are incurred in dwarf bean and faba bean crops due to unpredictable aphid flights.

Bean common mosaic virus (BCMV)

The symptoms caused by BCMV are fully described by Chamberlain (1954). BCMV is seed-borne and several years ago was extremely prevalent in dwarf beans in the Manawatu and South Island (Brien *et al.*, 1955) but rigorous roguing in

seed production areas combined with use of resistant cultivars led to almost complete elimination of the disease (Malone, 1978).

Cucumber mosaic virus (CMV)

This virus, encountered only in peas, produces a wilting and curling over of the growing point which later dies. Infected plants have brownish streaks along the stems and petioles and the pods remain flat and turn purplish brown.

Pea seed-borne mosaic virus (PSbMV)

In most pea cultivars grown under New Zealand conditions, PSbMV produces very few symptoms. Higher temperatures and longer hours of bright sunlight which prevail in Marlborough may result in symptoms being produced in the field in some years. When infected peas are grown in the glasshouse under 16 hours daylight and at 30°C, symptoms produced include stunting and a severe curling and downward rolling of leaves. The one sample collected during a survey of pea crops (see Table 1) was selected purely on the basis of an erect growth of the upper leaves.

Alfalfa mosaic virus (AMV)

Symptoms caused by AMV vary with strain of virus and cultivar of host, and the symptoms described here are those which were most frequently encountered. The most characteristic symptom of AMV infection in peas is the presence of black sunken areas on the lower pods. In severe cases there is also a brown discoloration of the seed coats and some yellowing and mottling of the leaves. In some plants necrosis of veins in the top leaves and of the stipules is also observed. The strain of AMV most commonly encountered in dwarf beans produces a bright yellow spotting in terminal leaves. In some cases the spots coalesce to produce large yellow patches on the leaves. In broad beans AMV is generally isolated from plants which show only a mild leaf mottle; plants which are infected at an early growth stage become necrotic and die.

Bean yellow mosaic virus (BYMV)

The symptoms caused by BYMV (Synonym: pea mosaic virus) in peas and broad beans have been described by Chamberlain (1954), and in dwarf beans by Bos (1970).

This virus occurs sporadically in all annual legume crops in Canterbury and is sometimes important in Hawke's Bay. Many of the pea cultivars currently grown are resistant to BYMV.

VIRUS DISEASE SURVEYS

In recent years the diversity and incidence of virus diseases affecting annual legume crops has increased dramatically. It is likely that this is a direct result of the activities of blue-green lucerne aphid (*Acyrtosiphon kondoi* Shinji) and pea aphid (*Acyrtosiphon pisum* Harris) which were accidentally introduced to New Zealand, probably in 1975/76. Before the introduction of these aphids the only virus diseases normally detected in annual legumes were top yellows, BYMV, and BCMV.

Surveys of annual legumes were conducted during 1979/80 to determine the present status of virus diseases in these crops. Only plants suspected of being infected by viruses other than SCRLV were collected. This was because SCRLV can only be transmitted by means of aphid vectors thus making testing procedures lengthy and labour intensive and also because the potential of this virus as a pathogen of annual legumes is already well understood. However a visual assessment of the incidence of SCRLV, and where possible of other viruses, was made in each crop visited.

Samples were ground in buffer (peas and broad beans in 0.5% K₂HPO₄; containing 0.5% bentonite; dwarf beans in 1% K₂HPO₄ containing 0.1% Na₂SO₃) and inoculated to indicator plants previously dusted with 600 mesh carborundum. The indicator species used were *Chenopodium quinoa* Willd., *Phaseolus vulgaris* L. 'Tendergreen', *Vicia faba* L. 'Evergreen' and *Pisum sativum* L. 'Victory Freezer'. After inoculation plants were grown in the glasshouse at 17-24°C and symptoms were recorded after 1-4 weeks. If necessary the identity of viruses isolated was confirmed by inoculation to additional host plants and/or by serology and/or by electron microscopy.

The results of the surveys are summarised in Table 1. Full details of the individual surveys may be obtained from the author on request.

TABLE 1: Summary of virus surveys of annual legume crops 1979/80. Number of crops in which virus was detected.

	Crops		
	<i>Pisum sativum</i>	<i>Phaseolus vulgaris</i>	<i>Vicia faba</i>
Alfalfa mosaic virus	14	3	5
Bean yellow mosaic virus	3	3	3
Cucumber mosaic virus	6	ni*	ni
Bean common mosaic virus	ni	5	ni
Pea seed-borne mosaic virus	1	ni	0
No. of crops sampled	17	14	22

* Not infected by this virus.

Peas

AMV was the most prevalent virus, being isolated from 14 of 17 crops surveyed and from 61% of all pea plants sampled. The incidence of plants infected with AMV was extremely variable and in one pea crop, grown alongside an established lucerne crop, it was estimated that 40% of the plants were infected.

CMV was isolated from 6 of 17 crops (8% of all plants sampled) but the incidence within crops was always low (less than 1%).

BYMV was isolated only from 2 crops but most of the crops surveyed were resistant to this virus. One of the susceptible crops was 'Victory Freezer' in which 5-10% of the plants were infected with BYMV. Other susceptible pea lines grown for evaluation at Lincoln had similar levels of infection with BYMV.

PSbMV although known to be present in some pea seed lines is almost symptomless in the field. Only one sample was infected by this virus.

Dwarf beans

Dwarf bean crops surveyed included Crop Research Division (CRD), DSIR, lines at Lincoln, process crops of 'Galatin 50' grown in mid-Canterbury and seed crops grown in Blenheim.

BCMV was isolated only from CRD lines and from 4 crops in Blenheim. In one of the Blenheim crops (cv. Small Red Mexican) at least 50% of the plants were infected and subsequent seed tests showed this line to have a 7.9% seed infection. Field infection in the other three Blenheim crops ranged between 1 and 5%. The level of seed infection of these other crops has not been tested.

AMV was of only sporadic occurrence, except in the crop of Small Red Mexican mentioned above, in which half of the samples collected were infected.

BYMV was also detected at a low level (2-3%) in three of the Blenheim crops.

Very little infection with SCRLV was detectable in the dwarf bean crops inspected. The process crops were sown in the second and third week in December and thus avoided the flights of the main vector *A. solani*. Many of the crops in Blenheim were becoming senescent when inspected which made detection of SCRLV infection difficult but in the few later sown crops surveyed no top yellows was observed.

Broad and Field Beans

The survey of broad bean seed crops in the Blenheim district and of field bean seed crops in the mid-Canterbury district was conducted partly in response to a request from the Ministry of Agriculture and Fisheries to determine whether or not two seed-borne viruses, broad bean stain and Ecthes Ackerbohnen mosaik-virus were present in New Zealand crops. Neither of these viruses were detected in the 22 crops (218 samples) tested.

A low level of AMV was detected in 5 crops. Broad beans are very susceptible to this virus when infected at an early growth stage but the autumn-sown crops are generally mature before the spring aphid flights occur. BYMV was detected only in 3 Blenheim broad bean crops. In one of these the incidence was high (about 15%) but in the other two crops was at 1-2% level. The high incidence in one crop was probably due to a seed-borne strain of BYMV which was present in that seed line. SCRLV was present at a low incidence (1-3%) in almost all faba bean crops surveyed.

VIRUS EPIDEMIOLOGY AND ECOLOGY

This is a preliminary report of some of the more pertinent results of a bait-plant study. For a fuller analysis of this work the reader is referred to Ashby *et al.* (in preparation).

Bait-plants of peas, dwarf beans, broad beans, and subterranean clover (*Trifolium subterraneum* L.) were exposed to aphid flights from the beginning of October 1979 to the end of January 1980 at three different sites. One site was surrounded by established white clover (*Trifolium repens* L.) another by established lucerne (*Medicago sativa* L.) and the third was in the middle of a pea crop. The plants at each site were replaced once a week and kept in the glasshouse for 4-6 weeks after which any virus symptoms were recorded and the identity confirmed as for the survey isolates. Aphids landing on the plants were removed three times a week, identified and counted.

The first set of bait-plants were placed in the field before the emergence of local pea crops but missed the beginning of spring flights of *A. solani* and *Myzus persicae* Sulz. which normally commence about mid September (Lowe, 1966).

SCRLV was isolated from 182, AMV from 130 and BYMV from 4, of the total of 2940 bait plants exposed during the 14 week period. The seven aphid species most frequently trapped (actual numbers in parentheses) were green peach aphid *M. persicae* (1287); blue-green lucerne aphid *A. kondoi* (591); dock aphid, *A. solani* (567); black bean aphid, *Aphis craccivora* Koch (555); pea aphid, *A. pisum* (330), cabbage aphid, *Brevicoryne brassicae* L. (121) and potato aphid, *Macrosiphum euphorbiae* C. Thomas (108).

Subterranean Clover Red Leaf Virus

Ashby *et al.* (1979) suggested that white clover may be an important source of SCRLV. This has been substantiated in the present study in which SCRLV was isolated significantly more frequently ($X^2 = 96.07$) from bait plants grown in the middle of a white clover crop than from plants grown in the middle of lucerne or pea crops (Table 2). There was no significant difference ($X^2 = 0.15$) between the frequencies with which SCRLV was isolated from plants grown in the middle of a lucerne crop and from plants grown in a pea crop, which suggests that lucerne is not a source of the virus. It would appear that white clover provides an important overwintering host for *A. solani*, the principal vector of SCRLV, since a mean population of 18 fourth instar nymphs per 0.1m² foliage was present in the white clover surrounding the bait plants, when sampled in the beginning of October (J. Farrell pers. comm.).

TABLE 2 — Frequency of isolation of three viruses from bait-plants placed within three crops — Lincoln 1979/80.

Crop in which bait-plants located	Number of bait-plants infected*		
	Alfalfa mosaic virus	Subterranean clover red leaf virus	Bean yellow mosaic virus
Clover	53	123	4
Lucerne	47	31	0
Pea	20	28	0

*out of 2940

In glasshouse tests, *A. pisum* has been shown to be a vector and *A. kondoi* to be a non-vector of SCRLV (Ashby unpublished data). The numbers of *A. solani* and *A. pisum* trapped each week are compared with the frequency with which SCRLV was isolated (Fig. 1) and these results suggest that *A. pisum* may have been responsible for some transmission of SCRLV as the frequency of virus isolation during the week ending December 18 was higher than would have been expected in

view of the declining numbers of *A. solani*. This period coincided with increasing numbers of *A. pisum* which reached its peak population four weeks later than *A. solani*.

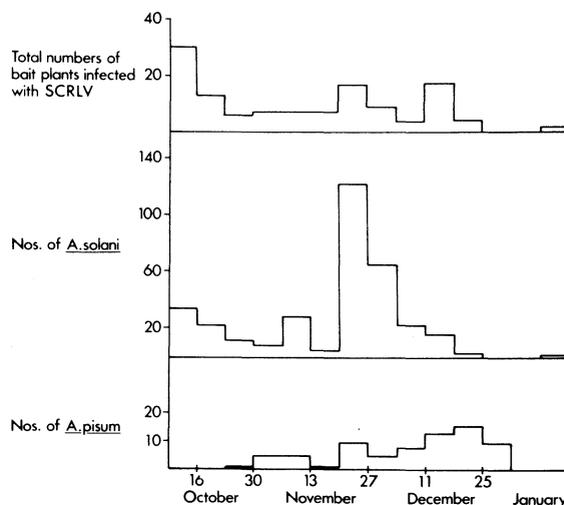


Figure 1. Frequency of isolation of SCRLV on bait plants and numbers of aphid vectors collected from them.

Alfalfa Mosaic Virus

AMV is transmitted in a non-persistent manner by at least thirteen aphid species (Kennedy *et al.*, 1961) including five of the seven commonly trapped during this study. This made it difficult to correlate virus isolation with any particular species because of the frequency with which several different species were trapped on the same bait plant. Since AMV has become a problem only in recent years it is suggested that the most likely vectors of AMV are the recently introduced *A. kondoi* and *A. pisum* which may achieve high population levels in lucerne and white clover. Furthermore these two forage crops are known to be major sources of AMV (Ashby and Fletcher, unpublished data) and in the present study there was no significant difference ($X^2 = 0.15$) between the frequencies of isolation of AMV at the lucerne and at the clover sites. AMV was isolated significantly less frequently ($X^2 = 18.85$) by bait plants grown at a distance from white clover and lucerne (i.e. in the middle of a pea crop). The bait plant records for *A. kondoi* and *A. pisum* and for *A. solani*, which is also commonly found on lucerne and clover, are compared with the record of AMV isolation (Fig. 2). The data suggest that *A. kondoi* is a more likely vector of AMV than *A. pisum* because the pattern of virus isolation closely corresponds to the changes in populations of *A. kondoi* whereas relatively little AMV was isolated at the time of the later peak populations of *A. pisum*. However there was also an apparent relationship between numbers of *A. solani* and frequency of AMV isolation, particularly at the beginning of the bait-plant study and during the week ending November 12.

DISCUSSION

The results of the surveys and of the bait plant study show that AMV has become an important pathogen of annual legumes, especially peas, in recent years. In the bait plant study it appeared that white clover and lucerne were equally good sources of AMV, and *A. kondoi* and *A. solani* were implicated as vectors of this virus. Numbers of *A. pisum* were considerably lower and the population peaks did not coincide with the peaks of frequency of isolation of AMV.

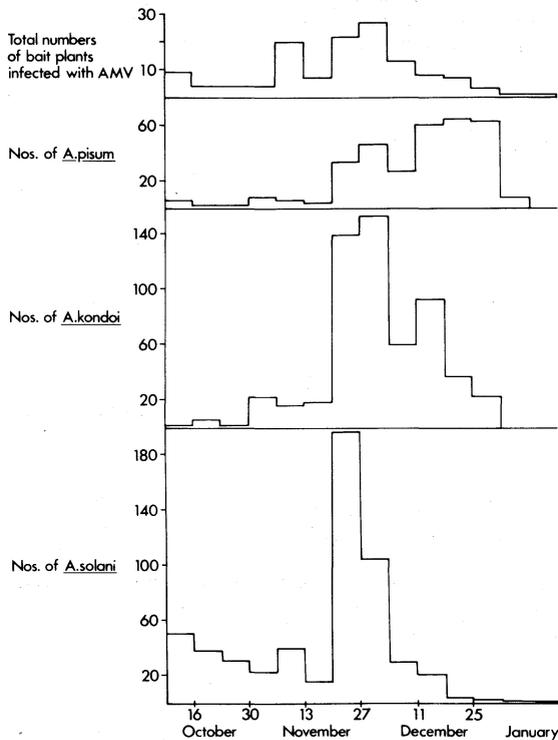


Figure 2. Frequency of isolation of AMV on bait plants and numbers of aphid vectors collected from them.

The aphid species trapped most frequently was *M. persicae* but this species did not originate from local lucerne or clover crops (J. Farrell pers. comm.) and it is not known if it was carrying AMV since its peak population coincided with that of *A. kondoi*. *M. persicae* is a vector of AMV and even if it was not carrying AMV on arrival it could be responsible for considerable secondary spread of the virus within annual legume crops.

Results of the present study confirm earlier reports that white clover was probably the main source of SCRLV and also demonstrate that it provided an important overwintering host of *A. solani*, the main vector of AMV. Crops susceptible to SCRLV therefore should not be grown close to established white clover. It is likely that heavy pre-winter grazing of white clover pasture would lower the survival of *A. solani*. From the bait-plant results it appears possible that *A. pisum* may contribute to the spread of SCRLV and because of its later flight activity might extend the period during which virus is spread. However, populations of pea aphids in white clover are generally low (T. E. Trought, pers. comm.), and it is not considered to be a significant vector of SCRLV.

The re-appearance of BCMV in dwarf bean seed crops is of considerable concern and a programme of seed testing and rejection of infected lines followed by crop inspection and roguing is necessary if this disease is to be controlled.

The non-expression of symptoms of PSbMV on peas under field conditions means that this virus is more widespread than is generally known. Restrictions recently introduced by Australia on importation of pea seed have meant that all parent seed of crops intended for export to that country must be tested and shown to be free of PSbMV. Since this virus is very readily transmitted by aphids it is imperative that PSbMV free seed should not be sown in close proximity to untested or to infected lines.

The reasons for the increase in virus problems of annual legume crops are twofold. Firstly the increase in aphid populations in forage legumes caused by the introduction of *A. kondoi* and *A. pisum* has resulted in a higher level of virus transmission within these crops thus providing more abundant sources of virus and secondly the numbers of aphids migrating from perennial to annual crops has been substantially increased.

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