Paper 8
LUCERNE DISEASES IN NEW ZEALAND AND THEIR CONTROL

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INTRODUCTION

When the first review of lucerne diseases in New Zealand was prepared in 1967 (Close, 1967) it listed those diseases which had been recorded in New Zealand. Since 1967, new diseases have been found to occur here, notably bacterial wilt of lucerne, and research has provided information on the biology, ecology, incidence and importance of many of these lucerne diseases. Over the last ten years there have been many articles on lucerne diseases.

In addition, the American Phytopathological Society's "Compendium of Alfalfa Diseases", with its many fine colour photographs, is a great help in identifying diseases.

This paper briefly discusses lucerne diseases and their control and outlines some problems where more research is needed. It also includes (in an appendix) a field key to the diagnosis of lucerne pests and diseases.

SEED-BORNE DISEASES

The main seed-borne disease of lucerne is spring black stem (*Phoma medicaginis* Malbr. and Roum var *medicaginis* Boerema). Percival and Wenham (1972) studied 86 seed lines and found that 4% contained no infection, 38% had 5%, 57% had 10%, 78% had 20%, and 22% had more than 20% infection (maximum 49%). Emergence experiments indicated that spring black stem could cause pre-emergence damping-off of the order of 2 to 9.5%. These data were obtained by comparing emergence of untreated seed with that of thiram-treated seeds. It would appear that spring black stem is only important prior to emergence, as A.J. McCully (pers. comm.) did not isolate this fungus from any lucerne seedlings during his study of post-emergence damping-off.

Other pathogens were isolated from lucerne seed by Percival and Wenham (1972), namely *Stemphylium botryosum* Wallr., *Fusarium* spp, and *Leptosphaerulina briosiana*. (Poll) Graham and Luttrell. These were present at much lower levels, and not all isolates of *S. botryosum* were pathogenic to lucerne seedlings. Their recommendation was to incorporate thiram and benomyl during the coating process, to provide protection against seed and soil-borne fungal pathogens.

Plant debris can be associated with seed and can harbour many pathogens. It is important therefore to use machine-dressed seed. Pathogens associated with debris are bacterial wilt, *Verticillium* wilt, stem nematodes, and sclerotes of *Sclerotinia trifoliorum* Eriksson. Infected hay can also spread these pathogens.

SEEDLING DISEASES

Seedling diseases are often referred to as 'damping-off', and are caused by fungi which can damage the seedlings either before (pre-emergence) or after emergence above ground (post-emergence). The net result is a reduction in the number of seedlings that emerge, or poor growth and eventual death of many that do emerge.

In a survey of 83 crops (43 in Canterbury and 40 in the Central North Island) A.J. McCully (pers. comm.) found that 30 crops (36%) showed evidence of post-emergence damping-off, with 19 (23%) having more than 5% infected seedlings, the range being from 5 to 42%. There was a negative correlation between damping-off and emergence (recorded as plants per m^2). If was found that sowing lucerne with a cover crop did not influence damping-off in the seedlings. *Pythium* species were most frequently isolated from lucerne seedlings with damping-off symptoms. *Fusarium* species, when isolated alone, came from seedlings showing poor growth, rather than from those with visible root or stem lesions. Of the many isolations, 75% were of *Pythium* spp., 10% were of *Fusarium* spp., and 15% were mixed isolations of these two. In no case was *Rhizoctonia solani* Kuehn isolated from seedlings, nor was *Phoma medicaginis* var. *medicaginis*, even though the latter is common in lucerne seed (Percival and Wenham, 1972).

Control of lucerne seedling diseases is possible by treating the seed with funigicides. In an initial trial (Close and Sanderson, 1977) plots from treated seed yielded twice as much herbage as those from untreated seed. In three trials in the 1976/77 season, the mean percent emergence was as follows: fenaminosulf — 93%, captan — 78%, untreated — 44%, carbendazim — 29%.

In the 1977/78 season, a series of trials was organised in co-operation with Coated Seed Limited (G.M. Bennett). All the Wairau lucerne seed was pelleted by the 'Prillcote' process, with half receiving a further treatment with fenaminosulf at the rate of 0.015% a.i. The seed was sown as observation trials in 22 paddocks, half of each paddock was sown with untreated, and the other half with treated seed (5 in the Taupo area, 3 Reporoa, 2 Waipawa, 5 North Canterbury and 7 in mid-Canterbury). The percent establishment was calculated from seedling counts in 50 $0.1m^2$. quadrats per treatment. When fungicide response and establishment were compared trials fell mainly within three categories: poor establishment with no overall improvement from seed treatment; good establishment with no improvement from seed treatment; good establishment and an increase of 17% (range 10% — 30%) following treatment (7 trials, mean untreated — 63%, treated — 80%). An expected category, i.e. poor establishment, but with a marked improvement from seed treatment, did not occur (except in one case). In eight trials, seed treatment resulted in better stand establishment (Fig. 1). The fungicide, at the rate used, did not affect nodulation of the lucerne plants. As the cost of treatment is low, it seems desirable to routinely include a chemical in the outer coats of all coated or pelleted lucerne seed. Fenaminosulf is satisfactory, but has some disadvantages when used on a large scale. Present trials are directed at finding effective compounds suitable for use in factories coating lucerne seed (F.R. Sanderson and C.M. Crompton-Smith, pers. comm.).

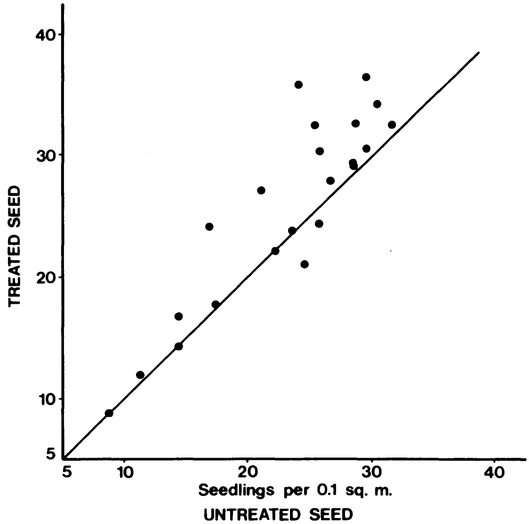

Figure 1: Effect of seed treatment with fenaminosulf on the establishment of lucerne in 22 field trials.

BACTERIAL WILT

Bacterial wilt (*Corynebacterium insidiosum* (McCulloch, 1925; Jensen, 1934) was first found in New Zealand in 1970 (Close and Mulcock, 1972) but it is likely that this disease had been present for many years. Its existence was drawn to our attention by the late J.S. Whitelaw, who realized its significance and the effect it could have on a lucerne-processing industry (Whitelaw, 1975).

Infected plants may be found scattered throughout stands, and in general, are easily detected among the healthy plants because of their yellow-green colour and stunted growth. However, plants showing a range of symtoms (from mild to severe) may be present. Mild symptoms consist of leaf-mottling together with slight cupping or curling upwards of the leaflet margins and some reduction in plant height. Moderately affected plants show mottling and cupping of leaflets, height reduction, and often a proliferation of stems giving a "witches'-broom" effect. Severely affected plants are only a few inches high, with thin, spindly stems and small leaflets often distorted and showing bleaching either marginal or entire. When the main tap-root of infected plants is cut obliquely, a ring of yellow-brown discoloration can be seen at the junction of the cortex and vascular cylinder. The cortical layer, when peeled away, reveals a yellow-brown discolouration of the inner vascular cylinder which contrasts markedly with the white colour in healthy plants.

An initial survey of New Zealand (Hale and Close, 1974) using rapid identification methods (Hale, 1972) showed that the disease appeared to be restricted to the South Island (Canterbury and further south). In 1974, bacterial wilt was discovered in the North Island, and since then has been found in most of the major lucerne growing areas (Sanderson, 1976). There is no doubt that in susceptible cultivars this disease is very destructive, reducing yields and ultimately causing death of plants, especially in stands grown in wetter areas or which are irrigated.

Many excellent wilt resistant cultivars (Dunbier *et al.*, 1976) have been introduced into New Zealand, and some possess good resistance to other pathogens as well. Providing plant breeding programmes continue to incorporate bacterial wilt resistance into all new cultivars, there should be a marked decline in the relative significance of this disease.

VERTICILLIUM WILT

The earliest symptom of Verticillium wilt (*Verticillium albo-atrum* Reinke and Berthold) infection is a wedge-shaped yellowing starting at the central veins of the lower leaflets. This may then extend to cover either one side or the whole of the leaflet). As infection of the stem progresses upwards, successive leaflets begin to yellow, till finally the whole stem becomes wilted and then desiccated. Wilting is obvious when the plants are under moisture stress, especially if the stand is overmature. There is no stem proliferation (as with bacterial wilt), and plants are generally not stunted.

As top symptoms of Verticillium wilt can be absent during the early stages of stem-elongation, infection at this stage is detected by an examination of the woody tissue in the tap-root. Early infection is seen as a partial or complete ring of darker tissue near the edge of the woody tissue of the root. As infection progresses the whole of the woody tissue may become discoloured. Root symptoms at this late stage are easily confused with those of bacterial wilt, so root symptoms where possible, should be coupled with an examination of leaf and stem symptoms of the plant.

Sanderson (1976) records that in the 1975/76 National Lucerne Survey this disease was found in all the lucerne-growing areas, and in approximately 68% of the crops sampled. A recent field trial (Dunbier *et al.,* 1981) showed that one isolate of the Verticillium wilt fungus was not as severe a pathogen as bacterial wilt. In fact the plant survival was similar in the uninoculated plots, and in the Verticillium plots at all times after inoculation i.e. at 12, 20, 26 and 38 months after inoculation. There may still be other isolates that are more pathogenic, hence a comparison of isolates from many locations would be worthwhile. This research is proceeding (B.T. Hawthorne, pers. comm.).

In the same trial (Dunbier *et al.,* 1981) the U.S.A.-developed cultivars Saranac, Washoe and 520 were no more severely infected than Vertus and Maris Kabul, European cultivars specially selected for Verticillium resistance. Verticillium wilt has now been recorded in U.S.A. (Graham *et al.,* 1979; Christen and Peaden, 1981). It appears that it may have been there, undetected, for some years.

VIRUSES: SAP-TRANSMISSIBLE

Three sap-transmissible viruses have been recorded in New Zealand (Ashby *et al.,* 1979).

Alfalfa mosaic virus (AMV)

AMV can be seed-borne (Graham *et al.,* 1979) but was detected in only one out of seven seed-lines of Wairau tested by Teh (1979). It is transmitted by a number of species of aphids in a non-persistent or stylet-borne manner.

In a recent survey (Ashby *et al.,* 1979) 2.3% of the plants collected from 68 symptomless lucerne crops were found to be infected with AMV. The overall incidence varied from 0 to 36% and was low compared with overseas data. This is probably because the data was collected in 1976 prior to the introduction of the blue-green lucerne aphid (*Acyrthosiphon kondoi*), and the pea aphid (*Acyrthosiphon pisum* Harris), both of which appear to be more active (Ashby, 1980) in transmitting AMV than *Aulacorthum solani* KHb., previously the main aphid in lucerne.

Further surveys are now required to check on the possible increased incidence of AMV in lucerne, for AMV has now been shown (Ashby, 1980) to be an important pathogen of annual legumes such as peas and broad beans.

Australian lucerne latent virus (ALLV).

In the survey (Ashby *et al.,* 1979) 9.6% of plants collected from symptomless lucerne were found to be infected with ALLV. The virus is seed-borne (Blackstock, 1978) and this may be indicated by only 24% of the sampled crops being not infected, whereas 60% were not infected with AMV (Table 1). In one crop which was sampled in detail, there was the same amount of ALLV at the edges (33%) compared with the centre (30%), whereas with AMV there was more infection at the edge (45%) than in the centre (17%). With AMV this reflects aphid activity, while with ALLV it indicates its seed-borne nature. There are no known vectors for ALLV although it may be spread by nematodes.

Lucerne transient streak virus (LTSV).

The average incidence in plants obtained from crops was 3.5%, with the virus not being detected in 43% of the crops sampled. The virus is not seed-borne (Forster and Jones, 1979), nor is there a known vector.

The incidence of these three viruses (Table 1) shows that ALLV is more common (detected in 76% of the crops sampled) and in general was at a higher incidence in crops. Both AMV and LTSV were less common and crops did not contain large numbers of infected plants. The economic importance of these three viruses has not yet been determined. It is expected that AMV will increase in incidence with the prevalence of new aphid vectors.

TABLE 1: Incidence of infection with three viruses in 68 lucerne crops in New Zealand. (After Ashby *et al.,* 1979).

Range of percentage incidence of infection	Number of crops in category		
	AMV	ALLV	LTSV
0	41 (60%)	16 (24%)	29 (43%)
1 - 5	22	20	26
6 - 10	1	10	6
11 - 20	2	16	6
21 - 40	2	2	1
40	0	4	0

VIRUSES: CIRCULATIVE APHID-TRANSMISSIBLE

Subterranean clover red leaf virus (SCRLV).

In a survey of lucerne (Ashby *et al.*, 1979) SCRLV was not isolated from 80 tested lucerne plants. However, lucerne could be infected by the virus in inoculation experiments. In a bait-plant study (Ashby, 1980) the incidence of SCRLV was the same whether the plants were located within a pea crop or a lucerne crop, indicating that lucerne was not a source of this virus. The data strongly suggested that white clover was the major source of SCRLV and of the aphid vector *Aulacorthum solani.*

STEM NEMATODE

Stem nematode (*Ditylenchus dipsaci* Kuhn) was first recorded from lucerne in New Zealand by Morrison (1957). Recent records show that it is present in lucerne stands throughout the South Island, and field evidence suggests that it is increasing in incidence (Wood, 1972).

Damage due to stem nematode shows in spring as patches of stunted plants, with swollen shoots and small distorted leaves. Plants may appear to recover during summer. The nematode can be introduced to crops in debris with seed, hence the recommendation to always use machine-dressed seed (Wood and Close, 1974). Spread on farms and between farms occurs by the use of infected hay, as the organism can survive in such hay for some years. For this reason, infected lucerne hay should never be fed out on lucerne stands sown with susceptible cultivars.

The effect of stem nematode on productivity and persistence of lucerne cultivars has been tested (Dunbier *et al.*, 1979). Only cultivars with resistance gave high yields and maintained adequate plant numbers in infected plots. Resistant cultivars are the best means of control and in districts where stem nematode is known to be present, Washoe or AS13R should be sown. Other resistant cultivars are being evaluated (Burnett *et al.*, 1979).

ROOT KNOT NEMATODE

Root knot nematode (*Meliodogyne hapla* Chitwood) affects the roots of lucerne, as well as those of white clover, and is known to occur from Northland to Canterbury. It is not known whether it reduces yield. Damage to the root system by large numbers of nematodes is likely to affect plant establishment, subsequent growth, and affect the plants tolerance to drought. Grandison (1976) reports trials on the control of root-knot nematode with nematicides, and showed that there were some chemicals that could reduce the number of nematodes per gram of roots. Further trials examining resistance to this nematode found only one line, Nevada Synthetic XX, had a satisfactory level of resistance.

PHYTOPHTHORA ROOT ROT

Phytophthora root rot (or black root rot), caused by *Phytophthora megasperma* Drechs, has not been recorded officially in the literature in New Zealand. However, there have been six reports of its identification (H.M. Dance, I.C. Harvey, B.T. Hawthorne, A.J. McCully, F.R. Sanderson and H.C. Smith, pers. comm.). There is also circumstantial evidence of its presence and of its effect on yield. This evidence comes from two sources.

Firstly, symptoms shown by infected plants are very similar to those described overseas (Graham *et al.*, 1979). Infected plants often occur in the lower areas of fields, and show wilting and yellowing of lower leaves. The roots show brown to black lesions with diffuse margins, varying in size from a few mm to 30 mm and circling the root. Often the lower part of the tap-root may have rotted away completely, and several new roots have formed near the soil surface. This gives the tap-root a forked-branched appearance.

Secondly in some cultivar trials, especially an irrigated trial at Winchmore, and a trial on low-lying land at Greenpark, the only cultivars surviving satisfactorily after five years were Washoe and Lahontan which are resistant to this disease.

The disease occurs in low-lying areas of fields where soil moisture is abundant, and occurs on heavy rather than light well-drained soils. However, even on the latter the disease can be a problem when irrigation is frequently applied.

There is clearly a need for more information on the distribution, ecology, and significance of this pathogen. It could well be much more important than is presently realized.

In areas where the disease is thought to be causing plant and yield loss, control can be gained by improving drainage and by the use of resistant cultivars. Of the cultivars now commercially available in New Zealand, Washoe, AS13R and WL318 are resistant to Phytophthora.

CROWN ROT

Crown rot is widespread in New Zealand and is one of the first diseases to appear in established crops, and can increase throughout the life of the stand. In the 1975/76 National Lucerne Survey, of the 247 crops sampled only one was recorded as not having crown rot. The average infection index was 25% (combining severity with incidence) with a range of 0 to 55%. There was no one area in New Zealand with more or less crown rot than any other. The survey also indicated a correlation between stand age and crown rot index ($r = 0.478$, $P < 0.001$), and a negative correlation between percentage cover and crown rot ($r = -0.266$, $P < 0.001$).

Crown rot is best identified in the field by cutting down into the crown with a sharp knife, as the rotten area can often extend in a V pattern from the crown into the tap-root of the plant.

A range of fungi, either acting alone or together, have been implicated as casual agents of crown rot (see Sanderson, 1976). The range includes:

Fusarium spp. — e.g. *F. avenaceum* (Fr.) Sacc.; *F. solani* (Mart.) Appel & Wr.; *F. sambucinum* Fuckel var. *coeruleum* Wollenw.; and *F. oxysporum* Schlecht.

Rhizoctonia solani (= Pellicularia filamentosa (Pat). Rogers).

Stagonospora meliloti (Lasch) Petr. (teleomorph- *Leptosphaeria pratensis* Sacc & Briard).

Sclerotinia trifoliorum.

Thielaviopsis basicola Berk. & Br. Ferraris (Hill, 1979).

Phoma medicaginis var. *medicaginis.*

Some other species of fungi have been isolated from the crown and roots of lucerne (B.T. Hawthorne, pers. comm.) and these are being tested to determine their pathogenicity and their role in the crown rot complex.

Many of the crown-rotting fungi gain entry to the crown through damaged tissue which has been cut or crushed by machinery, trampling by stock or chewed by insects. Waterlogging can also allow entry of fungi, especially *R. solani.* Pathogens such as *S. trifoliorum* and *P. medicaginis* var. *medicaginis* (the causal organisms of *Sclerotinia* wet rot and spring black stem respectively) can spread down into the crown from infected stems and contribute to or initiate a crown rot complex. The crown rot phase (Irwin, 1974) of anthracnose (*Colletotrichum trifolii* Bain and Essary) has not been recorded in New Zealand.

Although there is no evidence that crown rot alone causes plant mortality or that crown-rot reduces yield of a stand, growers are advised to adopt management practices that encourage rapid growth. They should avoid plant stress and damage by not overgrazing or trampling a crop; ensure adequate drainage in areas prone to waterlogging; and allow sufficient regrowth between cuts to maintain healthy vigorous plants. These practices will all contribute toward longer stand-life and lessen the effects of crown rot. Set stocking of lucerne paddocks in winter and over-grazing appear to be factors predisposing lucerne plants to infection by crown-rotting fungi.

RHIZOCTONIA

Rhizoctonia solani (= Pellicularia filamentosa), can cause a range of diseases ranging from damping-off of seedlings, to root canker, crown rot and stem blight. Conditions of high moisture and warm temperatures are required for damage to take place, and this is not common in most lucerne-growing areas unless excess irrigation is applied, or summer flooding occurs in areas with a high water-table. Root cankers, especially of the tap-root, are tan to buff-coloured with a dark margin. The lesion colour is actually not very different to that of healthy root tissue. Lesions become black with age or drying of the soil. *R. solani* can grow into the crown causing crown rot, and advance up stems, causing brown to black cankers, which can often completely girdle stems.

Seedling loss occurs during warm, wet soil conditions. *R. solani* has a wide host range and can also survive saprophytically in soil or as sclerotia. No control is available except avoidance of waterlogging during summer.

STAGONOSPORA ROOT ROT

The fungus that causes Stagonospora root rot, *Stagonospora meliloti* (teleomorph — *Leptosphaeria pratensis)* also causes a leaf spot disease, and is widespread throughout New Zealand. The 1975/76 National Lucerne Survey found 52% of all crops sampled had infection with this root disease. However, Sanderson (1976) when commenting on the diseases encountered on this survey, gave Stagonospora only passing mention as in the majority of cases, Stagonospora was noted only as "flecks" in the tap-root. Stephen *et al.,* (1981) noted that the disease was more prevalent on a 'winter-dry' site than on a 'winter-wet' one. The disease was never recorded as being very severe in any of 16 cultivars at either trial site. The reason for the higher relative index on dry soil is unexplained.

Smith (1955) stated that the disease was widespread in Canterbury and Otago, causing serious losses, but the above evidence does not fully support this statement. Nevertheless, on two occasions the Plant Health Diagnostic Station at Lincoln has had reports of serious losses from this disease in lucerne crops, one crop being in Central Otago and one in Central Canterbury. The roots of the specimens were extensively rotted and contained sexual fruiting bodies (perithecia). It is obvious that this disease requires more study in New Zealand, both into its incidence and importance, and the reasons for it becoming a factor in the decline of some stands.

FUSARIUM ROOT ROTS

Fusarium spp. are commonly isolated from rotting lucerne roots, entering either as primary pathogens, but more commonly as secondary invaders after damage by insects or other mechanical means. These fungi can hasten plant decline under adverse growing conditions, especially following attack by other pathogens such as *Stagonospora* or *Phytophthora megasperma.*

CROWN WART

This disease is caused by the water-borne fungus *Physoderma alfalfae* (Lagh.) Karling and is found throughout New Zealand, especially when lucerne is grown in wet areas. Stephen *et al.,* (1981) found on a winter-wet trial site, that the two cultivars Lahontan and Washoe persisted best and yielded highest after five years, but had the highest incidence of crown wart. In contrast T.P. Palmer (pers. comm.) found no significant difference in crown wart infection among Wairau, Saranac, Washoe and Du Puits. It is considered not to be a serious disease.

LEAF SPOT DISEASES

Lucerne in New Zealand is subject to a number of leaf spot diseases, and these can be identified by using a field key (see Appendix). Many of these do little direct damage to crops, but some cultivars are particularly susceptible to common leaf spot (caused by *Pseudopeziza medicaginis* (Lib.) Sacc.) (Harvey and Martin, 1980) which can build-up to cause serious defoliation in autumn. Pepper spot (caused by *Leptosphaerulina briosiana*) can cause damage to crops in the North Island (Boesewinkel, 1976). Occasionally during summer in Canterbury, crops can show extensive damage by yellow leaf blotch (caused by *Pseudopeziza jonesii* Nannf.) especially if stands are left rank and humidity increases below the canopy. Crops saved for seed can often be devastated by leaf spot pathogens, especially common leaf spot and spring black stem on susceptible cultivars. The latter disease and *Stemphylium botryosum* can also attack pods reducing seed production through shrivelling and pod shedding.

Leaf spotting fungi also cause a dramatic increase in coumestans, which depress ewe ovulation rates and the subseqent lambing percentages (Jagusch, Paper 9).

There are large differences in the susceptiblity of different cultivars to leaf disease (Dunbier *et al.,* 1976; Harvey and Martin, 1980; Purves *et al.,* 1981; Dunbier and Easton, Paper 19). Purves *et al.,* (1981) also showed that while the susceptible cultivars Wairau and Washoe gave a significant yield response from fungicide treatment, Saranac did not because of its resistance. From their research they concluded that a combination of resistant cultivars and strategic grazing management could keep coumestan levels low over the vital flushing and mating period.

Hart and Close (1979) in a trial with the cv. Wairau, found that if benomyl fungicide was applied to seed crops four weeks after closing, and four weeks after flowering ends, then a significant increase in seed-yield was obtained through the control of some leaf spot pathogens. However, pathogens such as *Stemphylium botryosum*, and weak secondary invaders such as *Alternaria alternata* (Fr.) Keissler, can contribute to the shedding of pods before harvest, and the inclusion of a further fungicide to control such fungi might be a wise precaution. These fungicides could well be tank-mixed with insecticides to control sucking insects (see Donovan, 1981).

CONCLUSIONS

Prior to 1970 the main cultivar was Wairau. The introduction of new cultivars from overseas was strictly controlled in order to prevent bacterial wilt entering New Zealand. Since this disease was found in 1970, many resistant cultivars have been imported and tested throughout New Zealand. It has also become clear that bacterial wilt had been present for many years, and was probably responsible for the death of lucerne plants and subsequent deterioration of stands.

In addition to resistance to bacterial wilt, many of the new cultivars have the additional benefit of resistance to other pathogens. This is because screening for these resistance factors has been going on, particularly in the U.S.A., for over 50 years, and thus many cultivars with multiple resistance have become available.

Therefore resistant lucerne cultivars can be used to control the following diseases: bacterial wilt, stem nematode, Phytophthora root rot, and leaf-spotting fungi (see Dunbier and Easton, Paper 19, for list of cultivars and their reaction to pathogens).

The initial selection of a cultivar must be combined with good agronomic practices to minimize the effects of other pathogens. For example, obtain and sow machine-dressed seed of high germination. Sow stands in well-drained soils, control weeds and supply adequate fertilizers especially where there is cutting and cartage of herbage from the stand. Cut or graze the stands at the correct stage to avoid losses from leaf spot diseases (see Janson, Paper 11). Avoid over-grazing (especially in winter), and do not feed out infected lucerne hay on lucerne stands. These practices will help reduce the effects of pathogens.

Future research on the pathology of lucerne should be directed to obtaining more information on the role of Phytophthora root rot, in all areas of New Zealand, as a cause of lucerne decline. Linked to this should be further work on the significance of Verticillium wilt, the effects of which at present appear to be partially negated by grazing or cutting management. Nothing is known about its role in reducing the plant population in stands. There have been numerous agronomic trials on lucerne (conducted over several seasons), and there appears to be a reluctance by agronomists to determine initial plant establishment, and the change from one year to the next in plant population and disease development. This is valuable information which would help the understanding of the effect of factors such as cutting-frequency, fertilizers and cultivars on plant mortality, and the crown rot problem. Further research on the effects of root-knot nematode on establishment and on yield may also be required.

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APPENDIX

A Field Key to the Common Pests and Diseases of Lucerne in New Zealand

(after Harvey and Somerfield, 1977)

The national lucerne disease and pest survey carried out by M.A.F. and D.S.I.R. scientists in 1975-76 led the authors to formulate the following key to the common diseases and pest of lucerne, for field use. Some problems, such as the localized basidiomycete problem in the central plateau area of the North Island, root knot nematode, seedling disease, some trace element deficiencies, and insects of lesser significance, are not included in the key.

The application of the key in the field necessitates the use of a spade, a sharp knife to cut roots and crown open, and a hand lens to observe fruiting bodies, lesion characteristics and insects.

KEY

Plants stunted and/or yellowing 1
Plants wilting 4
Plants with leaf damage (chewing), spots or discolouration 7
Plants with swollen, damaged or dead crowns 20
Plants with root damage or discolouration 22

STUNTING SYMPTOMS

1. Stunted plants fairly normal in colour 2
   Stunted plants yellow or lime-green 3
2. Plants and seedlings up to two year old, dying, roots chewed off and curved larvae around roots .... Grass grub *(Costelytra zealandica)*
   Plants with swollen compressed stems (shortened internodes), stems brittle, often with brown leaf bracts; stunted plants in patches or following drainage or hay feeding-out patterns .... Stem nematode (eelworm) *(Ditylenchus dipsaci)*
3. Plants with yellowing foliage, leaves and young stems distorted; plants stunted after prolonged or heavy infection. Aphids clustered on stems, less frequently on leaves:
   Aphids 2-3mm long, bluish-green in colour, often waxy in appearance, favoured by cool conditions .... Blue-green lucerne aphid *(Acyrthosiphon kondoi)*
   Aphids 4-5mm long, light to medium green (sometimes with yellow tinge), shiny, favoured by warmer conditions .... Pea aphid *(Acyrthosiphon pisum)*
   Stunted plants with lime-green foliage, leaves small, cupped and plant bushy, associated with vascular root staining (see also — 26) .... Bacterial wilt *(Corynebacterium insidiosum)*

WILTING SYMPTOMS

4. Plants wilting, stems with lesions 5
   Plants wilting, stems without lesions 6
5. Lesions on stems light coloured, watery in damp or humid condtions, with white, cottony growth; often extending down to crown, and with black resting bodies within stem or on older lesions .... Sclerotinia rot *(S. trifoliorum)*
   Dark bordered elliptical lesions at base of stems, with central black, pin-head size fruiting bodies .... Anthracnose *(Colletotrichum trifolii)*
6. Stems wilting, lower leaves with greenish-yellow to buff, wedge-shaped segments at tips and with root showing vascular staining (see also - 26) .... Verticillium wilt *(V. albo-atrum)*

LEAF SYMPTOMS

7. Leaves showing insect feeding damage 8
   Leaf spots light in colour (white, light brown, yellow-green) 9
   Leaf spots dark in colour (brown-black) 15
8. Feeding patterns as many small windows between veins .... Lucerne flea *(Sminthurus viridis)*
   Feeding pattern as very fine marks, especially on leaf under surfaces .... Thrips (several species) (can be confused with potassium deficiency).
   Feeding pattern as scallop-shaped areas chewed from leaf edges, extending to midrib in severe cases .... Sitona weevil *(S. discoideus)*
   Feeding pattern as irregular chewed areas mainly from edges of leaves; more prevalent in southern areas (esp. Otago) .... Winter moth *(Zermizinga indocilisaria)*
9. Spots well defined 10
   Spots diffuse 12
10. Spots white, oval, around edge of top leaves .... Potassium deficiency
    Spots light brown with yellow halo 11

11. Spots small with irregular outline, numerous, with brown border and sometimes causing defoliation
.... Pepper spot (advanced stage)
(Leptosphaerulina briosiana)
Spots oval to fairly regular in outline, light tan in colour, with thin brown border, never killing the leaf
.... Stemphylium leafspot
(S. botryosum)

12. Spots as streaks or fan shaped 13
Spots as blotches 14

13. Streaks yellow-orange, sometimes faded brown when older .... Yellow leaf blotch
(Pseudopeziza jonesii)
Fan-shaped area, light green, yellow or straw coloured, associated with root vascular discolouration and often with stem wilting (see also 6 and 26)
.... Verticillium wilt
(V. albo-atrum)

14. Blotches light green to yellow, sometimes associated with twisting and buckling of leaves. Mostly with greyish purple growth on under-surface of leaf
.... Downy mildew
(Peronospora trifoliorum)

15. Dark spots well defined 16
Dark spots diffuse 19

16. Spots small (generally less than 3 mm) 17
Spots large (generally more than 3mm) 18

17. Spots as reddish-brown pustules, mainly on underside of the leaf .... Leaf rust
(Uromyces striatus)
Spots dark brown to black, with finely stippled margins, and associated with yellow halo, or yellowing defoliation of lower leaves (hand lens may reveal cushion shaped fruiting body)
.... Common leaf spot
(Pseudopeziza medicaginis)
Spots as above but with well defined margins (can expand to kill leaf) .... Pepper spot (early stage)
(Leptosphaerulina briosiana)

18. Spots mostly large but sometimes varying in size, black with well defined border and yellow halo, often associated with black stem spots.
.... Spring black stem
(Phoma medicaginis var. *medicaginis)*

19. Spots large and often with mixture of light and dark brown, and mostly causing triangular lesions at leaf tips. Contains brown fruiting bodies
.... Stagonospora leaf spot
(S. meliloti)

CROWN SYMPTOMS

20. Crowns with dead, dying or damaged shoots 21
Crowns not dead but with white to brown galls, 2-22 mm in diam. with red-brown internal mottling when cut open. Generally having little effect on total plant growth, but sometimes reducing stem numbers
.... Crown wart
(Physoderma alfalfae)

21. Crowns largely dead and rotted, often in a V-shaped pattern extending down into the tap root.
.... Crown rot
(Fusarium spp.)
Crowns and shoots of smaller plants damaged, shoots eaten off or on ground, not dead (in absence of heavy stocking), caterpillars found with digging
.... Porina feeding
(Wiseana spp.)

ROOT SYMPTOMS

22. Root damage external 23
Root damage and discolouration internal 25
(as revealed when the root is cut obliquely, and the bark peeled back).

23. Large areas chewed out of roots, especially when lucerne grown in light or sandy soils, legless larvae often present .... White fringed weevil
(Graphognathus leucoloma)
No chewing damage but tap root with rotted areas 24

24. Rotted areas or roots yellowish-brown to black, occurring in poorly-drained soils, that have been or are waterlogged for long periods. Stand may thin-out and roots rot off .... Phytophthora root rot
(Phytophthora megasperma)
Rotted area firm with red and black speckling (see also - 27) ..... Stagonospora root rot
(S. meliloti)

25. Internal rotting and discolouration extending well down the root 26
Internal rotting or discolouration largely restricted to the crown 27

26. Discoloration yellowish-brown, especially as a ring *directly* under the bark and often extending to the inner root cylinder (top symptoms may not be present) .... Bacterial wilt
(Corynebacterium insidiosum)
Discolouration yellowish-brown to dark brown, *not* directly under the bark but just inside the inner root cylinder (not always associated with top symptoms)
.... Verticillium wilt
(V. albo-atrum)

27. Rotting area mainly restricted to, or originating from,the crown, but often extending some way into the root in a V-pattern; brick-red, violet or black in colour. Reduced shoot production and sometimes plant death .... Crown rot
(Fusarium spp.)
Discolouration as a fleck or streak — brown to brick-red or both. Sometimes extending out to, or in from the bark. Mostly having little effect on plant growth
.... Stagonospora root rot
(S. meliloti)