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Lupins in Western Australia. 3. Cultivation methods continued

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THE characteristics of the lupin varieties grown in Western Australia were described in the first two articles of the series (Journal of Agriculture, August and September, 1969), together with recommendations for growing bitter sandplain lupins. This article gives general recommendations for growing grain lupins, and discusses the main diseases and pests of lupins in Western Australia and their control.

GENERAL RECOMMENDATIONS FOR GROWING GRAIN LUPINS

Place in the farm rotation

Grain lupins (sweet lupins grown for grain) can be grown on new or old land, but best yields are usually obtained on old land whose fertility has been built up under crops and pastures. Failure on new land is often associated with poor nodulation, the risk of which is reduced by a preceding cereal crop and by other measures (see below).

In an established rotation including cereals, it seems logical to grow lupins after the cereals, when soil nitrogen has been depleted.

Seeding

It is most important with lupins that seeding be as early as possible, preferably before the middle of May and certainly by the beginning of June. Experience to date has suggested that in the case of Uniwhite and Borre, dry seeding where feasible may give the best result of all. Rapid growth of the lupins in the warm early part of the season enables them to compete very successfully with weeds, and to continue growing strongly through mid-winter. Some risk exists with dry seeding that the seedlings may die if a long dry spell follows the opening rains. However, observation over a number of years has suggested that the risk is normally small.

Perhaps because of their rapid root penetration, lupin seedlings are able to survive autumn dry periods in which seedlings of many other species, such as subterranean clover, perish.

Seeding rates for grain lupins have not yet been sufficiently studied in Western Australia. Tentatively, 50 to 60 lb. per acre is recommended for both Weiko III and Uniwhite, with perhaps higher rates under weedy conditions.

The seeds of both varieties should be inoculated, using the standard commercial lupin-serradella culture, wherever the land has not carried lupins or serradella within the last four or five years. (The precise interval before inoculation again becomes necessary is not yet known). Lime pelleting of the inoculated seed is not essential, but it may be convenient to ensure separation of the seeds, and is definitely recommended where the inoculated seeds are likely to come in contact with superphosphate containing trace elements.

Whether seed is pelleted or not, use of a sticking agent is advised to assist adhesion of the bacteria on the seeds. The quality of commercial lupin bacterial cultures appears to be less reliable than that of cultures for clovers and many other legumes, and some nodulation failures may be due to this. As a precaution, special care should be taken...
to store the cultures under refrigeration and to sow as soon as possible after inoculation.

The risk of nodulation failure is least on old land, and is minimised by early sowing with ample superphosphate.

A shallow seeding depth is desirable, preferably about 1 in. with dry seeding or when the soil is moist enough to ensure prompt germination, and never more than about 2 in. Deeper sowing can result in poor emergence.

**Fertilisers**

General fertility and fertiliser requirements of the different species are summarised in Table 1.

In common with other legumes, lupins require ample phosphate. Growth on new land tends to be directly proportional to the amount of superphosphate applied, and it is worth remembering that whereas fertilising of a normal pasture legume on new land may be geared to a gradual build-up of productivity, grain lupins are sown with the aim of immediate maximum yield.

Rates of not less than about two bags (373 lb.) per acre are recommended for newly cleared sandy soils, and three bags for gravelly soils. That part of the application containing trace elements is probably best broadcast and ploughed under before seeding. The rates can be reduced on older land which has already received substantial amounts of phosphate, but under few circumstances should it be less than one bag per acre.

Some responses to potassium are likely to be obtained with narrow-leafed lupins on sandier soils in higher rainfall districts. Weiko III also responds on more highly deficient soils. The symptoms of deficiency are an unhealthy pale green colour and marginal leaf scorch, together with stunted growth. The economics of potassium application to grain lupins have not yet been studied in Western Australia.

Experience with other legumes suggests that sulphur deficiency may prove to be important in lupins. No experimental findings on the sulphur nutrition of lupins have so far been reported.

<table>
<thead>
<tr>
<th>Species</th>
<th>General fertility requirements</th>
<th>Phosphorus</th>
<th>Potassium</th>
<th>Trace elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>L. cosentini (sandplain, or W.A. blue, lupin)</td>
<td>Grows on all but the most infertile white sands, given adequate superphosphate.</td>
<td>All lupins need ample superphosphate on new land. On old land there is some evidence that lupins are more efficient than many plants in exploiting phosphate reserves which have built up in less readily available forms, but sulphur applications may still be needed. L. angustifolius and L. albus are thought to have generally higher phosphorus requirements than L. cosentini or L. luteus.</td>
<td>Tolerant of deficiency. Responses likely only on highly deficient soils.</td>
<td>Susceptible to molybdenum deficiency. Responses to copper, zinc, or cobalt unlikely, but cobalt may be needed for stock.</td>
</tr>
<tr>
<td>L. luteus (yellow lupin)</td>
<td>Highly reputed overseas for ability to grow on infertile soils. In local experience, may not quite equal L. cosentini in this respect.</td>
<td></td>
<td>Reasonably tolerant of deficiency, but worthwhile responses are likely on more strongly deficient soils.</td>
<td>Appears tolerant of most trace element deficiencies. May respond to manganese on calcareous coastal soils or deep white sands.</td>
</tr>
<tr>
<td>L. angustifolius (narrow-leafed, or N.Z. blue, lupin)</td>
<td>Has higher general fertility requirements than L. cosentini or L. luteus, but can be grown on quite poor soils with proper attention to fertilising. Grows well on most well-drained soils that will support subterranean and other clovers.</td>
<td></td>
<td>Moderately susceptible to deficiency. Worthwhile responses will probably be obtained on many lighter soils in higher rainfall districts.</td>
<td>Very susceptible to cobalt deficiency; possibly less so to molybdenum deficiency than L. cosentini. Responses to copper and zinc may be obtained. Occasional manganese deficiency on coastal soils, but less frequently than L. luteus.</td>
</tr>
<tr>
<td>L. albus (white lupin)</td>
<td>Has the highest fertility requirement of the four. Should not in general be sown on sands or gravelly soils.</td>
<td></td>
<td>Probably susceptible to deficiency.</td>
<td>May be susceptible to deficiencies.</td>
</tr>
</tbody>
</table>
Trace elements

Nor is enough known for firm recommendation on trace elements. Molybdenum and cobalt are both likely to be marginal or deficient for plants and/or stock on soil types used for lupins, and could perhaps be included routinely where they have not been applied before.

Marked molybdenum deficiency has been seen experimentally in sandplain lupins, and may be more widespread in that species than previously thought. Narrow-leafed and yellow lupins on the same soil showed only slight deficiency.

The symptoms of molybdenum deficiency are a uniform, clear pale green colour and reduced growth.

There is evidence (author's unpublished data) that narrow-leafed lupins are unusually susceptible to cobalt deficiency. Substantial yield responses to cobalt have been obtained in the Darling Range near Perth, with concentrations in the untreated plants only a small fraction of those needed by grazing stock. Cobalt should fairly definitely be used for Uniwhite and other narrow-leafed lupins in districts where deficiency is known in stock.

Little is known of possible copper or zinc deficiencies in grain lupins in Western Australia. Samples analysed have regularly shown lower concentrations of both elements in narrow-leafed lupins and *L. albus* than in yellow or sandplain lupins, indicating that the first two are probably more prone to deficiency.

On the other hand, manganese deficiency may occasionally be seen in yellow lupins, especially on coastal sandy soils. It is probably less common with other lupins, although suspected cases have been seen in narrow-leafed lupins.

The main symptom of manganese deficiency is yellowing of the older leaves and the tips of the younger leaves, together with, in more severe cases, burning of the leaf margins like that seen in potassium deficiency. Growth is stunted.

Magnesium and boron deficiencies have been recorded for narrow-leafed lupins in Europe, but nothing is known of their possible occurrence in Australia.

Growing season care

As already noted, grain lupins cannot be grazed at any stage during growth. Protection against vermin may be needed, particularly in the seedling stage and with small acreages.

The use of herbicides for weed control in lupins has not been studied in Australia, but is widely practised in Europe. The importance of early sowing suggests that such methods, combined with minimum tillage, could find an important place on weedy soils under local conditions.

The main diseases and insect pests of lupins, and their control, are discussed in a later section.

Harvesting

Harvesting of Weiko III can safely be left until the crop is fully dry. A few pods may split and scatter their seeds at or after maturity under hot, dry conditions, but serious losses are rare.

Uniwhite is much more prone to pod shattering, although it represents a marked advance over previous narrow-leafed lupin varieties in this respect. It should be harvested at the first opportunity, and if ripening of the crop is uneven, harvesting in sections as soon as they are dry enough is advisable.

Both varieties are best harvested in moderately cool weather where possible, as under hot, dry conditions the pods (especially of Uniwhite) become very brittle, and burst readily on impact with harvesting machinery. Seeds also become brittle under these conditions, and consequently more liable to injury in threshing.

Harvesting of lupins can be done with a normal header-type harvester, suitably adjusted. Every second tooth should be removed from the comb. A standard wheat drum can be used in conjunction with a pea concave, or alternatively with a wheat concave and wide drum clearance. The drum speed should be as low as possible, to minimise injury to the seeds.

Stubble grazing and natural regeneration

Grazing of the stubble forms a significant part of the economics of grain lupin growing, and is discussed in a later article in this series. As a part of the
general cultural system it is also important, because fungal diseases are carried from one season to another on crop residues. Residues should therefore be cleaned up as completely as possible after harvest. Experience has shown that with sweet lupin varieties this can usually be achieved by grazing, but sometimes raking and burning may also be needed.

Removal of residues is especially important where there is the prospect of a volunteer crop the following season. Good natural re-seeding is often achieved with a semi-shedding variety such as Uniwhite, or where unharvested lupins have been grazed as a standing crop. As with bitter sandplain lupins, natural regeneration seems to occur best on soils with a loose, sandy surface, into which seeds are readily trodden by stock. Light harrowing in late summer will assist on firmer soils.

Where natural regeneration is aimed at, stock must be removed from the paddock as soon as the opening rains fall. Elimination of the lupins, if desired, is easily achieved by stocking heavily after the opening rains. It is worthwhile to ensure, when this is done, that odd pockets of lupins do not persist, as these might act as disease reservoirs which could prejudice future use of the paddock for lupin cropping.

MAINTENANCE OF VARIETAL PURITY

For reasons which will be discussed more fully in later articles, maintenance of varietal purity is of paramount importance. This applies particularly to the maintenance of sweet varieties free from contamination with bitter plants.

Fortunately, the task poses no insuperable problems in Western Australia. One reason for this is that natural crossing cannot take place between species, only between varieties within species. For instance, yellow lupins can cross with other yellow lupins, but not with white, sandplain, or narrow-leafed lupins. The danger of contamination by other lupin species is therefore purely one of physical admixture, which can be avoided if reasonable care is taken.

Secondly, bitter lupins of the same species as the main crop varieties are not at present grown to any extent in districts where crop lupins can be grown. Bitter yellow lupins are extremely rare, and bitter narrow-leafed lupins relatively so. However where present, they form a threat to the purity of sweet crop varieties, both by physical admixture and (more insidiously) by natural crossing.

Farmers contemplating growing crop lupin varieties are strongly urged to eradicate completely any bitter yellow or narrow-leafed lupins on their farms, and preferably throughout the district as a whole.

Both Weiko III and Uniwhite are distinguished by their white seeds and complete lack of purplish pigmentation on the
stems or buds, while Uniwhite differs from the bitter types of narrow-leafed lupin also in having white rather than blue flowers. Contamination with bitter lupins can therefore easily be detected by inspection of the seeds or of the growing plants, particularly in the bud stage. It is worth while, where a danger of contamination exists, to grow stud areas for pure seed production, which can be rogued each year for off-type plants. Detailed instructions for this in the case of Uniwhite are given in Bulletin 3502.

INSECT PESTS

A number of insect pests attack lupins, and several are capable in Western Australia of causing serious damage. Lupin species vary considerably in their susceptibility. For some insects there are also differences between bitter and sweet varieties of a given lupin species. These differences are summarised in Table 2.

Red-legged earth mite

Red-legged earth mites attack mainly young seedlings, and may cause complete destruction by eating out the young growing points. *L. luteus* is the species chiefly attacked, sweet yellow lupin varieties being much more susceptible than bitter.

Prompt control (see Department of Agriculture Bulletin 3433) is essential where there is serious attack. This normally occurs only on old crop or pasture land.

Narrow-leafed lupins are less often affected. Mites may sometimes be seen on them, but observations to date suggest that they are unlikely to do enough damage to warrant special control measures.

Early sowing helps by ensuring that the seedlings make rapid growth, and are past the most susceptible growth stage by the time the mites appear in number.

Lucerne flea

Damage by lucerne fleas is also confined mainly to sweet varieties. It occurs during winter, and may be recognised by bleaching of the leaves. The economics of control measures for lupins have not yet been studied, but it seems unlikely that spraying will be warranted except with heavy infestations.

<table>
<thead>
<tr>
<th>Table 2.—Principal diseases and pests of lupins in Western Australia, and susceptibilities</th>
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</thead>
<tbody>
<tr>
<td><strong>L. cosentini</strong> (bitter varieties only)</td>
</tr>
<tr>
<td><strong>Pests—</strong></td>
</tr>
<tr>
<td>Red-legged earth mites (<em>Halotydeus destructor</em>)</td>
</tr>
<tr>
<td>Lucerne fleas (<em>Smynthurus viridis</em>)</td>
</tr>
<tr>
<td>Aphids (<em>Aphis spp.</em>)</td>
</tr>
<tr>
<td><strong>Diseases—</strong></td>
</tr>
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</tbody>
</table>
Aphids

Aphid attack is confined mainly to sweet yellow lupin varieties, although it may occasionally be seen with sweet narrow-leafed lupins as well. Bitter lupins are immune. Infestation is most common at the bud stage in spring, the aphids clustering mainly around the buds and greatly reducing the chance of normal flowering and seed setting. Incidence within a paddock is usually patchy.

Aphids can be controlled by systemic insecticides, but the economics of this are at present unknown.

Climbing cutworm

Climbing cutworms are probably the most universal and destructive of all lupin pests in Western Australia. The grubs and their life cycle are described in Department of Agriculture Bulletin 2230. Attack occurs in the spring, when the grubs, hatching from eggs laid by the climbing cutworm moth, burrow into the developing pods and eat out the young developing seeds.

With a heavy infestation, the loss in seed yield may exceed 90 per cent. However this can occur only when the pods are young and succulent. Once the pods are fully developed, and the walls and seeds become tougher, attack is no longer possible.

All lupins are susceptible to climbing cutworms to varying degrees, with no apparent difference between bitter and sweet varieties. Yellow lupins are probably the most susceptible, followed by sandplain and white lupins (L. albus). Narrow-leafed lupins seem significantly less susceptible than the others. Infestation is quite common, but the losses are less frequently devastating. Many other plants besides lupins are attacked, including peas, linseed and various garden plants.

The time at which climbing cutworm grubs appear varies with district. They tend to be active about September in northern agricultural districts, and in October around Perth. In higher rainfall districts of the South-West they may not appear until November-December. Damage to lupin crops is less frequent in the South-West than in drier districts.

Whether or not a lupin crop suffers damage from climbing cutworm attack depends primarily on its state of maturity when the grubs appear. Late-sown crops are the most susceptible, because their pods are still young and succulent at the time of attack. By contrast, self-sown or dry-seeded crops may escape serious damage, even in years of heavy infestation. For the same reason it may be anticipated that early-maturing lupin varieties, when they become available, will have a better chance of escaping attack than existing varieties.

Prompt control is needed if climbing cutworm grubs appear while the crop is still at a susceptible stage. Preferably this should be by aerial spraying, to avoid knocking down a proportion of the plants. DDT was at one time recommended, but is no longer because of the likely presence of residues during summer grazing. Dip-terex or carbaryl compounds should give effective control.*

Considerable fluctuation in the incidence of climbing cutworms occurs in lupins from year to year. In some years virtually no grubs are seen. Recent years have been relatively cutworm-free. The reason for this is uncertain, but may lie partly in seasonal weather differences. There is also some evidence suggesting that a parasitic wasp exercises partial natural control.

Other pests

Several other pests have been observed to attack lupins, although seldom seriously. Seed-eating grubs other than climbing cutworms are sometimes seen, but little is so far known about them. Ordinary cutworm grubs may on occasions attack young plants, and can cause a substantial thinning of the stand if not controlled.

Grasshoppers can cause damage by chewing through the lupin pods and lacerating the seeds. This generally occurs with late-sown lupins, which have remained green after surrounding pastures have dried off. From limited observation it appears that sweet lupin varieties are more susceptible, although bitter types may also be attacked.

* Carbaryl is marketed under the trade names Lebaryl, Sevin, Septene, Zevilon, Dicarbam and Septem.
LUPIN DISEASES

Lupin diseases have so far been little studied in Australia, particularly fungus diseases. Yet these may prove to be the most important long-term factor limiting grain lupin production, both by reducing yields and by limiting the frequency with which lupins can be grown on the same land.

The principal fungus and virus diseases known to occur in Western Australia, and the susceptibilities of the different lupin species to them, are summarised in Table 2.

Fungus diseases

By far the most important of the fungus diseases under Western Australian conditions is the brown leaf spot *Pleiochaeta setosa* (formerly known as *Ceratophorum setosum*). This is most destructive under cool, wet conditions, and is prevalent in June and July. Lupin species vary greatly in their susceptibility. *L. albus* is extremely susceptible, and *L. angustifolius* and *L. luteus* fairly markedly so. *L. cosentini* shows good resistance, and is only attacked under conditions specially favourable to the disease. This is doubtless one of the factors which has allowed *L. cosentini* to persist year after year on the same land.

Control of brown leaf spot is made more difficult by the fact that the disease is to some extent seed-transmitted. Badly diseased seeds tend to be pinched and to show brown blotches. No fully successful seed treatment has yet been devised, nor are proved means available for control by spraying. However crops sown on new lupin land, using healthy seed, are seldom significantly affected. As with most fungus diseases of lupins, resistance of the plants to attack is greatly enhanced by use of ample fertiliser (particularly phosphate), and by early sowing.

A number of other fungus diseases are known to occur overseas, of which several have been recorded in Western Australia. Their local importance, if any, is unknown.

Virus diseases

Several virus diseases are capable of damaging lupins, but only one appears to have widespread significance. This is the bean yellow mosaic virus (BYMV), which in addition to lupins affects a wide range of legumes such as peas, beans, subterranean clover, and a number of perennial ornamental and native legumes. The latter harbour the disease over summer and may provide the main source of infection, whence it is transmitted to annual legumes by aphids, mainly in spring. This would explain why BYMV in lupin crops is commonest around towns or uncleared bush in the vicinity of towns. Most serious infections in Western Australia are within 50 or 60 miles of Perth.

Some seed transmission has been recorded in yellow lupins, but not in sandplain or narrow-leafed lupins. Therefore yellow lupins are more likely to be affected further afield, if the seed is from an infected source; and being a common host for aphids, may provide a reservoir from which other lupin species can be infected.

The main symptoms of BYMV in yellow and sandplain lupins are palish mottling and distortion of the leaves, dwarfed bunchy growth ("bunchy top"), and a drastic reduction of seed setting if infection takes place before flowering; or small and misshapen seeds if infection is after flowering.

In narrow-leafed lupins the growing tip turns over to one side ("shepherd's crook") and blackens, and if infection takes place before flowering, the plant...
usually dies. With infection after flowering, the pods become discoloured and fail to fill. In all lupins the surviving diseased plants fail to mature properly, and can easily be recognised as still-green plants scattered through the crop when the rest have ripened.

The incidence and general seriousness of infection vary among lupin species. Sandplain lupins are probably the most susceptible, and white lupins \((L. \text{albus})\) the least. Yellow lupins are fairly highly susceptible, with the added possibilities of carry over in seed and, in sweet varieties, of spread within the crop by aphids.

Narrow-leafed lupins, by contrast, suffer less overall damage. Individual plants may be killed, but the lack of seed transmission and spread within the crop means that generally fewer plants are infected. It is notable with this species (as with sandplain lupins) that the disease is usually most obvious around the edges of a crop, especially on the western side. This is the side most exposed to the prevailing winds, which carry potentially infected aphids in from the outside.

The risk of loss from BYMV is minimised by early sowing, which ensures that the plants are well advanced in growth by the time flying aphids appear in number in the spring, and by use of reasonably high seeding rates. The latter is especially effective with narrow-leafed lupins. Here, with little spread within the crop, the number of infections per acre appears to be governed principally by the number of virus-carrying aphids arriving from the outside. In a dense stand, the proportion of plants infected is smaller, and their places are more quickly overgrown by the surrounding healthy plants.

With yellow lupins, care should be taken where possible to use seed only from healthy crops. Where this cannot be ascertained, the seed sample should be checked to see that it contains only evenly sized and regularly shaped seeds. Infected plants tend to produce small, angular seeds, and in addition to betraying the presence of virus in the parent crop, there is evidence that these are several times more likely to transmit the disease than normal-shaped seeds, even when the latter are from infected plants. Spread of the disease within a crop of yellow lupins, or from them to other lupins in the vicinity, is also minimised by effective aphid control.
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