Better practicies for higher production

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Better practices for higher production

By G. H. Walton, Plant Research Officer

As long ago as 1932, G. K. Baron Hay and H. G. Elliott of the Department of Agriculture offered recommendations for sowing the lupin as a pasture. “Drill-sow at one inch depth into stubble straw without cultivation. Use a seed rate of 30 to 60 lb/ac and sow in May. June sowing is inferior”.

In 1967 the release of the sweet narrow-leaved Uniwhite was accompanied by recommendations for its production, based on personal observations by Dr J. S. Gladstones on the natural adaptation of the lupin, as well as on experiments by others on nutritional requirements, and on environmental requirements such as daylength and atmospheric temperature.

The Uniwhite variety requires a low temperature (less than 5°C) to start it flowering, so flowering does not start in Perth before August 1, irrespective of the date of sowing. Early sowing (before mid-May) encourages high yields by ensuring plenty of plant growth before flowering. This is the basis for high yields. Subsequent lupin varieties such as Uniharvest and Marr, based on the Uniwhite parent have this requirement for a vernalisation (cold) period. Another breeding line, which became Unicrop, showed no such need for vernalisation. It starts to flower 70 to 80 days after sowing, irrespective of the sowing date.

The sowing date of this line of lupin varieties must be timed to prevent flowering occurring too early when the climate is not suitable for seed development.

By 1969, the recommendations for growing lupins were; “Sow before the middle of May. The seed should be inoculated and sown at one inch depth.” A tentative seed rate was 50 to 60 lb/ac. It was known that lupins had a higher general fertility requirement than cereals on newly cleared soils, so “360 to 540 lb of superphosphate per acre” was recommended. Observations suggested that potassium deficiency was likely on the sandy soils in the high rainfall districts, sulphur deficiency was possible and molybdenum deficiency might be “marginal”.

It was recommended that lupins be grown after a cereal crop, when the soil nitrogen had been depleted.

In 1971, when the lupin breeding programme was transferred to the Department of Agriculture, many of the progeny from the programme were ready for field testing before release.

In particular, the newer early flowering lines which could be expected to extend the limits of the lupin growing area from the 450 to the 350mm rainfall isohyet, needed evaluation by the Department to establish recommendations for seeding and nutrition and to set guidelines to get the best from the potential of lupins.

Advances in research
To make a fair comparison between lupin varieties it was essential to establish the most appropriate time of planting and seeding rate to get the maximum grain yield from each variety. Two experiments in 1971, at Badgingarra and Mt Barker Research Stations, gave preliminary data which showed clearly that for the districts north of Perth, lupins had to be sown in May at a seeding rate of 90kg/ha, while to the south of Perth, sowing could be delayed until mid-June, also with a seeding rate of 90kg/ha. There was no difference
between the early flowering Unicrop and the later flowering Uniharvest in the research station results. At both sites, later sowings required higher seeding rates, giving denser crops for maximum yield. This contrasted with the cereal crop requirements because of the differences in growth between cereal and lupin plants. The cereal plant tillers early in its growth, during winter, and establishes its yield potential early in the season, based on the number of ears per plant and of florets per ear. The lupin plant does not branch until spring after flowering starts, then it establishes yield based on the number of flowering spikes per plant and number of flowers per spike. Because the potential for yield in lupins is established late in the growing season, it is more susceptible to late season moisture stress than cereals. Later sown lupin plants can encounter moisture stress, causing fewer branches to develop, thus higher plant densities are required to compensate for poorer individual plant growth.

Using this basic agronomic information on lupin growth, research workers compared the available varieties. It was evident that the original Uniwhte variety did not yield as well as the fully non pod-shattering narrow-leaved varieties Unicrop and Uniharvest. The yellow-flowered lupin, Weiko III, was not suited to the Western Australian environment and consistently yielded only one-half that of the narrow-leaved lupin. The white Mediterranean lupin, Ultra, was first evaluated in 1973 and except for its clear preference for the more fertile sandy-loam soils, was not significantly different to the narrow-leaved lupins in its response to the main production inputs. Both give their maximum yield at crop densities of about 45 plants per square metre.

Since Ultra’s seed weight is twice that of narrow-leaved lupin, it requires twice the seeding rate, 180kg/ha. Today, as varieties come off the “breeding line” . . . Marri, Illyarrie Yandee and Chittick . . . they are included in varietal trials for comparison with the commercial varieties. To date, no new variety has given a different response to time of sowing or seeding rate.

With the basic production requirements established for lupins, the agronomic research expanded in 1975 to gain information on the interaction between the factors involved in lupin production . . . such as the crop growth response to crop densities, soil types, fertiliser levels, rainfall and climate and competition from weeds.

**Time of sowing**

The lupin’s need to be sown early is based on its need to escape moisture stress during flowering and seed set. Experiments show that on the sand plain country north of Perth, the critical sowing date to avoid rapid yield decline is May 15. For the longer growing period south of Perth, the critical date is June 15. For each week’s delay after the critical sowing date, the seed yield falls, on average, from 150 to 200kg/ha. In one experiment conducted in 1973, plant research officer M. Perry found a seed yield decline of 300kg/ha for each week’s delay from May 10.

For the same reason that late planting reduces yield, the use of late-flowering varieties in the districts north of Perth will reduce yield.

**Seeding rates**

Today’s lupin varieties respond with increasing yields up to a crop density of 45 plants per square metre. In the
longer growing season of the southern coast, this response can be modified to a maximum yield at 35 plants per square metre if nutrition and disease do not limit yield. If there are more than 45 plants per sq. m. the increasing number of plants cannot compensate for the severe reduction in seed yield per plant through competition, so the crop yield declines.

<table>
<thead>
<tr>
<th>Germination (%)</th>
<th>Seed rate (kg/ha)</th>
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<tr>
<td>100</td>
<td>64</td>
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<td>80</td>
<td>80</td>
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<td>70</td>
<td>91</td>
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<td>50</td>
<td>128</td>
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Crop establishment never reaches 100 per cent. Usually it is about 70 per cent. If the seed’s germination rate has been adversely affected for any reason, the seeding rate must be increased to achieve the desired crop density. Poor harvesting techniques, resulting in cracked seed, or manganese deficiency ("split-seed") are two common causes for poor seed germination. Sowing the seed too deep also will cause substandard seedling establishment.

A good plant establishment also will help the crop to suppress weed competition during the season. However, experiments in 1980 demonstrated that high crop density alone cannot completely overcome competition and that the best yields are obtained in combination with the use of herbicide or cultivation at seeding to reduce the density of weeds germinating with the crop.

Crop nutrition

Superphosphate

Lupins’ yield responses to rates of superphosphate application were investigated first in 1972. These experiments showed that on newly cleared land lupins gave maximum yields at rates up to 600kg/ha... twice the rate wheat required. However, on 'old land' the lupins and wheat responded to the same superphosphate rates. Since 1972, many experiments have contributed to defining the yield response of lupins to super rate. Because of the high cost of superphosphate, it is not appropriate to talk of maximum grain yield, but rather maximum profit. A crop’s response to superphosphate depends on a combination of the phosphate reserves in the soil... from the natural fertility and previous fertiliser applications... the rate of phosphate applied with the crop and other crop factors, such as seeding rate, which modify the potential yield. To determine the most profitable rate of superphosphate for each individual paddock requires a knowledge of the phosphate reserve in the soil, either from soil testing or by extrapolating from the history of previous applications, and calculation of the fertiliser cost: lupin price ratio. Using this approach, the most profitable rate can be read from a chart prepared by the Department of Agriculture.

If the recommended rate of superphosphate exceeds 300kg/ha the grower should be careful to avoid phosphate’s toxicity to seedlings when the fertiliser is banded with the seed. To prevent this, amounts higher than 300kg/ha must be applied by topdressing. Superphosphate’s effectiveness in promoting a response is reduced when it is topdressed, so much so that one and a half times the drilled-in rate is required.

Manganese

By 1973, a ‘split-seed’ disorder in lupin crops caused major concern on the acidic deep grey sands and gravelly sands which comprise the major soil types in the South West Land Division of Western Australia. Manganese deficiency was shown to be responsible for reducing seed yield in narrow-leaved lupins by as much as 50 per cent. Researchers discovered that the genetic basis for low alkaloid content, or ‘sweetness’, in the narrow-leaved lupin varieties in some way made those lupins highly susceptible to manganese deficiency. By 1975, the incidence of split-seed on susceptible soils was largely overcome with 15 to 30kg/ha of manganese sulphate applied at seeding. Other agronomic practices such as early seeding and using early flowering varieties also helped reduce the incidence of split-seed. Alternative genetic lines of narrow-leaved lupins were no better than the original sweet types. However, sweet lines of the sandplain lupin species showed greater tolerance of manganese deficient soils, and suffered little or no seed yield reduction.

Potassium

On the grey and pale yellow sands in the westerly west and south coastal areas, potassium deficiency is encountered frequently in cereals and pastures. In 1975 the Department’s agronomists examined lupins’ potential for plant tissue testing as a means of identifying soil pH value of crops. Dr W. Cox discovered a relationship between the level of potassium in the top 10 centimetres of soil and the lupins’ yield response to it. The results indicated that a yield response was unlikely if the soil contained more than 40 parts per million potassium. As with phosphorus, the amount of potassium chloride applied depends on the cost/price ratio. The most profitable rate of application ranges from nil with 40ppm of potassium in the soil, to about 100kg/ha with less than 20ppm. More work is needed to define the response to potassium because the deep rooting lupins may be more efficient at extracting potassium from depths below the top 10cm. Dr Cox has recorded possible critical concentrations of potassium, associated with 90 per cent of maximum yield in various lupin plant parts.

As with manganese, the sandplain lupin species seems less susceptible to potassium deficiency.

Soil type

The results accumulated from a large number of experimental sites has demonstrated the lupins’ range of adaptation on acidic to neutral reaction soils. A soil pH value of 7.5 is their upper limit... for instance the black and red alkaline wattle sands with pH 8.0 are not suitable for lupin growth largely because of induced nutrient deficiencies. The lupins’ ability to grow on the acid wodgill sands (pH 4.5) is still under review.

In 1976, a trial was conducted to compare a number of lupin varieties growing on waterlogged soil during September. The white Mediterranean lupin Ultra was wiped out
completely, the narrow-leaved Unharvest lost 30 per cent yield, while the sandplain lupin Erregulla lost 12 per cent yield. All were compared with controls on a well-drained site. The heavy, poorly drained soils are not suitable for lupins. The Ultra variety prefers the fertile sandy loams. In an experiment on an alluvial loam site, Ultra yielded 2200kg/ha, while on a pale yellow sandplain soil its yield was 320kg/ha. This yield depression was a consequence of poor growth through moisture stress, and a heavy disease infection. The observation that poor plant growth through moisture stress or poor plant nutrition leads to heavier disease incidence is a common one.

Climate
A lupin plant's growth is a combination of its response to rainfall, temperature and sunlight. In general, it responds directly and positively to each of these factors. It is not possible to predict lupin growth and yield without a complex interrelation involving all three climatic components.

Rainfall—From studies of the frequency of achieving an experimental yield of 1.5 tonnes per hectare or more on a range of sites, there are indications that a potential yield of 1.5t/ha is possible from today's early flowering varieties in 450mm or higher rainfall districts. Where the annual rainfall is less than 450mm, there is little likelihood of obtaining such a yield because too little rain falls during the reproductive phase in September and October. Adequate soil moisture during the reproductive phase is vital to lupin yield. Research indicates that seed yield increases by 3kg/ha for each 1mm of rain that falls during the crucial phase from August to November. We know very little about the influence on lupin yields of rainfall distribution during the growing season. This information is important to any extension of lupin cropping into the drier districts of the wheatbelt.

Temperature—Plant growth responds directly and positively to higher temperatures. By sowing early... in April or May... when surrounding temperatures are still high, rapid plant growth ensures a good plant structure for high yields. Low temperature... less than 11°C... during flowering will cause flower and seed loss. Temperatures like this may occur for a short period of one to two weeks in June/July, so very early sowing (March, April) is not suitable for non-vernalised varieties such as Illiyarrie and Unicrop, which might start flowering too early is not suitable.

High temperatures (more than 25°C) during flowering will cause lupin flowers to abort increasingly late in the season.

Future research
As plant breeders produce a wider range of lupin types to fit into specific geographic or climatic areas, agronomists must continue their research into the means of improving yields by selecting sowing dates, seedling rates and varieties. Other researchers will need to examine ways to control disease and insects as the industry expands.

New techniques may involve sowing mixtures of lupin varieties, since varieties with slightly different growth habits, plus resistance to disease and insects, may give higher yields in problem areas. The sowing of determinate (minimum branching) and indeterminate (branching) lupin varieties together could make better use of erratic and highly variable rainfall in some districts.

Techniques using mixtures of herbicide, insecticide and growth regulators, sprayed onto the crop at crucial stages of growth, may prove economic. Growth regulators which change the plant's structure in favour of more seed development, or prevent the lupin pod being dislodged from the plant in front of the harvester, could be used in conjunction with nutrients applied as a spray at early flowering.

Another aspect of lupin agronomy requiring continued research is the place of this crop in the farm rotation.

In many dry wheatbelt situations, lupin crops may fail as grain producers yet build up economically valuable soil fertility.

The sandplain lupin is not being used as a grain crop plant at present, although it has shown better adaptation to many coastal sandplain soils. The high hard seed content of the sandplain lupin, which prevents up to 90 per cent of the seed from germinating each year, is the major obstacle to its full exploitation. Research is proceeding to investigate ways to use this hard seed characteristic in a regenerating cropping system with cereals on a 1:1 ratio. Otherwise this hardseeded component of the plant could be eliminated by breeding.

Bibliography


80