LUPINS

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ABSTRACT

There are currently two species of lupins, *Lupinus angustifolius* and *L. albus*, which have potential as grain legume crops for the New Zealand environment. *Lupinus angustifolius* was grown in Canterbury before and immediately after the second war as a fertility- restoring crop and as a source of high quality feed for sheep. New Zealand experiments conducted in the early seventies with the then new, West Australian, sweet, non-shattering genotypes of this species gave experimental seed yields in Canterbury of 7 t/ha. New Zealand farm yields were up to 5 t/ha. Experiments also confirmed the ability of this species to fix large quantities of atmospheric nitrogen. When a standing lupin crop was grazed by sheep, up to 80 kg/ha of nitrogen was returned to the soil for succeeding crops.

Yields of *L. albus* have not been as high, but this species is of interest to animal nutritionists - because of its high seed protein and oil concentration - for the formulation of rations for monogastric animals. Maximum reported seed yield in New Zealand is 4.0 t/ha.

In the longer term the South American species *L. mutabilis* may have potential in New Zealand as both an oil and protein crop.

Additional Key Words: Agronomy, pests and diseases,Phomposis leptostromiformis.

INTRODUCTION

It is ironical that the lupin species *L. angustifolius*, which is the basis of the large West Australian lupin seed industry, was for many years known in that state as the New Zealand blue lupin. Claridge (1972) records that in the late 1940s more than 4,000 ha of *L. angustifolius* were grown for seed in Canterbury. The plant was used for the feeding of lambs and ewes and to restore fertility. Over the years the interest in lupins for seed has waned and they now no longer feature in the agricultural statistics. During this time, mainly as a result of the efforts of J.S. Gladstones (a West Australian plant breeder), a new range of *L. angustifolius* genotypes was being produced without many of the poor agronomic features that dogged the pre-war genotypes and made them so unreliable to grow. Gladstones combined the alkaloid-free gene discovered by von Sengbusch in the 1920s with genes for non-shattering and for the removal of a vernalization requirement (Gladstones, 1970). These new lines became the foundation of the Australian lupin seed industry. The estimated area sown to lupins in 1989 - 90 in Australia is 898,000 ha in Australia (ABA & RE, 1989a) where it still has a major role in its traditional uses as a supplementary feed for sheep (Hill, 1988) and in soil fertility restoration (Rowland *et al.*, 1986). However, sweet *L. angustifolius* seed is extensively used in Australia for the production of pig and poultry rations and pet food (Hill, 1977, 1986). Its popularity in this role arises from its high seed protein concentration and lack of toxic factors common in other grain legumes. At the same time lupin seed is being exported from Australia, mainly to Asia. The gross value of the Australain lupin crop for 1989 - 90 is estimated at $A179 million and the 445,000 t which were exported earned Australian Farmers $A101 million (ABA & RE, 1989b).

Potential *L. angustifolius* yields are considerably better in New Zealand than in Australia and the early Australian cultivars appeared to be well adapted to the New Zealand environment (Herbert & Hill, 1978a; Herbert,1978). Seed yield potential of *L. albus* in New Zealand is greater than 4 t/ha (Herbert, 1977a; Kelly, pers comm.). *Lupinus albus* seed has both higher seed protein and oil concentrations than *L. angustifolius* (Hill, 1977). However, despite their agronomic potential neither species has gained widespread acceptance in New Zealand agriculture. This paper briefly reviews agronomic knowledge of these two lupin species in the New Zealand environment and closes with a brief discussion of the potential of the South American highland species *L. mutabilis* in the New Zealand environment.

AGRONOMY

Sowing date: Unlike a number of other grain legumes such as faba beans and lentils there appears to be little advantage in autumn-sowing lupins in New Zealand. Experiments with *L. albus* and *L. angustifolius* conducted at Lincoln, which involved a series of sowings from April to November, showed little difference in seed yield among the various sowing dates before the November sowing (Horn & Hill, unpublished data). The high yields obtained by Herbert & Hill (1978a) from *L. angustifolius* were from an early October sowing, and *L. albus* yielded well when sown in late September (Herbert, 1977a). The higher yields from spring sowings might be the result of reduced plant population of autumn sowings in the spring, following selective grazing during winter of young sweet lupin plants by hares.

Plant population: Herbert & Hill (1978a) investigated the effect of plant population on irrigated and unirrigated *L. angustifolius* at populations from 27 to 156 plants/m^2. There was no yield response in unirrigated plants but with irrigation there was a linear increase in yield as population fell. Hill *et al.* (1978) found no difference in lupin seed yield when lupins were sown in rows 20 cm apart and 40 cm. Similar results were obtained by Herbert & Hill (1978b) with rows 15 cm and 30 cm apart. Although yield fell as population was increased, a population of 70 plants/m^2 in narrow rows was recommended for reasons of improved weed suppression (Herbert *et al.*, 1978) and more uniform crop maturity at the end of the growing season (Herbert, 1977b).

Similarly with *L. albus*, Herbert (1977a) found that seed yield increased from 2.1 to 3.2 t/ha as plant population increased from 16 to 36 plants/m^2.

Seed bed preparation: Lupins are large-seeded and tend to do well in friable soils which are free draining. They do not require fine seedbeds and respond very poorly to soil compaction. Further, there have been no reports in the New Zealand literature of seed lupins responding to phosphate fertilizer on cropping soils and therefore only maintenance levels of superphosphate need to be applied. Although generally there are sufficient rhizobia in New Zealand soils to nodulate lupins without inoculation Rhodes (1976) obtained yield increases of up to 500 kg/ha in response to inoculation.

Herbicides: In early New Zealand work, trifluralin was used for weed control in lupins. Lucas *et al.* (1976) found that atrazine at 1.1 kg a.i./ha maximised seed yield. Similarly, Rhodes (1976) found that as the rate of atrazine increased from 0.2 to 0.8 kg a.i/ha, yield increased significantly. In Australia simazine at 1.5 l/ha, or simazine in conjunction with trifluralin, are recommended for weed control in grassy paddocks (Gilbey, 1986).

Irrigation responses: Stoker (1975) at Winchmore, on a Lismore stony silt loam, increased the mean yield of *L. angustifolius* and *L. luteus* from 1.2 t/ha to 3.5 t/ha with irrigation. However, Herbert (1978) found that on a Wakanui silt loam, in a wet season, crop yield in *L. angustifolius* was reduced by irrigation. In both these trials irrigation water was applied in accordance with the physiological growth stage of the crop rather than on calculated or measured soil moisture deficit. It is therefore possible that significant yield increases to irrigation may be obtainable with lupins if water were applied according to crop demand. More work is required in this area.

Aphids and viral diseases: A major problem with the growing of sweet lupins in Canterbury is the transmission of aphid borne viral diseases particularly bean yellow mosaic virus and the persistent subterranean clover red leaf virus (Teh, 1978). It is therefore important that aphid infestations are controlled during the growth of the crop.

NITROGEN TRANSFER

Total nitrogen fixation: The growing of lupins has traditionally been promoted for the large amount of nitrogen fixed by the crop. Burtt & Hill (1981) measured the equivalent of 330 kg N/ha in a standing lupin crop which had been grown on a soil on which cereals had responded to nitrogen fertilizer in the previous season. In a somewhat less productive crop McKenzie & Hill (1984) found 150 kg N/ha in a standing lupin crop. However, it is not the amount in the standing crop that matters but how much is available for the following crop that is important.

Once lupins are grown they can be either grazed *in situ* or harvested for seed. In the former case most of the nitrogen in the crop is returned to the soil, while in the latter case only the nitrogen in the crop residues is available. McKenzie & Hill (1984) grazed a standing spring sown lupin crop 100 days after sowing and estimated that 80 kg N/ha was returned to the soil. Although initially with autumn sowing Janson & Knight (1980) found little benefit from grazing autumn sown lupins a later experiment using a bitter cultivar of *L. angustifolius* (Janson, 1984) gave a substantial yield increase in spring wheat from 3.2 t/ha to 4.6 t/ha. While in McKenzie & Hill's (1984) trial the yield of Tama ryegrass was increased from 3.4 t/ha following barley to 5.6 t/ha following lupins grazed at 100 days after sowing.

Because a considerable amount of the total nitrogen in the lupin crop is in the seed at harvest most of the above ground nitrogen is removed with the crop. Thus the only nitrogen left is in pods walls and stubbles. For example Burtt & Hill (1981) found that of 33 g/m^2 of nitrogen in the standing crop only 3 g/m^2 was in the stubble at crop maturity. However, in Australia substantial wheat yield increases have regularly been obtained from the growing of wheat after lupins (Rowland *et al.*, 1986). It can be argued that wheat yields in Australia are generally lower than in New Zealand but in Launceston, Tasmania wheat after wheat yielded 3.83 t/ha while wheat after lupins gave 4.46 t/ha. Further, McKenzie & Hill (1984) showed that following the harvest of a lupin crop for seed the yield of the following greenfeed crop was the same as when the land was fallowed. There are three possible explanations for this increase in yield in spite of the apparently low amounts of nitrogen involved. Firstly, by maturity the leaves fall off lupin plants and no measurements have been made of their nitrogen content. Secondly, there is no published information as to either the total underground lupin biomass or its nitrogen concentration at crop maturity and the amounts involved may be quite substantial. Finally, no account is taken of harvesting losses of lupin seed. Australian work has indicated that these can amount to 360 kg/ha (Croker *et al.*, 1979) which would contain about 18 kg/ha of nitrogen. Thus the benefits gained from growing a crop of lupins are greater than the value of the forage or seed produced, and in a cropping situation their use could provide a method of increasing the intensity of the rotation. Apart from the addition of nitrogen a further advantage of lupins is that they are not an alternative host to the pea root disease *Aphanomyces euteiches* (Scott, 1987).

FUTURE POTENTIAL

Based on published agronomic results there is little doubt that good farm yields of both *L. angustifolius* and *L. albus* can be obtained in New Zealand. Since the breeding of Uniwhite, Unicrop and Uniharvest West Australian plant breeders have continued to produce new lupin varieties. Many of these are now resistant to a range of diseases of lupins and in particular a recent releases Gungrurru (Gladstones, 1988) is resistant to the fungus *Phomopsis leptostromiformis* which is the causative agent of the disease lupinosis in sheep. Further work in Western Australia is aimed at producing determinate cultivars. However, the variety Danja which was released in 1986 has improved pod number and harvest index and thus a higher yield. It would therefore be important that if *L. angustifolius* was to be considered again for evaluation in New Zealand that the most recently available varieties are tested.

Similarly with *L. albus* more recent varieties may give higher yields than the cultivars tested in the 1970s. The variety Llaima bred by von Baer in Chile and tested recently in Canterbury gave seed yields of up to 4.0 t/ha (Kelley, pers comm.) compared with a maximum of 3.2 t/ha for variety Hamburg obtained by Herbert (1977).

Finally the South American Andean species *L. mutabilis* which has a seed oil concentration similar to that of soya beans combined with an extremely high seed protein concentration (Hill, 1977, 1986) of high nutritional quality (Savage *et al.*, 1983, 1984) grew well in early New Zealand trials (Hill *et al.*, 1977; Horn *et al.*, 1978). The breeding of the alkaloid free variety Inti of this species by von Baer & von Baer (1986) indicates that it should also be further evaluated in the New Zealand environment.

Agronomically lupins can be grown, it remains to promote their use in local animal feed formulation. Having establish a local market it should be possible for New Zealand to obtain a share of the market for lupin seed that the Australians have developed.

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