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LUPINS

Family: *Leguminosae* (Tribe: *Genisteae*)

Genus: *Lupinus*

Species: *species*

Source: http://www.plantbio.ohiou.edu/epb/facility/images/lupinus.jpg

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General Background

Lupins have been cultivated for over 2000 years, originating around the Mediterranean and along the Nile valley where they were used for human consumption. Lupins have digitate leaves [1] with flower terminating racemes up to 1.5m high [2]. The flowers are quite distinctive and mainly self-pollinating but can be pollinated by bees. The inflorescence bearing the flowers varies between 10-60cm long depending on the species and also depending on the species the flowers can be white, pink or blue and are 12-16mm in size. The seed pods are green and silky, up to 13cm long and often constricted between the seed [1]. Lupin has different growth habits than other legumes, emergence is epigeal (cotyledons emerge above ground before the development of true leaves) and early seedling growth is slower than the later vegetative stages, the plant is growing at the fastest rate during flowering.

Several annual species are still used as fodder and green manure. These annuals can reach 1.5m in height. They are not frost hardy but will grow on light acidic soils where all other legumes fail. Only on these soil types do they merit consideration [2].

Although used for fodder some lupins are unpalatable and often toxic owing to presence of lupins and other alkaloids, the concentration of which is highest in the pods and seeds. They may be removed however by leaching and steaming. The toxins can lead to lupinosis in the animals feeding on the lupin [2].

Sweet lupins are varieties or species with low contents of these alkaloids 0.01-0.03% compared to 0.8-0.9% in the 'Bitter' varieties, but care is still necessary when feeding sweet lupins to livestock [2].

There are over 300 species of the genus *Lupinus* but only five are cultivated:

- White Lupin (*Lupinus albus*)
- Blue Lupin (*Lupinus angustifolius*)
- Yellow Lupin (*Lupinus luteus*)
- Variable Lupin (*Lupinus mutablis*)
- Garden Lupin (*Lupinus polyphillus*)

and only three are suitable for cultivation as a high protein crop.

Blue Lupins (*Lupinus angustifolius*)

- Up to 1m high, with small pale blue (white forms also exist) flowers in short racemes. The pods are almost 5cm long with 4-6 ovoid seeds 9mm in size, with a TGW of 227g. The plant is quick growing and early ripening [2] but its alkaloid content is higher than approved [3].

White Lupins (*Lupinus albus*)

- Up to 1.5m tall with white flowers in continuous racemes. The pods are large, up to 13cm long with large, flat, white seeds which are up to 15mm in size. The TGW is 625g. Large seeded varieties are used as a pulse crop, the seed being apparently safe for consumption after steeping and cooking [2]. The white lupin is best suited to well drained soils in the pH range 5-7.

Yellow Lupins (*Lupinus luteus*)

- Up to 1.1m high with bright yellow whorled flowers whorled in long racemes. Seeds are white with black markings and are approximately 7.5mm in size, the TGW is 151g. Establishment of this species is slow [2].

Details of Quality Characteristics

Seed:

Oil Content: 5-18% w/w

Crude Protein Content: 35-40%

High Quality Dietary Fibre: 30%

Lupins are thought to be a good dietary substitute for soya beans due to its protein content, for incorporating into stock feed [3].

Pearl lupins (*Lupinus mutablis*) – contain 66% crude protein, 14% oil but also 1.4-2.0% alkaloids [2].

The following table shows the characteristics of the dominant varieties currently available on a commercial scale in the UK.

	Agena	Arthur	Lucyanne	Lucille	Ludet	Lunivers
Cold tolerance	Moderate	Good / Moderate	Good / Moderate	Good	Moderate	Very Good
BYMV resistance	Good	Good	Good	Good	Good	Low
Stature	Indeterminate	Normal	Normal	Dwarf	Indeterminate	Dwarf
Flowering time[1]	Early	Medium	Medium	Medium	Early	Late
Flower colour	Blue	White	White	Blue / White	Blue	Blue
Maturity[1]	Early	Medium	Medium	Medium / Late	Early	Late
Seed coat	Off White	Off White	Off White	Off White	Off White	Mottled
Seed size[2]	Small	Medium	Medium	Medium	Small	Large
Protein content[3]	Low	Medium	Medium	Medium	Low	High
Yield potential	High	Medium	Medium	Medium / High	High	Medium / High

Source: IACR (2002)

[1] Range: 10 days

[2] Range: 220-320g TGW

[3] Range: 35-42% of dry seed

Current Production and Yields

Lupin production in Europe 2001:

Country	Area Harvested '000 ha	Yield t/ha
Austria	n/a	n/a
Belgium/Luxembourg	n/a	n/a
Denmark	n/a	n/a
France	12.00	2.83
Finland	n/a	n/a
Germany	n/a	n/a
Greece	100	1.00
Ireland	n/a	n/a
Italy	3.50	1.42
Netherlands	n/a	n/a
Portugal	0.01	1.00
Spain	9.70	0.65
Sweden	n/a	n/a
UK	2.0	3.8-4.5

Source: FAO (2001)

Constraints upon Production

Lupin crops have a narrow drilling window to ensure good establishment, the seed must go in at the right time to ensure the crop is at the right stage of growth through winter. If the crop is sown too early it will be too forward, lush and vulnerable to the cold winter weather. The crop must, on the other hand, be sown early enough to allow 5 leaves, or at least four to be present to get through the bad weather. The crop is generally late to harvest, optimum dates being late September/early October, and seed yields tend to vary greatly between species and seasons.

The crop requires well drained, south facing sites with a pH of no higher than 7.0-7.3. Alkaline soils can not currently be tolerated which is a major constraint upon increased successful production of the crop.

The old lupin genotypes that were unsuccessful in Northern Europe in the past were spring sown and had indeterminate growth habit. They ripened late because the time required for pod and grain growth was too long in the Northern European climate, and crops could not be brought to maturity by advancing flowering with early sowings or hastening ripening with desiccants. The first breakthrough in the development of new European genotypes was the breeding of winter hardy varieties. These had twice the yield potential of spring varieties (4 of 2t/ha) and although they were autumn sown and flowered early, they too did not ripen consistently enough in Northern Europe. The cool moist maritime climate of Northern Europe encourages vegetative growth so that flowering and pod production continue well into the autumn when damp conditions cause crops to ripen poorly and late.

The major constraints to increased production of the crop are larvae (seed corn maggot) and fungal diseases. Currently there are no insecticides labelled for safe use in lupin crops.

Markets and Market Potential

Currently over 2M tonnes of soya bean grain and cake worth over £300M are imported into the UK annually. Lupins could substitute for much of this, and as they

grow on neutral to acid soils would not greatly decrease the current acreage of peas and beans (Milford *et al,* 1996). The main potential market for white lupin grain clearly lies in ruminant feed where its high oil and protein contents are of great value because of the absence of anti-nutritional factors. It is thought that lupin can replace up to 65% of soybean meal in a dairy cow diet and up to 100% of soybean meal in lamb diets. The potential market through industrial processing or through on-farm use is very large in Western European countries.

The other potential market for lupins is as an ingredient in human feed, primarily the hulls and flour are incorporated into pasta and bread or used in crunchy cereals and snacks, baby formula, soups and salads. Currently only *L.albus, L.angustifolius* and *L.luteus* are suitable for this purpose due to the toxicity of other species. In order for the species to be suitable certain quality standards have to be met:

Alkaloid content	<150ppm
Minimum protein percentage	38% DM
Optimum water content	10-12%
Fat content	9-10%
Cellulose content	10-12%
Proportion of broken seeds	<3%
Proportion of flat seeds	<0.3%
Constant colour	
Constant diameter	

Other Information

Lupins are very sensitive to temperature. During the growing season 1400ºC of accumulated heat units are required for pod formation and a southern climate is most favourable. There may be later maturity leading to later harvesting, perhaps into November if the crop is grown in more Northerly situations.

White lupins prefer non-alkaline, fertile, free draining, well structured soils. Very light or very heavy land should be avoided, a medium loam being preferred. Yellow lupins mature up to three weeks earlier than white lupins and are suited to poorer, acid

soils. Blue lupins grow on most soils and have good resistance to frost, they tend to mature earlier than the white species.

Sowing of the crop should take place during the optimum sowing window, this varies between September to November for winter crops and March to April for spring crops depending on a number of factors, including latitude, altitude, aspect and soil type. Winter crops currently have several advantages over spring sown crops although they are not always practical in Northern European climates. Generally yield is 1t/ha higher, crude protein content 8% higher and oil content 5% higher.

Seed should be sown at a density of 40 seeds/m² and no deeper than 5cm, the seedbed should be fine and firm to reduce the risk of pre-emergence attack from a number of pests, the most important being slugs. Growers can expect to lose up to 50% of planted seeds over winter, 20seeds/m² is sufficient to optimise yields in the spring. If more than 28plants/m² are present the crop will be at high risk from lodging.

Lupins are a nitrogen fixing species. On first sowing of the crop in a rotation rhizobium innoculant should be added to the soil, the crop will then be self-sufficient in Nitrogen. Maintenance dressings of Phosphorus and Potassium should be applied at some point during the rotation to replenish what the lupin crop has removed. Pre-emergence weed control is essential to get good control of broad-leaved weeds and grasses. Rapid stem extension in mid-May shades out weeds and reduces the requirement for post-emergence herbicide application.

Pests: Bean Seed Fly and Slugs are the common causes for wilting in young plants. Where a serious infestation occurs this problem should be treated. Aphids and BYMV are the common summer pests, post-flowering infection is not a serious threat to seed yield.

Diseases: No fungal diseases effect the crop over winter, however crops that are susceptible to frost attack may become more susceptible to botrytis and fusarium infection. Fusarium wilt can cause huge losses in the crop by cutting off the nutrient supply from the roots, this is one of the biggest dangers facing lupin production in

Europe at present. This disease has been known to destroy up to 70% of the Western Australian million hectare crop.

As growth of lupin crops become more common the role of Brown Spot (*Pleiochaeta setosa*) will become more important. A pre-flowering fungicide treatment should be applied to protect the main leaves on the plant, this may also have a growth regulator effect. Rust is the most common disease problem in summer.

The crop should be desiccated prior to harvest, the pod walls should be thin and the seeds fully grown before the desiccant is applied. Usually Reglone or Diquat are applied with a wetter when the pods are brown, seed coat is green-grey and endosperm is bright yellow. The crop should be harvested 7-10 days later using the same setting as for a pea or bean crop. Target moisture content at harvest is 20%, this should be lowered to 14% for storage.

In the UK the gross margin to growers for the winter grown lupin is currently around £459/ha.

Research

The main research areas currently being carried out in lupins are resistance to high pH, frost and drought. It appears that breeding alkaline tolerant varieties is a long term prospect rather than short term. Yield stability may also be improved by further development of dwarfing and determinate genotypes.

Tolerance of Fusarium wilt is currently being investigated in Poland and Russia to reduce the potential effect of the disease on yield loss and reduction. This trait is currently being bred into Australian varieties to reduce losses in their vast crop.

Drought resistance is also being researched into to allow the crop to grow successfully across a wider range of land, moisture delving techniques are currently thought to be improving the problem of low moisture availability.

New processing technology is expected to be developed in the future for high quality lupin protein isolates and neutraceuticals with the potential to grow a valuable new lupin processing industry (Biorex Health Ltd).

Useful Websites

http://www.iacr.bbsrc.ac.uk/aen/lupins/ - Vast amounts of general growth and agronomy information on lupin crops

http://www.agri-obtentions.fr - General information on all lupin varieties currently grown

BioMat Net

AIR1-Ct92-0461 – Demonstration Project: Agricultural refining of Bitter Lupins into Derivates with High Added Value

AIR3-CT94-2224 Workshop – 4th TRANSLEG Workshop

FAIR-PL97-3778 – Industrial Application of Plant Proteins as Binders and Co-Binders in Paper and Paints

FAIR-1529 – Pathogen Resistant Grain Legumes Using Gene Transfer Methods

AIR2-CT93-0879 – Pod Shatter in Rape

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