

WHITE LUPINE

Lupinus albus L.

Plant Symbol = LUAL22

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Alternate Names

Common Names: white lupine, sweet lupine

Scientific Names: *Lupinus graecus* Boiss. & Sprun.
Lupinus jugoslavicus Kazim. & Now., *Lupinus termis* Forsk

The seeds and green parts of white lupine contain alkaloids which are toxic to humans and livestock. Care must be exercised when consuming this plant. Soaking in running water, for up to three days, boiling, or selecting 'sweet' cultivars is required to remove the harmful toxins. Use low alkaloid cultivars when using white lupine for either food or livestock feed.

Description

General: White lupine is a non-native, annual legume, reaching heights up to 47 inches. It has a strong taproot penetrating over 2 feet into the soil (Brebaum and Boland, 1995). Leaves are alternate and compound with 5-9 leaflets, nearly smooth above and hairy beneath. Individual plants produce several orders of inflorescences and branches, resulting in clusters of long, oblong pods, each cluster having 3-7 pods, and each pod containing 3-7 seeds. White lupine flowers in May-June. The flowers are white to violet with the upper lip being entire and the lower lip entire or slightly 3-toothed (Jansen, 2006).

White lupine is primarily cross pollinated crop, but self-pollination of 50-85% has been reported (Brebaum and Boland, 1995).

White lupine seeds are generally classified as sweet or bitter depending on the alkaloid content, which ranges from 0.01 to 4% (Bhardwaj and Hamama, 2012). The bitter seeds contain the quinolizidine alkaloids lupanine and sparteine. The presence of these alkaloids limits the use of lupine seed as food and feed. The Australian standard is 0.02% as the upper alkaloid content limit for sweet lupines (Cowlings et al., 1998).

White lupine has an indeterminate growth habit arising from its sequential branching pattern (Munier-Jolain et al., 1996). Flowering starts at the main stem and develops 10-14 days later on primary branches (Brebaum and Boland, 1995). During flowering, water requirements are high. High temperatures and water stress may cause flowers to die. Very early seeded lupine may undergo vernalization reducing the number of nodes, flowering date, maturity date, heights and yields (Brebaum and Boland, 1995).

Distribution:

White lupine is thought to have originated in southeastern Europe and western Asia (Jansen, 2006). Chile is the world's largest producer of lupines with ~62,000 acres in cultivation and annual production of ~40,000 tons (von Baer et al., 2009).

White lupine, wild and cultivated types, are highly variable (Jansen, 2006). The wild type (subsp. *graecus*) (Jansen, 2006) is found in southeastern Europe and western Asia. The petals are dark violet and seed pods shatter at maturity. Seed are small and mottled brown with an impermeable seed coat.

For current distribution, please consult the Plant Profile page for this species on the PLANTS Web site.

Habitat:

White lupine is found in different habitats throughout the world. It grows at mean monthly temperatures of 59-77°F. Higher temperatures and drought stress hinder flowering and pod setting. White lupine is cold-tolerant, but temperatures of 21 to 18°F are harmful at germination. Rainfall of 15-39 inches during the growing season is optimal. It shows good frost resistance, but this will vary by genotype and climate.

Adaptation

White lupine is adapted to climates ranging from northern Europe and Russia, to the arid Australian plains, to the Andean highlands. Spring and fall sown types are grown,

but only the spring types are adapted to the northern Midwestern United States and northeastern United States.

White lupine prefers disturbed sites, poor soils, and areas with reduced competition. It grows well in acidic soils, but tolerates mildly alkaline soils and slightly calcareous soils. Soil pH of 6.5 or less is suitable. Soil acidity is less critical for lupine production than for other legumes such as alfalfa and soybean (Brebaum and Boland, 1995). Growth is hampered on heavy clay, waterlogged and alkaline soils. Some cultivars of white lupine are more tolerant to salinity and heavy soils than other crops (Jansen, 2006).

Uses

Approximately 5 million acres of lupine species are cultivated worldwide (Jansen, 2006). Sixty percent for seed production and 40% for forage and green manure. White lupine is a promising annual legume crop for human consumption, green manure, cover crops and forage production (Jansen, 2006).

Livestock feed: Sweet cultivars of lupine are used for livestock and human consumption. The seed composition and high protein content make the sweet cultivars highly suitable for livestock diets, in intensive farming systems.

White lupine can be used for late winter and early season grazing as fresh or dry fodder (Jansen, 2006). It can be fed as whole or ground seed, whole plant silage, and as hay. From 65% to 80% of the lupine protein is rumen degradable. This rapid protein degradation results in inefficient nutritional utilization, which may cause low dry matter consumption, low milk production and milk protein and should not be the only source of protein feed to ruminants (Brebaum and Boland, 1995). Dairy and livestock farmers in central Minnesota and Wisconsin have successfully incorporated lupine in their feeding programs (Putnam, 1993).

The anti-nutritional quinolizidine alkaloids in white lupine seed are responsible for poor feed utilization (Zdunczyk et al., 1998). Introduction of fodder lupine varieties with alkaloid content of less than 0.01% limit the anti-nutritional effect of alkaloids on palatability, consumption and feed utilization. Since most alkaloids in white lupine are water-soluble, the alkaloid levels can be decreased by soaking them in running water, brine, or scalding (Erbas et al., 2005).

Azo et al. (2006) studied the use of white lupine in organic production and lupine/cereal mixtures. They found that bi-cropping lupine with cereals was successful and gave good forage yields. The combination of 'Dieta' white lupine and spring wheat or spring triticale, was most successful in yield and protein content. Also, harvest dates are as crucial as seeding rates for lupine/cereal forage because time of harvest determines the stage of maturity

and therefore, forage quality. Harvesting between 116-130 days is recommended. (Azo et al. 2012).

McKenzie and Spaner (1998) suggest that white lupine can be used as an alternative legume in oat-legume green chop mixtures on mineral soils in Newfoundland.

Bhardwaj et al (2010), studied the potential to use white lupin as a forage crop in the Mid-Atlantic region of the U.S. They found in their preliminary evaluation that white lupin has an average of 18.7% crude protein content and has potential as a forage crop in this region and compared quite well with alfalfa.

Green Manure/Cover Crop:

White lupine has a long history in the US as a green-manure nitrogen source. By the 1940s, it was so prevalent in the southern coastal plain the area was nicknamed the 'Lupine Belt' (Bhardwaj et al., 2004) (Mask et al. 1993). At one time, over 2,500,000 acres of blue, yellow, and white lupine were grown as a green manure for cotton in the South. Today, Utilization of white lupine use is increasing once again in the southern US. White lupine was shown to fix 140-175 lb N/acre in trials in Minnesota (Putnam, 1993).

White lupine has a positive effect on succeeding crops due to its ability to fix nitrogen, enhance the availability of phosphorus, and improve soil health. By comparing a 10-year white lupine-wheat rotation to continuous wheat, Chan and Heenan (1993) found that wheat yield was always higher in the lupine rotation, regardless of supplemental nitrogen fertilization. The lupine rotation also resulted in higher soil organic matter, improved macroaggregate stability, and a slower decline in soil pH than under continuous wheat production.

White lupine can be a phosphorus efficient plant and could help reduce the need for P fertilizer and enhance yields. It forms cluster roots in response to phosphorus starvation (Cheng et al., 2011). Such an adaptation leads to a striking increase in root surface area available for phosphorus uptake from the rhizosphere. Gardner and Parberry (1983) found exposure to low levels of soil phosphorus enhanced the uptake of phosphorus by white lupine. They also concluded that the ability of white lupine to utilize existing soil and added phosphorous decreased as pH increased.

Human Consumption: Sweet white lupine seeds have been used for human consumption for many years. “Sweet lupine” is defined as having less than 0.02% alkaloid content (Jansen, 2006). The first sweet forms of white lupine with low alkaloid concentrations were developed in the 1930s in Germany (Brebaum and Boland, 1995).

The fiber-rich flour made from white lupine seeds are used by humans. The flour is a good source of macro- and micro-nutrients, protein, fat, carbohydrates, minerals, and vitamins (Yanez, 1996). It is used to enrich pastas, cake mixes, cereals, and other baked goods (Birk, 1993). Sweet white lupine flour also is added to emulsify meat products to increase nutritional value, aroma and to modify texture (Erbas et al., 2005).

The average price of lupine seed is about \$185/ton.

Fish food:

White lupine is being used for fishmeal in turbot, red seabream, and rainbow trout for its high protein and lipid content (Tabrett et al., 2012).

Abandoned mines:

Rocio et al. (2013) looked at white lupine as a potential crop to be planted on abandoned mercury mines in Europe. It has a relatively high tolerance to a number of contaminants and can act as a good phytostabilizer.

Alternative uses:

In Germany, a method for extracting alkaloids from bitter lupines has been developed and researched to determine possible uses as a fertilizer and for its biocidal effects. The alkaloid extracted may have insecticidal properties that could reduce or prevent insect damage when applied to vegetable plants (Brebaum and Boland, 1995).

In traditional medicine, white lupine has varied uses. Lupine seeds are used to cure worms, reduce boils and skin ailments (Jansen, 2006), repel insects, enhance sugar tolerance in diabetics, and heal sores (Duke, 1981). In England, white lupine meal mixed with goat gall and lemon juice forms an ointment (Duke, 1981).



Ethnobotany

White lupine crops were important to many Mediterranean civilizations and was domesticated in the Old and New World (Putnam, 1993). The large seed was reportedly used as play money during the Roman times, and was mentioned by the poet Virgil in 70 BC and by playwrights in 1500 BC.

The history of lupine cultivation in the Old World is associated with ancient Egyptian civilization, more than 2,000 years ago (Zhukovsky, 1929). It is more likely that white lupine was originally cultivated in ancient Greece, where the greatest biodiversity was concentrated and wild-growing forms have been preserved (Kurlovich, 2002).

Status

Please consult the PLANTS Web site and your State Department of Natural Resources for this plant’s current status (e.g., threatened or endangered species, state noxious status, and wetland indicator values).

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Planting Guidelines

Establishment

There are winter and spring forms of white lupine and the cultivar will determine when to plant for greatest seed and plant production.

In general, white lupine needs a growing season of at least five months, with no moisture stress. Areas with mild winters, plant seed from mid-September to late October and planting as late as December has produced adequate stands (Duke, 1981). Seed should be sown at a rate of 50-160 lb/acre and inoculated with *Bradyrhizobium lupine*. A grain drill can be used to plant seed at a depth of 1-2 inches. White lupine may also be successfully established with a broadcast seeding. Preparing a weed-free seeded is crucial for establishment and after seeding, firm the soil with a cultipacker or other means to ensure adequate seed to soil contact (Brebaum and Boland, 1995).

Cool temperate weather conditions are important during the vegetative stage. Temperatures lower than 50°F and short days are required to induce flowering. Seed prediction declined about 47 lb/acre per day in later seeded plants. However, very early plantings can induce vernalization. This will reduce height, node number, and yield due to early cold effects on the seedlings (Putnam, 1993). Thermosensitivity in white lupine remains an important agronomic factor in a spring-sown crop and the window for optimum seeding date is relatively narrow.

Irrigation increased white lupine seed yields over three years of research trials in Minnesota, primarily through increased pod number. Seed crude protein concentration declined at high irrigation rates, and irrigation was cost-effective in most years on sandy soils (Putnam, 1993).

Early sowing dates produce longer growth periods and higher yields. However, crops sown very early may be more affected by weed competition, low temperatures or by pests and diseases. Early autumn sown crops have a shorter emergence period, greater vegetative growth, more lateral branches, a longer flowering period, greater dry matter yield, and greater grain yield than crops sown in the winter (Lopez-Bellido et al., 1994).

Management

White lupine is sensitive to phosphorus deficiency. Depending on soil test results, an application of 250-1000 lb/acre of superphosphate may be required to prevent yield reduction. Poor sandy soils may require 25-50 lb/acre potassium and in some areas potassium and sulfur are applied (Duke, 1981). The roots of the plant can increase phosphorus availability by acidifying the rhizosphere. This property may be beneficial to which associated plants (Jansen, 2006).

Pests and Potential Problems

Sweet and bitter lupines can cause livestock poisoning. Lupineosis can occur when white lupine is fed as dried forage. This disease is caused by toxins produced by the fungus *Diapore toxica* that colonize lupine plants. It primarily occurs in sheep, but can occur in other livestock. It is characterized by severe liver damage, resulting in loss of appetite and condition, lethargy, jaundice, and often death. Lupineosis may be avoided by using *Diapore* resistant cultivars such as 'Kiev' and 'Ultra' (Jansen, 2006).

Fungal pathogens such as *Ascochyta* sp., *Fusarium avenaceum*, *Fusarium oxysporum*, and *Pleiochaeta setosa* are important pathogens on lupines (Brebaum and Boland, 1995). Brown spot (*Septoria glycines*) is widely distributed and a problem on autumn-sown white lupine plants. Fungal diseases may be controlled with the proper use of an appropriate fungicide. Anthracnose (*Colletotrichum* sp.) resistance has been found in some cultivars (Jansen, 2006). Romer et al. (2000) found the most efficient way to control anthracnose is through seed treatment.

Bean mosaic virus is the major viral disease affecting white lupine and is transmitted by aphids and seed. White lupine is immune to cucumber mosaic virus, a major disease of other lupine species.

Aphids are also a problem for white lupin and are mostly found during budding and early pod stages. Their direct feeding effects will reduce crop yields and leads to no flower or pod formation. Aphids in lupin can also

transmit diseases which will also have a detriment to the crop yields. The extent of yield reduction is related to the variety used and precipitation amounts (Berlandier, 1999).

Other pests that affecting white lupine are bean seedling maggots (causing seedling to wilt and die), beetle and moth larvae (kill seedling), slugs (attack leaves), thrips (attack flowers and leaves), mired bugs (attack young seed pods), and budworms (feed on pods and seeds).

The most effective management practices for disease and pest control in white lupine are crop rotations and the use of disease-free seed.

Control

White lupine is slow to develop a closed canopy, which may result in weed competition (Brebaum and Boland, 1995). Folger et al. (2010) found cultivation and companion crops such as black oats successfully reduced weed competition without injury or yield loss.

Please contact your local agricultural extension specialist or county weed specialist to learn what works best in your area and how to use it safely. Always read label and safety instructions for each control method. Trade names and control measures appear in this document only to provide specific information. USDA NRCS does not guarantee or warranty the products and control methods named, and other products may be equally effective.

Seeds and Plant Production

White lupine can produce high seed yields. They are indeterminate plants and managing main stem racemes results in improved yield (Clapham et al. 2000).

There are approximately 500-6,000 seeds/lb and 62 lb/bushel of white lupine. The wide range is related to the cultivar used and area grown. Seed can be stored for 2-4 years under normal conditions, and longer storage is possible at lower temperatures.

White lupine seed yields vary with climatic conditions. The major producers of white lupine seed are Australia, Europe, South Africa, Russia, and the US. Seeds are best harvested in cool weather to prevent shattering pods and damaging seeds (Huyghe, 1997). For seed production in the US and Europe, chemical defoliant are used before harvest. Seed yields range from 700-5,300 lb/acre (Brebaum and Boland, 1995). United States, yields fluctuate from 900-2,000 lb/acre.

Bhardwaj et al. (2004) found that white lupine seed yield, in Virginia, was dependent on planting date and row spacing. In the mid-Atlantic region of the US planting should be before the third week in October with a row spacing of 1.5 feet.

In southern Minnesota and Wisconsin, seed planted in April will be ready for harvest during August and

September in northern areas. Moisture content of the seed at harvest should be 15-18%, to reduce damage (Putnam et al. 1992). Harvesting lupine with conventional combines is possible because the crop is not susceptible to lodging, has non-shattering pods, and the seeds are primarily located near the top of the plants.

Lupine Cultivars, Improved, and Selected Materials (and area of origin)

White lupine is not commonly available from nurseries, garden stores and other plant dealers and distributors. Major germplasm sources are in France, United Kingdom, Australia, and Spain (Huyghe, 1997). White lupine breeders are selecting for accessions that grow rapidly, are alkaloid-free, disease resistant, high-yielding, alkaline-tolerant, frost tolerant, dwarf cultivars, and well adapted to specific local ecological conditions (Jansen, 2006).

It appears that bitter cultivars tolerate cold and disease stress better than sweet ones. High levels of cross pollination may limit the release of sweet white lupine cultivars in regions where bitter, weedy or cultivated types are present. Pollen of the latter would reintroduce the bitter character in sweet varieties, since the bitter gene is dominant (Jansen, 2006).

Some of the well-known cultivars of white lupine are 'Eldo', 'Kiev', 'Multolupa' and 'Ultra' (Jansen, 2006). Numerous other breeding lines and cultivars of sweet white lupine exist; Germany ('Blanca', 'Gela', 'Plugs-Gela', 'Astra'); Poland ('Kali', 'Wat', 'Kalina'), and France ('Lublanc', 'Lucky'). In Ontario, Canada, the cultivar 'Novella' is currently registered.

Commercial lupine seed suppliers are located in Australia, Chile, Germany, South Africa, and the United Kingdom. Cultivars should be selected based on the local climate, resistance to local pests, and intended use. Consult with your local land grant university, local extension or local USDA NRCS office for recommendations on adapted cultivars for use in your area.

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