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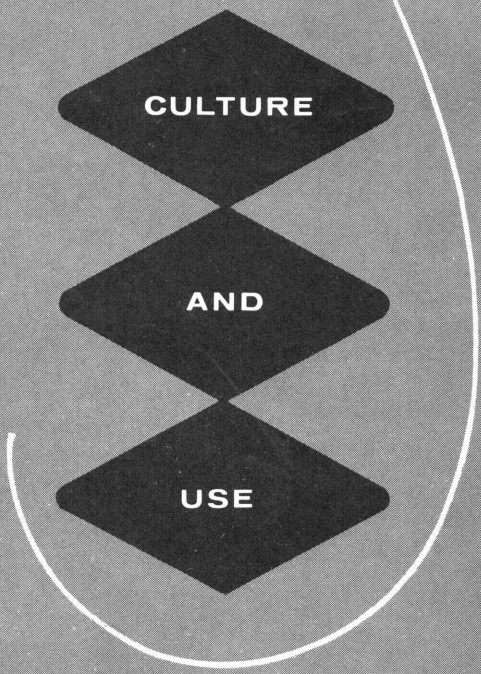
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Lupines



CULTURE

AND

USE

FARMERS' BULLETIN NO. 2114

U. S. DEPARTMENT OF AGRICULTURE

LUPINES . . .

Advantages

- A valuable legume for winter cover and for green manure.
- Sweet, or low-alkaloid, varieties provide good winter and early spring grazing.
- Does well on sandy soils of low fertility.
- Stands are easily obtained.
- The blue varieties produce abundant and easily harvested seed.

Requirements

- Inoculate seed at time of seeding.
- Rotate lupines with other crops to

avoid or reduce injury from diseases.

- Use superphosphate on soils of low fertility.
- Seed only deep enough for contact with moisture.

Precautions

- Do not allow hungry livestock in bitter lupine fields when other feed is not available. Bitter lupines contain an alkaloid poisonous to livestock.
- To avoid serious seed loss, harvest blue lupines before pods are sufficiently ripe for shattering, and clean and dry seed immediately after combining.

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By P. R. HENSON and J. L. STEPHENS, research agronomists, Crops Research Division, Agricultural Research Service

Lupines have been known for over two thousand years, and for the past two hundred years they have been grown on the sandy soils of the central European countries, chiefly for soil improvement.

There are many species. The annuals are the ones most used commercially and are as follows: Blue lupine (*Lupinus angustifolius*), yellow lupine (*L. luteus*), and white lupine (*L. albus*).

Until 1935 all varieties of these species contained alkaloids that were poisonous or toxic to livestock. During the thirties, German plant breeders found plants with a low percentage of alkaloid, and the development of low-alkaloid, palatable varieties followed.

Varieties containing toxic amounts of alkaloids are called bitter lupines, and varieties with an alkaloid content so low as to be nontoxic are called sweet lupines. Bitter plants can be detected by their taste and by chemical means. Plants that differ in alkaloid content do not differ consistently in other respects.

Adaptation

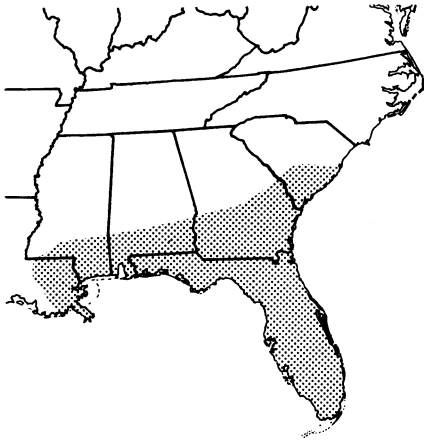
In 1930, experimental plantings of lupines at the Florida Agricultural Experiment Station, Gaines-

ville, and at the Georgia Coastal Plain Experiment Station, Tifton, indicated a possibility of growing the crop commercially in the Lower South. Subsequently, lupines appeared particularly well adapted in trials at the North Florida Agricultural Experiment Station, Quincy, and it was in this area of Florida that lupines were first extensively used.¹

Plantings, mainly of the blue and yellow species, have given good results in the eastern gulf coast area (fig. 1), and extensive plantings of both species have become a part of the cropping systems.

In the lupine-growing area, lupines are fall-planted. They are plowed under as green manure from late February to early April or are harvested for seed in May and June. Lupines make excellent winter growth. The sweet varieties are

¹The men responsible for this early work were G. E. Ritchey, U. S. Department of Agriculture (in cooperation with the Florida Agricultural Experiment Station, Gainesville), Phares Decker (of the Florida Agricultural Experiment Station, Gainesville), the late J. D. Warner (of the North Florida Agricultural Experiment Station, Quincy), and J. L. Stephens, U. S. Department of Agriculture (in cooperation with the Georgia Coastal Plain Experiment Station, Tifton).



BN-4894

Figure 1.—The lupine-growing area of the Southeastern States.

Varieties

The plants of almost all species are upright and have coarse stems and medium-sized digitate (finger-like) leaves. The field-crop species are annuals; some ornamentals are perennials. Blue and white lupines usually reach a height of 2 to 4 feet and yellow lupines 2 to 3 feet. The principal interest has been in varieties of the blue and yellow species. Bitter and sweet varieties of both species are grown. Blue lupines are more winter hardy than the yellow varieties and are grown northward into Alabama, Georgia, and South Carolina. Yellow lupines are limited almost entirely to Florida.

valuable for grazing, cover crop, soil improvement, and seed production. The grazing value of the sweet blue and sweet yellow is now recognized by cattlemen in Florida and southern Georgia.

Hungry livestock may be poisoned by grazing the bitter, high-alkaloid varieties if good forage is not available. The situation is similar to that on western ranges, where livestock, primarily sheep, have been poisoned by grazing certain other lupine species that are native to the Western States. For information on these western lupine species, see PA-325, *Reducing Livestock Losses From Lupine Poisoning in the Western States*; copies may be obtained by writing to the U. S. Department of Agriculture, Washington 25, D. C.

Attempts to grow lupines in the northern United States as a spring-planted, full-season crop have been successful in limited areas. Additional trials are needed before definite recommendations can be made.

The common bitter blue lupine is the most widely grown variety in the Southeastern States (fig. 2). Approximately 75 percent of the lupine seed crop is of this variety. Because of the high percentage of alkaloid in the plant, it is toxic to animals and is grown only for soil improvement.

The Borre sweet blue lupine, introduced from Sweden, has consistently yielded more than other sweet blue varieties. It has compared favorably with common bitter blue in forage and seed yields. It has the added advantage of furnishing winter grazing or seed for feeding purposes.

Seed production of yellow lupines has declined in recent years because the lupine virus reduces seed yield. An early variety of sweet yellow lupine, Florida Speckled, was developed by the Florida Agricultural Experiment



21849

Figure 2.—Common bitter blue lupines nearing full bloom in a large field planting.

Station in cooperation with the U. S. Department of Agriculture. Although this variety was superior in seed yield to other sweet yellow lupines, seed, at maturity, shattered badly, which made the harvest yield unsatisfactory. Seed of this variety is limited.

The white-seeded yellow lupine is nonshattering and is generally preferred by Florida growers and livestock men. Some seed of this variety is imported from Europe each year.

The white lupines are nonshattering and are grown to a very limited extent in the more northern area of the Lupine Belt.

Most flowers of blue, yellow, and white lupines are self-fertilized. Yellow lupines will cross under field conditions. Seed fields of new varieties of yellow lupines must be

isolated from other yellow lupines if varieties are to remain pure. There is no evidence of natural crossing in blue lupines. Successful crosses have not been made between the blue and yellow lupines or between either of them and the white species. Artificial crosses are readily made between plants within any one species.

Winter hardiness

The extent of winterkilling in lupines depends on the stage of growth, soil moisture, location, and cultural practices. A period of warm weather, of sufficient duration to cause the lupines to start growing, followed by a hard freeze, with temperatures between 15° and 20° F., favors severe winterkilling. Critical temperatures are higher during very dry winters.

The condition of the seedbed is also important. An entire stand of blue lupines drilled in a Bahia-grass or Bermudagrass sod may be killed by 22° F., but the same variety planted in a prepared seedbed is not injured.

Acreage

Information on the total acreage of lupines for soil improvement and grazing is not available. The average annual production of lupine seed for the 10-year period 1946-55 was 54 million pounds, according to estimates of the Agricultural Marketing Service. This quantity of seed would plant about one-half million acres of lupines. About two-thirds of the lupine seed crop is produced in Georgia. Alabama, Florida, and South Carolina each produce about 10 percent of the crop. The annual production of seed in 1956 and 1957 dropped to 15 and 17 million pounds, respectively. About 75 percent of the lupine seed crop is made up of the bitter varieties.

Uses

Green manure

In the Lower South the comparatively large growth made by lupines during the winter months makes them an excellent crop to turn under for soil improvement. Where lupines are adapted, they make a heavier yield of herbage than hairy vetch or Austrian Winter peas. Average yields of 2 tons of dry lupine herbage per acre are not unusual.

A large taproot and its smaller lateral branches furnish an abundance of unusually large nodules that supply nitrogen to the soil. The supply of nitrogen and the large quantity of organic matter that lupines produce early make the plant a most desirable soil-improving crop to precede cotton, corn, or peanuts.

Blue lupines, both bitter and sweet, are productive when planted in Bahiagrass or Bermudagrass sod. Although planting of lupines in this way is an excellent cover crop practice, the lupines are more subject to winterkilling than lupines planted in a clean, prepared seedbed. At Tifton, Ga., lupines planted in sod were winterkilled 2 out of 5 years from 1950 to 1955.

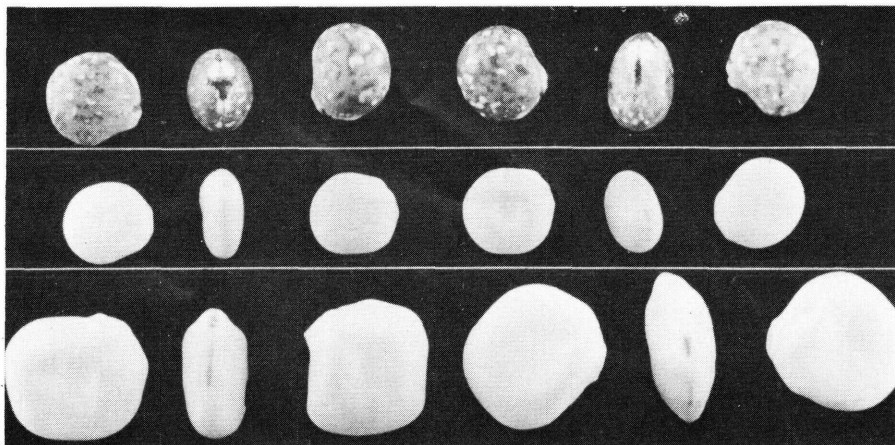
When planted in sod for soil improvement, the bitter lupines must be disked or plowed under. The sweet blue variety, however, may be grazed if winter or early spring grazing is needed.

Winter grazing

The sweet lupines, both blue and yellow, are showing considerable promise for winter grazing and soil improvement.

The Borre sweet blue lupine is now used by farmers of southern Georgia. At the Georgia Coastal Plain Experiment Station in 1954, two 3-acre pastures of Borre were grazed from January 18 to March 30; each pasture carried 11 steers. An average beef gain of 311 pounds per acre was obtained for this period.

Ordinarily, livestock will not eat bitter lupines, which contain poisonous alkaloids, but they eat im-



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Figure 3.—Seed of three species of lupines: Top row, blue; center, yellow; bottom, white.

mature plants of some bitter species without harm. The seed of the bitter varieties contain a higher percentage of alkaloids than any other part of the plant.

Other uses

In some parts of Europe sweet lupines are used as a silage crop. Both the sweet blue and sweet yellow should make satisfactory silage.

Some lupines are good honey plants, but little information is available on their use for this purpose.

The seed

Blue lupine seed is roughly oval and mottled gray to brownish gray. Yellow lupine seed is flat; it may be solid white or speckled white and black. White lupine seed is large, flat, and creamy white. The most common variety of yellow lupine now grown is the white-seeded variety. Seed of the three species are shown in figure 3.

Seeds of all species, so far as is known, retain their viability under good storage conditions. White lupine seed has germinated 100 percent after 5 years and ordinarily has no hard seed; blue and yellow lupines often contain some hard seed. In the South, seed of blue lupines sometimes deteriorates seriously in the second year, but when dry at time of storage it has retained germination well for 2 years. Seed of yellow lupines seems to retain its viability somewhat better than the blue, but good storage conditions and a low moisture content in the seed are necessary to insure good viability beyond 1 year.

The following shows the approximate number of lupine seeds in a pound and the approximate weight of a bushel:

	Seeds per pound	Weight per bushel (pounds)
White lupine.....	1, 000	55
Blue lupine.....	2, 900	60
Yellow (white-seeded) lupine.....	4, 300	60

Soil requirements

Lupines differ from one another in their adaptation to soils of different fertility levels. Yellow lupines do well on moderately acid, light sandy soils of low fertility. Blue lupines require neutral or slightly acid soils of at least moderate fertility, and white lupines need fertile neutral soils for satisfactory growth.

Fertilizer

The effect of fertilizers on the productivity of lupines has not been intensively studied. An application of 300 to 500 pounds of an 0-10-20 fertilizer is recommended unless the previous crop in the rotation was heavily fertilized. Fertilizer should not be applied in contact with the seed, because inoculation and germination will be reduced.

Seeding

*Inoculation*²

Bacterial preparations called inoculants have been developed for inoculating the seeds of legumes. The bacteria in these inoculants obtain nitrogen from the air and are nitrogen-fixing in that they fix nitrogen in a form that is used by the plants. The nitrogen obtained by the bacteria contributes to the nourishment of the plants and, after their death, to the enrichment of the soil.

² Prepared by L. W. Erdman, principal bacteriologist, Soil and Water Conservation Research Division, Agricultural Research Service.

Inoculation of lupine seed is essential and it should be done every year. When seed is well inoculated, nodules are produced in great abundance. Without inoculation the lupine plants are usually yellow and spindly and produce poor yields (fig. 4). When legumes are not inoculated they must obtain all the nitrogen for their growth from the soil.

Time

In regions with mild winter (15° F. or above), seeding should be done from mid-September to late October, if possible, although plantings can be made up to December 1. Later plantings sometimes give good results. Some varieties of blue and yellow lupines may volunteer some plants but cannot be depended on to volunteer a full stand. Seedings in northern States should be made early in spring (April 1 to May 15).

Rate

Following are recommended seeding rates for lupines seeded in close drills or broadcast: White lupine, 160 pounds per acre; blue lupine, 60 to 80 pounds; yellow lupine, 40 to 60 pounds. These rates are suited to average conditions. With favorable weather conditions and a good seedbed, they can be decreased about one-fourth.

Method

A grain drill can be used, or the seed can be broadcast and covered by disking. Plant seed to a depth of 1 or 2 inches, and firm the soil



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Figure 4.—A field of blue lupines showing inoculated plants (left) and uninoculated plants (right).

with a cultipacker or by other means to insure contact between the seed and moist soil. Seedings can be made in rows up to 3 feet apart without reducing seed yields.

Harvesting

In the gulf coast area of the Southeastern States, fall seedings mature in May and early June. In northern States, early spring seedings mature in August and early September. Seed losses in harvesting blue lupines are frequently serious since seeds are lost when the pods pop open as they mature. Because of seed shattering, it is necessary to combine the seed while it still contains too much moisture for safe storage. To avoid excessively high seed moisture content, the

grower should delay harvesting until some shattering has occurred. Even with the delay in harvesting, some high-moisture seed will be combined because of differences in ripening or maturity in the field.

Yields of 1,500 to 2,000 pounds of blue lupine seed per acre are not unusual. Under Florida conditions yields of yellow lupines are much lower. Comparative seed yields for varieties of the blue, yellow, and white species are not available.

Seed storage

Freshly combined lupine seed should be put through a seed cleaner immediately to remove large green seed and green trash in the form of green leaves and broken stems.

Small lots of seed may be spread out 6 inches deep on a floor to dry. The seed should be stirred twice a day until dry. In wet, humid weather, artificial heat may be necessary to dry the seed satisfactorily.

Larger lots of seed should be taken to a commercial drying plant and dried down to 12-percent moisture.

Seed dried and stored under good conditions may be held into the second year or until the second planting season without serious loss in germination.

Diseases³

Cultivated lupines are subject to a number of diseases in the United States. Only a few of the more important ones are discussed here. Farmers' Bulletin 2053, Diseases of Cultivated Lupines in the Southeast, contains more detailed information.

Anthracnose

Anthracnose is most prevalent and destructive in the southern lupine area. It is especially severe in wet seasons when entire fields may be severely affected and the seed crop destroyed.

The fungus that causes this disease sometimes attacks fruits, such as peach, apple, and plum. It also attacks other plants, such as coffee-weed and crotalaria. The disease may be carried in the seed, in the

soil, or on volunteer plants in a field.

The anthracnose fungus produces brown to nearly black spots on leaves. Diseased leaves frequently drop prematurely. The principal damage, however, is to stems, where dark-brown to black lesions are produced. These lesions develop into cankers that girdle the stem and kill the plant. When the fungus attacks pods, concentric rings may be formed in the dark lesions. The seeds beneath the lesions are frequently decayed or discolored. The best control for the disease is to plant disease-free seed or seed that is at least 2 years old. Crop rotation is also helpful.

Brown spot

Brown spot is also widespread but is more damaging in the northern lupine area. The fungus that causes brown spot can also attack vetch, rough pea, and crotalaria. All parts of the plant aboveground are affected, but the disease is most prevalent on leaflets. It causes serious defoliation of old plants and may cause death of seedlings.

The lesions produced by brown spot are variable in shape, size, and color. The spots are usually circular but they may be irregular and netlike. The lesions are usually brownish black. Lesions on petioles are similar, and they may extend around the petiole and kill it. The fungus also attacks the pods and discolors the seed. Control consists of planting disease-free seed or using a lupine rotation on a 3- or 4-year basis.

³ Prepared by K. W. Kreitlow, research pathologist, Crops Research Division, Agricultural Research Service.

Powdery mildew

Powdery mildew is common, especially in the Lupine Belt. The fungus causing the disease produces irregular whitish blotches on leaves and stems. Lower leaves are usually infected first and may drop off. Severely infected plants produce few or no seed, and the plants may be killed. No resistant varieties or control measures are known.

Ascochyta stem canker

Ascochyta stem canker is caused by the same fungus that produces a blight of cotton. It is found only in fields where cotton has been grown the preceding summer and where the old cotton stalks were improperly turned under. The cankers produced on stems resemble those of the anthracnose fungus and are dark brown to black. They often girdle the plant and cause it to wilt and die at any age. The disease is controlled by completely turning under old cotton stalks. Rotation in which lupines follow nonsusceptible crops is helpful.

Virus diseases

In northern Florida and southern Georgia, virus diseases have become one of the major limiting factors in seed production of sweet yellow lupine. Blue lupine and white lupine are damaged less severely.

The viruses that attack lupines are transmitted by insects and are found on other leguminous plants nearby. They also are seedborne. Affected plants usually have numerous small branches along the stem with small leaves that may curl

downward or stand rigidly upright. Infected plants are usually stunted and some become yellowish or reddish. Plants infected early may be killed prematurely or they set no seed. Those that are infected later may mature some seed. No resistant varieties are available.

The following control measures are recommended: (1) Plant only virus-free seed obtained from fields that show a low incidence of disease; (2) avoid planting lupines adjacent to other fields of legumes; and (3) dust with insecticides.

Root rots and seedling blights

Several different fungi can attack lupine roots at any stage of growth from seedlings to mature plants. Species of *Pythium* and *Rhizoctonia* produce a water-soaked decay of roots and stems at or just below the ground level. Affected plants usually collapse and fall over.

Species of *Rhizoctonia* and *Fusarium* attack seedlings and older plants. They cause rotting of the underground parts. Affected roots are usually discolored reddish, straw colored, or orange. Infected plants generally wilt and die at any stage of maturity.

Root rot is found more frequently in low, poorly drained areas of a field. Sometimes large groups of plants are killed.

Another disease, southern blight (*Sclerotium rolfsii*), attacks small groups of plants in a row, usually just below the surface of the soil. The roots decay and the fungus forms small, white, round sclerotia on lesions.

No varieties are resistant to root rots and seedling blights. Rotation, good seedbed preparation, and good drainage are helpful control measures.

Root knot

Root knot is widespread. The nematodes that cause root knot produce galls or swellings on roots of affected plants. Diseased plants are usually yellowed or stunted. The nematode gall is a swelling of the root tissue. These galls should not be confused with nodules produced by the nitrogen-fixing bacteria. The nematode galls cannot be detached from the roots, whereas the nodules, which are usually attached to the sides of roots, can be detached easily.

Because the nematode population increases in the soil through continuous lupine culture, crop rotation helps control this disease.

Insects⁴

Although lupines are generally free from insect attack, several pests have caused an increasing amount of damage to this crop. One is a root weevil (*Sitona ex-plicita*), which seriously reduces stands of blue lupine planted as winter cover crops in South Carolina. The root weevil is also found in Alabama, California, Florida, and Georgia. The larvae feed on the nitrogen-fixing nodules of the blue lupine, which is planted in the

fall. The foliage of infested plants turns yellow and the plants gradually die. The adult weevils are very active and also feed on the leaves of wild cherry and plum.

Another pest of the blue and white lupines is the lupine maggot (*Hylemya lupini*). This insect has been reported from the Pacific Coast States, several Southwestern States, and Alabama, Georgia, and Florida in the Southeast. In southern Georgia and in northern Florida it is frequently abundant on blue and white lupines during the winter months. The larvae eat into the tender buds, kill them, and thus reduce the seed yield. Their feeding also stunts the plants.

In the Southeast, thrips (*Frankliniella tritici* and *F. bispinosa*) injure lupines, especially the Borre sweet blue variety. The insects feed on the foliage, young stems, blossoms, and green seed pods. Their feeding causes stunting of the plants, poor development of the bloom, and early defoliation. Infested pods become roughened and discolored.

Larvae of white-fringed beetles (*Graphognathus* spp.) attack the roots of lupines in the Southeastern States. Grasshoppers, aphids, and several caterpillars occasionally feed on the plants.

For information regarding the control of insect pests of lupines, consult your State agricultural experiment station or the Entomology Research Division, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Md.

⁴Contributed by the Field Crops Insects and Bee Culture Research Branch, Entomology Research Division, Agricultural Research Service.