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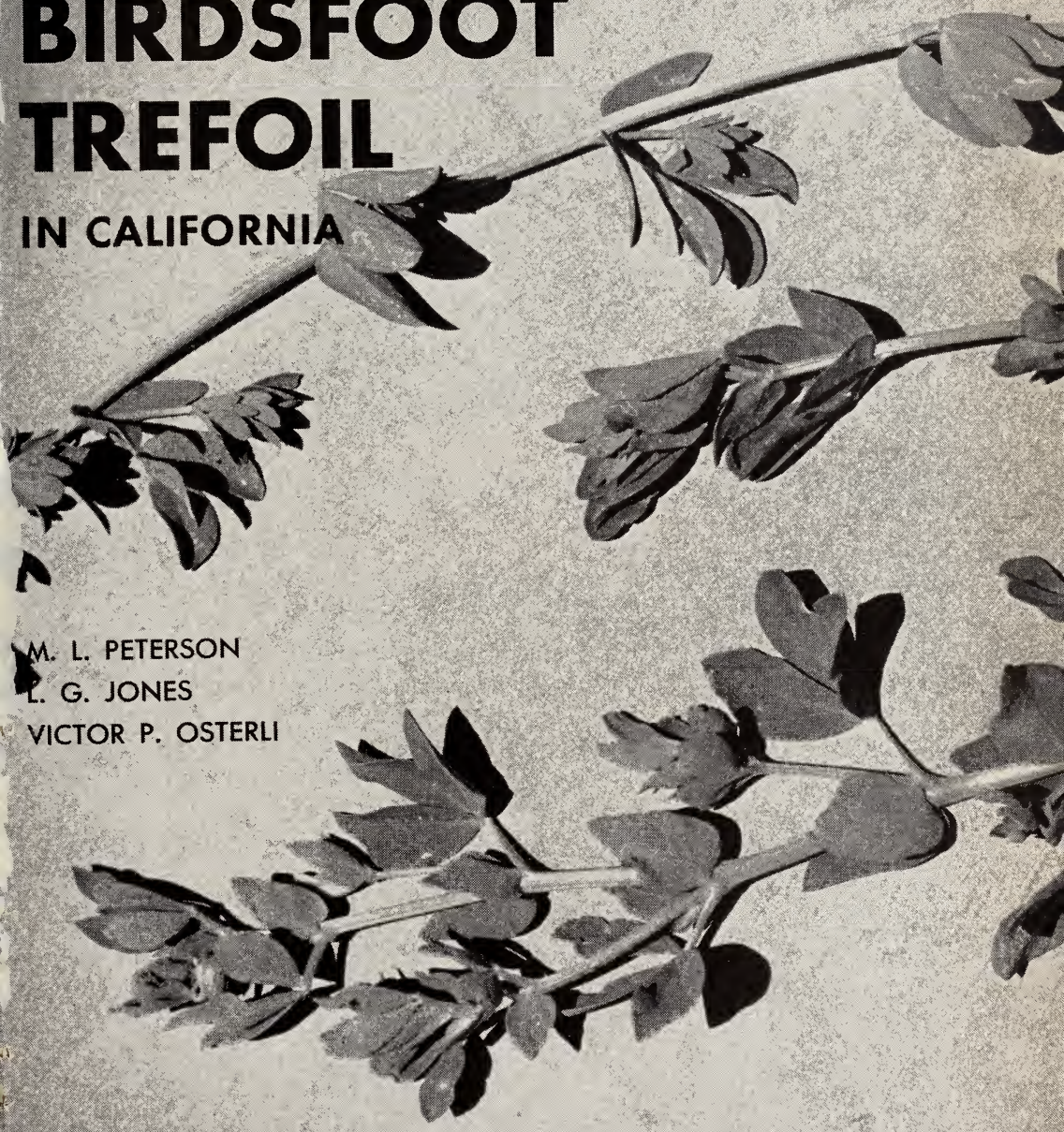
BIRDSFOOT TREFOIL

IN CALIFORNIA



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CALIFORNIA AGRICULTURAL
Experiment Station
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CIRCULAR 421

ARROWLEAF
trefoil grows well under a wider variety of soil conditions than does alfalfa or Ladino clover.

BY WAY OF COMPARISON

ROADLEAF
trefoil can be used at higher elevations, where the winters are cold, than can narrowleaf.

BIRDSFOOT TREFOIL

IN CALIFORNIA

M. L. Peterson L. G. Jones Victor P. Osterli

Birdsfoot trefoil is a perennial legume that produces good-quality irrigated pasture. Although it is grown throughout California, it is used most extensively on very heavy soils that are difficult to drain after irrigation. It is also used on saline and alkali soils, where it has proved superior to other common pasture legumes. It has still another advantage in seldom, if ever, causing bloat in cattle or sheep, even when grazed in pure stands.

These characteristics have brought about a rapid expansion in the use of trefoil. However, on many soils and in many areas in California, birdsfoot trefoil is not the most productive pasture legume, nor the most nutritious that can be grown. This circular describes the different types of trefoils, their adaptation to soils and climate, methods of establishment, grazing management, and seed production.

Narrowleaf trefoil is the most widely used in California. It is known by the botanical name *Lotus tenuis* and by some authorities, *Lotus corniculatus* var. *tenuifolius*. Its common names are narrowleaf trefoil, creeping trefoil, and prostrate trefoil. No improved varieties of narrowleaf trefoil are in general use at present. However, individual plants differ greatly in productivity and growth characteristics. In various parts of the country breeding work is in progress, which may lead to the development of improved varieties.

When narrowleaf trefoil was introduced into this country is not definitely known. It was first seen in ballast near Portland, Oregon, in 1917. It spread naturally for a number of years before it was recognized as a valuable forage plant.

NARROWLEAF TREFOIL

Description. Narrowleaf trefoil is a long-lived herbaceous perennial with a relatively deep but branching taproot. The stems grow flat along the ground, except in very thick stands or in mixtures when competition for sunlight causes them to grow more upright. As many as a hundred or more stems may rise from a single crown, these reaching a length of 20 to 40 inches. The leaves are arranged in groups of five leaflets; three are grouped like alfalfa and two are at the base of the leaf branch, one on each side. Individual leaflets are less than half as wide as they are long and usually smooth or with only a few hairs.

The flowers are yellow to bright orange and are arranged in clusters of three to eight single blossoms. After pollination, done mostly by bees, the flowers wilt, and long, straight pods an inch or more in length grow in their places. An individual pod may contain 12 or more seeds. The resemblance of the pods to the toes of a

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A hundred or more stems may rise from a single crown of narrowleaf trefoil.

bird's foot gives the plant its common name, birdsfoot trefoil.

Adaptation. Under central California conditions, narrowleaf trefoil begins growth in early February, when the average daily temperatures range from 40 to 50° F. However, growth is very slow until warmer weather arrives, with greatest growth occurring during late June. Temperatures around 80° are believed most favorable to growth. Production begins to drop slowly during July and August, until by early November, growth has nearly ceased. High summer temperatures do not kill the plants; satisfactory stands survive temperatures of 120° in the Imperial Valley.

Areas that have hard, killing freezes are not well suited to this type of trefoil, which is subject to winter killing. In regions without hard, killing frosts the plants remain green throughout the winter but make very little growth. However, the fact that the plants remain green and hold their leaves in cold weather makes narrowleaf suitable for some winter grazing if late summer and fall growth is allowed to accumulate ungrazed.

Narrowleaf trefoil grows well under a wider variety of soil conditions than does alfalfa or Ladino clover. Alfalfa is much more productive than narrowleaf trefoil on deep, coarse-to-medium-textured soils. Limited evidence indicates that alfalfa may produce 40 to 50 per cent more than trefoil on a very fertile, well-drained soil, where both legumes are managed for maximum production. Ladino clover, under similar conditions, may produce 15 to 20 per cent more than trefoil.

On the heavy-textured clay soils, where both surface and subsurface drainage are poor, alfalfa is quickly killed and Ladino clover makes very poor growth. On saline and alkali soils, Ladino clover either cannot be established or, if the condition is not too severe, makes very poor growth. Narrowleaf trefoil, on the other hand, is the only legume in common use that is capable of producing good pasture under conditions of high salt and poor drainage. It is for this reason that a large part of the trefoil acreage is concentrated on these problem soils.

The tolerance of narrowleaf trefoil to soils containing large quantities of soluble salts, including sodium, has been established by experimental methods. A. D. Ayers of the U. S. Regional Salinity Laboratory at Riverside grew trefoil on soils artificially salinized by irrigation with salty water. Growth was 35 per cent of normal on soil with salinity as high as 7,500 parts per million, whereas Ladino clover and other legumes were killed.

Narrowleaf trefoil, being somewhat deeper rooted than Ladino clover, produces under an infrequent irrigation schedule that causes Ladino clover to wilt and gradually die. The trefoil yield is likely to decrease, however, if irrigations are spaced too widely. In field practice, trefoil is irrigated almost as frequently as Ladino clover. Narrowleaf trefoil withstands excessive amounts of water better than Ladino clover. In one greenhouse trial it produced 54 per cent of normal when continuously flooded for 80 days. Under these same conditions, Ladino clover produced 47 per cent, broadleaf trefoil 22 per cent, and alfalfa, 5 per cent of their normal growth.

BROADLEAF TREFOIL

Description. Broadleaf trefoil (*Lotus corniculatus*) is also known by the common names erect trefoil and upright trefoil. As these names imply, broadleaf grows more upright than narrowleaf. It has broader leaves, with individual leaflets usually more than half as wide as long. There are many varieties of the broadleaf trefoil. Most of them have coarser stems than narrowleaf, although flowers and pods are similar to those of narrowleaf. Except during the period when the yellow flowers are conspicuous, the full-grown plants resemble a fine-leaved alfalfa plant. Numerous stems rise from a single crown, and the mature plants may reach a height of 20 to 40 inches.

Adaptation. Adaptation of broadleaf trefoil can best be described by comparing it with narrowleaf trefoil. With the approach of cold weather in the fall, leaves of broadleaf begin to turn yellow, and eventually to drop. In regions of frequent, hard freezes the plants die back to the crown and show little, if any, green foliage during winter. Therefore, this type of trefoil is not well suited to winter grazing. Response to temperature during summer months appears similar in the two varieties.

The strong tendency of broadleaf toward complete winter dormancy makes the plants more resistant to cold and able to survive winters that would kill narrowleaf. Broadleaf trefoil therefore can be used at higher elevations where winters are cold.

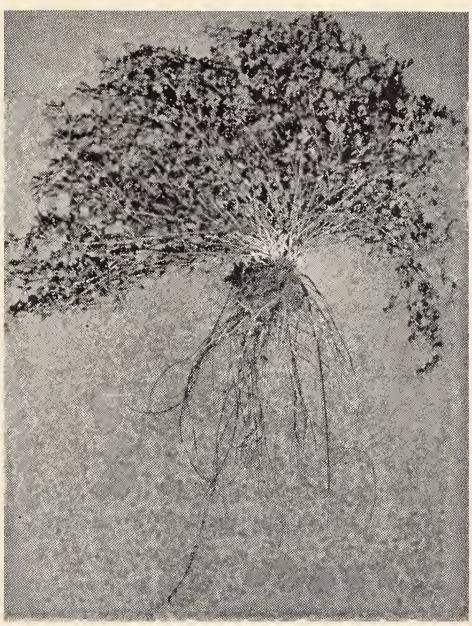
Roots of broadleaf trefoil are deeper than those of narrowleaf, and the plants are more drought-resistant. In Italy, where much of the seed used in California is produced, broadleaf is grown on rocky, calcareous, and droughty soils. New York farmers report broadleaf to be more resistant to drought than white clover, red clover, and alsike clover. Seedings made on dry land in northern California coastal counties have produced some green feed in summer months when most native species are dormant.

Broadleaf trefoil is much less tolerant of poor drainage or overirrigation than narrowleaf. As mentioned earlier, broadleaf produced only 22 per cent of normal when kept continuously flooded, whereas narrowleaf produced 54 per cent of normal. In seedings containing equal parts of broadleaf and narrowleaf trefoil made in 1947 on a heavy clay soil that was poorly drained, broadleaf has almost been eliminated. Narrowleaf continues to survive under the same conditions.

Broadleaf trefoil is being used very successfully in irrigated pastures in the Sierra Nevada foothills. With limited water available on these coarse-textured soils, this type appears to excel in production.

Varieties

Granger. This variety is a selection made by H. A. Schoth at the Oregon Agricultural Experiment Station, Corvallis.



Big trefoil has vigorous underground stems, or rhizomes, which enable the plant to spread vegetatively in thickening the stand.

Seed was obtained from France by the United States Department of Agriculture. It was under test by the Oregon station for about twelve years before it was given the variety name Granger and released for seed increase. Present indications are that the amount of seed available for general use will be relatively small until after the 1954 harvest.

Granger is very uniform, relatively fine-stemmed, upright in habit of growth and has broad leaves. One of its outstanding features is its rapid development, both as a seedling and in rapid regrowth after grazing or mowing. It appears to resist some of the diseases prevalent in the Pacific Northwest and to maintain good stands over a long period of time. In the Oregon trials, yields of forage have been about equal to those of Ladino clover. Seed yields, where shattering losses are kept at a minimum, are around 200 pounds per acre. Granger is certified in Oregon and Washington by the respective crop improvement associations.

Cascade. This broadleaf strain was selected by the Bellingham (Washington) Soil Conservation Nursery. It traces to three imported lots, from which the most vigorous plants were selected and grown in an isolated block for seed increase. In Washington, this strain has yielded somewhat better than other broadleaf types. Limited trials at Davis indicate that Cascade is similar in appearance and yielding ability to the ordinary imported broadleaf trefoil. Cascade is certified in Washington.

Empire. Empire is the increase of a naturalized stand grown in the vicinity of Preston Hollow, New York, made by the New York Experiment Station. Certified seed of this variety is available in limited quantities from New York. This variety is also eligible for certification in California, where some plantings have been made for seed production.

Compared with the imported broadleaf, Empire has finer leaves and stems, grows more dense, and tends more toward the creeping, rather than the erect, types. It recovers more slowly after cutting or grazing. Also, it goes into dormancy earlier in the fall and recovers later in the spring. Empire is extremely winter-hardy but almost completely dormant in cold weather. Yields from row plantings have been very good. In broadcast seedings and in mixtures with grasses, production has been inferior to imported broadleaf.

Viking. This is another selection from imported European broadleaf trefoil, made by the New York Experiment Station. Production data on the growth of this variety in California are not yet available.

BIG TREFOIL

Description. Big trefoil (*Lotus uliginosus*) is also called Marsh or Greater trefoil. The botanical name *Lotus major* is used by some writers. Varieties with hairy leaves and stems are given the additional variety designation *villosus*, and those with smooth leaves, *glabriusculus*. In general appearance big trefoil resembles broadleaf. The most important difference in growth habits between big trefoil and other trefoils is the vigorous growth of its underground stems, or rhizomes. This characteristic enables the plant to spread vegetatively so that plantings even in rows 3 feet or more apart soon form a solid stand. The stems are generally finer-textured than those of broadleaf and will stand erect only when supported by other vegetation. In northern coastal counties big trefoil reaches a height of 4 feet or more when growing among supporting shrubs. Under ordinary conditions, a height of 2 to 3 feet is attained.

The flowers are brilliant yellow and arranged in clusters of 8 to 12 individuals. Pod diameter is smaller than in other trefoils. The seeds are green and so small that approximately a million are required to weigh a pound. By comparison, broadleaf trefoil averages around 375,000 seeds per pound.

Adaptation. The range in adaptation of big trefoil has not been fully established. Its present growth is confined to regions of relatively mild winter temperatures along the north Pacific Coast from Washington through northern California. It is believed that the naturalized occurrence of big trefoil along the coast is the result of seed transported by migratory waterfowl. Summer temperatures are cool in the regions where it commonly grows. In the interior valleys, where high summer temperatures occur, production has not been satisfactory, but it is not definitely known that high temperature is the reason for poor growth.

In Humboldt County, big trefoil is usually found near the ocean on land that is frequently flooded. Many stands that have been flooded for three or more months during the winter show no apparent damage. However, it is also grown to a limited extent in some inland areas and in areas that are not excessively wet.

On the basis of our present knowledge of the growth habits of big trefoil, its use should be restricted to coastal areas or near-coastal areas, and not to interior valleys. Also, its superiority to other trefoils is largely under extremely wet conditions rather than in areas where drainage is possible. It is not implied that big trefoil prefers these wet locations. Nearly all plants grow best when soil and climatic conditions are normal.

Varieties

Beaver. This variety of big trefoil is distinguished by hairy leaves and stems. Seed is produced largely in Clatsop and Tillamook counties, Oregon, and in Pacific County, Washington. Beaver is certified by the Oregon Crop Improvement Association, and seed is available commercially.

Columbia. Columbia big trefoil is a smooth-leaved variety that has been under observation and in experimental trials in Oregon for many years. H. B. Howell, Superintendent of the John Jacob Astor Branch Experiment Station, Astoria, Oregon, states that this smooth-leaved type appears to be preferred by livestock. Certified seed is available from Oregon.

HOW TO ESTABLISH STANDS OF TREFOIL

Birdsfoot trefoil usually develops productive pasture more slowly than does Ladino clover or alfalfa, since the seedlings develop somewhat more slowly. Also the seedlings are more likely to be crowded out in the early stages by competing weeds and other plants.

High-quality seed is needed for good stands. Germination, including hard seed, should be 90 per cent or better, although some imported seed has been somewhat lower. Always check the analysis on the seed tags before purchasing.

Seed purity should be 98 per cent or better. However, for pasture purposes, presence of other crop seeds, such as Ladino clover and alsike clover, are not objectionable.

When to seed. Birdsfoot trefoil is normally seeded in October and November or in February. This enables the stands to become established under normal rainfall in the Sacramento Valley, northern San Joaquin Valley, and other areas of abundant, natural winter rainfall. December and January are generally too cold for good seedling establishment.

It is a fairly common practice to seed in standing water on some of the very flat lands that are irrigated by contour checks. Successful stands are obtained throughout late summer and early fall by this method. After the land is prepared for irrigation, the field is flooded and the seed broadcast upon the water from an airplane. The land is flooded for about

48 hours. By this time the seed coat has been ruptured, the cotyledons have emerged, and the primary root has begun to develop. As the water is drained off, or seeps into the soil, the primary root is anchored in the mud. If the water is held on the land longer than 48 hours, the seedlings may float and be driven to the levee by the wind. This is why length of flooding time is an important factor.

Type of seedbed. A firm seedbed is essential. Also, the field should be relatively free of weeds. Cultipacking before and immediately after seeding is advisable, except on soils likely to crust badly after rains. Rolling the seedbed will cover the seed, yet not bury it too deeply for the small seedlings to emerge. Seedings made during the rainy periods normally produce good stands without covering.

Seeding rates. These range from 3 to 5 pounds per acre. Under favorable conditions, 3 pounds per acre are ample for a satisfactory stand. Under average conditions, 5 pounds per acre will give a good stand more quickly.

Irrigation. One or two light irrigations following the initial flooding usually insure a good stand. Seedings made in August by this method develop rapidly enough to provide a little grazing in the fall and full production the next year.

Studies made at Davis indicate that this planting method should not be used during extremely hot weather. Water temperatures as high as 90° reduce germination.

Inoculation. This is essential to successful stands in areas where trefoil has not grown previously. Trefoil bacteria are not naturally present in most California soils. Commercial cultures suitable to birdsfoot trefoil are available from most seed companies. Directions for inoculating seeds appear on the containers.

Big trefoil requires a specific inoculant, different from the one used for broadleaf and narrowleaf trefoil. Many failures with big trefoil can be attributed to lack of inoculation.

Trials carried out in Humboldt County show that seedings of big trefoil made without inoculation were unsuccessful, while seeds coated with soil from around inoculated plants, or seeds inoculated with bacterial cultures, developed strong, vigorous seedlings. Experiments carried out in Iowa showed that with broadleaf trefoil, number and height of seedlings were increased by more than 100 per cent three months after inoculating and seeding on various soil types.

PASTURE MIXTURES USING TREFOIL

The kinds of pasture mixtures used by farmers are usually determined by individual preferences and experiences. The species used and the seeding rates can often be changed considerably with equally good results. However, farm experiences together with experimental trials have shown certain combinations to be consistently good and others to be unsatisfactory. Using many species in a single mixture is a common practice that wastes seed and sometimes leads to complications in management. A more desirable practice is to plan a combination of pastures to provide feed at the particular season each is needed.

The general idea of using a wide variety of plants in a single mixture to provide a long season of growth is greatly overemphasized. The more aggressive varieties or those favored by the particular management system generally increase to the disadvantage of other varieties, thereby defeating the original purpose.

Trefoil Grown Alone

Narrowleaf trefoil for sheep pasture is usually sown in pure stands, at seeding rates of 3 to 5 pounds per acre. The selective grazing habits of sheep make extremely difficult the maintenance of a desirable balance of grasses with trefoil. Usually the trefoil is selected by the sheep, and the grasses are left to become more

mature and even less palatable. The use of grasses as a bloat-control measure is not necessary with trefoil.

Trefoil and Ladino Clover

In some areas narrowleaf trefoil is sown in combination with Ladino clover for sheep pasture. Sheep appear to show less preferential grazing between these two legumes than between the legumes and grasses.

Mixtures of Ladino clover with both narrowleaf and broadleaf trefoil were compared with each of the trefoils grown in pure stands for yielding ability. Ladino clover, grown alone, was also included in these trials. The test was conducted on a poorly drained, heavy clay soil, with yields measured by mowing and weighing the forage.

In this trial, Ladino clover was less productive than the trefoils. The broadleaf type gave the heavier yield of the two, but this may have been caused, in part, by the difficulty of mowing the low-growing narrowleaf type. Ladino clover when mixed with the trefoils had little influence on the yield of narrowleaf but depressed the yield of broadleaf.

Trefoil and Alfalfa

Trefoil and alfalfa are rarely compatible in mixtures. If mowed or grazed at intervals of 25 to 30 days, the alfalfa will crowd out the trefoil. When grazed more frequently the trefoil will persist, whereas the alfalfa is eliminated. In some farm seedings, 1 or 2 pounds of alfalfa per acre were included with trefoil with good success. The alfalfa plants were far enough apart not to shade out the trefoil.

Trefoil and Perennial Ryegrass

The principal reasons for including grasses in pasture mixtures are to: 1) provide a better sod; 2) improve yields; and 3) control bloat, a factor of no importance with trefoil. In trials at Davis, the use of perennial ryegrass in mixtures of the different trefoils did not significantly influence total yields for the season. As shown in table 1, only the narrowleaf strain produced more when combined with perennial ryegrass than when grown alone. Production from the mixture of ryegrass and trefoil was highest in spring and fall and less so in summer.

Among the various grasses with which trefoils have been tested experimentally, perennial ryegrass has been one of the most satisfactory but not necessarily the most productive. Seeding rates should be 2 to 3 pounds of perennial ryegrass with 3 to 5 pounds of trefoil per acre.

Trefoil and Orchardgrass

Seeding rates per acre for this combination should be 3 to 5 pounds of trefoil and about 5 pounds of orchardgrass. The mixture is not recommended for sheep

Table 1. Yield in tons per acre of three strains of trefoil grown alone and in combination with perennial ryegrass (At 12 per cent moisture)

Variety	Tons per acre	
	Alone	With ryegrass
Narrowleaf trefoil	6.54	6.84
Broadleaf trefoil (imported)	7.32	6.97
Empire trefoil	6.50	5.66
Average	6.79	6.49

This single plant of narrowleaf trefoil shows the creeping habit of stem growth.

pasture unless the farmer is able to mow the pasture often enough to control bunchiness.

Trefoil and Alta Fescue

The combination of trefoil and alta fescue is not recommended because fescue is kept from crowding out the trefoil only by great effort. This mixture is productive in test plots where it is mowed at regular intervals, but livestock show a strong preference for the trefoil. As a result, the alta fescue becomes mature and unpalatable and eventually eliminates most of the trefoil.

Other Mixtures

Numerous other grass-trefoil combinations are used on California farms. Local experiences largely determine which are most satisfactory. The ones discussed above are those on which the most information is available.

Chemical Composition

The chemical composition of broadleaf trefoil growing in a mixture of perennial ryegrass, orchardgrass, and alta fescue was compared with alfalfa and Ladino clover growing under similar conditions. The grass portion of these mixtures was less than 25 per cent on weight basis, the major portion of the mixture consisting of the legumes in every case. These results, shown in table 2, indicate that the trefoil-grass mixture was the lowest of the legumes in protein percentage on a dry-weight basis. Since trefoil is higher in percentage of dry matter than Ladino clover, where the two are compared on a fresh-weight basis, the differences only slightly favor Ladino clover.

Crude fiber of trefoil was intermediate between alfalfa and Ladino clover, while nitrogen-free extract was not greatly different between trefoil and Ladino clover.

In considering all of these factors, the feed quality of broadleaf trefoil appears to be slightly less than that of the other legumes. It is not known how the broadleaf and narrowleaf trefoils compare in chemical analysis, but broadleaf trefoil is believed to be the coarser of the two.

GRAZING MANAGEMENT

Sheep pastures. Part of the trefoil acreage in California is used exclusively for lamb-feeding operations. The grazing habits of sheep and their short feeding period necessitate grazing-management systems somewhat different from those used for cattle. Sheep are very selective in grazing habits, choosing only the species and parts of plants most palatable at that particular time.

A good practice followed by some lamb feeders is to graze the pasture with ewes and lambs in early spring so that by March 15 or April 1 the pasture is grazed down rather closely. The ryegrass and other grasses that grow in cool weather are grazed down so that the trefoil is better able to compete. Pastures are then allowed to grow without grazing until around May 1.

Good trefoil pastures will carry from 12 to 15 lambs per acre from May 1 on through the period of rapid spring growth. The rate of stocking can then be reduced as early lambs are sold. During the latter half of the summer, a good trefoil pasture will carry 9 to 10 lambs per acre. Buying and selling operations, together with fluctuations in markets, may necessitate overstocking or understocking of pastures, but only for short periods of time.

Experiences of lamb feeders have shown that frequent rotation of lambs from one pasture to another is a good practice. One system is to use four pastures and rotate the band from one pasture to another every three days. The pasture is irrigated after each grazing. Only about half of the top growth is removed at each grazing. If the trefoil pasture is stocked so heavily that it is grazed down closely each time, the trefoil will become progressively weaker. Production is then reduced and competition from unpalatable weeds increased.

Cattle pastures. With dairy cattle, the number of animals is usually constant through the season. Therefore, variation in production of the pasture through the season must be taken care of either by increased use of supplementary feeds in slack seasons or by harvesting hay or silage in the season of rapid growth. In rotation grazing, certain of the pastures can be dropped out of the rotation system during the season of overabundant pasturage and can be cut for hay or silage. These pastures are then brought back into the rotation schedule later in the season when growth is less abundant.

Table 2. Percentage composition of broadleaf trefoil, Ladino clover, and alfalfa, each grown in mixture with grasses, and harvested at 28-day intervals (Dry weight basis)

Chemical composition	Broadleaf trefoil	Ladino clover	Alfalfa
Crude protein	17.0	19.5	21.1
Crude fiber	24.6	18.6	30.5
Nitrogen-free extract	37.4	39.5	27.4
Ether extract	2.2	2.0	1.8
Ash	9.5	10.3	9.6
Moisture	9.3	10.1	9.6

The procedure most satisfactory for rotation grazing must be worked out to fit each individual case. The length of growth interval between grazings influences both yield and quality of feed produced. Clipping studies conducted at Davis have provided information on yields, at various growth intervals, of a mixture of broadleaf trefoil and grasses clipped at intervals of two, three, four, and five weeks over a period of three years. Yields in tons per acre at 12 per cent moisture are shown in table 3.

Average yields over three years were 3.64 tons per acre when harvested every two weeks. This method of harvesting does not greatly differ from the close grazing systems practiced by many farmers. By extending clipping intervals to three weeks, yields were increased 26 per cent; to four weeks, 44 per cent; and to five weeks, 90 per cent. From 1949 to 1951, when cuttings were spaced at four- and five-week intervals, production increased, but when spaced at more frequent intervals it did not increase.

Livestock men are well aware of the considerable amount of waste by livestock turned into a field of tall pasture. Trampling and fouling by manure droppings can damage so much of the feed that the benefits of taller growth are lost. Wastage of this kind can be greatly reduced by confining livestock to a small area that will be grazed down in a very few days. In general, the shorter the grazing period, the less the waste. A good system is to use six pastures, grazed about five days each. This will provide a regrowth period of 25 days. A number of dairymen use portable electric fence to provide a fresh pasture daily or twice daily. They are enthusiastic over the results in every case.

Molybdenum toxicity to animals grazing on trefoil may be a problem in certain parts of the San Joaquin Valley where soils contain excessive molybdenum. The areas known to be affected at present are principally on the west side of Kern, Kings, Fresno, and Madera counties and on scattered areas in Riverside and Santa Barbara counties. Trefoils should not be included in mixtures where molybdenum is known to be present. More detailed information on this problem is available in a report entitled, "The Molybdenum Problem with Livestock," available in the University of California Farm Advisors' Offices in the different counties.

Fertilization

Legume pasturage production has been increased more by fertilization with phosphate than with any other fertilizer element. Soils responding to phosphorus occur quite widely, but the foothill and terrace soils along the eastern margin of the Sacramento and San Joaquin valleys, some calcareous and imperfectly drained

Table 3. Effect of length of growth intervals on yields of a broadleaf trefoil grass mixture at Davis (Tons per acre at 12 per cent moisture)

Length of growth intervals	Growing season			Average	
	1949	1950	1951		
	tons	tons	tons	tons	per cent
Two weeks	4.00	3.17	3.74	3.64	100
Three weeks	4.47	4.09	5.14	4.57	126
Four weeks	4.83	4.87	5.98	5.23	144
Five weeks	5.64	6.92	8.21	6.92	190

A dairy pasture of trefoil and grasses in the Sacramento Valley.

soils in valley basins, and certain residual upland soils in coastal areas are very likely to be deficient.

Although phosphorus is the element most likely to be deficient, there are areas where sulfur-containing fertilizers and nitrogen and potash fertilizers may be needed. Your University of California Farm Advisor should be consulted if pasture growth is unsatisfactory and if a soils problem is suspected. If the fertilizer needs of the particular soil are not known, he can suggest methods of trial applications.

Weed Control

The best methods of weed control in trefoil pastures are careful grazing management and avoidance of overirrigation. Even with the best of management, weeds sometimes become serious. Frequent use of the mower, particularly before weeds go to seed, is advisable. Mowing immediately after grazing will waste only a minimum amount of forage.

When preventive methods fail, weeds can be killed by spraying. Curly dock, plantain, chicory, and star thistle are controlled by using the 2,4-D salt at the rate of ½ pound of acid equivalent per acre in 10 to 15 gallons of water if a plane is used, and 40 to 60 gallons if a ground rig is used. To minimize injury to the trefoil, the pasture should be kept in a thrifty, growing condition for a month following spraying. This can be done by good irrigation practices and by not permitting grazing.

Foxtail, ripgut, and chess are controlled in seedling stands of pure trefoil by spraying with 2 pounds of I.P.C. per acre in 100 gallons of water. For older stands, 3 to 4 pounds of I.P.C. can be used in 100 gallons of water. This material is used in the fall, winter, and spring.

SEED PRODUCTION

Seeding and management practices for trefoil seed production are similar to those used for pastures. The most important differences are: 1) seedings are made in pure stands (no grass); 2) seed should be free of other crop seeds, such as alsike or Ladino clover; and 3) irrigation should be frequent enough to keep the ground moist throughout the period of seed setting and ripening. Frequent irri-

Direct combining of narrowleaf trefoil follows defoliation with dinitro diesel oil. Harvesting must follow spraying as soon as possible to avoid shattering losses.

gation is necessary to maintain a canopy of new growth above most of the seed pods and to keep the humidity high enough to reduce seed shattering.

Trefoil seed entering the hopper of the combine contains pods, sticks, and leaves. The seed must be cleaned immediately or spread out to dry if heating of seed is to be avoided.

When birdsfoot trefoil was first observed, its extensive use was not considered possible because of severe shattering of the ripened seed. The pods ripen over a long period of time and ripe seed, green pods, and flowers may be present on a single plant at any one time. Although good seed yields have been produced, frequently most seed is lost through shattering in curing and threshing.

Seed yields in California have ranged from less than 100 pounds to 425 pounds per acre on a field basis. These differences in yields are largely differences in the amount of shattering.

Direct combining after defoliation. The direct combining of birdsfoot trefoil can be done very satisfactorily by using dinitro compounds as a conditioner. Although this treatment does not completely defoliate the leaves before

harvesting, it does cause the foliage to wilt and lose enough moisture to permit harvesting before the pods shatter appreciably.

For airplane application, 1 to 2 pints per acre of the general dinitro defoliant material in 10 to 12 gallons of diesel oil are recommended. For ground application by spraying, the amount of oil used should be increased to 15 or 20 gallons per acre. It is important to apply the defoliant at one time to an area that can be harvested in a single day. If sprayed trefoil is permitted to stand too long before threshing, severe shattering may occur. When temperatures are 100° or above, the harvesting should be done on the same day the defoliant is applied—perhaps as soon as five hours after spraying. If the temperature drops appreciably below 90°, the interval between spraying and beginning of harvesting may be one or two days. A little experience will indicate how soon after spraying combining should begin.

Direct combining of trefoil without defoliating is a slow and difficult process. The green straw chokes the machine, juice from green leaves reduces threshing and sieving capacity, and the threshed seed will cling to wet straw and be lost. Still further losses result from improper threshing of tough pods that are near the ground. Finally, the threshed seed must be cleaned or spread out to dry immediately because the green material in the seed will begin to heat and impair germination of the seed.

Seed losses from direct combining without defoliating may range from 50 to 90 per cent. By using the defoliant, threshing operations are done more rapidly; they can begin earlier in the season and sometimes can be started earlier in the day. Also, green succulent weeds are dried by this method, so they do not interfere seriously with threshing.

Mowing before threshing. Mowing and drying in the swath for 8 to 24 hours before combining has been a successful method of harvesting trefoil. The rate of drying after mowing is about the same as that for defoliated stands; harvesting procedures are similar. Thick, matted stands of trefoil are difficult to mow, and the tractor wheels cause some shattering of seed.

Windrowing trefoil is not recommended. When it is windrowed after mowing and is permitted to cure, as in the harvesting of alfalfa seed, almost all of the seed is lost from shattering.

Some farmers have mowed the trefoil at night or early morning, loaded it immediately into seed-tight vans, and transferred it to a hard-surfaced curing lot, such as an airplane landing strip, cement feed lot, or an expanse of canvas. The material is spread out to dry; it is then threshed, and the shattered seed is salvaged by a suction or sweeping process. Nearly all of the seed can be saved by this method. However, not many farmers have curing lots conveniently available and, furthermore, labor and equipment costs for the method are rather large. The use of preharvest spraying as a conditioner to direct combining is therefore the most successful method of harvesting trefoil.

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