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Red clover (*Trifolium pratense* L.) was one of the first legumes grown in Minnesota. Although it is native to southeastern Europe and Asia Minor, it is adapted in many humid parts of the world. Early colonists brought red clover seed to New England. Today red clover is raised in all parts of the United States where rainfall is sufficient for its growth or where irrigation is available.

Red clover, a short-lived perennial, generally acts as a biennial under Minnesota conditions. It is grown most widely in the southeast, northeast, and north-central sections. In some years the acreage across southern Minnesota increases, indicating that red clover can be produced throughout the state and is acceptable as a forage crop.

Besides being a cheap source of good livestock feed, red clover contributes to and helps maintain desirable soil conditions. Exact acreage and distribu-

tion data for red clover in Minnesota are not known because it is often grown in mixtures and used for numerous purposes such as hay, pasture, silage, and seed production.

From 1959 through 1963, clover-timothy mixtures were grown for hay on an average of 544,000 acres annually in Minnesota; annual production averaged 837,000 tons. Acreage decreased during 1964 and 1965 to 466,000 acres, and production was 769,000 tons annually.

The average annual production of red clover seed was 4,306,000 pounds from 51,000 acres during 1954-65 (see table 1). The value of this seed averaged \$1.25 million a year. Although total acreage decreased during this period, production per acre increased slightly.

While overall acreage and production of red clover seed have been decreasing, production of

Table 1. Red clover seed acreage, yield, production, and value, and amount of seed certified, Minnesota, 1954-65

Year	Acreage harvested	Yield per harvested acre	Production (clean seed)	Season average price per 100 pounds	Value of production	Seed certified
	1,000 acres	pounds	1,000 pounds	dollars	1,000 dollars	pounds
1954	79	82	6,478	41.60	2,695	.....
1955	100	70	7,000	29.30	2,051	.....
1956	57	72	4,104	33.90	1,391	.....
1957	65	65	4,225	25.20	1,065	.....
1958	63	75	4,725	30.50	1,441	645
1959	38	95	3,610	25.40	917	1,031
1960	55	110	6,050	19.90	1,204	3,386
1961	27	115	3,105	28.40	882	30,926
1962	27	85	2,295	32.20	739	21,065
1963	29	125	3,625	31.80	1,153	55,608
1964	38	90	3,420	23.00	787	117,118
1965	32	95	3,040	22.50	684	26,192

Sources: State Farm Census and the Minnesota Crop Improvement Association.

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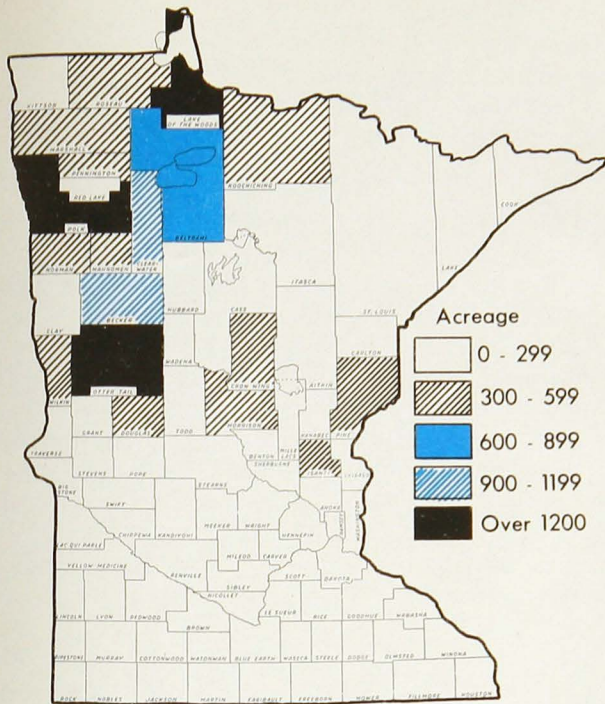


Figure 1. Distribution and average annual acreage of red clover cut for seed, Minnesota, 1961 through 1964. Source: State Farm Census.

certified seed has been increasing. Certified red clover seed was not produced in Minnesota prior to 1958. Distribution of seed production from 1961 through 1964 is shown in figure 1.

Varieties and Types

The two general types of red clover are:

- Medium or double-cut types which are predominant in the United States and most of Minnesota.

- Mammoth or single-cut types which are used sometimes in northern Minnesota.

MEDIUM RED CLOVER

Most Minnesota farmers prefer medium or double-cut red clover because it allows for two hay cuttings, one hay cutting plus grazing, a full hay cutting plus seed production (in the southern two-thirds of the state), or a hay cutting plus regrowth for plow down in one season. Regrowth after the first cutting is often used for a purpose other than hay.

Since 1945 the Minnesota Agricultural Experiment Station has conducted trials with named red clover varieties (see table 2). All varieties were harvested at the same time each year at each station. In 30 station years of trials, Lakeland and Dollard yielded significantly better—approximately one-fourth ton per acre—than either Pennscott or Kenland. The difference could mean a substantial amount to individual farmers as well as to Minnesota's agricultural economy.

The consistently higher yields of Lakeland and Dollard show their superior adaptation in this state. Yield differences between locations for the same variety do not indicate poor adaptation in some areas, but may reflect fertility levels in tests or rainfall differences between stations and years.

Red clover normally acts as a biennial in Minnesota. With good fertility and management and when diseases and winterkilling are not major factors, red clover can survive longer than 1 crop year. This characteristic can be advantageous if you grow red clover in a mixture with grasses; you then can maintain the legume content of such mixtures for an extended time.

Between 1955 and 1962, five variety trials were

Table 2. Average hay production of four red clover varieties the 1st year after seeding with three or four replications in each trial, seven Minnesota Agricultural Experiment Stations, 1957-64*

Variety	Station and number of years of trials							Average of 30 station years
	Rosemount 4	Waseca 5	Lamberton 2	Morris 3	Crookston 4	Grand Rapids 8	Duluth 4	
	tons per acre.....							
Lakeland	3.60	2.49	3.18	2.76	1.39	3.43	2.96	2.83 at
Dollard	3.68	2.41	3.37	2.76	1.44	3.35	2.82	2.83 a
Pennscott	3.34	2.32	2.98	2.61	1.22	3.12	2.72	2.61 b
Kenland	3.52	2.27	2.79	2.58	1.12	3.04	2.78	2.58 b

* Either one or two cuttings were made at different stations and in different years.

† Averages with the same letter are not significantly different from one another.

Table 3. Red clover forage yields of the 2nd crop year, three Minnesota Agricultural Experiment Stations, 1955-62

Variety	Rosemount		Waseca	Grand Rapids		Average
	1959* 1961	1960 1962	1959 1961	1955 1957	1957 1959	
	..... tons per acre.....					
Lakeland	1.10	3.56	2.18	2.85	2.44	2.43
Dollard	1.00	3.71	2.04	2.75	2.49	2.40
Pennscott	0.59	3.72	1.38	2.39	2.19	2.05
Kenland	0.73	3.04	1.64	2.46	2.12	2.00

* Top date is year seeded; bottom date is year harvested.

Table 4. Average stand percentages recorded in 25 station years, seven Minnesota Agricultural Experiment Stations, 1957-63

Variety	First crop year	Second crop year
	..... percentage of stand.....	
Dollard	84.1	59.7
Lakeland	82.2	50.4
Pennscott	76.6	30.1
Kenland	75.9	33.1

maintained into the 2nd crop year. Forage yields from these trials are presented in table 3. Average stand percentages for 25 station years between 1957 and 1963 are presented in table 4. The better persistence of Lakeland and Dollard probably indicates that they are more disease resistant than the other two varieties.

Variety recommendations are based on superior yield potential under Minnesota conditions. Yield potential largely depends on inherited yielding capacity, ability to recover after harvest, winter-hardiness, and disease and insect resistance. When new varieties are developed, they are tested by the Minnesota Agricultural Experiment Station. Performance data are reported in University of Minnesota Miscellaneous Report 24, *Varietal Trials of Farm Crops*. Refer to this publication before selecting varieties.

MAMMOTH RED CLOVER

Mammoth or single-cut red clover usually is less desirable than medium red clover for hay production in Minnesota. It generally produces only one hay crop in a season, and that crop is rank and of poorer quality than medium red clover. Neverthe-

less, many northern Minnesota farmers prefer mammoth clover because of the large yield from the one cutting. Seed production is only dependable from the first cutting in any season.

Adaptation and Fertilization

Red clover has found greatest favor where soils are acid and low in fertility because it is more productive than other legumes under these conditions. When the price of red clover seed is low compared to alfalfa seed, red clover acreage usually increases in some or all Minnesota areas. On droughty soils and on wet soils with high water tables, stands and

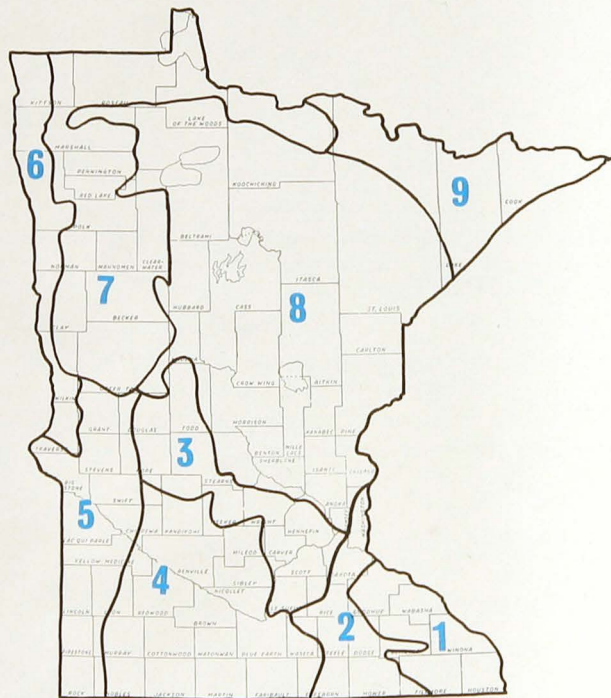


Figure 2. Soil areas with similar fertility needs.

Soil area	Average fertility		Total plant food recommended		Example grade	Rate per acre
	P	K	N+P ₂ O ₅ +K ₂ O	N+P+K		
1	M*	M	8+25+70	8+11+59	4-12-36	200
2	M	L to M	10+35+90	10+13+75	4-12-36	250
3	M	M	8+25+70	8+11+59	4-12-36	200
4	L to M	M to H	15+60+30	15+26+25	6-24-12	250
5	L	H	20+85+0	20+37+0	11-48-0	175
6	L to M	H	10+50+0	10+22+0	11-48-0	100
7	M to H†	L to M	12+25+50	12+11+42	6-12-24	200
	L to M‡	M to H	15+45+15	15+20+13	10-30-10	150
8	H	L	12+25+165	12+11+140	6-12-24	200
					+0-0-60	200
9	Limited agriculture, no general recommendations					

* M = medium, L = low, H = high.

† Coarse textured soils (loams or coarser).

‡ Fine textured soils (silt loams or finer).

yields are inadequate for economic production. For maximum yields, use soils that are naturally well drained or tile drained.

Although you can establish red clover and get moderate yields without using fertilizers, you will obtain the most profit by adjusting the soil to adequate pH and fertility levels and by selecting the legume crop that grows best under these conditions. Red clover does well with pH ranges of from 5.5 to 6.5, but liming to a pH of 6.5 is recommended. Incorporate lime 6 to 18 months before seeding. Red clover also responds well to added phosphorus and potassium where these nutrients are deficient. Addition of these elements supplies carryover fertility for following crops.

Soil areas with similar fertility needs are grouped together in figure 2. Suggested fertilizer grades and rates are based on averages determined by soil test summaries. But to know your exact fertility needs, have your soil tested.

The fertilizer suggestions in figure 2 are for new seedings of red clover when established with a small grain companion crop. Fertilizer that you topdress after harvesting the companion crop is not as effective as fertilizer incorporated into the soil before seeding. Fertilizer containing nitrogen primarily benefits the grain crop but also helps establish the clover seeding. If you topdress red clover after removing the companion crop, don't use a nitrogen fertilizer.

Soil Improvement

Red clover, like other legumes, adds nitrogen to the soil by converting atmospheric nitrogen to a

form usable by plants. The amount contributed depends on whether you plow down the clover the 1st year or let it remain on the field a 2nd year. If you remove one cutting for hay and plow under the second cutting, more nitrogen is added to the soil than if you remove two cuttings and return only roots and stubble to the soil.

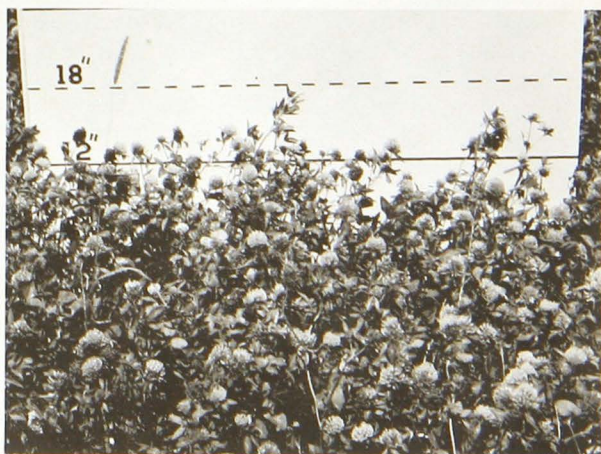
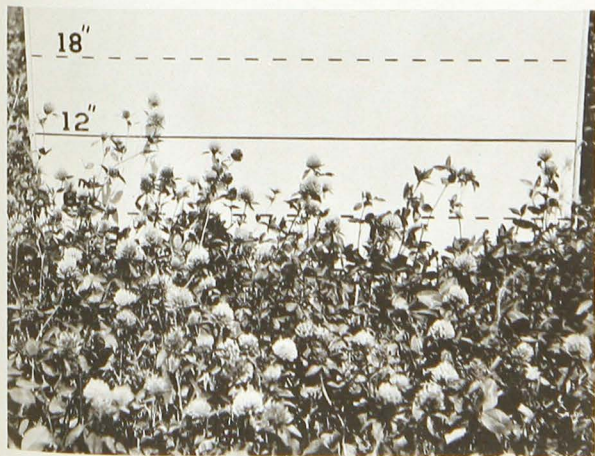
Increases in yields of crops following legumes vary with the soil's initial nitrogen fertility. If the soil is initially high in nitrogen, only small benefits are observed. According to Minnesota studies, clover, when plowed down, is nearly as effective as alfalfa in supplying nitrogen. Growth conditions and the legume's vigor of growth greatly determine the amount of nitrogen supplied when you use the crop as green manure.

Soil receives benefits other than nitrogen from the clover crop. During the time the field is in sod, especially if the crop is a legume-grass combination, erosion is practically negligible. The soil is physically improved in an approximate proportion to the total amount of added organic residue.

Establishing Stands

Seeding failures are costly—you lose seed, time, labor, and money. Failures also upset crop rotation systems and create hay and pasture shortages. Carelessness in any step of establishment can cause seeding loss and wasted effort. But if you follow good seeding methods, you will need less seed per acre to establish stands and reduce chances of failures.

Soil Test, Lime, and Fertilize—Make fertilizer and lime applications according to soil test—not by



Second year growth of red clover at the Agricultural Experiment Station at Rosemount, Minnesota. Left: no fertilizer; right: 300 pounds per acre of 0-20-20 applied at seeding. The taller, thicker, more luxuriant growth shown at the right is a direct response to fertilizer.

guess. Instead of disking in lime and broadcast fertilizer after plowing, make plow down applications; these applications are placed deeper so they are more readily accessible to plants. If your field is to be fall plowed, do your sampling and testing early enough to have lime and fertilizer spread before plowing. To prevent delays due to heavy workloads in the soil testing laboratory, take samples in the fall for spring plowing. Incorporate lime 6 to 18 months before seeding.

Select Good Seed—Select the best quality seed of a variety adapted to your area. Poor quality seed can lead to poor germination or introduction of other crop seeds or weeds. Seed certification is your assurance of getting the variety you want. Certified seed is produced under rigid field and laboratory inspections. Accurate records of seed sources are kept, and varietal purity is strictly maintained.

High quality seed has good germination and mechanical purity. Percentage figures for these two factors appear on the seed analysis tag. After selecting a variety, make further selections for high quality by studying the tag.

Prepare a Good Seedbed—Because clover seed is small, don't seed it deeper than one-half inch. Seeds must have close contact with soil; moisture must be maintained near the soil surface. A firm seedbed helps achieve these conditions.

For spring seedings, fall plowing is better than spring plowing because the soil has more time to become firm and establish better contact between the plow layer and soil beneath. If you plow in the spring, you must make a firm seedbed by working with harrows, disks, and cultipackers.

Cultipacking before seeding is helpful, particularly if seed is drilled. Cultipacking prevents the drill from seeding too deeply and puts seed in close contact with firm, moist soil.

Inoculate Clover Seed—Legumes can utilize nitrogen from air because of the rhizobia bacteria that grow in their root nodules. However, the bacteria population probably is inadequate for good nodulation if well nodulated plants of the same legume were not grown on the soil for several years. If you have any doubt about adequate bacteria populations, inoculate your legume seed. Commercial inoculants sold by seed dealers are satisfactory for this purpose. Preinoculated legume seed also is available. If the seed was commercially inoculated within 6 months of planting and stored under cool temperatures, good nodulation is probable.

But you may simply waste the time and money

spent for proper inoculation if your soil pH and fertility are not satisfactory for good plant growth. Poor soil conditions can result in poor nodulation.

Seed at Right Time—You usually will obtain your best stands if the weather is cool and moist after seeding. Such conditions help keep the soil moist around germinating seeds and young seedlings. Therefore, early spring seedings are generally the most successful. If moisture is adequate for germination and establishment, summer seedings also are profitable.

Because seedlings must make adequate growth before winter to survive, do not seed clovers later than August 1 in Minnesota. Clover seedlings are more susceptible to freezing injury than alfalfa seedlings.

Seed Carefully—Shallow seeding is essential. Red clover seeds have little stored food available to use for emerging from deep in the soil. But don't leave seed on the soil surface where the whole seed cannot contact moist soil.

Band seeding has given excellent results in many trials. If you seed directly over a band of fertilizer, young seedlings are lightly covered with soil and have a nearby source of fertilizer immediately after germination. You can attach flexible hoses rigidly to the drill and arrange them to place seeds 10 to 12 inches behind the drill shoe. Use of a cultipacker after seeding helps establishment.

Another reliable seeding method is drilling into a firm, moist seedbed. A firm seedbed is essential to prevent the wheels and disks from sinking too deeply into the soil. In summer seedings or when surface soil is dry, cultipacking after drilling can aid establishment. You may hinder establishment if you follow the drill with a cultipacker when the soil is moist.

Seeding Rates and Mixtures—Since red clover normally behaves as a biennial, it is used primarily in stands planned for 1 or 2 years. When seeded alone, the recommended rate is 8 to 10 pounds per acre.

Red clover usually is seeded in mixtures with grasses or other legumes and grasses. Typical mixtures with uses of each are shown in table 5.

Companion Crops—Companion crops are seeded with forages to reduce weed competition. But they also provide extra competition for the forage seeding. Improperly managed companion crops can damage forage seedings. Properly managed companion crops retard weed growth, reduce soil erosion, and provide a return from the land while the leg-

Table 5. Some common forage mixtures using red clover

Mixture	Use
1. Clover, 6 to 8 pounds (may be: (1) 8 pounds red clover or (2) 5 pounds red clover and 2 pounds alsike). Timothy, 4 pounds.	Silage or hay in short rotation — not as productive as alfalfa-grass mixture.
2. Alfalfa, 5 pounds. Clover, 3 pounds (may be 2 pounds red clover, ½ pound alsike, and ½ pound Ladino). Grass, 7 to 8 pounds (may be: (1) 8 pounds brome, (2) 6 pounds brome and 2 pounds timothy, (3) 5 pounds brome and 2 pounds orchardgrass, or (4) 5 pounds brome and 3 pounds meadow fescue).	Best mixture for flexible use, pasture, grass silage, or hay. Alsike and Ladino good for low areas in field where alfalfa kills out. Double rate of Ladino if primary use is for poultry or hog pasture.
3. Clover, 6 to 7 pounds (may be: (1) 6 pounds red clover or (2) 4 pounds red clover, 2 pounds alsike, and ½ pound Ladino). Grass, 6 to 8 pounds (may be: (1) 6 to 8 pounds brome, (2) 6 pounds brome and 2 pounds timothy, or (3) 5 pounds brome and 3 pounds meadow fescue).	Pasture, silage, and hay.

umes and grasses are getting established.

When using oats as a companion crop, seed them at one-half to two-thirds the normal rate. Select only early maturing, stiff-strawed varieties if you plan to harvest grain. Late maturing varieties offer competition for a longer period and hinder forage establishment. Weak-strawed varieties may lodge and smother the seeding.

To help establishment materially, remove the oat crop for hay or silage by the dough stage. When oats are 10-12 inches tall, they may be grazed off. But prevent excessive grazing of the forage seeding. When you combine a companion crop, remove straw promptly to prevent smothering of the seeding.

Flax is an excellent companion crop and can be seeded at normal rates.

Consider Chemical Establishment — You can establish stands without companion crops by controlling weeds with chemicals. Stands the year after establishment are usually more vigorous and thicker when established chemically than when established with a companion crop because there is little competition from either weeds or the companion crop.

However, this establishment method requires an out-of-pocket expense for chemicals and an extra spraying operation. And it yields no return from a companion crop. You must weigh the value of the possibility of a better stand and of one hay crop the 1st year against the cost of chemicals and no return from a companion crop.

Before using chemicals for weed control, read the label on the container and follow directions exactly. Be certain the chemical is cleared for your intended use. Labels on old containers may have out-of-date information. University of Minnesota Extension Folder 212, *Cultural and Chemical Weed Control in Field Crops*, contains suggestions for specific chemicals and details about application. This publication is revised annually.

Red Clover for Hay, Silage, and Pasture

Red clover and clover-grass mixtures are useful as hay, silage, and pasture crops. They fit readily into many crop rotations and improve physical conditions of the soil for future crops.

Hay — Red clover hay is readily eaten by most livestock. If it is not well cured, however, it may be too dusty; its palatability then is reduced. The protein content in red clover is usually higher than it is in grasses but slightly lower than it is in alfalfa.

For hay, cut the first crop of red clover or red clover-grass mixtures in early bloom stage. The hay will be leafier and more valuable as feed than if cut when more mature. Cutting in early bloom also allows plants more of the growing season for regrowth.

To reduce drying time and save leaves, condition hay with a crusher or crimper. Stems normally dry slower than leaves. Breaking the stems speeds drying so the leaves are not as likely to get brittle while the stems cure. Brittle leaves shatter when the crop is handled. Because more feed value is concentrated in leaves than in stems, the hay loses value when leaves are lost. Quick drying also helps get the crop into storage early, thereby reducing chances of rain damage.

You can also reduce leaf loss by wilting the crop in the swath and then raking it into windrows while it is still damp. Hay cures almost as rapidly if it is raked when the leaves on top of the swath are ready to shatter as when all curing is done in the swath. If you must rake the hay after this stage of curing, you will lose the fewest leaves by raking in the morn-

ing or evening when the crop is damp with dew.

Silage—Red clover is useful for silage if handling and storage are satisfactory. Although you should cut the crop at the same stage as for hay production to get best feed value, direct chopped clover plants in early bloom contain too much water for silo storage. Wilt before chopping. Excess water seeps out, carrying some feed nutrients with it. Excess water also retards preservation so sour smelling, unpalatable silage results.

Wilting avoids these problems; addition of carbohydrates to high moisture silage also helps. To speed wilting and reduce field losses, condition the crop. Exclusion of air from silage is necessary for adequate preservation. For further information, see Extension Bulletin 308, *Silage Production and Preservation*.

Pasture—Red clover makes excellent pasture for all livestock. However, like other clovers and alfalfa, it may cause bloat. Red clover-grass mixtures are less likely to cause bloat than pure clover stands. Although the exact cause of bloat is unknown, it usually is associated with livestock eating too much and too fast when turned onto a pasture of succulent legumes. To avoid bloat, do not start hungry cattle on pasture. Provide readily accessible supplies of water, salt, and dry forage in the pasture.

Grazing is most efficient if livestock are allowed only as much pasture at one time as they can consume in several days or a week. Move them to a new area when a pasture is grazed down. Allow 3-4 weeks before again starting the grazing cycle on the first area.

Regrowth of red clover can be pastured after you harvest the hay. But give the regrowth a chance to recover from cutting or you will weaken stands and reduce yields during the season.

Seed Production

If you plan to produce red clover seed, select a variety for which there is a market. The demand is increasing for certified seed of improved varieties. Before beginning production of certified seed, contact the Minnesota Crop Improvement Association for a copy of "Minnesota Seed Certification Standards." Standards are set for germination, varietal purity, weed seed content, etc. Certification requirements include:

- Seeding of foundation or registered seed if there is a registered class.

Table 6. Red clover seed yields in pounds of seed per acre from different seeding rates and methods, Crookston, 1960 and 1961

Variety	18-inch rows (pounds per acre)				Broadcast (pounds per acre)	
	1	2	3	4	2	4
1960	.....pounds of seed per acre.....					
Dollard:						
Early clipped	420	420	.....	358	325	356
Late clipped	397	376	.....	338	400	316
Lakeland:						
Early clipped	640	550	.....	491	304	386
Late clipped	565	517	.....	495	408	349
1961						
Dollard:						
Early clipped	522	475	527	460	435	478
Late clipped	599	537	577	445	351	416
Lakeland:						
Early clipped	767	609	615	560	436	533
Late clipped	710	679	813	548	591	570

- Cropping history.
- Isolation from other red clover.
- Field inspection.

Seed fields can be sown broadcast at about 2 pounds of seed per acre or in 18-inch rows at 1-1½ pounds per acre. One or two cultivations during the seeding year are possible in row plantings for weed control. Cultivate in such a way that soil is level for harvesting. Roguing is easier and more effective in rows than in broadcast plantings. In Minnesota trials, seed yields from 18-inch rows seeded at 1-2 pounds per acre equaled broadcast plantings at 4 pounds (table 6).

Harvest seed of medium red clover the year after seeding. Clip the crop in early to mid-June. At this time in northern Minnesota (and perhaps in southern areas), forage yields are not sufficient to produce hay or silage economically. Early clipping forces flowering during a period when conditions are favorable for pollination and there is less competition for bees. Weather is often best for seed maturation when seed is produced after a clipping. Clipping also reduces the amount of straw that must be handled.

Red clover seed usually is marketed through established seed companies. These companies have facilities for cleaning, packaging, storing, and selling seed.

Demand for seed of mammoth red clover is not as great as for medium red clover. Seed production

of mammoth is dependable only from the first cutting in any one season. Mixtures of both types are discounted in the seed trade.

POLLINATION

Lack of pollination largely accounts for unsatisfactory red clover seed yields in Minnesota. Pollination of the seed crop is done almost entirely by honey bees and several species of wild bees. An individual honey bee may work red clover for pollen and/or nectar. The red clover floret is a closed tube with pollen near the mouth. Therefore, any bee visiting florets on different red clover plants for either pollen or nectar will effect cross pollination.

Bumblebees usually pollinate red clover more efficiently than honey bees. They stay longer hours in the field, visit more florets per minute, and work in cooler temperatures than honey bees. Nevertheless, if honey bees are more abundant than bumblebees, they may pollinate a larger proportion of the seed crop. Since the abundance of bumblebees varies considerably from year to year and from farm to farm, you cannot depend on them for adequate pollination. So locate two strong colonies of honey bees per acre in or near red clover fields.

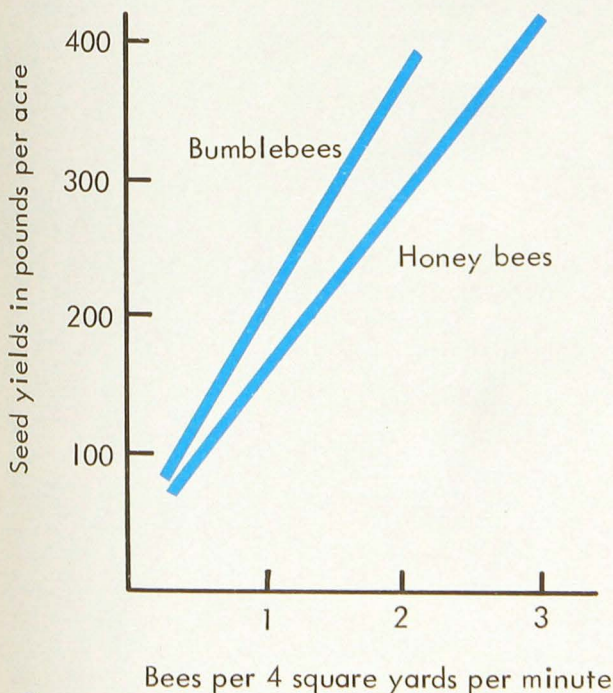


Figure 3. Effect of varying numbers of either honey bees or bumblebees on seed yields of second crop medium red clover, Clearwater and Polk Counties, Minnesota. Source: A. G. Peterson, B. Furgala, and F. G. Holdaway. Aug. 1960. "Pollination of Red Clover in Minnesota." *J. Econ. Ent.* 53 (4): 546-50.



Honey bees are important for red clover seed production. Because colonies can be controlled, satisfactory populations can be maintained for adequate pollination and seed production. This honey bee is taking nectar from a floret of a red clover blossom.

As illustrated in figure 3, a field of red clover should have an average of two or more bees per 4 square yards. Count the numbers of bees in several 4-square yard areas about twice a week. If there are not enough bees for adequate pollination, locate more honey bee colonies near the field while plants are in bloom. Although the information in figure 3 is a useful guide, results may vary between seasons and locations.

Locate colonies either in the red clover field, along its margins, or within one-fourth mile of it. The abundance of honey bees on red clover decreases markedly when the apiary is more than one-half mile away (see table 7). Calculated seed yields resulting from pollination by honey bees also decreases with increasing distance between the apiary and the field.

Honey bees prefer alfalfa and sweet, alsike, Ladino, white, and mammoth red clovers to medium red clover. However, they adequately pollinate medium red clover if competing crops are not available. In northern Minnesota, clipping red clover in mid-June largely eliminates such competition by delaying flowering of red clover until after the flowering of competing crops. Harvesting nearby alfalfa hay fields in early bloom removes that source of competition.



Good seed yields depend largely on the number of bees actually working in the clover blossoms. Counting the number of bees per minute working in a 4-square yard area of clover is a good way to determine if the population is adequate. Two or more bees per minute in 4 square yards are desirable for good pollination.



Large populations of honey bees are essential for good yields of red clover seed. Forty colonies of honey bees were located along the edge of this 20-acre seed production field near Fosston, Minnesota. The field yielded 500 pounds of seed per acre.

Table 7. Relationships of honey bee abundance and seed yields to the distances between fields of second crop medium red clover and the nearest apiary, Clearwater and Polk Counties, Minnesota, 1953-56

Year	Distance from apiary	Bees per 4 square yards per minute		Seed yield	Yield owing to honey bees
		Honey bees	Bumble-bees		
	miles	average number		pounds per acre	
1953	0	2.16	0.30	540	456
	1.0	0.67	0.24	190	129
1954	0	3.01	0.43	507	426
	0.75	1.85	0.62	469	324
	1.25	0.56	0.34	116	64
	3.00	0.04	0.99	383	11
1955	0	1.30	0.07	222	207
	0.25	1.71	0.09	224	209
	1.00*	1.78	0.09	271	254
	1.00	0.43	0.78	270	79
	1.75	0.02	0.05	32	7
	4.00	0.02	0.09	42	6
1956	0	1.73	0.56	276	193
	0.25	1.60	0.56	370	252
	1.50†	0.97	1.35	235	82
1956	0.25	1.27	0.30	162	123
	0.50	1.90	0.35	247	198
	1.25	0.25	0.33	46	17

* Equidistant from two apiaries.

† Honey bees quite numerous at one end of field as if from a bee tree but the source was not found.

Source: A. G. Peterson, B. Furgala, and F. G. Holdaway. Aug. 1960. "Pollination of Red Clover in Minnesota." *J. Econ. Ent.* 53(4):546-50.

HARVESTING THE SEED

Red clover generally is ready for harvest when most seed heads are brown but before they start to shatter. Weather often affects maturity; observe the field frequently so that harvest is not delayed. The most common practice in Minnesota is to swath the crop and then thresh a few days later with a pickup combine. Most attempts to use defoliant have not been satisfactory.

Although you can adjust most combines for threshing red clover, observe the operation to be certain that a good job is done. Cylinder speeds, air, and screens must be properly adjusted. To prevent seed losses in the field, the combine must be tight. According to experimental studies, over half of the red clover seed may be lost during the threshing operation.

Clovers for Bee Pastures

Clovers are excellent sources of nectar and pollen for honey bees; the honey derived from clovers is light colored and mild flavored. Minnesota frequently ranks first nationally in production of honey and beeswax. Although sweet clover and alsike clover used to provide enough nectar for the honey bees, reduced acreages of these crops in recent years have raised problems for the beekeeper. Without adequate bee pasture, Minnesota's production of honey and beeswax cannot be maintained.

Beekeepers might profitably move bees from one flowering crop to another as they come into bloom. Trucks can be equipped with a hoist or bees can be left on trailers to facilitate the moving of hives during the summer.

To utilize existing acreages of clovers most efficiently, beekeepers should locate colonies at intervals along field margins or within fields. Red clover has less nectar than sweet clover. But in the absence of sweet clover, honey bees can collect an appreciable quantity of nectar from red clover.

Consider planting clovers primarily for bee pasture as well as for seed and forage production. Arrange cutting schedules to provide a sequence of bloom. Clovers are desirable for the production of honey—bees are essential for production of clover seed. Farmers and beekeepers will find that cooperation works to their mutual advantage.

Injurious Insects

INSECTS AFFECTING FORAGE PRODUCTION

Because red clover fields are suitable breeding places for red-legged and migratory grasshoppers, grasshoppers greatly affect forage production. Succulent red clovers attract grasshoppers from nearby fields and roadsides. Inspect your red clover fields for young grasshoppers particularly. Look for ragged foliage, the first sign of grasshopper injury.

The tarnished plant bug, *Lygus lineolaris* (P. deB.), may cause dead and deformed areas in leaves and stunting of plants. This species is probably more important on clover grown for seed than on clover grown for forage.

The pea aphid, *Acyrtosiphon pisum* (Harris), and other species of plant lice occasionally cause curling of leaves, wilting, and stunting of new growth. They also transmit several virus diseases.

The potato leafhopper, *Empoasca fabae* (Har-

ris), frequently is abundant enough in southern Minnesota to cause curling and drying of leaves, shortening of internodes, and stunting of plants.

INSECTS AFFECTING SEED PRODUCTION

Plant bugs generally are the most important pests on red clover grown for seed. These pests include the tarnished plant bug, *Lygus lineolaris* (P. deB.); the rapid plant bug, *Adelphocoris rapidus* (Say); and the alfalfa plant bug, *Adelphocoris lineolatus* (Goeze).

All three plant bugs produce similar injuries consisting of dead and deformed areas in leaves, stems, and flower heads and shortening of internodes. In 15 experiments conducted over 4 years, these plant bugs and lesser clover leaf weevils were controlled by an insecticide application when clover was in the bud stage. The result was an average increase of 73 pounds of seed per acre.

The lesser clover leaf weevil, *Hypera nigrirostris* (F.), is a striking blue-green snout beetle about one-eighth inch long. It is usually a minor pest of red clover. However, the larvae may become so abundant that their burrowing in buds and terminal shoots almost eliminates flowering.

The clover seed midge, *Dasineura leguminicola* (Lint.), and the clover seed chalcid, *Bruchophagus platyptera* (Walker), may be important on first crop medium red clover or on second crop clover following a late cutting of the first crop. The pink midge larva develops inside the floret and destroys the ovary. Infested florets do not open; heads develop a deformed, uneven appearance. The chalcid larva develops inside the maturing seed. At harvest-time, each infested seed is only a shell with a round hole through which a chalcid wasp emerged.

The only effective control for the midge and the chalcid is to cut the first crop at or before 10-percent bloom. Then larvae cannot complete their growth. If you leave the first crop past 50-percent bloom, many midges and chalcids emerge and infest the seed crop.

While red clover thrips, *Haplothrips niger* (Osborne), can be found in most flower heads of red clover, they are seldom important pests. The adults are small, slender, black insects; the young are bright red. When numerous, thrips may discolor petals and injure the anthers and pistil. Consider controlling thrips if you find more than 10 to 15 per head of clover.

The clover seed weevil, *Tychius stephensi* (Schonk.), is a tiny, gray, snout beetle whose larvae destroy maturing clover seeds. Usually occurring in

small numbers, this pest has not been important in Minnesota.

INSECT CONTROL

Since insecticide recommendations change frequently, always consult current publications of the Minnesota Agricultural Experiment Station and Agricultural Extension Service. Extension Bulletin 263, *Insecticides and Their Uses in Minnesota*, is revised annually.

You normally do not have to use insecticides for controlling plant bugs, leafhoppers, and aphids on clover grown for forage. If plant bugs or leafhoppers become more abundant than three per sweep of an insect net, or aphids more abundant than 100 per sweep, control may be justified. To control large grasshopper populations, apply insecticides with aerial or ground equipment.

To control grasshoppers, plant bugs, leafhoppers, and the lesser clover weevil in red clover for seed production, apply insecticides before flowers bloom. If you must spray during the flowering period, use only materials with a low toxicity to bees; make applications in late evening or early morning when bees are not in the field. After colonies of honey bees are located near the field, do not apply insecticides without the beekeeper's consent.

Diseases of Red Clover

Diseases of clovers cause heavy losses in most areas of Minnesota, especially when the crop is grown for forage or seed instead of being plowed under for green manure. Diseases of red clover, alsike clover, Ladino clover, and sweet clover often are the same or similar.

The most common diseases of clovers are seedling blight (damping-off), crown and root rots, black stem, mildew, leaf spots, and rust. They generally cannot be completely controlled, but you can reduce severity through:

1. Use of adapted resistant varieties.
2. Seed treatment.
3. Sanitation.
4. Good cultural practices.

DAMPING-OFF OF SEEDLINGS

Caused by soil-borne fungi, damping-off may occur either before or after seedlings emerge from

the soil. In some cases, particularly if seed is cracked or of poor quality, the seed may rot in the soil before it germinates. Damping-off is most likely to occur if:

- Seed is of poor quality.
- Seed is planted more than one-half inch deep.
- Soil is heavily infested with one or more damping-off fungi.
- Seeding is followed by unfavorable growing weather.

To control damping-off, prepare the seedbed carefully and follow the planting methods described in this bulletin. Although seed treatment usually controls damping-off, results of extensive field tests do not justify recommending it. Stands of red clover were increased only slightly by seed treatment. Since treating red clover seed does not reduce germination or nodulation, you may want to treat for the added assurance of getting a good stand. If so, use a fungicide according to label directions for red clover. But you may prefer to have your seed treated with a commercial treater or to buy treated seed.

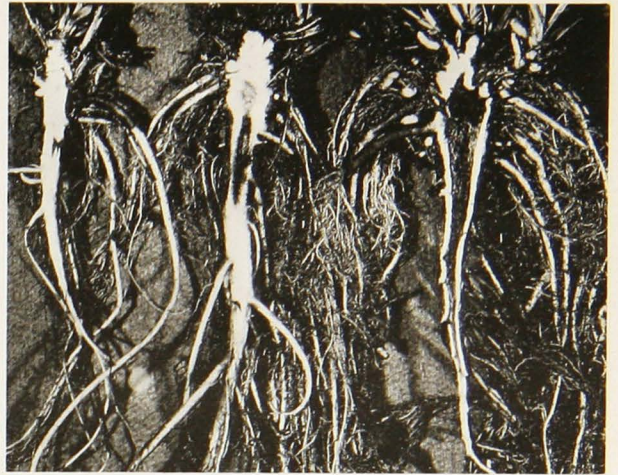
The question is frequently asked, "Is it safe to inoculate treated legume seed with nodule bacteria?" In field tests at St. Paul, the number of nodules was not less on plants grown from seed inoculated following seed treatment. Treat seed several days or several weeks before planting. If you use nodule bacteria, apply them immediately before planting according to directions on the containers. Do not treat preinoculated seed.

CROWN AND ROOT ROTS

Crown and root rots are caused by approximately 20 different fungi species, many of which live for a long time in soil. Some of these fungi injure clover roots and crowns at all periods of growth, from very early spring through hot dry mid-summer to cool fall. At least three species can grow at temperatures below freezing.

A close relationship exists between winterkilling and crown and root rots. Plants having low vigor because of low temperatures, drying, and smothering or plants injured by freezing, thawing, and heaving of the soil are readily attacked by these fungi. Damage frequently occurs during thawing and freezing periods in spring when plants are resuming growth. Injuries resulting from frost offer excellent entrances for fungi.

Root and crown rots also make plants suscepti-



Root rots are usually more severe the year after seeding than in the seeding year. Root interiors are brown and soft. Frequently the main root of the plant may be completely decayed.

ble to winterkilling. For example, plants infected with these diseases in summer may go into winter dormancy in a weakened condition. Because they do not function properly, they cannot store enough food to carry them through winter.

To control these diseases, use adapted varieties and good crop management. Even in the absence of crown and root rots, varieties that are adapted to a given area survive unfavorable periods better than unadapted varieties. In addition, adapted varieties are not predisposed to diseases as readily as unadapted varieties.

And always cultivate carefully—wounds from implements make easy entrances for fungi. Although efforts are being made to develop varieties with more resistance to crown and root rots, such varieties are not presently available.

OTHER FUNGUS DISEASES

Stemphylium leaf spot, *Stemphylium botryosum* Wallr. and *S. sarcinaeforme* (Cav.) Wiltshire, is common on red clover and sometimes kills lower leaves. At first the lesions are small, irregular, dark brown, and sunken; later they develop into irregular, zonate, light- and dark-brown spots. Dead leaves remain on the plants. No control measures are known.

Black stem disease, *Phoma herbarum* West. var. *medicaginis* Fckl. or *Ascochyta imperfecta* Pk., has similar symptoms on different species of clover but may be caused by one or more fungi. The symptoms are partial or complete blackening of stems, girdling of stems, leaf spots, and infection of floral parts.



Leaf spots are caused by a number of pathogens. As seen on this leaf, various pathogens cause different kinds of "spots." Some may be simple brown or black spots, some may be shaped like targets or take other forms. Spots can occur on any above-ground part and may cause early death of the foliage.



Powdery mildew appears first as a light-gray or white powdery growth on leaves. When the disease is severe, infected leaflets turn yellow, then brown, and then die. Yield and hay quality can be reduced by severe infections.

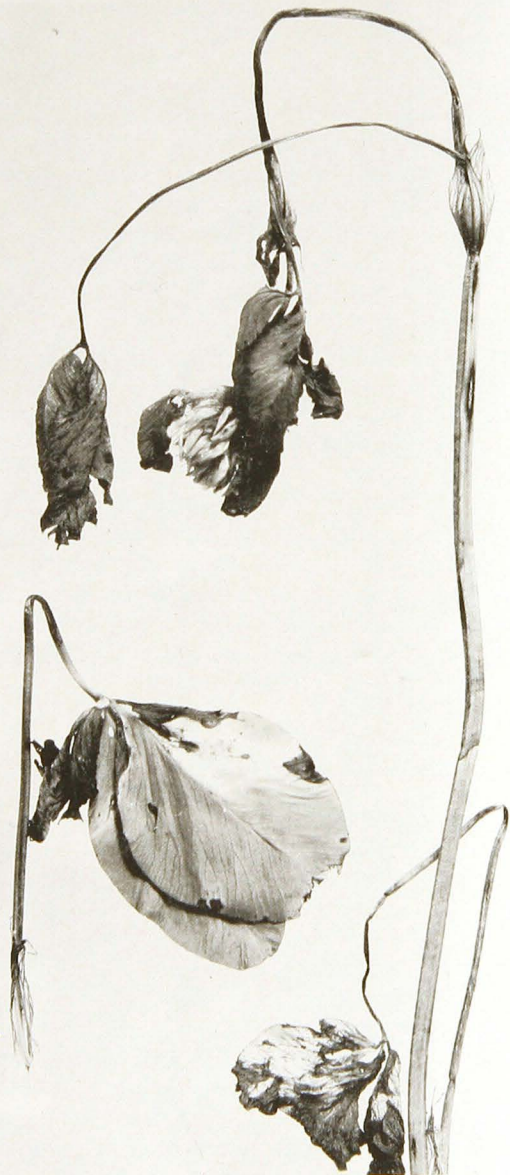
Various phases of the disease appear any time during the growing season; forage losses result primarily from falling leaves or destruction of leaves and stems. If floral parts become infected, seed yields may be reduced considerably.

Control is accomplished by proper management and use of adapted varieties. Crop rotation is practical because the fungus survives in crop residue and can infect a new planting on the same field for 1 or 2 years. You should also remove old stems from fields in early spring before the crop starts to grow. Although this task sometimes can be accomplished by burning, this method is not generally recommended.

Powdery mildew, *Erysiphe polygoni* DC, is a common, widespread disease of red clover. Severe

epidemics reduce forage yield and quality of hay. The disease appears as a light-gray powdery growth on leaves; leaves turn yellow and brown when the infection is severe. To control the disease, use resistant varieties.

Pepper spot, *Leptosphaerulina trifolii* (Rost.) Petr., generally occurs on clovers throughout Minnesota but not in epidemic proportions. It is characterized by numerous black sunken spots on leaves. As the spots grow older, they develop reddish-brown margins. If the disease becomes severe, it causes



Northern anthracnose showing the characteristic "shepherd's crook." Stems and leaf petioles are killed by the pathogen, allowing the leaves to droop and form the crook. Brown, diamond-shaped lesions also appear on stems and petioles.

browning of the leaves. No control measures are known.

Northern anthracnose, *Kabatiella caulivora* (Kirch.) Karak., severely damages red clover during cool, wet periods. Long, brown, sunken lesions harm stems and leaf petioles, and there is frequent girdling of stems. For best control, use resistant varieties. If a severe epidemic develops in your field, harvest early to salvage as much of the crop as possible.

Clover rusts, *Uromyces trifolii* (Hedw. f.) Lev., usually appear in patches on fields. Although individual plants or patches may be seriously reduced in forage quantity by loss of leaves and stems, losses from rusts usually are not great. First crops seldom are heavily infected with rust because they are harvested early enough to escape it. If a second crop is threatened, harvest the crop early to avoid continuous loss.

VIRUS DISEASES

Virus diseases are characterized by various degrees of mottling, streaking, spotting, and yellowing of leaves. The diseases may reduce forage and seed yield; they are generally spread throughout Minne-



sota. Infected plants are easily destroyed by root rots and extreme weather conditions such as high or low temperatures. Varieties with field resistance are preferred over susceptible varieties.

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