

killed at lower rates than weed seeds and fungal or bacterial pathogens.

- **Soil texture.** As the microscopic spaces between soil particles get smaller and less abundant (as in heavy or compacted soils), fumigant rates must be increased to overcome reduced or slower diffusion and penetration. On heavy soils, rototilling (when dry) can increase the pore space of the soil, improving the effectiveness of subsequent fumigation.
- **Soil temperature.** For effective fumigation, soil temperature at a depth of 6 inches must be at least 50°F. Higher soil temperatures favor greater volatilization of fumigants and greater movement through soil spaces.
- **Soil organic matter.** Decomposed organic matter improves soil structure and generally helps fumigant dispersion in the soil. However, very high amounts of organic matter may adsorb or tie up a fumigant, reducing its effectiveness. Fresh (undecomposed) crop debris may hinder fumigant dispersion in the soil and may also harbor insects and pathogens that escape the fumigant. Organic matter is most beneficial when it is thoroughly decomposed.
- **Soil moisture.** Fumigants move in soil water and must enter the soil solution to contact and kill pests. Moderate levels of soil moisture therefore aid in obtaining effective fumigation.

During or immediately after application of soil fumigants, the soil surface should be sealed to prevent the fumigant chemical from escaping into the air too rapidly. This can be done by rolling, irrigating, or covering with a tarp or plastic. At least two to three days of fumigant activity and at least four to 14 days of venting (for fumigant dissipation) should elapse between application of fumigants and planting. A three- to four-week interval is better. For this reason, fall is usually the best time to fumigate. Spring fumigation can be very effective, however, if soils are warm enough and the proper preplant interval is observed. Avoid plowing too deeply after fumigation so that untreated soil is not mixed with treated soil near the surface. Shallow plowing or tilling with clean equipment is recommended. See Table 8-8 (on page 207) for a summary of the characteristics of common soil fumigants.

Preplant Cover Crops

Seeding a preplant or green-manure cover crop on a site the year before planting is an excellent way to improve soil organic matter content. After a season of growth, the green manure is plowed or otherwise incorporated into the soil where it decomposes and adds organic matter to the soil. Benefits of preplant cover crops are greatest when:

- The soil is sandy and organic matter content is low.
- No animal manure is available to add to soil.
- The cover crop is a legume, which offers a good source of nitrogen.

Most cover crops perform best under the same general range of soil nutrients and conditions required by brambles. Small grains or vigorous sod grasses take considerable amounts of nitrogen from the soil but release it back slowly as they decompose. In accordance with soil test results before planting the cover crop, add 40 to 50 lbs. of nitrogen per acre and adjust soil pH, potassium, and phosphorus. These practices will help establish the preplant cover crop and promote more rapid decomposition when it is incorporated, preventing nitrogen drag (a lack of available nitrogen) when brambles are planted the following spring.

Since preplant cover crops are not intended to become permanently established, minimum seeding rates are usually recommended by suppliers to produce an acceptable turf stand. Where a dense, vigorous cover is needed to suppress weeds, higher seeding rates of cover crops such as buckwheat, rye, annual ryegrass, or sudan grass will maximize weed suppression and contribute much organic matter to the soil.

Preplant cover crops are usually plowed under in the late fall or early spring prior to planting. Those with low nitrogen content (most grains and dry grasses) should be plowed under in the fall to allow adequate time for decomposition and to prevent a lack of soil nitrogen needed by newly planted brambles. Leguminous cover crops contain more nitrogen and can be turned down in early spring, a month or so before planting brambles.

Usually, preplant cover crops are incorporated into the soil by plowing, disking, or rototilling before



planting the brambles. Weed-free alleys between rows are then maintained by preemergence herbicides, mulching, or periodic tilling.

An innovative preplant preparation method worth considering is known as killed sod. For the killed sod method, a vigorous sod grass, such as annual ryegrass or tall fescue, is established and then killed with systemic herbicides the following spring. Brambles are planted either directly into the killed sod or into a narrow, tilled strip. Studies of killed sod use in orchards suggest that this method provides some of the benefits of mulches. Killed sod may reduce residual weed seed germination by minimizing soil disturbance and may provide other benefits associated with no-till practices in field crops.

Selecting a Preplant Cover Crop

The selection of a preplant cover crop should depend upon several conditions:

- Time of year
- Crop to follow
- Soil pH and fertility
- Available tillage equipment
- The length of time the cover crop will be allowed to grow.

Descriptions of many species used for preplant cover crops are provided in this section. The descriptions include details about soil requirements, seeding rates, and planting dates for establishment, and other information related to growth and incorporation. Remember that seeding rates for preplant cover crops are much lower than for permanent cover crops because full establishment is not necessary.

Alfalfa is a perennial legume that requires a well-drained soil with a high pH (6.0 to 7.0). The most desirable periods for planting are early April to late May or late July to mid-August. The recommended seeding rate is 145 pounds per acre. Alfalfa grows tall enough to become difficult to incorporate if allowed to overwinter from a spring seeding. The cost of alfalfa seed is much greater than the cost of clover seed. It is recommended that alfalfa seed be inoculated when seeded on an area for the first time.

Buckwheat can be seeded successfully on sites with low soil pH. While there is fast growth of the top

portion of this grain, there is little organic matter contribution from the roots. The plants should not be allowed to mature, since reseeding will readily occur. Early seedings in late May or early June are better than summer seedings in late July. Buckwheat may be seeded at 60 lbs. per acre.

Alsike, ladino, and white clovers have low to moderately upright growth and tend to establish a good legume stand in about 10 weeks. Alsike clover, a very short-lived perennial, can be established on low pH soils. Ladino and other common white clovers respond to high soil fertility (notably phosphorus) and high soil pH. All of these clovers are fair to moderately good nitrogen-producing crops. They establish best when seeded in early April to late May or from late July to mid-August. Early seedings in either season are more successful. A late fall or late winter broadcast application to open ground may be another effective method of seeding these crops, depending on the soil-seed contact that follows.

The cost of seed varies with the type of clover, common white clover and alsike clover being cheaper than ladino. The cost of seed per acre is low for clover preplant cover crops, since the recommended seeding rate is only 4 lbs. per acre of alsike and common white clover and 2 lbs. per acre for ladino. Volunteer clovers grow naturally in most fields, so it may not be necessary to inoculate clover seed; however, several pounds of seed can be treated with inoculant for only a few dollars.

Red clover produces a top growth of 12 to 18 inches and establishes relatively quickly, depending on soil moisture and seed-bed conditions. Red clover grows best in soils with a pH of 5.6 or higher. Like other clovers, red clover should be seeded early in April or late May or from late July to mid-August. Early seedings in either season are more successful. As with white clovers, a late fall or late winter broadcast application on open, unfrozen soil may produce a successful seeding. Red clover is a good nitrogen-producing crop and is adapted to a broader range of soil conditions than alfalfa. The seeding rate for red clover is 8 lbs. per acre.

Sweet clover is a slow- to moderately fast-establishing biennial legume that responds better to higher soil pH than other clovers. It also responds well to soils with good phosphorus levels and is most easily established when seeded from early April to



mid-May or during the first half of August. Large, deeply penetrating roots and heavy top growth make large contributions of nitrogen and organic matter to the soil when incorporated. Second-year top growth may exceed 50 inches. However, this growth must be cut at a lower height and incorporated after cutting. The seeding rate is 12 lbs. per acre.

Hairy vetch is adapted to a range of soil conditions and is a moderately fast-growing winter annual when seeded in August or very early September. In the Northeast, the best practice to ensure good growth is early establishment. This vetch can supply much nitrogen to the soil when grown under ideal conditions. In the mid-Atlantic states, hairy vetch can provide up to 125 pounds of nitrogen for the next crop. Hairy vetch is a true vetch with purple flowers and viney growth, and it should not be confused with another legume known as crown vetch, which is commonly seeded along highways for bank stabilization. Hairy vetch is seeded at a rate of 40 lbs. per acre.

Annual field brome is a fast-establishing winter annual grass and has a much more extensive and fibrous root system than most other green manure crops. Seedlings made during July and August tend to be much more successful than seedlings made in late spring. The following year's spring growth is rapid and, after the seeds ripen in July, the crop can be easily reestablished with no further seeding. Since this is not desirable with a preplant cover crop, thoroughly disk or plow down the heavy root system early in the spring. This seed is not readily available, so plans for obtaining it should be made well in advance of the seeding date. Annual field brome is usually seeded at a rate of 20 lbs. per acre.

Japanese millet is a fast-growing summer annual that competes well with weeds and establishes faster on cooler soils than sudan grass. If planted between late May and mid-July, millet will grow 4 feet high in seven to eight weeks. Unlike small-seeded legumes and grasses, the large millet seed should be covered from 3/10- to 1-inch deep in a firm seedbed. The planting may be cut back and allowed to regrow at any time after reaching 20 inches of growth. Millet should not be allowed to mature and drop seed. Millet seed is relatively inexpensive; seed at a rate of 20 lbs. per acre.

Spring oats, when used as a very early spring green manure crop, should be planted in early to mid-April. Because of the fast spring growth, plan to incorporate the planting in early to mid-June. Oats will grow on soils of relatively low soil pH (5.5) and with moderately good fertility; however, this crop requires good soil drainage. A mid-August seeding will provide good growth and ground cover for protection against soil erosion during the fall and winter months. Oats will be gradually killed back by successive frosts and will not grow again in the spring. The dead plant residue is easily incorporated with very light tillage equipment. Three bushels of oats (approximately 100 lbs.) are usually seeded per acre.

Annual ryegrass seedlings establish very rapidly in spring or late summer. Ideal dates for spring seedings range from early April to early June; late summer seedings are more successful when made from early August to early September. Heavy root growth and rapid seedling development make annual ryegrass a very desirable green manure cover crop in areas where good soil-water relations can be maintained. Ryegrass will die out early in the second year, leaving a heavy root system and a moderate top growth residue to incorporate into the soil. A seeding rate of 10 lbs. per acre is suggested.

Perennial ryegrass seedlings become established more quickly than seedlings of other common perennial grasses such as timothy, brome grass, and orchard grass. The fibrous root system is extensive and, with the vigorous top growth, provides substantial material for incorporation into the soil in early spring. The dry-matter root growth of perennial ryegrass is approximately equal to the top growth. For many other crops, the top growth represents 60% to 70% of the material turned under at plowing. A seeding rate of 25 lbs. per acre is recommended.

Winter rye, a cereal grain, establishes quickly from late summer and early fall seedings. However, fall seedings made after October 1 are likely to provide only winter cover and are slower to produce heavy spring growth. Excessive early spring top growth can create tillage problems if the crop is not incorporated by early to mid-May. This date will vary with the location and season. The seed is readily available and is usually sold in bushel quantities of 56 lbs. Use a seeding rate of 2 bushels per acre to establish.



Sudan grass is a summer annual that requires much heat for good growth. Seedings made in late May or early June will guarantee a more vigorous growth than seedings made in late June or early July. Hybrid sudan grasses may have larger seeds and should be planted at heavy rates. Like millet and sorghum-sudan hybrids, which also have large seeds, sudan grass should be seeded to a depth of 1/2 to 1 inch into a firm seedbed. Similarly, this summer annual will recover after being cut. Due to its tall growth habit, sudan grass should be cut back when growth exceeds 20 to 25 inches or plowed down if a second growth is not desired. Use a seeding rate of 80 lbs. per acre.

Sorghum-sudan grass hybrids require more heat for growth than sudan grass. These hybrids are more expensive to establish and fail to adapt to most soils as readily as Japanese millet. This crop will grow to a greater height than sudan grass under ideal conditions of heat, moisture, and fertility, but the 4- to 6-foot growth is very difficult to incorporate with small or moderately sized tillage equipment. Like sudan grass, this crop will make a second growth if climatic conditions permit. Growth will cease by mid-September if night temperatures drop to near freezing. The seeding rate will vary from 35 to 50 lbs. per acre, depending on seed size.

(Courtesy W. Lord, I. Merwin, and J. Mitchell, *Bramble Production Guide*, NRAES Publication No. 35.)

