Chapter 10

Cover and Green Manure Crops for Northwest Nurseries

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Abstract

Green manure crops are planted in Northwest bareroot nurseries primarily to produce organic matter to enrich soil. Available species include grasses, legumes, and brassicas. Legumes are deep rooting, decompose quickly, and can increase soil nitrogen by fixation but require good drainage and well-fertilized soils and can increase soil-borne pathogens. The most suitable species for short-term rotations are annual grasses, including small grains, certain legumes, and spring-sown brassicas. For longer rotations, tall fescue is well adapted to varied soil conditions, and birdsfoot trefoil, a legume, produces well on acid soils. The pros and cons of other species for various rotation lengths are discussed.

10.1 Introduction

The terms **cover crops** and **green manure crops** are frequently used interchangeably. Certain distinctions between the two, however, can be made. Cover crops are grown primarily for soil cover to help prevent various forms of erosion. Green manure crops are grown primarily to produce organic matter and are usually incorporated into the soil for the benefit of succeeding crops. Although both objectives may be accomplished with the same crop in some cases, the grower should determine the prime objective before selecting and planting the crop.

Results of the OSU Nursery Survey (see chapter 1, this volume) show that 750 of Northwest nurseries use cover crops and do so to produce organic matter. These crops generally are planted in spring and plowed under in late summer or early autumn; because this is a period of low erosion potential in the Northwest, they can be considered green manure crops.

This chapter will familiarize nursery managers with the most suitable plant species for organic matter production in the Northwest.

10.2 Benefits of a Cover or Green Manure Crop

The benefit of a cover crop for soil protection is well established. The kinetic energy of falling raindrops dislodges soil particles. This "splash effect" results in the breakdown of soil aggregates, forming a less pervious surface layer, which in turn creates a "puddling effect." The result is decreased infiltration rate and increased runoff. The splash effect can also cause some downslope movement of particles, but most sediment is lost by surface-water runoff. Cover crops protect the soil from the splash effect by intercepting the raindrops and absorbing the kinetic energy. When a cover crop is used to control water or wind erosion, rapidity of establishment and increased seeding rate should be considered in selecting an appropriate species.

Some effects of soil organic matter provided by green manure and cover crops also are discussed in chapter 9, this volume. Organic matter increases soil aggregation and structure, water-holding capacity, and aeration. The high cation-exchange capacity (CEC) of organic matter helps soil retain cationic nutrients and buffers against changes in soil pH. Plant nutrients are released when soil organic matter is mineralized (decomposed). Reactive forms of organic matter chelate (form available compounds with micronutrients) iron and aluminum, preventing the formation of insoluble metal phosphates in acid soils. These physical and chemical advantages, as well as biological effects of pesticide interaction and energy sources for organisms, are fully discussed by Davey and Krause [2].

Although the benefits of organic matter just mentioned may be derived from both cover crops and other organic materials such as manure or compost, which are brought in, some benefits are peculiar to the organic matter produced by the growing crop. Deep-rooted cover crop species can reclaim nutrients that would otherwise be lost from lower soil levels. Cover crops can also catch and hold nutrients for later use (catch crops).

Cover crops can aid weed control. Although clean fallow is effective in weed control, use of a cover crop by no means

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indicates no weed control. Competition from a thickly sown and vigorous cover crop will discourage weed invasion. Later seed production of weeds can be prevented by mowing or turning under before seed matures. Use of a straight grass cover allows broadleaf weed control by herbicides; similarly, use of straight legume cover allows weedy grass control.

10.3 Species Longevity and Nursery Rotation

Available green manure crops include winter annuals and spring and summer annuals, biennials, and perennials.

Winter annuals require some amount of vernalization (low temperature) before proceeding to good vegetative growth and, later, reproduction. They are normally fall sown in areas with mild winters. Examples are crimson clover (*Trifolium incarnatum* L.), hairy vetch (*Vicia villosa* Roth), and the winter-type (fall-sown) small grains such as wheat (*Triticum aestivum* L.) and oats (*Avena sativa* L.). If cold requirement is insufficient (i.e., if seeds are sown in April-May), these species are likely to stay in the rosette stage and produce little organic matter until the following spring, thus behaving as biennials. However, some annual species, although more productive when fall sown, will produce fairly well if spring sown; examples are rye *(Secale cereale* L.) and annual ryegrass (*Lolium multiflorum* Lam.).

Other annuals, such as spring or common vetch *(Vicia sativa* L.), lupine (*Lupinus* spp.), peas (*Pisum sativum* subsp. *arvense* L.), and the spring-type small grains, have less cold requirement and can be sown successfully in March-April. Summer annuals include sudangrass (*Sorghum bicolor* L.) and corn (*Zea mays* L.), both of which need warm soil temperatures to germinate, and annual sweetclover (*Melilotus alba* var. *annua* Coe).

True biennials do not flower until the second growing season. Sweetclover (*Melilotus alba* Desr.) and the *Brassica* spp., including rape and kale, are green manure crops in this group. Sown in later summer or autumn, the brassicas are grown as winter annuals for seed production and winter feed for livestock; but when they are spring sown, vegetative production is rapid and continues through the summer with irrigation. New hybrid cultivars of kale are available.

Perennial species of green manure crops produce over a period of 3 years or longer. Typically, perennial grasses and legumes establish less rapidly and produce less the first year than annuals and biennials. The longevity of the green manure crop is, therefore, important in regard to the length of the desired rotation.

10.3.1 Short-term rotations

March-April to August-September is the most common rotation for seedling nurseries. Therefore, the most suitable species are the spring and summer annuals (Table 1). Where seasons are longer, two crops may be grown, as in the Weyerhaeuser Co. nursery at Aurora, Oregon; a spring crop of Austrian peas is followed by sudangrass in late May (OSU Nursery Survey). Also, if the full spring-summer season is utilized, the same crop may be grown twice. More production probably could be obtained by cutting the first crop and allowing regrowth. Crops suitable for regrowth are rape, kale, annual ryegrass, and sudangrass, although regrowth of sudangrass would extend well into September, possibly too late for turning under. Regrowth is more successful when higher stubble is left, especially for rape and kale.

10.3.2 Longer term rotations

If land is available over the winter season (fall, winter, spring), winter annuals can be planted in milder areas to provide good production the following spring. Biennial species also can be used. But if land is available for 2 or more years, it can be sown repeatedly to annuals or biennials-or to perennials (Table 1).

Legume species grown for 3 or more years include alfalfa (*Medicago sativa* L.), if soil pH, drainage, and nutrients are adequate, and birdsfoot trefoil (*Lotus corniculatus* L.), which tolerates poor soil drainage, low pH, and lower soil fertility. Among the grass species, tall fescue (*Festuca arundinacea* Schreb.) and meadow foxtail (*Alopecurus pratensis* L.) have wide tolerance to poor drainage and soil pH 5.0 to 8.0; these grasses can be sown singly or together to maintain a relatively weed-free stand for several years. Tall fescue has a strong, deep, fibrous root system that is very effective in promoting improved soil structure and tilth. Other locally adapted grasses may be useful in a long-term rotation, including orchardgrass (*Dactylis glomerata* L.) and timothy (*Phleum pratense* L.).

Certain species should be avoided in nurseries. Subterranean clover (*Trifolium subterraneum* L.), a winter annual, produces viable seed (including hard seed) at or below the soil surface before a good quantity of organic material is produced. White clover (*Trifolium repens* L.) reproduces through the summer and can become a weed problem. Rescuegrass (*Bromus cartharticus* Vahl.), although a very productive grass for up to 3 years, produces seed sporadically in late summer and could also become a weed problem in subsequent years. Species with rhizomes or stolons should be avoided because these are more difficult to eradicate.

10.4 Using Legumes to Produce Organic Matter

10.4.1 Advantages

Several advantages accrue from using legumes, as compared with grasses, for cover or green manure crops:

10.4.1.1 Deep rooting

Cultivated legumes typically have deep taproots. Deeper root penetration and channel development in soil horizons improve drainage, decrease the need for frequent irrigation, and allow plants to reclaim nutrients from lower soil levels.

Rooting depth depends on species and longevity. Though nursery managers are interested mostly in annuals, some land may be out of production long enough that perennials may be used to take advantage of deep root development. Alfalfa is the deepest rooting perennial legume, with roots penetrating 8 to 12 m if subsoil conditions are suitable. Red clover (*Trifolium pratense* L.), trefoil (*Lotus* spp.), and biennial sweetclover have relatively strong taproots 2 to 3 m deep. In contrast, white clover has a branching taproot that is normally restricted to the top 60 cm of soil. Annual legumes with rooting depth up to 1 m include vetches, crimson clover, and arrowleaf clover (*Trifolium vesiculosum* Savi). Deeper rooting annual legumes such as lupines and annual sweetclover may have roots that penetrate to a depth of 2 m or more.

10.4.1.2 Faster decomposition

Decomposition rate of leguminous green manure crops is greater than that of grass species, particularly for the herbaceous legumes, because of a more favorable carbon to nitrogen (C:N) ratio. However, this rapid decomposition rate could be a disadvantage if the objective were to increase soil organic matter over a long period.

10.4.1.3 Increased soil nitrogen

Cultivated legumes likely to be used in nursery management fix atmospheric N in root nodules following infection with effective strains of Rhizobium bacteria. The amount of N fixed

Table 1. Recommended green manure specks for various rotation lengths.

Species	Sowing rate, kg/ha	Sowing time	Dry matter production,[1] metric ton/ha	Remarks
		Short term (March -April to August-September)		
Legumes				
Spring vetch	75	March-April	4-6	Often sown with ! 00 kg/ha spring grain
Lupines	100	March-April	6	Will produce on acid soil
Annual sweetclover	14	March-April	6	Use Hubam cultivar; needs soil pH of about 6.0
Grasses				
Spring grains (wheat, oats, barley, rye)	150	March-April	6	Use local cultivars
Annual ryegrass	30	March-April	6-8	Will regrow after cutting for 2 to 3 crops
Sudangrass	35-40	May-June	8-10	Increase sowing rate 50% with sorghum hybrid
Corn	20	Late April-June	12-14	Sowing rate is for 70,000 plants/ha and depends on seed size
Other				
Brassicas (rape, kale)	6	March-May	8	Can grow 2 crops if planted very early
		Longer term		
		Fall sown (plow under in spring or summer)		
Legumes				
Crimson clover[2]	20	Sept.-early Oct.	4-6	Plow under when flowering
Arrowleaf clover[2]	15	Sept.-early Oct.	6	Flowers 1 to 2 months later than crimson clover
Hairy vetch[2]	50	Sept.-early Oct.	4	Often sown with winter grain
Grasses				
Winter grain (oats, rye, wheat, barley)	120	October	6	Use local cultivars
Annual ryegrass[2]	30	Sept-early Oct.	6-8	Mow or plow in
Other				
Brassicas[2] (rape, kale)	6	October	6	Plow in when flowering in spring
		Spring sown (for 2-year use)		
Legumes (sweetclover)	14	April-June	8	For low-rainfall, nonirrigated areas use yellow flowered
Grasses (tetraploid ryegrasses)	30	April-June	8	Oregon annual will produce through second year
Other (rape, kale[2])	6	April-June		Will flower in early spring: plow in and replant
		Perennial (3 years or more)		
Legumes				
Alfalfa	12-15	April-June	12-16	Use local cultivars; needs soil pH 6.0 or more
Birdsfoot trefoil	8	April-June	9-10	Use Granger or Cascade cultivars
Grasses				
Tall fescue	2 5	April-June	10-12	Use Alta or Fawn cultivars
Meadow foxtail	20	April-June	8-12	Light, fluffy seeds. difficult to drill
Timothy	10	April-June	8-10	Regrowth is less than for other grasses
Orchardgrass	18	April-June	10-12	Use local cultivars

[1]Based on production under irrigation at Corvallis, Oregon.
[2]Not winter hardy at higher elevations or east of Cascades.

depends on the legume species and the length of the growing season; estimates are about 85 kg/ha for vetches and 140 kg/ha for annual clovers for a full season of growth (fall sown, maturing the next summer). Where productive, alfalfa may fix over 500 kg/ha N in a season.

Efficient inoculation of legume seed just before sowing is essential to ensure high rates of N fixation. Available commercial peat inoculum is specifically labeled for each legume species and should be used by the date shown on the container. The inoculum should be applied liberally to seeds moistened with skim milk, sugar solution, or a weak solution of gum arabic. Application to water-moistened seeds may be sufficient if seeds are protected from the sun and drying and if planting occurs within a few hours of inoculation.

According to OSU Nursery Survey results, many Northwest nursery soils are acidic, which can reduce survival of the nodule bacteria of some legume species. Alfalfa, sweetclover, and related medics and burr clovers (*Medicago* spp.) have little tolerance to acidity and require a soil above pH 6.0 for nodulation and adequate growth. The true clovers (Trifolium spp.), however, are relatively acid tolerant and can be grown successfully at pH 5.5. Vetches and lupines, and their *Rhizobium* strains, can tolerate even greater acidity. Where soil pH values are below 5.5. effective nodulation is increased by using lime-pelleted seed [7]. Lime coating protects *Rhizobium* from desiccation when seeds are surface sown or drilled into dry soil and from acidity when seeds are sown into acid soils or when inoculated seeds are sown in contact with acid fertilizers.

10.4.2 Disadvantages

Several disadvantages temper the use of legumes as green manure crops in nurseries:

10.4.2.1 Hard seed

Most legume species have relatively hard seedcoats which are impervious to water and can retard germination, possibly carrying over to grow as weeds in the following seedling crop. This problem can be reduced by scarifying the seed (scratching the seedcoat against abrasive material), a process available at most seed-cleaning plants. In addition, the legume crop should be turned under before seed matures.

10.4.2.2 Need for good drainage

inadequate soil drainage may prevent good legume growth. Alfalfa and sweetclover require good drainage; vetches, lupines, and annual legumes require moderate drainage; and white clover and the trefoils will tolerate poor drainage. However, soil drainage for legumes is not a significant problem in the Northwest with spring-summer, one-season crops. The legumes most tolerant to waterlogging or flooding are alsike clover (*Trifolium hybridum* L.), white clover, and big trefoil (*Lotus pendunculatus* Car.) and are seldom used as nursery cover or green manure crops.

10.4.2.3 Need for high fertility levels

Legume production may require additional nutrient application. Some areas of western Oregon are deficient in molybdenum (Mo), which is essential in the N-fixation process. Although Mo can be deficient in soils with high pH values, it is more often deficient in acid soils due to decreased availability. Correcting this deficiency by liming or by adding very small amounts (0.25 kg/ha) of Mo to the soil often results in much higher production. Molybdenum can be added to inoculated seeds or to the coating of pelleted seeds if the seeds are drilled soon after into moist soil; delay may adversely affect *Rhizobium* survival.

10.4.2.4 Increased disease problems

The use of legumes as green manure crops may increase disease problems of succeeding tree crops. This potential problem is discussed later in this chapter (10.6).

10.5 Cultural Practices for Green Manure Crops

10.5.1 Seedbed preparation

Seedbeds for cover crops are prepared by plowing, followed by disking and harrowing or by rototilling. The main purpose of plowing is to eliminate vegetative material, dead or alive, that may interfere with sowing. Often, a seedbed may be prepared with only a disk and harrow. Most green manure or cover crops have small seeds, and a firm seedbed aids in controlling the depth of planting, which improves seedling emergence.

10.5.2 Sowing

Amount of seed sown depends very much on seed size. In addition, increased rate of sowing may compensate to some extent for the shorter productive life in the short-term rotation. The suggested sowing rates (Table 1) are somewhat higher than those for the same species when used in pasture or forage production. Because of competition, mainly for light, in the irrigated, well-fertilized field, high sowing rates generally do not increase yield.

One exception to the above is corn production for green manure. It produces few if any tillers. The corn crop likely would be turned under in August or September, before grain matures, or even before ears form. Plant population should be increased from the usual 60,000 to 70,000 plants/ha to nearly double that number. Seeds may be drilled) in closer rows or even sown with a grain drill.

Drilling is the most efficient method of sowing because it controls planting depth and seed distribution. Broadcast seeding can be a satisfactory method if seeds are covered by harrowing or with a corrugated roller.

Proper seeding depth depends on seed size. The small seed of clovers and trefoils should be sown about 1 cm deep. Vetches and lupines can be planted deeper, up to 3 cm. Grasses are sown approximately 2 cm deep and sudangrass, corn, and small grains somewhat deeper, up to 4 to 5 cm.

The seedbed may be rolled or cultipacked before sowing seed to provide the firmness necessary to control depth of seed placement. Rolling after sowing is beneficial because it firms the soil around seed to ensure better moisture contact for germination and better moisture conservation. Rolling may not be required, however, if the drill has press wheels, if a Brillion-type seeder is used, or if rain or irrigation follows shortly after sowing.

10.5.3 Planting and plow-down times

Planting time depends on species longevity and local climatic conditions. Winter annuals are sown from late September to early October in mild-winter areas. Small grains may be sown into November. East of the Cascade Mountains and at higher elevations, annual clovers and vetches are not hardy enough for winter planting and should be sown in early spring.

Spring-sown annuals may be planted as soon as conditions permit, from March through April; however, summer annuals need warm soil to germinate. In western Oregon, for example, corn may be planted from late April through June and sudangrass from mid-May through June. Brassicas for short-term (spring-summer) use generally are sown from April to May, but also can be fall sown in mild-winter areas, if land is available at that time.

Annual sweetclover is sown in spring. Biennial sweetclover (for longer rotation) may be sown either in spring or summer. Perennial species may be sown in the spring, or in the summer if irrigation is available.

Annual and biennial green manure crops should be plowed under and perennial crops mowed or chopped when plants are in the flowering stage, before seeds are produced.

10.6 Green Manure Crops and Seedling Pests

Although adding green plant material to nursery soil improves soil and nutrient conditions, green manure crops sometimes may increase pathogens (fungi and nematodes), insects, and other soil organisms (see chapter 19, this volume). This is one reason why green manure crops are not currently used in 25% of Northwest nurseries (OSU Nursery Survey).

Green manure crops may affect soil nematode populations. McElroy [6] tested 31 plant species for host suitability of the corky root pathogen *(Xiphinema bakeri* Williams) in the Fraser Valley of British Columbia and found that the nematode increased with rye, orchardgrass, and several species of weeds but decreased with brassicas. Where corky root occurs, rape or kale might be a suitable green manure crop. Corky root also can be controlled by keeping soil dry and working it frequently from August through September [9]. Other species which may be planted in corky root areas are annual ryegrass and spring-type grains. They are sufficiently vigorous to be plowed under in August, followed by soil drying and working.

Other pathogens that have a wide range of hosts may increase on green manure crops. Number of microsclerotia of the root-rot fungus *Cylindrocladium scoparium* Max. decreased with corn but increased with soybean *(Glycine max* L. Merr.) after a 5- to 6-month decomposition period [10]. Legumes, particularly alfalfa and red clover, are more susceptible to root rot than grasses [1]. Incorporating flax (*Linum usitatissimum* L.) or sorghum-sudangrass cover crops into a sandy nursery soil for 2 successive years significantly reduced the number of *C. floridanum* Sobers and Seymour propagules [3]; after four growing seasons, both species of cover crops reduced root-rot potential to innocuous levels. Menge and French [8] reported that cover crops influence soil fungi, even if they are nonhosts, because root-infecting fungi can grow in the rhizosphere of nonsusceptible plants.

Cover crops also can influence the incidence of *Phytophthora* fungi, whose hosts include Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco], alfalfa, and arrowleaf clover [4]. *Phytophthora* can be particularly severe on alfalfa and clover in the poorly drained soils of the Northwest. Several alfalfa cultivars with moderate to high resistance to Phytophthora are available for areas where this fungus is a potential problem.

Sorghum and sorghum-sudangrass residues contain toxins which may temporarily inhibit growth of the following crop of some conifer seedlings [5]. These crops, apparently beneficial for controlling root rot in Wisconsin, were found to damage seedlings, largely by eradicating mycorrhizal fungi. Damage decreased with early plowing, watering, and delayed fall seeding of the seedling crop. (See also chapter 20, this volume, for other examples of the relationship between green manure crops and mycorrhizae.)

10.7 Conclusions and Recommendations

Relatively few species of legumes, grasses, or other plant families are suited for use as green manure crops in bareroot nurseries. A species must be adapted to local conditions and must be sufficiently vigorous in its establishment and growth to make a significant contribution in organic matter during a relatively short period. The selected species also must favor the desirable soil fungi and inhibit at least some soil-borne pathogens.

Leguminous green manure crops have the advantage of deep rooting and can fix N but often increase the number of nematodes and soil-borne disease organisms. In addition, according to the OSU Nursery Survey, most nursery soils in the Northwest, certainly those west of the Cascade Mountains, are too acid for the production of certain legumes. Yet, it is desirable to maintain acid soils for suitable seedling production and to discourage pathogens, particularly damping-off organisms (those which cause rotting of seeds and succulent seedlings).

In the Northwest, the most suitable species for short-term green manure crops are annual grasses, including small grains, particularly oats and rye, corn, annual ryegrass, and sudangrass; among the legumes, spring vetch, peas, lupines, and annual sweetclover (on less acid soil); and spring-sown rape or kale. For a long-term rotation, tall fescue is widely adapted to varied soil conditions and is usually very productive. Birdsfoot trefoil, a legume, will fare well on acid soils, either planted alone or in combination with grass.

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