Winter Annual Cover Crops

NC STATE EXTENSION

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Introduction

Winter annual cover crops have been used in rotation with summer crops for many years in North Carolina, but now there are some interesting new applications of this practice. Early experiments date from the 1940s and show several important benefits of planting winter annual cover crops, chief among them erosion control, addition of nitrogen (N) to the soil for use by a subsequent crop, removal of N from the soil to prevent nutrient loading, buildup of soil organic matter, and buildup of residue that acts as a mulch for water conservation or retention.

Generally, winter cover crops are planted in early fall and allowed to grow over the winter until early spring, when their growth is terminated by plowing or herbicide treatment. In conservation tillage systems, the residue from the cover crop is not plowed under after the herbicide treatment and remains on the surface as mulch (Figure 1A). A newly developed alternative for certified organic farms that provides similar residue conservation without herbicides involves cover crop termination using a roller-crimper (Figure 1B).

Winter annual cover crops can be either legumes or cereals. The legumes best adapted to North Carolina soil and climatic conditions are crimson clover, hairy vetch, Austrian winter pea, and Cahaba white vetch. Recent trials have also included lupines, berseem clover, subterranean clover, and other legumes. Cereals or small grains that are best for North Carolina are rye, wheat, barley, triticale, and oats. Descriptions of many potential cover crop species can be found in the US Department of Agriculture publication *Managing Cover Crops Profitably*.

Figure 1A. Corn growing in a hairy vetch cover crop after herbicide has killed the vetch.

Figure 1B. Rye cover crop terminated by a roller-crimper prior to planting certified organic soybeans.

Cover Crop Establishment

Legume cover crops contribute N to a subsequent crop, relieving the farmer of some of the cost of buying fertilizer. Legumes can supply much of the N required for many summer crops, from row crops such as corn or grain sorghum to vegetables such as sweet corn, cabbage, squash, and pumpkins (Figure 2). In Figure 2, maximum yield was attained with both 104 lb fertilizer N/acre and with 54 lb fertilizer N/acre plus vetch; thus, vetch appears to supply the equivalent of 50 lb N/acre. In contrast, rye reduced corn yields unless sufficient nitrogen fertilizer was applied.

Small grains and other grasses help control erosion caused by wind or water (Figure 3). Erosion caused by wind and water are much greater on bare ground than on a surface protected by a cover crop. Cover crops in a conservation tillage planting system provide erosion control during the winter while the plant is growing and mulch for the soil surface during the summer in the form of crop residue. This surface mulch enhances summer rainfall infiltration, reduces soil water evaporation, and provides weed control by early shading. All these potential benefits are highly dependent on weather and management factors that should be considered when using cover crops. In contrast to legumes, grass cover crops can immobilize soil nitrogen as they decompose. Thus, they can reduce crop growth unless sufficient inorganic N is applied (Figure 2).

Management decisions such as the date and method of killing a cover crop influence the amount of cover crop growth and nutrient uptake, as well as the availability of the nutrients released to a following crop by decomposition. Plowing cover crops under early in the spring will increase the decomposition rate of the cover crop, but this early termination date also limits cover crop growth, which limits nutrient accumulation and the buildup of soil organic matter from the residue. Allowing the cover crop to grow until later in the spring will improve nutrient accumulation in the cover biomass, but it may reduce the ability of microbes to decompose residues for short-term use. Leaving the cover crop on the surface also reduces its decomposition rate compared to plowing. This extra surface residue accumulation can benefit subsequent crops, but it should be evaluated to determine whether it inhibits crop growth or encourages pests or diseases.

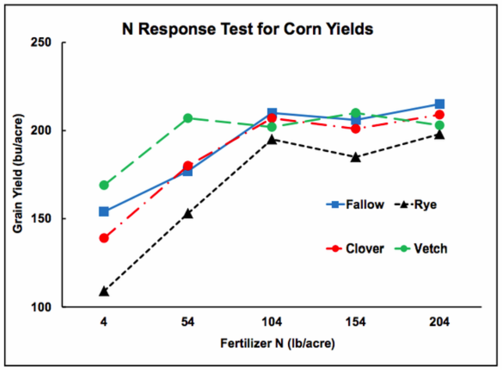

Figure 2. Results of N response test for corn yields, Tyrrell County, 2007.

Figure 3. A: Wind erosion during cultivation of a Roper muck. B: Water erosion on sloping land. C: Cotton strip-till planted into a wheat cover crop on Augusta fine sandy loam. D: Wheat cover crop on Caroline fine sandy loam, 2%–6% slopes.

Erosion Control

Cover crops in the coastal plain and tidewater regions of eastern North Carolina are used primarily for erosion control and to promote soil moisture retention. Wind erosion can be severe in cultivated organic and sandy soils of this region (Figure 3A). Seedlings are especially vulnerable to damage from sandblasting during cool, dry springs, when growth rates are slow. Many farmers use smallgrain cover crops to control erosion. There are many combinations to choose from: using winter wheat or cereal rye; planting flat or on beds; and planting the following crop no-till, strip-till, or conventional till. Strip-plantings of cereal rye can also be used as windbreaks to protect vegetable crops and tobacco from wind erosion (Figure 4).

The extent of soil erosion control provided by cover crops during the fall, winter, and early spring depends largely on when the crop is established (Figure 5). Timing is particularly important with legumes because late seeding results in small plants with limited root systems. If the legume cover crop is established early enough, adequate growth in the fall can help minimize soil erosion. The nonlegumes rye and triticale provide maximum erosion protection during fall and winter because of their rapid growth rates. Active cover crop growth in the spring, before the summer crop is planted, offers continued erosion control compared to bare ground.

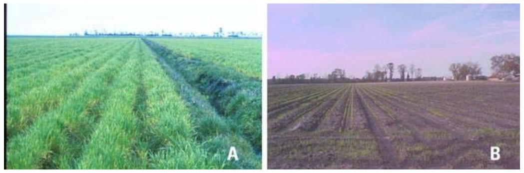

Figure 4. A: Cover crop wheat planted to protect stale seed beds during the winter. B: Cover crop wheat planted to protect a planned summer vegetable crop.

Figure 5. At a Wayne County site, the thin crimson clover cover stand on the left was planted late (November 19), whereas the plot on the right was planted as recommended on October 12.

Cover Crop Establishment

Although crimson clover, hairy vetch, Austrian winter pea, and common vetch are widely adapted to soil and climatic conditions in North Carolina, they do have some limitations. Hairy vetch tends to be more winter hardy than the others and generally can be planted later. Crimson clover grows faster in the spring, thereby maturing and obtaining peak dry matter production approximately three to four weeks ahead of hairy vetch. Hairy vetch is better adapted to more sandy soils and to more poorly drained soils than crimson clover, although crimson clover provides adequate dry matter production on most well-drained sandy loams. The erect growth habit of crimson clover may make it slightly easier to manage than hairy vetch, which has a viny nature (Figure 6).

The following general cultural practices are applicable to all legume cover crops:

Planting dates. A wide range of planting dates exists for most legumes (Table 1), although early plantings obtain the best results. Early seeding dates are easy to meet with legume cover crops following tobacco, corn silage, spring vegetables, or, in eastern North Carolina, grain corn. Soybeans are never harvested early enough for the seeding of legume cover crops. Because Cahaba white vetch does not possess much winter hardiness, it is not adapted to the western regions of the state. Freeze damage has also occurred with Austrian winter pea in higher elevations (above 2,500 feet). In general, planting late (late October to November) in the piedmont and mountains will increase the risk of winter kill.

Table 1. Planting dates for selected annual winter legumes.

<table>
<tr><th>Region</th><th>Crimson Clover</th><th>Hairy Vetch</th><th>Austrian Winter Pea</th><th>Cahaba White Vetch</th></tr>
<tr><td>Mountains</td><td colspan="3"></td><td rowspan="3">Not adapted</td></tr>
<tr><td>Preferred dates</td><td colspan="3">August 10 to September 15</td></tr>
<tr><td>Possible dates</td><td colspan="3">August 10 to September 15</td></tr>
<tr><td>Piedmont</td><td>August 25 to October 1</td><td>August 25 to October 15</td><td>August 25 to October 1</td><td>Not adapted</td></tr>
<tr><td colspan="5">Coastal plain</td></tr>
<tr><td>Preferred dates</td><td colspan="4">September 1 to September 30</td></tr>
<tr><td>Possible dates</td><td colspan="4">September 1 to October 30</td></tr>
</table>

Seeding rate, depth, and method. Seeding rates and depths vary with legume species (Table 2). Seed crimson clover at 20 to 25 pounds per acre broadcast and 15 to 20 pounds drilled. For both hairy vetch and Cahaba white vetch, the rates are 20 to 30 pounds per acre broadcast and 15 to 20 pounds drilled. For Austrian winter pea, the rates are 25 to 35 pounds per acre broadcast and 20 to 25 pounds drilled.

Table 2. Seeding rate and depth for selected annual winter legumes.

	Seeding Rate (lb/acre)		
Legume	**Broadcast**	**Drilled**	**Seeding Depth (inches)**
Crimson clover	20–25	15–20	$\frac{1}{4}$–$\frac{1}{2}$
Hairy vetch	20–30	15–20	$\frac{1}{2}$–1$\frac{1}{2}$
Cahaba white vetch	20–30	15–20	$\frac{1}{2}$–1$\frac{1}{2}$
Austrian winter pea	25–35	20–25	$\frac{3}{4}$–1$\frac{1}{2}$

In planting, use shallow planting depths for finer-textured, clayey soils and deeper depths for coarse-textured, sandy soils. Drilling into a conventional seedbed is the most reliable way to obtain a uniform stand; however, a no-till grain drill also can be used successfully, provided that residue from the previous crop is not excessive and soil moisture is sufficient to allow the drill to penetrate to the desired planting depth. Seeds may be broadcast if the soil has been disked and partially smoothed. Cultipacking after broadcasting will encourage good soil/ seed contact. Crimson clover, in particular, can be established quite easily with this method.

An innovative system that has shown promise in other southeastern states is to allow crimson clover to reseed itself naturally. This method will work in North Carolina where the following crop is midsummer vegetable crops (pumpkins), grain sorghum, or tropical silage corn (late spring establishment). Reseeding usually will not work for crimson clover planted before full-season field corn because crimson clover seed matures after corn planting dates. With careful management, this system can work for full-season no-till corn if strips of crimson clover are allowed to mature, produce, and disperse seed (as discussed in the "Legume N Economics" section, below).

Aerial overseeding into cotton at defoliation or into soybean prior to leaf drop has been successful in some cases (Figure 7). Overseeding can avoid the reduced productivity that might result if planting is delayed until after harvest of certain crops (Table 3).

Table 3. Crimson clover productivity of different establishment methods at a coastal plain site.

Prior Soybean Maturity Group	Seeding Method	Seed Date		Dry Matter (ton/acre)	N (lb N/acre)
		2006	2007		
3	Drill after harvest	October 12	October 9	1.5	88
4	Aerial overseed	September 8	August 21	1.3	79
4	Drill after harvest	October 12	October 9	1.5	92
5	Aerial overseed	September 8	September 19	1.5	85
5	Drill after harvest	November 19	November 21	0.4*	32*

* Dry matter and N accumulation were significantly reduced if planting was delayed until November following harvest of a maturity group 5 soybean (P<0.05).

Grazing or hay crop. Winter annual legumes can be grazed or cut for hay before the summer crop is planted. However, either of these practices would remove most of the nitrogen and mulch from the system because nitrogen is concentrated in the top growth. Legumes grow only a limited amount during fall and winter, which makes them a poor choice for grazing during this period. In the spring, if grazing continues too long, growers may find that the rough soil conditions caused by hoof traffic lessen the benefits they expected from spring no-till management.

Figure 6. An example of crimson clover and hairy vetch cover crops.

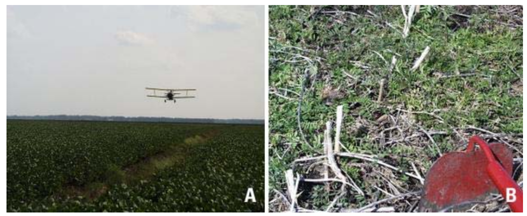

Figure 7. A: Aerial overseeding prior to soybean leaf drop in Pamlico County. B: Subsequent hairy vetch establishment.

Small Grains

Determine small grain lime and fertilizer needs based on soil test results. On coastal plain soils, supplemental N (25–35 pounds per acre) may be needed to obtain adequate top growth. Successful stand establishment generally can be obtained with planting dates later than those for legumes, even as late as early December in coastal plain regions (Table 4). This allows establishment of the cover crop after a late-fall-harvested crop such as soybeans. Remember, though, that late seeding dates may sacrifice some soil erosion protection. For sandier coastal plain soils, such as Wagram, Lucy, Kenansville, and Conetoe, rye is the preferred small grain cover crop. Seeding rates are 1 to $1\frac{1}{2}$ bushels per acre for rye, triticale, and wheat and 2 bushels per acre for oats. As previously discussed, seeding depth varies from $\frac{1}{2}$ to $1\frac{1}{2}$ inches, depending on soil texture. Planting methods are the same as those described for legumes. Aerial seeding of rye into soybeans just before leaf drop has been marginally successful.

Table 4. Planting dates for selected annual winter small grains.

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<tr><th>Location</th><th>Rye</th><th>Wheat</th><th>Barley</th><th>Triticale</th><th>Oats</th></tr>
<tr><td colspan="6">Mountains</td></tr>
<tr><td>Preferred dates</td><td colspan="4">August 15 to September 30</td><td rowspan="2">Not adapted</td></tr>
<tr><td>Possible dates</td><td colspan="4">August 15 to October 30</td></tr>
<tr><td colspan="6">Piedmont</td></tr>
<tr><td>Preferred dates</td><td colspan="5">September 15 to October 15</td></tr>
<tr><td>Possible dates</td><td colspan="5">September 15 to November 15</td></tr>
<tr><td colspan="6">Coastal plain</td></tr>
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<tr><td>Possible dates</td><td colspan="5">September 30 to December 15</td></tr>
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Using a small grain cover crop for silage or hay will greatly delay corn planting and thereby increase the risks of drought, heat stress, and pests associated with late planting. In addition, the potential for conserving soil moisture may be reduced if the cover crop is removed for silage, leaving less mulch and reducing the following corn yield (Figure 8).

Growers need to consider timing when planting winter wheat in locations where the Hessian fly may be a problem. If Hessian fly is present in your area, wheat should be planted after the first fall frost. If small grain must be planted before frost, consider choosing an alternative small grain. Hessian fly does not inhabit rye, triticale, barley, or oats.

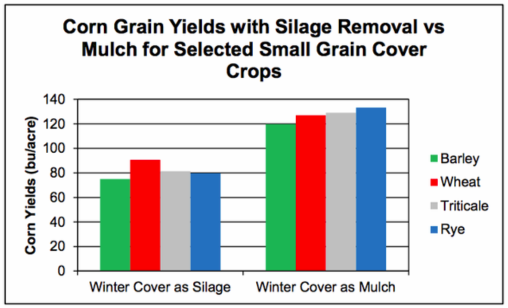

Figure 8. Corn yields in the piedmont are lower after small grain silage removal compared to leaving the small grain as mulch.

Mixtures: Multiple Benefits

Two or more cover crop species can be combined in a single planting to realize the benefits of each. Generally, a grass species is combined with one or more legume species. For example, when cereal rye and hairy vetch are planted together, the rapid germination and early fall growth of cereal rye help stabilize the soil surface and allow the more fragile hairy vetch seedlings to thrive. The next spring, the cereal rye plants provide physical support for the climbing hairy vetch stems.

Another example would be the use of wheat, triticale, or barley with crimson clover. All of these plants have similar heights, so deleterious shading would be at a minimum compared to using taller rye and shorter crimson clover.

In many areas of North Carolina, nutrient management is becoming increasingly important as farmers do their part to protect surface waters from nutrient loading. When cereal rye is planted early in the fall alone and in mixtures, it can greatly reduce available soil nitrogen that can be subject to leaching during the wet winter months. When hairy vetch, common vetch, crimson clover, and Austrian winter pea were planted in a mixture with cereal rye, spring oats, or winter wheat, the cereal rye/hairy vetch mixture had 30 to 45 percent less residual inorganic soil nitrogen than legume-only plots.

By combining grass and legume cover crops, farmers also can gain the benefits of nitrogen scavenging, high biomass production to build organic matter, biological nitrogen fixation, and moderated nutrient release, compared to a legume-only cover crop. Depending on the grass and legume cover crops chosen, a reduction in seeding rate may be appropriate.

Surface residue (from a cover crop or previous crop) helps conserve soil moisture during the spring/summer growing season by reducing water evaporation from the soil surface before the protective full crop canopy has been established. The cover also decreases rainfall runoff and increases water infiltration. Corn is highly sensitive to moisture stress at critical stages of development. Using no-till planting and cover residue can increase the reservoir of available soil water and can substantially increase corn yields in droughty years.

Do note that a cover crop depletes soil moisture during active growth, and it may be difficult to obtain adequate corn stands during dry spring seasons. With a small grain cover crop, killing it seven to fourteen days before corn is planted can reduce potential soil water depletion. If legumes are used, an early burndown is likely to reduce the amount of legume N available to the next crop. One solution is to consider planting fields with legume cover crops last and to monitor early spring conditions to minimize moisture depletion before corn-planting time. However, do not delay corn planting to allow additional growth of legume cover crops.

When the summer crops are grain sorghum or warm season vegetable crops, planting dates can be more flexible. Killing the cover crop about 10 days before planting no-till sorghum or vegetables can minimize soil water depletion.

N Contribution

A well-established legume cover potentially can supply 50 to 150 or more pounds of N per acre, or approximately two thirds of the N required by a corn crop and most of what is needed for grain sorghum and some vegetable crops (Table 3 and Table 5). The quantity of N available from legume cover crops will depend on growing conditions and location in North Carolina. Decomposition of legume residues proceeds rapidly under favorable conditions, and most of the N becomes available before the corn tassels and silks or by the time it is needed by grain sorghum or most short-season vegetable crops. In contrast to legume cover crops, small grain covers can reduce available soil N early in the growing season. Thus, they may act as a net drain rather than as a contributor of N to the system. For this reason, fertilizer N application rates should reflect both cover crop and summer crop potential constraints, with attention being given to timing and placement of fertilizer N to promote high yields (Table 6).

Table 5. Legumes' aboveground accumulation of N at corn planting (2-year average).

Legume	Total N (lb/acre)
Crimson clover	160
Hairy vetch	150
Austrian winter pea	130
Cahaba white vetch	100

Table 6. Effect of cover crop and N rate on corn grain yield (2-year average).

Cover crop	**Yield (bushels per acre)**
Rye	
0 lb N/acre	70
90 lb N/acre	113
180 lb N/acre	126
Crimson clover	
0 lb N/acre	121
90 lb N/acre	132
180 lb N/acre	136
Hairy vetch	
0 lb N /acre	129
90 lb N/acre	136
180 lb N/acre	136

Several studies comparing conventional and no-till corn in eastern North Carolina have documented the potential contribution of N by legumes. Hairy vetch has consistently performed well in these trials, and crimson clover is also promising on well-drained sites (Figure 2; Table 3). Nevertheless, few if any, large commercial farmers have adopted legume cover crops to supply N, probably because of cost (see next section) and management reasons. Most of those who have incorporated legumes into their farm management plans are small growers or farms using organic production methods. Crimson clover productivity has been much lower on poorly drained soils, with N accumulations of less than 25 lb/acre in some recent field trials.

Legume N Economics

Estimated costs associated with a legume cover crop include seed ($55/acre for hairy vetch at 25 pounds per acre), inoculation ($2/acre), planting ($8/acre), and burndown herbicide ($10/acre), for a total of $75/acre. A lower seed cost for crimson clover (approximately $1/pound) results in a total cost of $45 per acre. If a legume cover crop contributes 100 pounds of N/ acre, the legumes would cost the equivalent of a typical inorganic N fertilizer (30% N as UAN solution) priced at $275 to $450/ton for crimson clover and hairy vetch, respectively (Figure 9). In Figure 9, prices can fluctuate dramatically, but current total production cost estimates are $60–$75/acre/year for hairy vetch, $45–$60/acre/year for seeded crimson clover, <$30/acre/year for self-reseeding crimson clover, $40–$60/acre/year for winter pea, and $300–$400/ton for an inorganic fertilizer with 30% N as a UAN solution. Fertilizer costs vary due to market fluctuations but are generally in the range of $0.35 to $0.70/pound of N ($200 to $400/ton of 30 percent N solution). Producers that can achieve high productivity levels may be able to reduce N costs by using legumes. For certified organic farms, non-manure N sources often cost several dollars per pound of N, and legume use is usually cost-effective.

Even if economic factors do not favor the use of legume cover crops to supply N, farmers may be interested in building organic matter, enhancing available soil moisture, and benefiting the complex ecosystem effects that are often associated with legume and grass cover crops. Management to achieve sufficient cover crop biomass entails planting in September or October and killing about

April 1 in the east and in mid- to late April in the piedmont and mountains. Timely management is required to optimize cover crop and cash crop performance.

Legume cover crops are most likely to be adopted in the following scenarios:

- when future price increases or supply fluctuations make N fertilizers less attractive;
- if farmers want to take advantage of soil physical property benefits provided by cover crop residues;
- on certified organic farms.

One way to reduce the establishment costs of cover crops is to manage them for reseeding. In strip tillage systems or with banded herbicide applications, a crimson clover cover crop can be managed so that a proportion of the stand is allowed to continue growing and produce viable seed. This seed is then naturally dispersed and can germinate late in the summer when moisture becomes sufficient. While there is limited experience with this practice in on-farm situations, it is a viable option for innovative farmers.

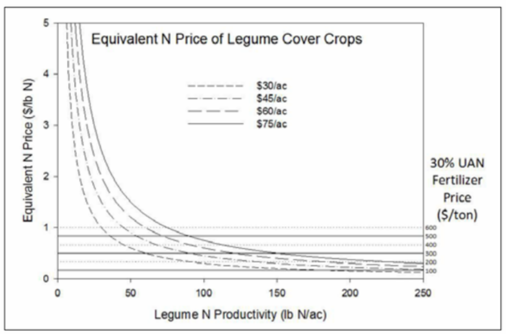

Figure 9. Equivalent N price of specific legume cover crop production scenarios.

Pest Concerns

Seed corn insects can be abundant in cover crops used as no-till mulch. Also, early-planted row crops and spring-planted vegetables tend to grow more slowly under mulched conditions because of lower soil temperatures. Therefore, use of a soil insecticide is recommended when planting without tillage into a cover crop. For double-cropped soybeans planted into small grain stubble, insect damage is no greater than with conventional tillage.

Residual weed-control methods for no-till crops planted into a cover crop are similar to those used for conventional planted crops, with the obvious exception of the use of cultivation for weed control. However, situations occur that make weed control very difficult under no-till management. Fields heavily infested with johnsongrass, bermudagrass, or nutsedge should not be planted to cover crops until adequate weed control has been achieved. In contrast, the presence of a cover crop, particularly rye, has had a beneficial effect on weed control by suppressing germination of many large-seeded broadleaf weeds. This alleopathic reaction has been attributed to the release of phytotoxic chemicals from decomposing residue.

Cover crop residue usually does not promote a higher population of nematodes in no-till corn. However, in a hairy vetch cover crop, increased populations of soybean cyst nematodes have been found. Crop rotation and timely nematode sampling are wise management practices.

Managing the Cover Crop and a Summer Crop

Cover crop growth can be terminated by tillage, rolling, or herbicides. In a wet growing season, tilling legumes into the soil may produce slightly greater yields in the crop that follows. This slight yield advantage is more than offset, however, if the legume residue is left on the surface to increase infiltration of water and conserve soil moisture when dry growing conditions prevail. The procedures for planting without tillage into a cover crop are similar to planting into residues of a previous crop, such as soybeans or corn. Some situations, however, require a different approach.

Cover Crop Burndown

Either Gramoxone Super or Roundup can be used to control existing cover crop vegetation. Use 1½ to 2½ pints of Gramoxone Super per acre or 1½ to 2 quarts of Roundup per acre. Rye is the easiest small grain cover crop to control with Gramoxone. In some instances, the effectiveness of both Gramoxone and Roundup on actively growing legumes has been enhanced by the addition of 2,4-D amine (½ to 1 pint per acre) or Banvel (½ pint per acre tank-mixed). Legume and small grain cover crops under drought stress are more difficult to control. Addition of a residual herbicide to the burndown herbicide also improves cover crop kill. It is essential that cover crop vegetation be thoroughly and uniformly sprayed for effective control. This means using a spray volume of 20 to 60 gallons per acre for Gramoxone and 10 to 30 gallons of water per acre for Roundup. High pressure (40 to 45 pounds per square inch) will help the spray penetrate dense vegetation. Spray solutions for Gramoxone can be water, nitrogen solution, or clear fertilizer solutions and must contain a nonionic surfactant. One or more residual herbicides are usually applied at the same time as the knockdown herbicide. Consult the *North Carolina Agricultural Chemicals Manual* for the appropriate residual herbicide combinations. Proper field scouting is important in determining the need for postemergence weed control measures

Summer Crop Establishment With No-Till Planting

No-till planting into a cover crop involves minimal soil disturbance—that is, opening only a narrow furrow for the seed. One exception is on coastal plain soils that are responsive to in-row subsoiling. Limited research indicates that these soils respond to subsoiling even with the presence of a cover crop mulch.

The performance of no-till seed-planting equipment has improved considerably, but the system's seedbed environment requires seeding rates to be 10 to 15 percent higher than those for conventional tillage. For corn and cotton, the generally lower soil temperature under the cover crop makes it imperative to select a hybrid that demonstrates excellent germination and seedling vigor under cool, wet conditions (Figure 10). Surface residue cools the soil considerably during the spring, with late-summer differences between the cover and bare soil lessening as the corn crop begins to shade the soil. The use of a starter fertilizer will ensure faster initial growth. For corn following a small grain cover crop, special consideration must be given to fertilization, especially with regard to the N source, placement, and timing of application. Other management factors in a no-till system are similar to practices used with conventional tillage.

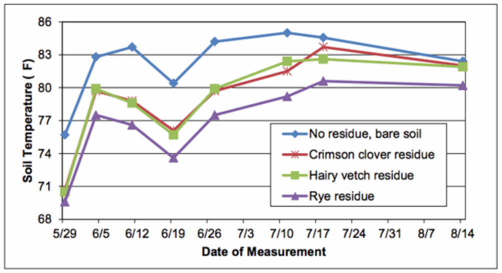

Figure 10. Variation in soil temperature at 2" depth with selected cover crops.

References

Anderson, J. R., N. L. Hubbard, F. D. Shaw, and F. W. Smith. 1990. *Managing winter-annual legumes as nitrogen sources for no-tillage corn on sandy Coastal Plain soils*. Raleigh, NC: Proceedings of the 1990 Southern Region Conservation Tillage Conference.

Kamprath, E. J., W. V. Chandler, and B. A. Kranz. 1958. *Winter Cover Crops: Their Effects on Corn Yields and Soil Properties*. Raleigh, NC: Agricultural Experiment Station, North Carolina State College. Technical Bulletin no. 129.

N.C. Cooperative Extension. *North Carolina Agricultural Chemicals Manual*. Raleigh, NC: N.C. Cooperative Extension, College of Agriculture and Life Sciences, NC State University.

Sustainable Agriculture Network. 1998. *Managing Cover Crops Profitably*. Beltsville, MD: Sustainable Agriculture Network. Handbook series book 9.

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