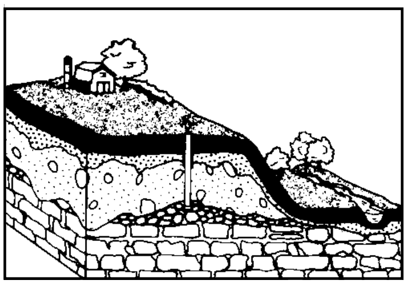

SoilFacts

Winter Annual Cover Crops

Winter annual cover crops have been used in rotation with summer crops for many years in North Carolina. Early experiments date from the 1940s and show several important benefits, chief among them being 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 water-conservation or -retention mulch.

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 1).

Winter annual cover crops can be either legumes or cereals. Legumes that are best adapted to North Carolina soil and climatic conditions are crimson clover, hairy vetch, Austrian winter pea, and Cahaba white vetch. Cereals or small grains that are best for North Carolina are rye, wheat, barley, triticale, and oats.

Benefits and limitations

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 like corn or grain sorghum to vegetables such as sweet corn, cabbage, squash, and pumpkins.

Grass or small grains help control erosion. 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 rainfall infiltration from summer rains,

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

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.

Management influences the amount of nutrients removed from the soil by the cover crops, as well as the availability of nutrients to a following crop as cover crops decompose. Plowing cover crops under early in the spring will increase the decomposition rate of cover plant material, but it also will reduce the amount of nutrients removed from the soil and limit the buildup of soil organic matter from the residue. Allowing the cover crop to mature 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, in turn, can benefit subsequent crops by leaving more residue to accumulate on the soil surface.

Erosion control

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. Timing is particularly important with legumes because late seeding results in

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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, because of their rapid growth rates, provide maximum erosion protection during fall and winter. Active cover crop growth in the spring, before the summer crop is planted, offers continued erosion control because mulch is left on the surface (Figure 2).

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 3), with seedlings especially vulnerable to damage from sand blasting during cool dry springs, when growth rates are slow. Many farmers use small grain cover crops to control wind erosion. They have a choice of numerous combinations: using winter wheat or cereal rye; planting flat or on beds (Figure 4); and planting the following crop no-till, strip-till (Figure 5), or conventional till. Strip-plantings of cereal rye also can be used as windbreaks to protect vegetable crops and tobacco from wind erosion (Figure 6).

Runoff occurs even on land with gentle slopes, and water quality concerns are especially important in the Albemarle-Pamlico drainage basin. A recent study funded by the U.S. Environmental Protection Agency in the Chowan River Basin compared sediment, N, and phosphorus (P) runoff between (a) cotton managed with winter fallow and conventional tillage (Figure 7a) and (b) cotton managed with a winter wheat cover crop and strip-tillage (Figure 7b). Runoff collectors were placed in crop rows (Figures 8a and 8b), and field runoff was measured after it had flowed through a vegetative border (not shown).

Figure 3. Wind erosion during cultivation of a Roper muck in Hyde County.

Figure 4. Wheat cover crop on planting beds formed during the fall on an Arapahoe fine sandy loam in Beaufort County.

Figure 5. Cotton strip-till planted into a wheat cover crop on an Augusta fine sandy loam in Perquimans County.

Figure 6. Cereal rye strips used as windbreaks to protect vegetable crops from wind erosion on a Conetoe loamy sand in Chowan County.

The cover crop/strip-till treatment reduced sediment loss for all sampling dates, especially during the year 2000. In that year, sediment losses were less than half of those with conventional tillage (Figure 9). Sediment loss also was reduced with cover crop/strip-till during the early growing season, before crop canopy closure. Sediment runoff rates were highest in 1999 due to the fall hurricanes (especially Hurricane Floyd) and in the summer of 2000.

Cover crop/strip-till reduced P runoff for several sampling dates, but reductions were less dramatic than with sediment. P can be lost both bound to the

Figure 7. Hertford County site used for runoff studies on a Caroline fine sandy loam (2 to 6 percent slopes). Figure 7a shows winter fallow prior to conventional tillage; Figure 7b shows wheat cover crop prior to strip-tillage.

Figure 2. Water erosion can be reduced with use of surface crop residues.

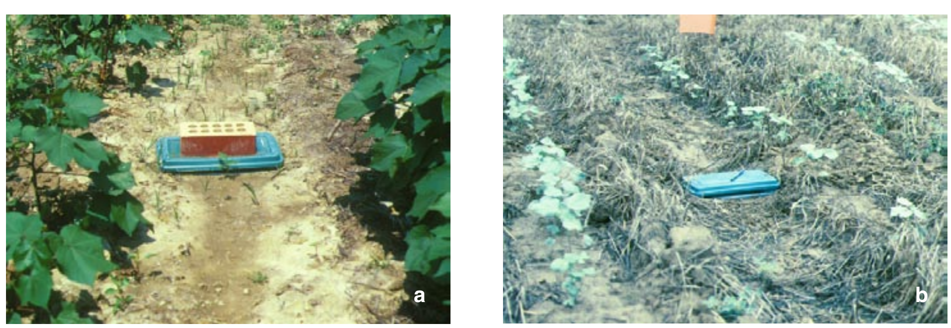

Figure 8. Runoff collectors buried in the middle of crop rows were used to collect sediment in winter fallow/conventional tillage (Figure 8a) and in wheat cover crop/strip-tillage (Figure 8b).

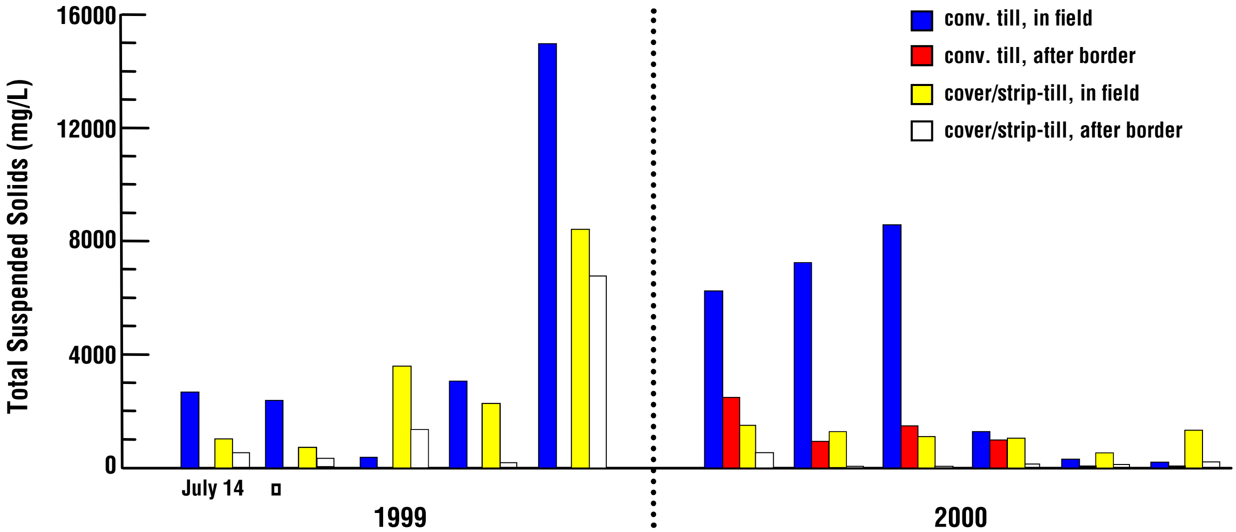

Figure 9. Effect of cover crop + tillage and vegetative borders on sediment loss with cotton.

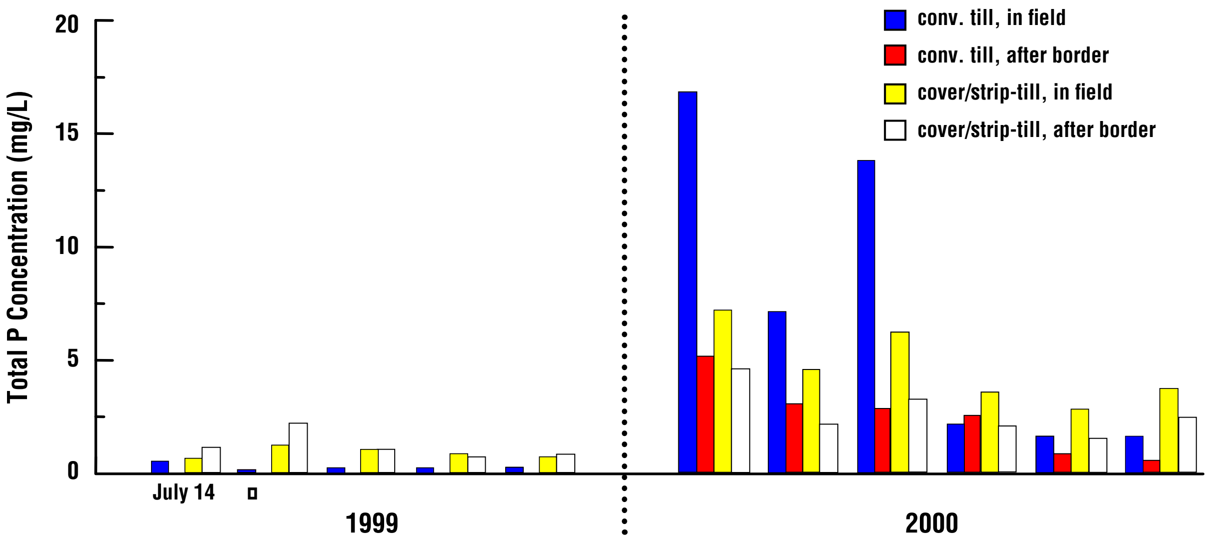

Figure 10. Effect of cover crop + tillage and vegetative borders on P loss with cotton.

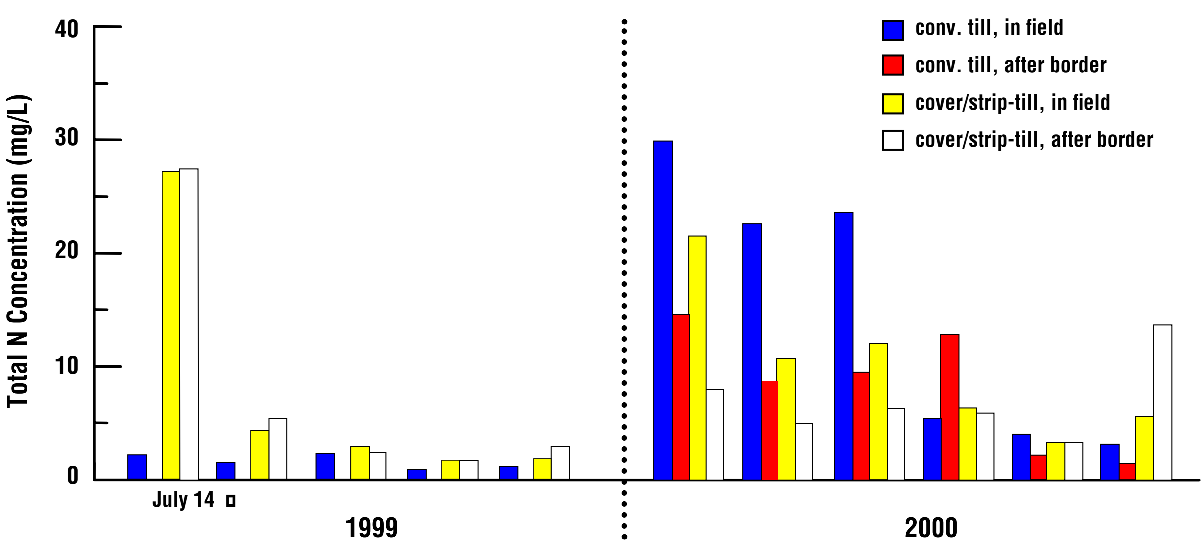

Figure 11. Effect of cover crop + tillage and vegetative borders on N loss with cotton.

sediment and soluble in water (Figure 10). Vegetative field borders further reduced runoff of sediment and sediment-attached P.

Data on N runoff were less consistent since N is primarily lost through the soil rather than as runoff (Figure 11).

Soil moisture conservation

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 and cover residue can increase the reservoir of available soil water and substantially increase corn yields in droughty years.

However, it may be difficult to obtain adequate corn stands during dry spring seasons if soil moisture has been depleted by an actively growing cover crop before corn planting. With a small grain cover crop, killing it 7 to 14 days before corn is planted can reduce potential soil water depletion. But if legumes are used, an early burndown is likely to reduce the amount of legume N available to the next crop, which would be corn in this example. One solution is to consider planting fields with legume cover crops last, but 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 the problem of soil water depletion.

Nitrogen contribution

A well-established legume cover potentially can supply 75 to 125 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 1). 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 2 and Figure 12).

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 other studies show crimson clover is also promising (Table 3). A legume cover crop plus a sidedress application of approximately 50 pounds of N per acre resulted in corn yields equal to or greater than that produced following winter fallow with sidedress N rates exceeding 100 pounds of N per acre. 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. Only small growers and farms using organic production methods have incorporated legumes into their farm management plans.

Table 1. Aboveground N Accumulation by Legumes at Corn Planting (2-year avg.)

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

Table 2. Corn Grain Yield as Affected by Cover Crop and N Rate (2-year avg.)

Cover Crop	N rate (lbs/acre)		
	0	90	180
	(bushels/acre)		
Rye	70	113	126
Crimson clover	121	132	136
Hairy vetch	129	136	136

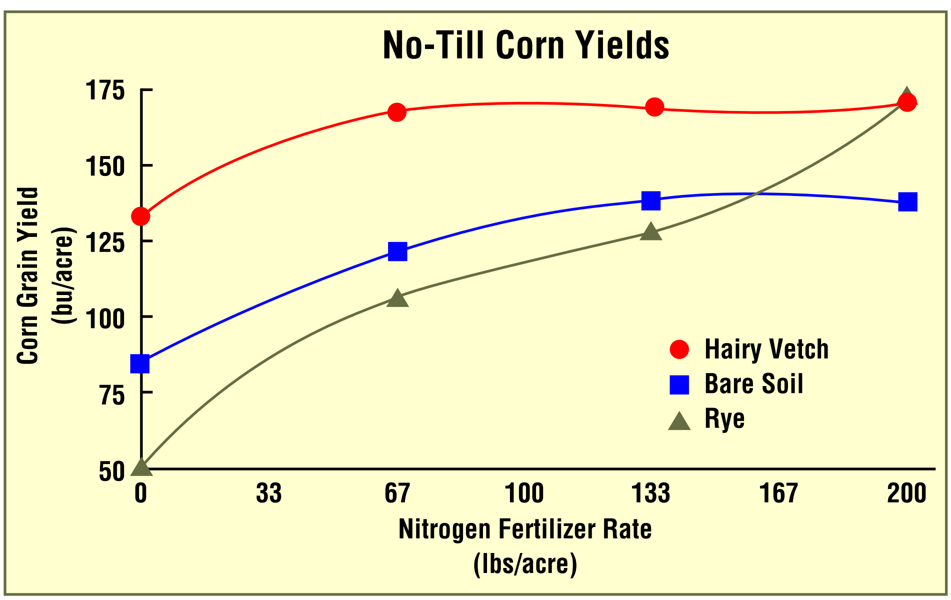

Figure 12. Influence of hairy vetch and rye cover residues on no-till corn yield response to N.

Table 3. Studies of N-supply by hairy vetch for corn in North Carolina								
Study	**Cover planted**	**Cover killed**	**Corn planted**	**Hairy vetch N**	**Grain Yield**			
					Vetch + 0 N	**Fallow + 0 N**	**Vetch + sidedress N**	**Fallow + sidedress N**
				lbs N/acre	**bu/acre**	**bu/acre**	**bu/acre (+ lbs N/acre)**	**bu/acre (+ lbs N/acre)**
Kamprath *et al.*, 1958 Coastal Plain	Mid Oct.	Early April	Mid April	75	62	12	73 bu (60 N)	76 bu (120 N)
Anderson *et al.*, 1990 Coastal Plain	Sept.	Early April	Mid April	159	109	12	117 bu (50 N)	85 bu (150 N)
Ambrose, 1997 Coastal Plain	Mid Oct.	April 11	May 3	----------	108	58	122 bu (40 N)	118 bu (120 N)
Wagger, 1989 Piedmont	Mid Oct.	Early April	Mid April	NA	53	50	71 bu (100 N) 80 bu (200 N)	76 bu (100 N) 69 bu (200 N)
Ranells, 1997a Piedmont	Mid Oct.	Early April	Mid April	154	NA	NA	55 bu (89 N)	NA
Ranells, 1997b Piedmont	Mid Oct.	Early April	Mid April	84	NA	NA	130 bu (134 N)	115 bu (134 N)
Hoyt, 1993 Mountains	Mid Oct.	Early April	Mid April	222	132	83	164 bu (67 N) 165 bu (134 N) 167 bu (200 N)	122 bu (67 N) 132 bu (67 N) 134 bu (200 N)

Legume N economics

Estimated costs associated with a legume cover crop include seed ($15 per acre for hairy vetch at 25 pounds per acre), inoculation ($1 per acre), planting ($8 per acre), and burndown herbicide ($4.50 per acre), for a total of $28.50 per acre. Assuming a legume cover crop contributes 70 pounds of N per acre, the legume alternative would be more profitable only if the fertilizer price exceeded $0.41 per pound of N ($244 per ton of 30 percent N solution), based strictly on N supply. Fertilizer costs vary due to market fluctuations but are generally in the range of $0.17 to $0.34 per pound of N ($100 to $200 per ton of 30 percent N solution).

Although current 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 (Table 4). 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:

1) If future price increases or supply fluctuations make N fertilizers less attractive.
2) If farmers want to take advantage of soil physical property benefits provided by cover crop residues.
3) 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 be-

Table 4. Summary of issues to be considered regarding legume cover crop planting.		
Issue	**Advantages**	**Disadvantages**
N supply	Substitutes for approximately 70 lbs N for a corn crop. Acceptable source for certified organic farms.	At current prices, chemical fertilizer N is cheaper.
Soil organic matter	Adds organic matter, can improve soil tilth.	Sufficient cover crop growth is required to enhance soil organic matter; plant Sept. to Oct. and allow to grow until April 1 (or later for mountain and piedmont).
Soil moisture	Maintains soil moisture due to increased soil organic matter and surface residue.	Cover crop growth can deplete soil moisture during dry spring; wait 2 weeks between burndown and planting.
Complex system effects	Can enhance nutrient recycling and suppress certain pests. Provides habitat for beneficials.	Can serve as habitat for pests (rodents, diseases).

comes sufficient. While there is limited experience with this practice in on-farm situations, it is a viable option for innovative farmers.

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 for no-till crops planted into a cover crop is similar to what is needed for conventional planted crops, excluding, of course, the use of cultivation for weed control. However, situations occur that make weed control under no-till management very difficult. 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 the 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.

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, there are 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

Figure 13. An example of crimson clover and hairy vetch cover crops.

vetch. Hairy vetch is better adapted to sandy soils than crimson clover, though crimson clover provides adequate dry matter production on most well-drained sandy loam. Crimson clover may also be slightly easier to manage, given its erect growth habit, than hairy vetch, which has a viney nature.

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

Fertilizer, lime, and inoculants
Adequate dry matter and N production will be obtained with a soil pH of 5.8 to 6.0. Soil testing is essential for determining fertilizer needs. Generally, legume cover crops use 50 pounds of phosphate (P_2O_5) and potash (K_2O) per acre. Bacterial inoculants should be applied to the seed before planting, and it is important to inoculate legumes with the proper strain of N-fixing bacteria. Rhizobia are similar for both hairy vetch and Austrian winter peas, but crimson clover requires different rhizobia.

Planting dates
A wide range in planting dates exists for most legumes (Table 5), though best results are obtained with early plantings. 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 rarely 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.

Seeding rates, depths, and method
Seeding rates and depths vary with legume species (Table 6). 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.

In planting, use shallow planting depths

Table 5. Planting Dates for Various Winter Annual Legumes.

	Crimson clover	Hairy vetch	Austrian winter pea	Cahaba white vetch
Mountains				
Preferred	Aug 10 Sept 15			Not adapted
Possible	Aug10 to Oct 15			
Piedmont				
Preferred	Aug 25 to Oct 1	Aug 25 to Oct 15	Aug 25 to Oct 1	Not adapted
Coastal Plain				
Preferred	Sept 1 to Sept 30			
Possible	Sept 1 to Oct 30			

Table 6. Seeding Rate and Depth for Various Annual Winter Legumes.

	Seeding Rate		
Legume	**Broadcast**	**Drilled**	**Seeding Depth**
	(lbs/acre)		(inches)
Crimson clover	20-25	15-20	1/4 - 1/2
Hairy vetch	20-30	15-20	1/2 - 1 1/2
Cahaba white vetch	20-30	15-20	1/2 - 1 1/2
Austrian winter pea	25-35	20-25	3/4 - 1 1/2

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 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 midsummer vegetable crops (pumpkins), grain sorghum, or tropical silage corn (late spring establishment) is the following crop. It usually will not work for 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).

As for other methods, planting rye at cotton defoliation has been successful. However, aerial seeding into a standing crop such as soybeans has been unsuccessful in a limited number of trials.

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, and this makes them a poor choice for grazing during this period. In the spring, if grazing continues too long, growers may find the rough soil conditions caused by hoof traffic diminish the benefits they expected from spring no-till management.

Small grains

Determine small grain fertilizer and lime needs based on soil test results. On coastal plain soils, supplemental N (25 to 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 of legumes, even as late as early December in coastal plain regions (Table 7). This permits establishment of the cover crop after a late-fall-harvested crop such as soybeans. Remember, though, that some soil erosion protection may be sacrificed with late seeding dates. 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 1/2 bushels per acre for rye, triticale, and wheat and 2 bushels per acre for oats. As previously discussed, seeding depth varies from 1/2 to 1 1/2 inches, depending on soil texture. Planting methods are the same as described for legumes. Aerial seeding of rye into soybeans just before leaf drop has been marginally successful.

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 14).

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.

Mixtures: Multiple benefits

It is possible to combine two or more cover crop species in a single planting and realize the benefits of each. In general, a grass species is combined with one or more legume species. For example, when cereal rye and hairy vetch are

Table 7. Planting Dates for Small Grains

Location	Rye	Wheat	Triticale	Oats
	(planting date)			
Mountains				Not adapted
Preferred	August 15 to September 30			
Possible	August 15 to October 30			
Piedmont				
Preferred	September 15 to October 15			
Possible	September 15 to November 15			
Coastal Plain				
Preferred	September 30 to November 15			
Possible	September 30 to December 15			

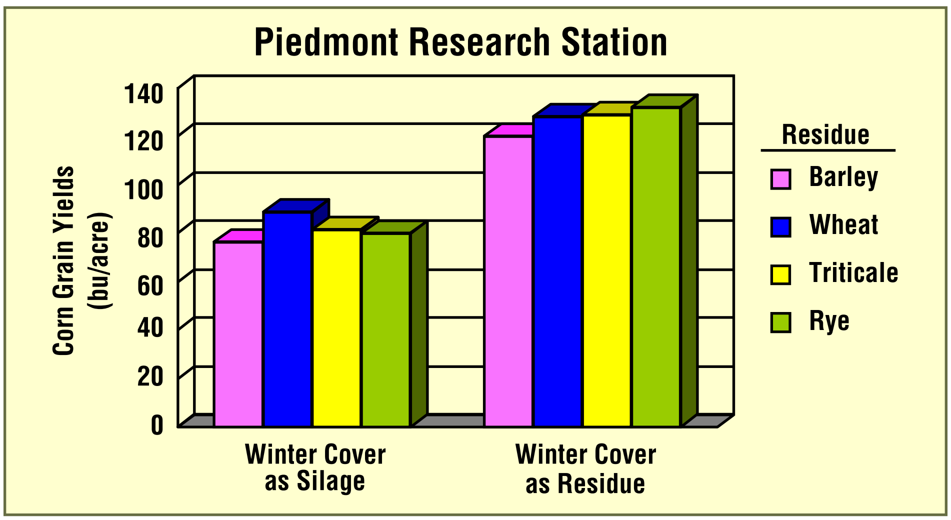

Figure 14. Corn yields in the Piedmont are lower following small grain silage removal, compared to leaving the small grain as mulch.

planted together, the rapid germination and early fall growth of cereal rye helps to stabilize the soil surface and permit the more fragile hairy vetch seedlings to thrive. The following 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. Cereal rye, when planted early in the fall alone and in mixtures, 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 lower residual inorganic soil nitrogen, compared to 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.

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 and will be discussed in the following sections.

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. Of the small grain cover crops, rye is the easiest 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 [psi]) will aid the spray in penetrating 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

No-till planting into a cover crop involves minimal soil disturbance, 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.

While no-till seed-planting-equipment performance has improved considerably over the years, the seedbed environment in the system dictates that seeding rates be 10 to 15 percent greater 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 15). Surface residue cools the soil considerably during the spring, with late summer differences among the cover and bare soil becoming less as the corn crop begins to shade the soil. The use of a starter fertilizer will insure more rapid initial growth. For corn following a small grain cover crop, special consideration must be given to fertilization, especially with regard to the nitrogen source, placement, and timing of application. Other management factors in a no-till system are similar to practices used with conventional tillage.

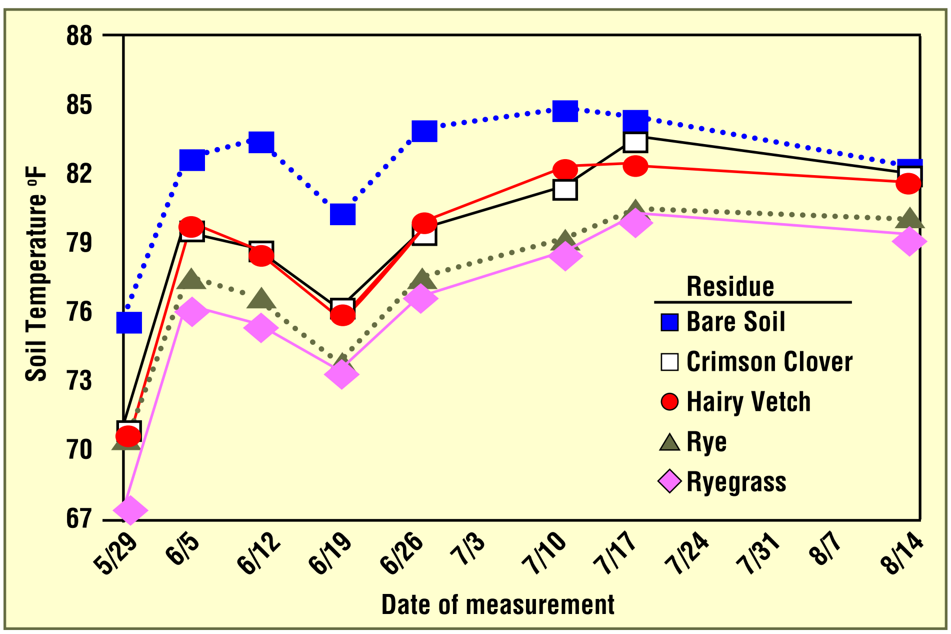

Figure 15. Temporal variation in soil temperature at 2-inch depth with selected cover crops.

References

Ambrose, L.G. 1997. Beaufort County 1997 On-Farm-Test Report.

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. Proceedings, 1990 Southern Region Conservation Tillage Conference, Raleigh, NC.

Kamprath, E.J., W.V. Chandler, and B.A. Kranz. 1958. *Winter cover crops: Their effects on corn yields and soil properties*. Tech. Bul. No. 129. Agricultural Experiment Station, North Carolina State College, Raleigh, NC.

2004 North Carolina Agricultural Chemicals Manual. AG-1. College of Agriculture and Life Sciences, North Carolina State University.

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