Managing Winter-Annual Legumes as Nitrogen Sources for No-Tillage Corn on Sandy Coastal Plain Soils

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Cultural practices that reduce soil erosion and conserve soil moisture are priorities among southeastern corn producers. The planting of corn into a legume mulch reduces soil erosion and may conserve sufficient soil moisture to increase grain yields in dry seasons. No-tillage corn planting into a legume cover also lowers labor and fuel requirements while providing substantial amounts of nitrogen (N) for the crop. A cropping system involving winter annual legumes followed by no-tillage corn may be especially useful in the southeastern coastal plain where corn is grown on soils that are low in organic matter, low in water-holding capacity and subject to wind and water erosion.

Effect of pH and Planting Date on Legume Performance

Since both the quantity of mulch and N produced by winter legumes is directly related to the accumulation of root and top growth prior to corn planting, an excellent legume stand is essential. Corn grain yield will be reduced where legume stands are inadequate. Soil pH and planting date greatly influence the establishment of legume stands. Most winter annual legumes are sensitive to soil acidity (Table 1). If soil pH is less than 5.8, it is best to postpone legume seeding until lime can be incorporated.

Table 1. Management suggestions for various winler annual legumes.

Legume	Seeding Rale Broadcast	Seeding Rale Drilled	Seeding Depth	Optimum pH
	-----bu/ac-----			
Hairy vetch	20-30	15-20	1/2 - 1 1/2	5.8 - 6.2
Cahaba White	20-30	15-20	1/2 - 1 1/2	5.8 - 6.2
A. winter pea	25-35	20-25	3/4 - 1 1/2	5.8 - 6.0
Crimson clover	20-25	15-20	1/4 - 1/2	

Optimum planting dates (Table 2) are equally important in the establishment of vigorous legume stands. Since late planting increases the sensitivity of winter annuals to low winter temperatures, it is important to plant legume cover crops in late summer or early fall when soil moisture is favorable. In North Carolina, optimum planting conditions are usually encountered around September 1. September-planted legumes produce more top growth in the spring that translates into extra pounds of N available for use by corn.

Table 2 Suggested planting dates for selected winter annual legumes in North Carolina

Legume	Coastal Plain Best Dales	Coastal Plain Possible Dales	Piedmont Best Dates	Piedmont Possible Dales
Hairy vetch	9/1-9/30	9/1-10/30	8/25-9/30	8/25-10/25
Cahaba white	9/1-9/30	9/1-10/30	Not Adapted	
A. winter pea	9/1-9/30	9/1-10/30	8/25-9/30	8/25-10/25
Crimson clover	9/1-9/30	9/1-10/25	8/25-9/15	8/25-10/25

It is unwise to encourage further legume growth by delaying corn planting into late April. It is preferable to stimulate legume growth with early seedling dates and good management of the cover crop. A special situation may arise when vigorous cover crop growth is accompanied by spring rainfall deficits. Cover crops may deplete soil moisture such that poor corn stands are obtained. If a dry spring appears to be forthcoming, it is advisable to destroy the cover crop one to two weeks ahead of corn planting (Wagger, 1989).

On-Farm Evaluation of Winter Annual Legumes

There are a number of legumes that may serve as N sources for corn. Several were evaluated in replicated, on-farm experiments in the coastal plain of North Carolina between 1982 and 1985. Legumes and legume management practices were examined in 4-row by 50 ft. plots arranged in split plot designs with at least four replications. Inoculated legumes were assigned to main plots and N fertilizer (ammonium nitrate) rates to subplots. Soil types were of the Norfolk or Wagram series.

After an initial screening, sweet clover *(Melilotus)*, red clover *(Trifolium pratense* L.) and subterranean clover *(Trifolium subterraneum* L.) were discarded. However, hairy vetch *(Vicia villosa* Roth), Cahaba White vetch *(Vicia sativa)*, crimson clover *(Trifolium*

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incarnatum L.; Tibbee variety) and Austrian winter pea (*Pisum sativum* subsp. *arvense* (L.) Poir.) all exhibited characteristics favoring their use as N sources.

Hairy and Cahaba white vetch The data (Tables 3 and 4) indicated that the greatest N production and highest grain yields were obtained with hairy vetch. Producers that grow small grains are often reluctant to use vetch in their rotations because of its reputation as a volunteer weed in wheat. An application of 2,4-D or dicamba effectively controls vetch in small grains. To date, producers using vetch as a winter cover have been able to chemically destroy it before seeds are produced. Volunteer vetch has not been a problem for those growers.

Table 3. Dry matter and nutrient content of legume top growth at corn planting..

Legume	Dry matter	% N	Total N	Total K
	(lb/ac)		(lb/ac)	(lb/ac)
Hairy vetch	3916	4.04	159	117
Cahaba white	3568	3.74	133	94
A. winter pea	2872	3.45	99	68
Crimson clover	5816	2.59	151	98

***Data represent the average of three experiments conducted during the 1983 and 1984 crop years. All legumes were planted in September following tobacco.**

Vetch is the easiest of the legumes to establish on sandy soils and, of the legumes tested, it was the best performer on poorly-drained soils. Hairy vetch was also the most winter hardy of the winter annuals tested. Cahaba White vetch was less winter hardy than hairy vetch; it also produced slightly lower corn yields and total above-ground nitrogen than hairy vetch (Tables 3 and 4). It was, however, easier to kill with paraquat and offered resistance to nematode diseases that are often a problem in eastern North Carolina.

Austrian winter pea: Austrian winter pea did not produce yields as high as the vetchs and generated the least amount of N among the legumes tested. Nevertheless, it was easy to establish on sandy soils, easy to kill with paraquat and, during the course of our studies, it was less expensive than vetch seed. Austrian winter pea also appeared to be more responsive to late seeding dates than Tibbee Clover and Cahaba White vetch. At one time, there were thousands of acres of Austrian winter pea in the coastal plain of North Carolina. They disappeared because Austrian winter pea was not resistant to common nematodes and were susceptible to troublesome peanut diseases like Southern stem rot. Nematode sampling of plots in 1983 and 1984 suggested that the legumes tested neither aggravated problem fields nor created new nematode infestations (data not shown). This observation probably resulted from the fact that the winter annual cover crops were present in fields when nematode populations were dormant.

Table 4. Effect of cover crop and nitrogen rate on corn yield.*

Legume	Nitrogen Rate 0	50	100	150
	--------(bu/ac)--------			
Hairy vetch	109	117	125	129
Cahaba while	89	109	106	115
A. winter pea	72	104	104	100
Crimson clover	73	88	96	105
No cover	12	43	68	85

***Data represent the average of three experiments conducted during the 1983 and 1984 crop years. All legumes were planted in September following tobacco.**

Crimson clover: Crimson clover produced large quantities of N and dry matter (Table 3). However, no-tillage planting into crimson was difficult in our tests because the thick vegetation hampered efforts to obtain consistent seeding depths. Moreover, the dense canopy of vegetation remained standing for several days after glyphosate was applied preemergence. The failure of the crimson clover to fall rapidly increased the incidence. of rodent damage to germinating seed. For this reason, it appeared advisable to use paraquat rather than glyphosate when chemically killing crimson clover.

Supplemental Nitrogen

The data from our on-farm tests suggested that vigorous, winter annual legumes provided corn with the equivalent of at least 100 lb/ac of fertilizer N (Table 3). It was still necessary to apply about 50 pounds of supplemental N (Table 4) although legumes provided all the necessary N when drought and pursuant low yields were encountered. Monitoring of soil inorganic N levels in 1984 and 1985 suggested that supplemental N should be applied in sidedressing applications 4- to 6-weeks after planting.

Managing Hairy Vetch as a Nitrogen Source

Collectively, our 1982-1983 data suggested that hairy vetch was the best legume alternative. Accordingly, additional studies were conducted in 1984-1985 to determine how to best utilize hairy vetch as a N source for corn. Two years of experimentation indicated that supplemental N was needed even when spring vetch growth averaged 3768 lb/ac (Table 5). Removal of vetch as a forage prior to corn planting reduced grain yield; however, the decrease in yield was overcome by the addition of 75 Ib/ac N. In-row subsoiling produced

Table 5. Influence of vetch management and N fertilizer rate on grain yield. Avenge of 1984 and *1985* experiments

Management Treatment	Abbreviation	N fertilizer rate (lb/ac) 0	75	150
		Corn grain ykld (bu/ac)		
No cover	F	50	91	117
Cover removed	CR	71	143	138
Cover incorporated	INC	115	126	139
No-till with subsoiling	NT	125	132	134
No-till without subsoiling	NS	97	114	120
Strip-killed/2 weeks	S2	95	115	108
Strip-killed/4 weeks	s4	88	93	110
Strip-killed/maturity	SM	70	72	91

Planned Comparisons

Source	df	MS	Source	df	MS
Management treatment	7	41.24**	N rate X Mgmt.	14	7.98**
F vs NT, NS (C1)	1	91.70**	NL X (C1)	1	33.61**
NT vs NS (C2)	1	23.30*	NL X (C2)	1	1.81
INC vs CR (C3)	1	5.34	NL X (C3)	1	18.18**
INC,CR vs NT,NS(C4)	1	0.44	NL X (C4)	1	15.25**
S2,S4 vs SM (C5)	1	44.76**	NL X (C5)	1	0.12
S2 vs s4 (C6)	1	5.00	NL X (C6)	1	0.79
S2,S4,SM vs Otrs (C7)	1	93.44'	NL X (C7)	1	13.79**
Error (a)	28	3.94	NQ X (C1)	1	0.26
			NQ X (C2)	1	0.12
N rate	2	80.02**	NQ X (C3)	1	20.15*
N rate linear	1	151.45**	NQ X (C4)	1	5.80
N rate quadratic	1	8.58**	NQ X (C5)	1	2.80
			NQ X (C6)	1	5.17*
			NQ X (C7)	1	5.85**
CV (a) = 29.63					
CV (b) = 12.98			Error (b)	64	0.76

'denotes significance at the P = .05 probability level.
** denotes significance at the P = .01 probability level.

grain yield increases at all N rates even though vetch residues on the soil surface provided a thick mulch. Incorporation of the vetch by disking prior to in-row subsoiling did not reduce grain yield. When vetch was killed in a 10-inch band over the corn row at planting, and vetch in the row middles allowed to grow for 2- to 4-weeks after planting, corn yield was decreased. Thus, "strip-killing" of vetch was eliminated as a viable method for increasing the volume of vetch mulch and its N contribution after corn planting.

Chemical Control of Legumes

Among growers, there is concern about the most effective method for chemically destroying standing legumes. Our experience between 1982 and 1985 suggested that the non-selective herbicides, paraquat and glyphosate, were effective on the four legumes tested. Paraquat appeared to be the most consistent of the two herbicides, particularly when it was tank-mixed with atrazine and UAN solutions. In either case, an inexpensive, layby application of 2,4-D or dicamba eliminated concerns about legume plants that escaped non-selective herbicide treatments. Our general observations regarding chemical control of winter annual legumes were consistent with those of White and Worsham (1990) who studied the chemical control of legumes in detail.

Moisture and Nutrient Conservation by Legumes

Legumes intended for use as N sources for corn are generally evaluated in terms of their potential N production. Often overlooked is increasing evidence that mulches and crop residues may be managed to conserve soil moisture, thereby increasing corn yields. Although we were, in our 1984-1985 studies, unable to document soil moisture conservation by a hairy vetch mulch during corn grainfilling, hairy vetch mulches do appear to retain additional soil water for crop use early in the growing season (Frye, 1989). Often overlooked is the ability of the legume covers to take up and store nutrients such as potassium (Table 3). In effect, the legume mulches may serve as a reservoir of nutrients that are essentially "slow-released" as corn develops on sandy soils.

In conclusion, it appears reasonable to suggest that legume cover crops are generally more economical to establish than rye or wheat when the value of their N contribution is considered. Thus, winter annual legumes offer many opportunities to the corn producer who is willing to manage them with the same care that he gives other crops. However, legume planting dates appear to be the most critical component of a successful legume/corn cropping system. Among current rotational schemes, continuous corn and corn rotated with tobacco provide late summer or early fall planting "windows" that facilitate adequate spring growth of winter annuals and permit the effective use of winter annual legumes as N sources for no-tillage corn.

References

Frye, W. W. and R. L. Blevins. 1989. Economicallv sustainable crop production with legume cover crops and conservation tillage. J. of Soil and Water Cons.44:57-60.

Wagger, M. G. 1989. Time of desiccation effects on residue composition and subsequent nitrogen release from several winter annual cover crops. Agron. J. 81:236-241.

White, R. H. and A. D. Worsham. 1990. Control of legume cover crops in no-till corn *(Zea mays)* and cotton *(Gossypium hirsutum)*. Weed Tech. 4:57-62.