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Grow Your Own N: Legumes in Row Crop Systems

The 21st Century, Alabama row crop farmer has few alternatives to the increasingly high cost of fertilizers. It's kind of like alternatives to gasoline. There are some, but our society has become addicted to cheap fuel and it will be a major lifestyle change to adopt these alternatives. Since World War II, modern Alabama agriculture has also become addicted to relatively cheap, inorganic fertilizers. We have often used increasing rates of fertilizer nutrients to substitute for intensive management e.g., crop rotations and building soil organic matter. No one really knows at what price or when fertilizer prices will stabilize but we are almost certain that they will continue to rise in the near future. So, what alternative does an Alabama cotton or corn farmer have? He can either pay the price for fertilizer N, use animal manures, e.g. poultry litter, if they are available, or use the tried and proven technique of growing your own N the form of legumes.

The Old is New Again

I have been told that as much as 1/3 of Alabama's cotton crop was grown with a winter legume prior to World War II. This was the only source of N for many farmers. It is not surprising that the oldest, continuous cotton experiment in the world, Alabama's "Old Rotation" experiment at Auburn (circa 1896), was an experiment to demonstrate the use of winter legumes for cotton and corn production. It continues to demonstrate that a good winter annual legume (crimson clover or vetch) can fix around 100 pounds N per acre, more than enough N to produce 2+ bales cotton per acre (Table 1). However, growing a legume in a conservation tillage system requires timely planting and lots of management. It is not easy but it can reduce purchased fertilizer N use. Legumes are an excellent choice where soil test P and K levels have been built up to "high" from past poultry litter or fertilizer applications. Some legumes which have been tried include crimson clover, hairy vetch, common vetch, and lupin.

Crimson clover in late March on the Old Rotation Experiment (circa 1896) at Auburn.

New Winter Legumes as Cover Crops

Auburn University has had an active legume breeding program for several decades. One of the objectives is to improve annual winter legumes for use as a cover crop and source of N for row crops. In the 1960s and 1970s, Auburn released 'Vanguard' vetch, 'Nova II'vetch, 'Cahaba White' vetch, 'Vantage' vetch, and Warrior' vetch. More recent introductions include 'AU Early Cover' hairy vetch and 'AU Groundcover' caley pea (1995). Some of the more promising winter legumes include hairy vetch, common vetch, crimson clover, and white lupines. Within each group are cultivars that have different growth and yield characteristics. In the 1990s a project was done to compare some of the more promising winter legumes as the only source of N for cotton. Tests were done at E.V. Smith Research Station and on farmers' fields in Alabama. At the same time, researchers at the Georgia Coastal Plain Experiment Station were doing similar studies. Some of these results are in Table 2.

Table 1. Mean cotton and corn yields on Alabama's "Old Rotation Experiment" (circa 1896) from 1996-2005.

	Nitrogen		Cotton lint	Corn grain
	Fertilizer N	Estimated legume N		
Treatment	-------lb N/acre-------		---lb lint/acre--	--bu/acre--
COTTON EVERY YEAR				
No N; no legume	0	0	390 d	--
Legume N only	0	100	1060 bc	--
Fertilizer N only	120	0	1170 b	--
2-YR COTTON-CORN ROTATION				
Legumes only	0	100	1060 bc	82 c
Legumes plus fertilizer N	120	100	1320 a	138 a
3-YR COTTON (legume)-CORN (wheat plus N)-SOYBEAN				
3-Yr Rotation	60 to wheat only	100 on corn; 40 on cotton	990 c	102 b

One of the problems with comparing different winter legumes is that they mature and bloom at different times. Out of necessity, all of those listed in each study were harvested at the same time regardless of maturity level. This introduces a lot of variability into the data when comparing one site with another. With on-farm tests, the farmers were responsible for establishing legumes in the fall. This presents a challenge when trying to plant small seeding clovers versus large seeded vetch and even larger seeded lupins. Regardless of the variability in dry matter yields, estimated N fixation, and cotton yields following the legumes, one thing is clear. Properly managed winter legumes can substitute for most if not all of the N needs of a good cotton crop. Note in Table 2 that we produced almost 3 bales of cotton per acre in 1997 using only the N from crimson clover. At the same site in 1996, we had very disappointing legume and cotton yields.

Sidedress N for Maximum Yields

If your goal is to produce maximum yield, then additional sidedress N may be needed regardless of the winter legume. This is especially true if you have a soil low in organic matter with no history of high residue management. Note in Table 1 that the absolute highest cotton and corn

yields on the Old Rotation were produced with a winter legume PLUS 120 pounds fertilizer N per acre. Without the additional sidedress N, cotton yields with legumes were about the same as continuous cotton with 120 pounds fertilizer N per acre and no legume. The winter legume actually increased the yield potential of the soil such that additional sidedress N produced higher yields. Corn grain has such a high N requirement that additional sidedress N is always needed for corn. Although 120 pounds N per acre were applied to the corn, a realistic sidedress N rate would be around 60 to 80 pounds fertilizer N per acre for a yield potential around 150 bushels per acre.

Table 2. Legume dry matter yields, N fixation and cotton lint yields from several experiments in Alabama and Georgia.

Winter legume	Dry matter yield[1]	Total N in herbage	Cotton lint yield[2]
	----lb/acre----	----lb/acre-----	-----lb/acre-----
E.V. Smith Research Center (1996)			
Hairy vetch	3720 a	136	420ab
Crimson clover 'Tibbee'	1940 b	58	490a
Crimson clover 'AU Robin'	1830 b	54	470a
Vetch 'Cahaba White'	1660 b	62	390ab
Vetch 'AU Early Cover'	1900 b	83	400ab
No legume/ 100 lb. N/acre	--	--	410ab
No legume/ no N	--	--	340 b
E.V. Smith Research Center (1997)			
Hairy vetch	3160	129	1290a
Crimson clover 'Tibbee'	5860	124	1430a
Crimson clover 'AU Robin'	4000	87	1260ab
Vetch 'Cahaba White'	3940	148	1060 b
Vetch 'AU Early Cover'	5100	194	1260ab
White Lupine	4970	130	1210ab
No legume/ 100 lb. N/acre	--	--	1450a
No legume/ no N	--	--	760 c
Mean of 4 Alabama on-farm Tests in 1995			
Hairy vetch	3200a	124	No yield taken
Crimson clover 'Tibbee'	3400a	85	No yield taken
Crimson clover 'AU Robin'	3550a	75	No yield taken
Vetch 'Cahaba White'	2580 b	89	No yield taken
Georgia Cover Crop Study (1996)[3]			
Crimson clover 'Tibbee'	3640	125	--
Crimson clover 'AU Robin'	4170	157	--
Vetch 'Cahaba White'	690	38	--
Vetch 'AU Early Cover'	2680	122	--
Lupine	0	0	--
Arrowleaf clover	2840	92	--
Ball Clover	273	112	--
Big berseem clover	4020	151	--
Red clover 'Cherokee'	2760	107	--
Rye	6670	88	--

[1] Values followed the by same letter are not statistically different at $P<0.05$.
[2] Values followed the by same letter are not statistically different at $P<0.10$.
[3] Data from Glen Harris et al. from a study conducted at Tifton, GA.

Crimson clover. AU Robin crimson clover has been grown on the Old Rotation since soon after its release in the 1980s. It is fairly easy to establish in standing cotton stalks; it produces good dry matter yields over a wide growing area; it grows erect which makes it much easier to strip till into the residue; and most importantly, it matures early often reaching full bloom by April 10 in Central Alabama.

Hairy vetch. Hairy vetch seed are larger and cheaper than crimson clover. Because they are larger, they must be drilled or disked into the soil for reliable germination and hairy vetch reaches full bloom a few days later than most crimson clovers. It also produces a tangled mass of vegetation that could present a problem when trying to strip till into it. AU EarlyCover, is the earliest flowering hairy vetch cultivar commercially available. Released in 1994, AU EarlyCover flowers 23 to 36 days earlier than common hairy vetch. AU EarlyCover is an excellent cover crop because of its early growth. When this cultivar is harvested or incorporated into the soil as a green manure on or around April 1 (about the time when many lower South farmers get ready to plant corn), it has a dry matter yield comparable or superior to the commercial type hairy vetch. By mid-February, when commercial hairy vetch has little accumulated growth, AU EarlyCover can have 150 to 200 lb per acre of dry matter, therefore, it can be turned earlier than commercial hairy vetch.

Common vetch. Cahaba white vetch is a common vetch released by Auburn in 1979, and has shown promise in row crop production. It has an earlier growth than common hairy vetch and it is resistant to root-knot nematode and soybean cyst nematode. It is less cold hardy than hairy vetch so is recommended for the southern 2/3 of Alabama.

Although commercial seed is not available yet, a new common vetch, AU Olympic, was released in 2003 by Auburn University and the Alabama Agricultural Experiment Station. It is resistant to root-knot nematode *(Meloidogyne arenaria)* and soybean cyst nematode *(Heterodera glycines)*. Testing in Alabama showed that forage dry matter yield of AU Olympic was consistently higher than Cahaba White. In 1999, the forage dry matter yield of AU Olympic was 21% higher than Cahaba, and in 2002, 12.8% higher. It flowers on the average about the same time as Cahaba white.

White lupin. White lupin varieties perform better in Alabama than blue lupin. All lupins must have well drained soils. They will not tolerate wet feet during the winter. Therefore, lupins are best adapted to upland, sandy soils of the Coastal Plain region. Seed are about the size of a pea and require drilling for successful establishment in the fall. Because lupins grow rather tall in the spring (2 to 3 feet), the residue is rather easy to plant into. They mature later than hairy vetch which could be a problem for cotton producers.

Other winter legumes. There are other winter legumes which are used successfully in other regions of the world or on selected soils, e.g. caley peas on Black Belt soils, Austrian winter peas, ball clover, fava beans, etc. Some biennials or perennial cool-season legumes have been tried e.g. white clover, red clover, berseem clover, and sweet clover. However, these often have limitations for use as a cover crop in Alabama for spring planted row crops. AU GroundCover is a caley pea that was released in 1994.

Seed of crimson clover, hairy vetch and caley pea can be obtained from
Southern Proprietary Seeds Inc.
P.O. Box 230
587 South West Third Ave.

Lake Oswego, OR 97034
Phone:503-636-2600
FAX: 503-636-7020

Seed of common vetch can be obtained from
Bailey Seed Co.
P.O. Box 12788
Salem, OR 973099
1-800-407-7713
email: BAILEYSEED@AOL.COM

Establishing Winter Legumes

The earlier winter annual legumes are seeded in the fall, the better the results. Late September to early October is best. If you haven't planted by November 15 in Central Alabama, leave the seed in the bag and store them until next year. You will be better off buying fertilizer N for your crop. Small seeded clovers can often be broadcast over standing cotton stalks with reasonable success. The seeds need to be in contact with soil moisture. Drilling may be preferred to increase the chances of germination. However, don't plant until AFTER a cotton crop has been defoliated; the defoliant could kill emerging seedlings. Large seeded vetches and lupins must be drilled. A seed innoculum is recommended if the legume has never been grown on this soil before. Seeding rate and depth of planting are in Table 3. This information was copied from Alabama Cooperative Extension Circular ANR-150 (revised 2005), "Alabama Planting Guide for Forage Legumes".
http://www.aces.edu/pubs/docs/A/ANR-0150/ANR-0150.pdf

Reseeding Legumes

Seeding annual legumes into a maturing cotton crop is an additional expense and effort that discourages most growers. Generally, this is an expense and effort that cannot be avoided. The question is often asked, "Can winter annual legumes reseed in a row crop system?" Actually, we have been successful in getting AU Robin crimson clover to reseed for 3 years in rotation with cotton. It is not easy, and it does require some very timely management and a little luck. Later maturing clovers and vetches have not been successfully reseeded in cotton. To get the clover to reseed, you have to let seed mature before killing the legume. It usually reaches full bloom about the second week in April. Allow the seed to mature until early May and then kill it just before planting strip-tilled cotton. This technique has also worked with late-planted tropical corn varieties. Many of the seed may germinate during wet weather in the summer but most of these die from hot weather or from herbicide applications. Enough hard seed remain to germinate in the fall and re-establish the crimson clover.

Killing Winter Annual Legumes

Refer to Alabama Cooperative Extension Circular ANR-05 (2006), "Cotton Insect, Disease, Nematode and Weed Control Recommendations for 2006", for labeled herbicides for preplant application to cotton.
http://www.aces.edu/pubs/docs/A/ANR-0500-A/VOL1-2006/cotton.pdf

The same publication has a chapter for weed control in corn, "Corn Insect, Disease and Weed Control Recommendations for 2006".
http://www.aces.edu/pubs/docs/A/ANR-0500-A/VOL1-2006/corn.pdf

Planting into a Legume Residue

For best results, the legume should be killed at least 2 weeks prior to planting. This is more critical in cotton than in corn. Corn is more tolerant of the damaging effects of decomposing residue than cotton. Cotton should not be planted into green, legume residue. An in-row subsoiler or paratill can be pulled through the residue at any time before or after the legume is killed with herbicides. A good rainfall is often necessary behind an in-row subsoiler to allow the soil to settle before planting. A row cleaner on the planter helps to remove the residue in a narrow (6-8 inch) wide strip. This usually results in better seed germination. Keep in mind that certain insects could be a problem with any row crop planted behind a vigorous winter legume. Be prepared to address these using recommendations in the above publications.

Table 3. Seeding rate and depth of planting of some winter annual legumes for Alabama (from ACES cir. ANR-150, revised 2005)

Legume	Seeding rate	Depth of planting
	----lb/acre---	--------inches-------
Arrowleaf clover	5-8	0 - ½
Black medic	10	0 - ½
Caley peas	15-20	¼ - ½
Ball clover	3-5	0 - ¼
Crimson clover	20-30	0 - ½
Sweet clover	12-15	¼ - ½
Common vetch (e.g., Cahaba White)	30-40	1 - 2
Hairy Vetch (e.g., AU Early Cover)	20-25	1 - 2

Legumes and Nematodes

Plant parasitic nematodes can dramatically reduce yields of cotton. Root knot *(Meloidogyne inconita and M. arenaria*) and reniform (*Rotylenchuylus reniformis*) nematodes are particular concerns of Alabama producers. Because most winter annual legumes can serve as a host for both species, some producers are reluctant to include legumes in a crop production system. Recent research by J.R. Jones et al. at Auburn University confirms that crimson clover, hairy vetch, and some other non-leguminous cover crops were excellent host for the reniform nematode in the greenhouse at constant temperature of 72 F. However, this did not occur in the field. In field trials, reniform population densities did not increase on crimson clover, subterranean clover, and hairy vetch over the winter months under natural conditions. This is good news for those who wish to try a legume as a source of N for cotton.

Summary

Just like there is no easy, cheap and quick solution to the high cost of gasoline, there is no easy, quick and cheap solution to the high cost of fertilizers. Both situations may results in a change in our habits. We do have a tried and proven technique to provide at least some of the N required for cotton and corn production. Successful use of winter annual legumes as a source of N and soil organic matter has been demonstrated on Alabama's Old Rotation Experiment for 110 years. However, there are expenses and a lot more management involved in planting a winter legume. An additional trip across the field is necessary to plant the legume in the early fall. Seed for improved varieties are not cheap. Results will depend on the weather. The legume must be killed in a timely manner and the crop must be planted into the residue. There may be additional pests to control. Especially with corn, some sidedress N is still required for high yields. The

advantage of using legumes as a winter cover crop is that it protects the soil, improves soil quality and yield potential, and adds free N to the succeeding crop.

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Crimson clover (foreground) and vetch (background) are being evaluated as a source of N for cotton in Hale County in 1995.

White lupin in full bloom in late April in Central Alabama on a sandy soil.