Crop Management and Cropping Systems

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No-till research has been conducted sporadically in the Southeast for many years. Intensive or large scale research programs were not, however, initiated until the mid 1960's in the upper South (primarily Virginia and Kentucky) and in the early to mid 1970's in the lower South.

The advantages of no-till such as soil and water conservation are understood by almost everyone associated with crop production. Extensive research conducted in Georgia, Tennessee, and Mississippi illustrates the advantages of mulches in soil and water conservation. Recent research conducted in Alabama and Kentucky documents the value of topsoil for maximizing corn, soybean, and cotton yields. Initial studies with no-till primarily involved comparing no-till yields with conventional tillage yields. From these studies came a wide range of conclusions; some favored no-till and some did not.

Although some studies suggested that no-till reduced yields or was not as economical as conventional tillage, most researchers realized that the advantages and long term benefits of no-till were great enough that elimination of these effects was necessary. Studies designed to improve the profitability of no-till systems are still in their infancy, but sufficient data have been collected to indicate that management is the key to success. Management is definitely more intense with no-till than conventional tillage. Studies currently being conducted through the Southeast include mulch selection and management, fertilizer application and placement, planter selection, row width, effects pest control and pesticide use, and cropping and tillage systems.

Pesults from studies conducted to date suggest that specific management practices for successful no-tillage may vary widely from region to region within the Southeast. Basic principles are, however, fairly uniform. Since specific management practices vary, only basic principles will be discussed in this paper.

Mulch Selection and Management

Mulch selection (winter cover crop) and management encompass a wide and diverse territory. Commonly listed disadvantages of winter cover crops are: soil water depletion, lower soil temperatures, and increased cost. Research studies are currently in progress to identify methods of managing these disadvantages.

One important aspect of mulch management is deciding when **it** is best to kill the winter cover crop. Research is currently being conducted in several states to determine this. In Alabama, cotton no tilled into green rye and vetch reduced seed cotton yields 380 and 1,670 pounds per acre, respectively, when compared to killing the cover crops 10 to 14 days prior to planting. In South Carolina, corn yielded better when planted into rye killed 20 days prior to planting than when planted into rye killed at planting. For soybeans, however, killing mulches in advance of planting has not shown any influence on yields. The better cotton and corn yields resulting from early kill dates are most likely due to less soil water depletion and better crop stands. In most Southeastern soils, water holding capacities are low, and it is a definite disadvantage to plant summer crops into soils with low water levels.

In some situations, killing winter cover crops prior to planting may result in warmer soils at planting. The adverse effect of cool soil temperatures is primarily associated with poor seed germination. There is also a relationship between immobile nutrient uptake and cool soil temperatures. A cool soil high in residual nutrients may not he able to provide a sufficient quantity of available plant nutrients. In some situations particularly in compacted soils, reduced nutrient uptake may well be one of the primary reasons why early-planted no-till crops sometimes grow slower and yield less than crops grown with conventional tillage.

It has long been known that the use of relatively low rates of starter fertilizers will help eliminate the adverse effect of cool soil temperatures on early season nutrient uptake. Several studies reported from heavy, compact soils in the upper corn belt have shown a beneficial effect from use of starter fertilizer, even on medium to high testing soils. A study conducted on a Zanesville soil in Kentucky showed no effect from use of a starter, while studies in Alabama have shown some positive responses, particularly on Coastal Plains soils with compacted layers in the root zone. Table 1 shows results obtained from starter fertilizer tests conducted in Alabama. Similar results have been obtained in Alabama with grain sorghum, cotton and in some situations, with soybeans and peanuts.

Table 1. Yield of corn grown in conservation tillage systems in South (Dothan soil) and North (Decatur soil) Alabama as affected by starter fertilizer, in-row subsoiling, and fertilizer placement.

Starter fertilizer[1/]	In-row subsoil	Fertilizer placement	Soil	
			Dothan	Decatur
			-yield,	bu/acre-
None	Yes	--	109	158
	No	--	40	125
N	Yes	deep	114	169
	Yes	2 x 2	128	165
	No	2 x 2	51	136
N-P	Yes	deep	124	167
	Yes	2 x 2	141	168
	No	2 x 2	57	140
FLSD (0.10)			10	14

1/ Application rate was 22 lb/acre N and 22 lb/acre P_2O_5.

Another aspect of planting winter cover crops is the cost involved. This can be a disadvantage in no-till systems. Although the soil conserving benefits of cover crops will likely exceed production cost, it may take years to realize these benefits, while the costs incurred for cover crop production costs are yearly expenses. Studies in several states have been established with the objective of finding methods of allowing the mulch crops to offset their cost on a year-to-year basis. Most of these studies have used winter legumes instead of cereal crops in hope that the value of N fixed by them would cover establishment costs. Results and conclusions from these studies have been somewhat erratic, but it appears that in most regions of the Southeast, N fixed by adapted legumes will be approximately equal to the cost of growing the legume which essentially results in a free mulch for no-till.

Studies have also tested reseeding systems as a method that can be used to reduce the cost of growing legumes and to increase N production. In these systems, a legume crop is allowed to mature before no-tilling a late summer crop such as grain sorghum or cotton into the mature legume. This has worked best in the deep South where legume seeds lying in the surface mulch germinate in late summer. This late summer germination prior to harvest of the summer crops often allows time for considerable growth and N production before winter dormancy. These reseeding systems eliminate seeding cost in subsequent years, and in addition, reseeded legumes can better tolerate severe winters as a result of the extra fall growth. Nitrogen production by early spring is also generally high as a result of the increased growth.

Growers using reseeding systems often wait longer than necessary to plant the summer crop which can reduce yields. In an attempt to overcome this, research was recently conducted in Alabama to determine the necessity of allowing crimson clover to mature before killing it for a mulch. This research (Table 2) indicates that crimson clover in full bloom contains an adequate number of hard seed for a viable reseeding system and allows planting the summer crop 3 to 4 weeks earlier.

Table 2. Seed production for crimson clover of the early and late bloom growth stages.

Growth stage	Seed: Soft	Seed: Hard	Seed: Dead	Production
	---------%	---------		lb/acre
Early bloom	48	31	21	30
Late bloom	7	91	2	500

Unfortunately, the optimum planting date for corn commonly occurs prior to maximum N accumulation by the winter legume cover crop and prior to seed set. This early planting-date requirements for corn in many areas of the Southeast reduces the economical advantage of using winter legumes as a N source and no-till mulch for corn. Some growers have attempted to improve the economics of legume-corn systems by planting corn into winter legumes before killing them. In these systems, herbicides are applied in a 9 to 12-inch band directly over the corn row at planting. Legumes between the corn rows continue to grow, produce N, and set seed for a reseeding system. When the winter annual legume matures, a shielded sprayer is used to apply herbicides to the corn middles. An upright legume such as crimson clover is more suitable for these systems than a spreading type legume such as hairy vetch. In some years, these systems produce excellent results but in others, especially dry years, they are detrimental (Table 3).

Table 3. Yield of no-till corn as affected by sidedress N and width of killed crimson clover strips in the corn row at planting. (Auburn data)

Sidedress N	Strip killed width for clover (inches)[1/]			
	0	9	18	36
	----------corn yield, bu/acre----------			
0	18	34	32	50
60	65	75	76	91

[1/] Row width was 36 inches, and the 36-inch kill width was a complete kill.

With carefully planned cropping systems, rotations can be established that will allow early planted crops to take advantage of N produced by legumes. Two cropping systems have been used with success in the mid to deep south. The first system is based on the fact that a legume crop will produce a sufficient number of hard seed to allow for stand establishments for 2 or 3 consecutive years with a single seed crop. In this system, grain sorghum or soybeans are planted into the first mature legume crop. If soybeans are used as the summer crop, seeding rates for the legumes can be cut by at least 50%. The first reseeded crop is killed during the early bloom stage in March just prior to planting corn and the second reseeded crop is allowed to mature and produce another seed crop. No-till corn yields from seeded vetch - no till soybeans - early corn - reseeded vetch - early corn system are presented in Table 4.

Table 4. Effect of N rates on yield of corn grown in a cropping system which included: 1st fall-seeded vetch, 1st summer - no till soybeans, 2nd fall-reseeded vetch, 2nd summer-no-till corn, 3rd fall-reseeded vetch, and 3rd summer-no-till corn. (Auburn data)

Applied N	First Yr corn	Second Yr corn
lb/acre	-----------bu/acre--------	
0	101	80
45	102	86
90	102	99
135	102	99

A second system consisted of planting low rates of crimson clover with wheat. Soybeans are no-till planted after wheat grain harvest, and corn can be planted into the reseeded clover the second summer. Since wheat and crimson clover are rapidly growing during the same time period, the wheat will not be able to utilize N produced by the clover. The purpose of planting crimson clover with wheat is to establish a clover reseeding system. High clover seeding rates will reduce wheat yields (Table 5); therefore, clover seeding rates should be 3 to 5 lb/acre.

Table 5. Wheat grain yields as affected by rates of interseeded crimson clover and N applied to wheat. (Auburn data)

Applied N	Clover seeding rate, lb/acre			
	0	5	10	15
lb/acre	---------grain yield, bu/acre--------			
0	49	46	44	36
30	65	62	60	40
60	64	59	56	45
90	62	60	55	45

Although corn is often successfully no-tilled into killed legume sods, some Alabama data has shown that planting summer crops directly into live or recently killed legumes can be detrimental to stand establishment. Shortly after killing legumes, a quick release of ammonia nitrogen can occur and some crop seeds, especially cotton, are extremely sensitive to ammonia. In research conducted in Alabama, cotton seedling mortality has been as high as 100% when legumes were killed the same day cotton was planted. This problem has been avoided by killing the legumes 10 to 14 days prior to planting. Some damage to grain sorghum planted into live legumes has also been reported.

Wheat straw and residue remaining in the field after wheat grain harvest is a good example of a free mulch. The value of the wheat grain should more than cover production cost. In some areas of the Southeast there are some questions concerning straw management in these systems. Whether the straw should be burned or used as a mulch is probably the most common question and research reports on the benefits of straw mulches are conflicting. A Georgia study by R.N. Gallaher indicated that physically removing rye straw would result in lower summer crop yields as compared to planting into green rye. Improved yields due to the rye mulch were attributed to the mulch-related soil moisture conservation. Research conducted by N.C. Edwards in Mississippi suggests that higher soybean yields can be obtained by burning the straw before planting. In a 3-year test conducted in Louisiana, grain sorghum yields were higher where straw had been burned in one year, lower in another, and equal in the other year. The 3-year average yield for burned and unburned straw was approximately equal. No general problems have been reported from the upper south where over a million acres of soybeans are no-tilled each year into straw and stubble directly following wheat and barley harvest.

No one is absolutely sure why burned straw sometimes results in higher yields than unburned straw. Some researchers suggest that straw can release toxic substances, but others believe the problem may be related to ineffective planting in unburned straw. In some situations, some planters cannot adequately cut through a straw mulch and place seed in good contact with the soil. In these situations, the straw should be burned. Burning straw can result in more weed problems than when straw is not burned. Increased weed pressure can be attributed to several factors including herbicide deactivation by charcoal and sunlight penetration to the soil surface.

Soil Fertility

Some of the first management research in no-till systems was directed toward soil fertility. This research was initiated in Virginia and Kentucky in the mid 1960's and spread into the Deep South in the 1970's. Although some concern has been expressed about possible phosphorus fertilization problems, most research has shown that the primary difference in fertility practices among tillage systems centers around soil pH and N fertilizers.

In continuous no-tillage systems, soil pH in the surface inch or two of soil may drop rapidly. The drop in pH is most likely due to surface applied N fertilizers and to organic acids released from decomposing mulches. The low pH problem can be easily corrected with lime, but if soils are not sampled correctly, the low surface pH might not be detected. A low surface pH may not affect plant growth, but it can result in severely reduced herbicide activity. To prevent this problem, some states are recommending that 0 to 2- or 0 to 3-inch depth soil samples be taken for determining lime requirements.

Nitrogen fertilizer selections and application methods probably are more critical in no-till than conventional-tillage systems. Surface residues contain high concentrations of urease enzymes, and when urea is surface applied, the potential for nitrogen losses through ammonia volatilization is high. In some areas of the Southeast, nitrogen solutions are widely used. A key point to remember is that most nitrogen solutions contain 50% ammonium nitrate and 50% urea. The urea in these solutions is as susceptible to nitrogen loss through ammonia volatilization as prilled urea. Dribbling nitrogen solutions onto the surface has been shown to be more effective than spraying them on the surface of no-till corn fields. In a study recently completed in Georgia, a surface spray application of 240 lb/acre N (32% solution) resulted in approximately 60 bu/acre less corn yield than from 160 lb/acre of ammonium nitrate-nitrogen.

Planter Selection

No-till planter comparison studies conducted during the past few years have shown few differences among brands. Most differences found were due to different types of planter units. These differences occur between units with in-row subsoilers and those without in-row subsoilers. Whether a subsoiler is needed is difficult to determine, and the need varies from region to region. Currently, it appears that in-row subsoilers are needed on many sandy Coastal Plain soils, but due to interactions between climatic conditions and subsoiling effects, yield responses to in-row subsoiling are not always obtained. Yield increases with in-row subsoiling have been reported on some Piedmont soils even though they do not generally contain severe root restricting hardpans. Higher yields from in-row subsoiling on these soils are probably due to improved water infiltration. Unfortunately, the use of in-row subsoilers on soils that do not need subsoiling will sometimes result in yield decreases. To determine if subsoiling is needed, fibrous rooted crops such as corn or sorghum probably should be grown as the test crop instead of tap rooted crops such as cotton and soybeans.

There are two major disadvantages associated with in-row subsoilers: operational cost and row-width restrictions. Subsoilers are expensive to pull, but the expense is justifiable on soils with severe root restricting hardpans. Subsoil units currently on the market are not designed for row widths narrower than 30 inches. This row width restriction may be a yield limiting factor as discussed in the followina section.

Row Widths

Row widths are important considerations in any cropping system. Data from research conducted in the Southeast for many years generally indicate that the later the planting date, the more important narrow rows become. Except for cotton, row widths probably should be narrow enough to permit a closed canopy by the early bloom stages. The primary purpose of green plants is to convert sunlight into usable energy. When sunlight penetrates to the soil surface, three adverse effects are occurring: 1) sunlight is being lost, 2) soil moisture is being evaporated, and 3) weed seeds are germinating Most of the residual herbicides used in the Southeast are effective for approximately 4 to 8 weeks. If the crop canopy is not closed when herbicide activity is lost, weeds can become a problem. Soil moisture is a valuable resource and every possibly inch should be preserved. Mulches help decrease evaporation losses, but like herbicides, mulches do not last all summer, especially in the Deep South. Narrow rows help ensure a fast-closing canopy which can protect soil moisture after the effectiveness of the mulch is lost. Optimum row width is difficult to define, but a reasonable rule to follow is that if the canopy is not closed by the early bloom stage, row widths are too wide.

Too often, no-till gets blamed for low yields of crops planted after wheat harvested for grain. The low yields are, however, often due to wide rows and not to double cropping or no-tilling. Research conducted in several states indicates that soybeans planted after wheat may yield nearly as high as early planted soybeans, **if** optimum row widths are used. One should not, however, expect late-planted soybeans in 36- or 40-inch rows to yield as high as full-season early planted soybeans. In addition, we normally do not expected soybeans planted 1 to 3 weeks after wheat harvest to yield as high as soybeans planted immediately after wheat harvest.

Pests

Weed control efficiency and cost are a big concern in no-till systems. Herbicide research is being conducted in every state in the South. Some researchers have begun looking at cropping systems as a valuable aid in weed control. Because of different weed problems from area to area within the South and from field to field within a specific area, it is difficult to generalize on results of weed control studies.

There are, however, some generalizations that can be made on weed control in no-till systems. The primary generalization is that the economic advantage of no-tillage depends tremendously on weed control systems cost. The economics of any system requiring a complex mixture of herbicides costing $40 to $100 per acre are definitely questionable. When exceptionally high herbicide costs occur, they are often due to poor management or improper herbicide selections. Excess herbicide costs are generally associated with postemergence applied herbicides.

Letting weeds get too big prior to herbicide application requires higher herbicide rates for adequate control than applying herbicides to small weeds and often do not completely kill them. A post-emerge over-the-top herbicide application is an effective method of controlling some weeds in some crops, but some of these herbicides are expensive. Unless big weeds are directly in the row, directed spray applications with shielded sprayers and/or drop nozzles may be the most economical approach to postemergence herbicide applications. Herbicides used with directed spray applications sometimes cost 60 to 70% less than herbicides used in over-the-top applications.

Several researchers in the South are working with insecticide, nematicide, and fungicide applications in various tillage systems. Research reports suggest that complexes of various pests can change with tillage and cropping systems, but there are no strong indications that the overall pest complex is better or worse with no-till than conventional tillage. Published data indicate that **if** populations of pests are high enough, yield increases can be obtained with pesticide applications regardless of tillage systems.

Summary

An aggressive no-till research program is currently being conducted in most of the southern states. The amount of data reported from these programs was too large for all projects to be adequately documented in this paper. The general concepts presented were developed from many published reports and personal communications with researchers in almost every state in the South, and they are probably valid throughout most of the South. However, specific production practices do vary widely, primarily because of different climatic conditions, soils, and cropping systems. The Cooperative Extension Service in each state can provide information on specific practices.