AGRONOMY AND SOILS
EXTENSION SERIES NO. 4

OCTOBER, 1983

PROCEEDINGS OF FIFTH ANNUAL

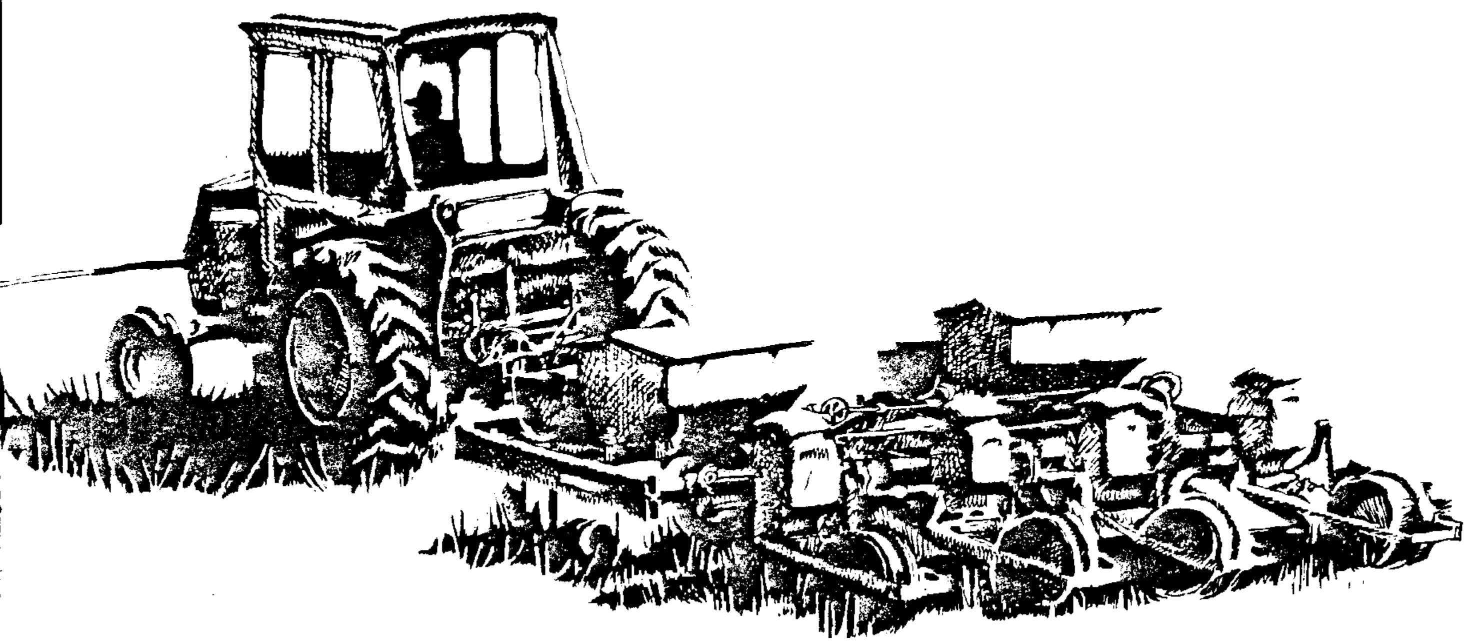
SOUTHEASTERN NO-TILL

SYSTEMS CONFERENCE

JULY 15, 1982

FLORENCE-DARLINGTON TECHNICAL COLLEGE

FLORENCE, SOUTH CAROLINA



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INTRODUCTION

The 5th Annual Southeastern No-Till Systems Conference was held July 15, 1982 at Florence-Darlington Technical College, Florence, South Carolina. This meeting is conducted on an annual basis and is cosponsored by agribusiness and the following land-grant universities:

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Also, thanks is expressed to personnel from the Pee Dee Research and Education Center, USDA Coastal Plains Soil and Water Conservation Research Center, and Florence-Darlington Technical College for their assistance with registration, the program, the exhibits, and the luncheon.

These proceedings were complied and edited by J. H. Palmer and E. C. Murdock, Extension Agronomists, Clemson University, Clemson, SC 29631. Appreciation is also expressed to Carol Boyer and Vickie Greene for their assistance.

FERTILIZATION AND COVER CROP CONSIDERATIONS IN NO-TILL CROPPING SYSTEMS

J. T. Touchton, D. H. Rickerl, G. W. Martin, and F. Karim*

Department of Agronomy and Soils, Auburn University

Auburn, Alabama

Throughout the Southeast, extensive research studies have been conducted to identify optimum management practices for no-till cropping systems. The data presented in this paper are from previous and on-going fertility related management studies in Alabama. Some of the information presented represents only one year of data. Therefore, firm recommendations should not be drawn from this information.

Lime, Phosphorus, and Potassium

The fertilization of crops using soil test results does not differ greatly between tillage systems. Plants grow best within certain soil pH ranges and require a specific quantity of each major nutrient to produce optimum yields regardless of the tillage system. In a continuous no-till system, however, a soil sample from the top 2 to 3 inches should be taken for determining lime and other fertilizer requirements. Research conducted in several states has shown that the pH of the soil surface drops rapidly in no-till systems. A low pH in the top surface inch of soil may not be detrimental to crop growth, hut it may result in poor herbicide activity. Chemical weed control is essential in no-till systems, and lime is too inexpensive to allow low soil pH to reduce the activity of herbicides.

Since phosphorus (P) does not move down through the soil like nitrogen (N) and potassium (K), there have been some questions about the effectiveness of surface-applied P fertilizers. However, research conducted in several

J. T. Touchton is Associate Professor, Soil Fertility, and D. H. Rickerl, G. W. Martin and F. Karim are graduate research assistants, Department of Agronomy and Soils, Auburn University, AL 36849.

states during the past few years has shown that surface applications of P do not result in lower yields than incorporated P, even if the original soil phosphorus levels were low. Data presented in Table 1 are from studies conducted in Georgia, and these are typical of other studies conducted in the Southeast with surface P applications. Data from studies conducted in Georgia (Table 2) also suggest that a 0 to 3 in soil sample may be suitable for determining the P fertilizer requirements for a continuous no-till system.

Table 1. No-till soybean yields as affected hy P applied to a Cecil sandy loam soil in the Southern Piedmont of Georgia.*

	Applied P (lb/acre)			
Year	0	30	80	120
	.... yield, bu/acre------------			
1978	34	46	48	45
1979	30	39	39	40
1980	34	35	35	37

*J. T. Touchton et al, 1982, Soil Sci. Soc. Am. J. (In press).

Table 2. Soil test P levels as affected by P applied to a Cecil sandy loam soil in the Southern Piedmont of Georgia, 1980.*

	Applied P (lb/acre)			
Sample depth	0	30	60	120
------In-----	-----------------soil P, lb/acre-----------------			
0 to 3	11	20	38	72
3 to 6	4	7	9	16

*J. T. Touchton et al., 1982, Soil Sci. Soc. Am. J. (In press).

Nitrogen Fertilizers

Nitrogen sources and application methods should he carefully selected in no-till systems. It is not uncommon to hear "a pound of N is a pound of N regardless of source". However, this statement is true only if proper application methods are used. Proper application methods in no-till systems are extremely important for urea and some of the N solutions.

If solid urea is surface applied to a pasture, lawn, or no-till crop, severe N losses can occur through ammonia volatilization. Such losses due to ammonia volatilization can also occur with surface applications of N solutions containing a mixture of urea and ammonium nitrate. N solutions containing more than 19% N are most likely made from urea-ammonium nitrate combinations. The most common solutions (28, 30, and 32% N) contain approximately 50% urea N, and urea in solution is just as susceptible to N losses through ammonia volatilization as is the N in solid urea.

The most inefficient N applications probably occur in no-till systems. These inefficient applications occur primarily when N solutions are used as a carrier for pre-emergence or post-directed herbicides. Data from research conducted in the Piedmont of Georgia in 1979 (Table 3) illustrate the inefficiency of 32% N solutions when applied as a spray application. Corn fertilized with N at 240 lb/acre applied as a spray application yielded approximately 15 bushels per acre less than did corn fertilized with 80 lb of surface-applied ammonium nitrate or incorporated N solution. The yield of corn fertilized with the surface dribble application of N solution was less than yields obtained at the lower N rates when the solution was incorporated. This indicates that some N losses did occur with the surface dribble application.

The data in Table 3 clearly indicate that spray applications of N solutions containing urea should not be used. Reasonable responses to N can be obtained with the surface dribble system, but some N losses can be expected. If the surface dribble system is used, every effort should he made to place the N below the no-till mulch.

Table 3. Yields of irrigated corn as affected by nitrogen source and application method.*

Applied Nitrogen	Nitrogen Source and Method of Application: Ammonium Nitrate Surface band	Incorporated	Surface band	Broadcast Spray
lb/acre	BU/Acre			
80	130	135	120	80
160	160	165	145	100
240	170	160	160	115

*J. T. Touchton and W. L. Hargrove. 1982. Agron. J. 74 (In Press).

Cover Crop Considerations and Nitrogen

Many growers plant winter crops for the sole purpose of providing a mulch for no-till summer crops. Rye and wheat are probably the most common crops planted for use as no-till mulches. If these crops are planted for mulch purposes only and not for grain harvest, they may not be the most desirable mulch crops. Various winter legumes will provide the same mulch benefits as rye and wheat, and in addition, they may provide part or all of the nitrogen required hy non-leguminous summer crops such as corn, sorghum, and cotton.

Several studies conducted in Alabama and Georgia have demonstrated that various winter legumes will produce the entire N needs for subsequent sorghum and cotton crops. In these studies, applied N has not increased yields of grain sorghum or cotton. Some of these data are presented in Tables 4 and 5. It should be noted that yield of cotton following clover and vetch was reduced by applied N. The yield reduction with applied N has also occurred with grain sorghum at some locations.

Table 4. Yield of no-till cotton as affected by winter cover crop and applied nitrogen, Macon County, Alabama, 1981.

Winter cover crop	Applied N, lb/acre 0	30	60
	-----------	lint yield, lb/acre	----
Fallow	457	561	543
Crimson Clover	649	568	512
Common Vetch	678	525	647

Table 5. No-till grain sorghum yields as affected by winter cover crop and applied nitrogen, Camphill, Alabama, 1981.

Cover Crop	0	30	60	90
	----------------	yield, bu/acre	----------------	
Fallow	56	67	70	80
Rye	53	73	77	85
Austrian Winter Pea	94	94	94	97
Crimson Clover	91	90	84	83
Common Vetch	97	104	88	92

One of the primary complaints with using winter legumes for no-till mulches is that the costs of seeding and growing the legumes are often equal to the commercial value of the N they produce. This complaint may not be completely valid. We have conducted several experiments in Alabama with legumes and seldom have situations where the value of the N produced does not exceed the costs of growing the legume. With most winter legumes, 80 lb per acre of N in the above-ground tissue is sufficient to cover the costs of growing the legume, and this does not include the mulch effect. Nitrogen produced by some winter legumes in the Piedmont and Coastal Plains of Alabama in 1981 are listed in Table 6. We have found that the best N-producing legume will vary among locations and years, and depends primarily on climatic conditions at specific locations. The key to high N production and sometimes winter survival is early planting. With some summer crops, especially cotton and some soybean varieties, adequate early planting requires flying the legumes into the summer crop just prior to leaf drop or defoliation.

Table 6. Aboveground dry weight and N production of various legumes grown in the Coastal Plains and Piedmont of Alabama, 1981.

Winter Cover Crop	Coastal Plains Dry Weight (lb/A)	Coastal Plains Nitrogen Conc. (%)	Coastal Plains Nitrogen Content (lb/A)	Piedmont Dry Weight (lb/A)	Piedmont Nitrogen Con. (%)	Piedmont Nitrogen Content (lb/A)
Arrowleaf clover	2950	2.9	86	--	--	--
Crimson clover	5540	2.4	133	4640	2.4	79
Common vetch	5800	2.0	174	5000	2.6	180
Austrian winter pea	--	--	--	5980	4.4	263

Adequate soil fertility levels and proper inoculations are essential for optimum growth and N production of legumes. The effects of pH and P on N content of common vetch are shown in Table 7.

Table 7. Nitrogen in the aboveground tissue of common vetch as affected by soil pH, soil P and plant growth stage, Macon County, Alabama, 1981.

Soil pH	Soil P (lb/acre)	Growth Stage: Bloom (N, lb/acre[1])	Growth Stage: Maturity (N, lb/acre[1])
5.0	6	9	6
	50	48	65
	94	66	R3
5.8	6	21	28
	50	77	94
	94	77	94

[1]Nitrogen produced is from ahoveground tissue only.

Specific bacteria are needed for proper nodulation of most legumes, and commercial bacteria produced for one legume are often ineffective with other legumes. For effective nodulation, line prill inoculation procedure is recommended. This involves wetting the seed with a sticker (i.e. sugar water, watered-down syrup or a commercial sticker), applying the inoculum and mixing well. Lime is then added and mixed to provide a protective coat.

A good method for reducing cost of seeding winter legumes is to develop reseeding systems. These reseeding systems have produced excellent results in Georgia and Alabama. In these systems, early maturing winter legumes are allowed to mature prior **to** the no-till planting of the summer crop. Seeds produced by the winter legumes generally germinate and reestablish a stand in the summer crop canopy during August. Due to early establishment, the reseeded winter legumes are exceptionally winter hardy and are seldom killed by severe freezes.

A drawback to the reseeding system is summer crop limitations. The earliest maturing legumes currently used in Alabama mature in early May in south Alabama and late May in north Alabama. This late maturity restricts summer crop plantings tograinsorghum in north Alabama and sorghum or late planted cotton in south Alabama.

Current work involves attempting to establish systems that will allow us to plant corn in reseeding legume systems. This system is based on the fact that a legume crop will produce a sufficient number of hard seed to allow for stand establishments for two or three consecutive years with only one seed crop. In these systems, grain sorghum and soybeans are planted behind the first mature crop of vetch and clover. 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. 1982 is the second year of this study, and so far, this system has been successful.

Some growers are attempting a reseeding legume-corn system involving no-tilling the corn into the legume during the early bloom stage. Herbicides are applied in a 9 to 12 in band directly over the row at planting. As soon as the plants between the rows mature and produce seed, a shielded sprayer is used to apply herbicides to the corn middle. An upright legume such as clover is more suitable in these systems than a running legume such as vetch. In extremely dry periods, it is doubtful if the young corn seedling can compete successfully with the established legume, with the result that the legume may have to be killed with directed herbicides prior to maturity.

There have been some problems with stand establishment of no-tilled summer crops planted into the winter legumes. The problem has occurred primarily with cotton on fine-textured soils. In studies currently being conducted, it appears that killing the winter legumes two to three weeks prior to planting will reduce the detrimental effect that the legumes have on cotton seedlings.

Starter Fertilizers

Too often, no-till spring crops grow at a slower rate than conventionally-planted crops. To increase early season growth rates, starter fertilizer studies are being conducted with grain sorghum and corn. The crops in these experiments,are planted with an in-row subsoiler, and starter fertilizers are dropped directly in the subsoil track. All soils selected for these studies were high in residual P and K, and responses to any nutrient other than N would not be expected.

Early season plant growth has responded favorably to starter fertilizer applications. Growth responses to starter fertiilzer 4 to 6 weeks after plant emergence in 1981 are illustrated in Table 8. Responses in all years (5 years for sorghum and 2 for corn) are similar to the data presented in Table 8. The greater plant height obtained with the starter fertilizer (12 in for corn and 7 in for sorghum) could be critical if post-directed herbicide applications are needed.

Table 8. The effect of starter fertilizer on growth of early season corn and sorghum growth.

Growth Measurement	Starter[1] Fertilizer	Sorghum	Corn
Height (in)	no	18	17
	yes	25	26
Dry weight, (lb/acre)	no	145	69
	yes	215	238

[1]Starter fertilizer for sorghum was 120 bu/acre of 10-34-0 and 300 lb/acre of 7-14-23 for corn.

In 4 of the 5 years of studies with grain sorghum, 3 in Georgia and 2 in Alabama, starter fertilizer increased grain yield. The lowest yield increase was 7 bu per acre and the greatest was 31 bu per acre. Data from one of these studies are presented in Table 9. The data in Table 9 appears to indicate that starter fertilizer resulted in a smaller yield increase in the conventional tillage system. Without the starter fertilizer, highest yields were obtained with the conventional tillage system, but with starter fertilizer, highest yields were obtained in the no-tillage system.

Table 9. The effect of starter fertilizer and sidedress N on the yield of no-till grain sorghum, Headland, Alabama, 1980.

	Tillage and Starter Fertilizer			
	No-tilled		Tilled	
Nitrogen	Yes[1]	No	Yes	NO
lb/acre	yield, bu/acre			
0	50	39	55	44
40	72	62	73	71
80	85	72	83	81
120	92	70	88	81

Yes indicates 120 lb/acre of 10-34-0 and No indicates no starter.

Two years of data (Table 10) from starter fertilizer studies with non-irrigated corn also indicate that if an in-row subsoiler is used for planting, fertilizer should be placed in the subsoil track at planting. In 1981, it appeared that the N-P-K starter resulted in the best yield, but in 1982, N-P resulted in yields as high as those obtained with the N-P-K combinations. Although the starter fertilizer application increased yield of both conventional and no-till corn, the greatest yield increases occurred in the no-till system. Averaged over both years, the increase due to starter fertilizer was 14 bu per acre in the conventional system and 19 bu per acre in the no-till system.

Table 10. Corn grain yield as affected by starter fertilizer and tillage.

Starter Fertilizer[1]	1981		1982	
	Till	No-Till	Till	No-Till
(%)				
$N\text{-}P_2O_5\text{-}K_2O$	bu/acre			
0	60	79	58	65
7-0-0	72	93	66	73
7-18-0	69	97	67	80
7-18-24	78	103	65	78

[1]Application rate was 300 lb/acre.

Although data from both the corn and sorghum studies indicate that yield increases can be obtained from in-row subsoil track fertilizer applications, these fertilizers should be applied with care. If placed too close to the seed or not dropped deep enough into the subsoil track, severe seedling damage can occur. Seedling damage can occur from both solid and solution fertilizers, but the most severe problems have been with solution fertilizers.

Summary

No-till'cropping systems do not necessarily require a higher level of management than conventional tillage systems, but they do require some practices which differ from those used with conventional tillage. Some of the factors unique to no-till systems include: lower surface-soil pH; higher ammonia volatilization potentials with some surface applied N fertilizers; selection of mulch crops; and cooler soils for spring crops. These factors require different management techniques such as pulling shallow (2 to 3 in) as well as deep (6 to 10 in) soil samples in continuous no-till systems, incorporating urea containing N solutions, and applying starter fertilizer to spring crops in order to promote early plant growth.

INSECT MANAGEMENT IN NO-TILL

J. N. All and B. Rogers

Department of Entomology, University of Georgia

Athens, Georgia

Insect management in no-till cropping varies from conventional tillage operations. Our research in Georgia over the past eight years, and studies in other states, indicate that the pest potential of certain insects is increased with no-till cropping. Involved are primarily soil pests or insects that attack young crop seedlings. Most reports of pest problems in no-till systems have been with corn (Zea mays L.).

(1) Southern corn billbug (SCB) (Sphenophorus callosus Oliver)

SCB damage has been consistently greater in no-till compared to conventionally tilled corn in five years of tests in Georgia. Damage often is high in early planted corn and injury is compounded with droughty weather. High populations of SCB are often found in fields with nutsedge (Cyperus spp. **L.)** and certain grass weeds. Control with insecticides is effective in no-till, especially with Counter at planting time with banded applications of 2 lbs active ingredient per acre. Research also demonstrates that in-furrow subsoiling is a cultural practice that aids plant recovery from SCR injury.

(2) Armyworm **(AW)** (Pseudaletia unipuncta Haworth), Black cutworm (BC) (Agrotis ipsilon Hufnagel), and Sugarcane beetle (SB) (Euetheola rugiceps Leconte).

AW, BC, and SB infestations have been observed in no-till corn in various locations. However, little quantitative information is available demonstrating an increased hazard in no-till compared to conventional tillage. Information is also not available on whether the infestations are associated with other environmental conditions. Recommended control procedures for AW, BC, and SB in conventional tillage systems also are effective in no-till.

(3) Maize chlorotic dwarf (MCD) and maize dwarf mosaic (MDM) are insect-transmitted virus diseases of corn and are increased in no-till cropping. This is especially evident when johnsongrass (Sorghum halepense **(L.)** Pers.), the overwintering host of the pathogens, is present. Use of disease-resistant hybrids and early planting is central to management of MCD and MDM. However, research indicates that the Systemic insecticide carbofuran, at a rate of 2 lb active ingredient per acre, controls the insect vectors of MCD and can produce a substantial increase in yield of no-till corn in areas with a high disease hazard.

In the three following situations, the environment created in no-till cropping is beneficial to insect pest management.

(1) Lesser cornstalk borer (LCB) (Elasmopalus lignosellus Zeller)

LCB infestations are reduced in no-till as compared to conventional tillage. This has been demonstrated with corn, sorghum (Sorghum bicolor **(L.)** Moench), and soybeans (Glycine max (L.) Merr.). However, sporatic infestations can occur in no-till, especially when the crops are planted late and drought conditions occur. The insecticides chlorpyrifos and fonofos are effective in suppressing LCB damage when used at 1 to 2 lb active ingredient per acre.

(2) Fall armyworm (FAW) (Spodoptera frugiperda **J**. E. Smith)

FAW can cause serious damage in no-till crops of corn and sorghum when these crops are used in late planted multiple cropping systems. However, in corn tests comparing no-till and conventional tillage, it was observed that seedlings in no-till were not heavily attacked until they grew above the mulch. Thus, a delay of about seven days occurred before the seedlings in no-till began receiving heavy FAW oviposition as compared to conventional tillage. This could benefit pest management by allowing more time for seedling establishment, and by reducing the number of insecticide applications required to protect seedlings.

(3) Carabid beetles and other predatory insects typically have higher populations in no-till compared to conventional tillage. Thus, the potential for enhanced biological control is increased in no-till. However, the quantitative level of enhancement of natural biological control in no-till systems is unknown, nor is it known whether pest populations can be held at subeconomic levels.

Our research indicates that most insect pests that attack the latter growth stages of no-till crops have similar infestations as those planted with conventional tillage. These include the corn earworm (*Heliothis zea* Boddie), European corn borer (*Ostrinia nubilalis* Hubner), Southwestern cornstalk borer (*Diatraea grandiosella* Dyar) and others.

Possibly the most important consideration in insect pest management in no-till crops is the relationship of planting date and pest hazard. Many no-till systems use multiple cropping practices (e.g. double cropping of winter grains followed by a field crop such as corn, sorghum, or soybeans) which involves later planting of the field crop than in monocropping. Most of the pest problems discussed previously are substantially increased with later planting, especially for corn. In comparisons of corn, sorghum, and soybeans, it has been demonstrated that, from the viewpoint of pest management, it is the least hazardous to use soybeans in multiple cropping with no-till, followed by sorghum. Corn has greater vulnerability to several pests. Corn growers should have increased concern for pest monitoring and should anticipate the need for chemical control applications in these cropping systems.

WEED CONTROL CONSIDERATIONS IN NO-TILL CROPPING SYSTEMS

E. C. Murdock

Extension Weed Scientist, Clemson University

Most weeds can be adequately managed in crops planted with the no-till method. Since the option to cultivate is usually eliminated, weed management in no-till crops depends almost entirely on the application of foliar and soil-applied herbicides. Therefore, making the correct decisions may determine the success or failure of this practice. The following are some considerations in weed management for no-till crops.

Field Selection

Fields with moderate to heavy infestations of weeds that cannot be controlled effectively with pre- or postemergence herbicides should be avoided. For example, in corn and grain sorghum, control of species such as johnsongrass, nutsedge, or common hermudagrass usually requires a soil-incorporated herbicide plus cultivation to complement other management practices. Other grassy weed species that are difficult to control in corn, such as broadleaf signalgrass and texas panicum, should also be avoided.

For soybeans, moderate to heavy infestations of florida beggarweed and sicklepod require a soil applied herbicide plus cultivation for adequate control. Morningglory spp., johnsongrass, and common bermudagrass are other weeds which should be avoided.

Herbicide Selection

To help tailor a good weed management system for soybeans and corn, note Tables 1 and 2 which detail weed responses, by species, to the pre- and postemergence herbicides recommended in South Carolina. Detailed herbicide recommendations are given in the current Agricultural Chemicals Handbook and other Extension commodity circulars availahle in the county Extension offices.

A number of good herbicide combinations may be used in no-till cropping systems. Growers should pay special attention to rates, spray volume, and pressure directions on the labels. An effective herbicide system for no-till crops usually involves a knockdown herbicide (e.g. Paraquat@ or Roundup@) in combination with one or more preemergence herbicides, depending on the weed species present. Postemergence herbicides should be used to provide additional control of broadleaf weeds if needed.

The postemergence grass control materials for soybeans, POAST and FUSILADE, are important new components of the grower's herbicide arsenal. Though expensive, they add a dimension to no-till soybean cropping systems which growers did not previously have. Innovative growers and equipment manufacturers are looking at ways to utilize these highly selective materials to achieve their greatest benefit with the least costs possible.

TABLE 1. WEED RESPONSES TO HERBICIDES RECOMMENDED FOR USE IN NO-TILL SOYBEAN PRODUCTION IN SOUTH CAROLINA*

	DUAL	LASSO	SURFLAN	LOROX	SENCOR OR LEXONE	BASAGRAN	BLAZER	VISTAR	POAST OR FUSILADE	PREMERGE	SENCOR OR LOROX + BUTYRAC 200 OR BUTOXONE	PARAQUAT
Time of application	**PRE**	**PRE**	**PRE**	**PRE**	**PRE**	**POT**	**POT**	**POT**	**POT**	**PDS**	**PDS**	**PDS**
Crabgrass	E	E	E	G	F	P	P	P	E	P	F	G
Goosegrass	G	G	G	F	F	P	P	P	E	P	F	G
Fall panicum	E	E	G	F	F	P	P	P	E	P	F	G
Texas panicum	P	P	G	P	P	P	P	P	E	P	F	G
Johnsongrass (seedling)	F	F	G	P	P	P	P	G	E	P	F	G
Johnsongrass (rhizome)	P	P	P	P	P	P	P	G	E	P	P	P
Cocklebur	P	P	P	F	P-G	E	G	P	P	G	E	G
Cowpea	P	P	P	P	P	P	F-G	P	P	F	F	F
Croton	P	P	P	P	F	G	E	P	P	G	G	G
Florida beggarweed	P-F	P-F	P	F	G-E	P	F	P	P	F	E	G
Hemp sesbania	P	P	P	P	F	P	E	P	P	F	E	G
Jimsonweed	P	P	P	F	P-G	E	G	P	P	G	E	G
Morningglory	P	P	P	F	P	F	G-E	P	P	G	E	G
Nutsedge	F-G**	F**	P	P	P	G**	P	P	P	P	P	F
Pigweed	G	E	G	G	G	P	E	P	P	P	G	G
Prickly sida	P	F	P	F	G	G	P	P	P	G	E	G
Ragweed	P	F	P	G	F	F	G	P	P	F	E	G
Sicklepod	P	P	P	P	G	P	P	P	P	P	E	G
Smartweed	P	F	P	F	F	G	F	P	P	P	E	G
Velvetleaf	P	P	P	F	F	G	P	P	P	F	E	F

*Based on observations of research plots, Extension test-demonstrations, and field use for several years in South Carolina. It is assumed that the herbicides are applied according to label directions. Control may vary depending on time and method of application, weather conditions, size of weeds, etc.
**Yellow nutsedge only.
E = 90%+ control; G = 80-89% control; F = 50-79% control; P = Less than 50% control.
PRE = Preemergence; POT = Postemergence over-the-top; PDS = Postemergence directed spray.

	LASSO	DUAL	PROWL	atrazine	BLADEX	PRINCEP	LASSO + ATRAZINE OR BICEP	atrazine	BASAGRAN	2,4-D	BANVEL	EVIK	LOROX	PARAQUAT OR GRAMOXONE	PARAQUAT + atrazine
Time of application	PRE	PRE	PRE	PRE	PRE	PRE	PRE	POT	POT	POT or PDS	POT or PDS	PDS	PDS	PDS	PDS
Crabgrass	E	E	E	F	G	G	E	F	P	P	P	E	E	G	G
Goosegrass	G	G	G	F	G	G	G	P	P	P	P	E	G	G	G
Johnsongrass (seedling)	F	F	G	P	P	P	F	P	P	P	P	G	G	G	G
Fall panicum	E	E	G	P	F	G	E	P	P	P	P	E	E	G	G
Texas panicum	P	P	F	P	P	P	P	P	P	P	P	G	G	G	G
Signalgrass (broadleaf)	F-G	F-G	G	F	F	F	G	F	P	P	P	G	G	G	G
Cocklebur	P	P	P	E	F	G	E	G	E	E	E	G	G	G	G
Croton	P	P	P	E	G	G	E	G	G	G	G	G	G	G	G
Florida beggarweed	P-F	P-F	P	E	G	G	E	G	P	F	G	E	E	G	E
Jimsonweed	P	P	P	E	G	G	E	G	E	E	E	E	E	G	E
Lambsquarters	G	G	G	E	E	E	E	E	F	E	E	E	E	G	E
Morningglory	P	P	P	E	G	G	E	E	F	E	E	E	E	G	E
Nutsedge	F**	F**	P	P	P	P	F	P	G**	P	P	G	G	F	F
Pigweed	E	G	G	E	F	E	E	E	P	F	G	E	E	G	E
Prickly sida	F	P	P	E	G	E	E	G	F	G	E	E	E	G	E
Ragweed	F	P	P	E	G	E	E	E	F	E	E	E	E	G	E
Sicklepod	P	P	P	G	F	G	G	G	P	F	G	G	G	G	G

*Based on observations of research plots, Extension test-demonstrations and field use for several years in South Carolina. It is assumed that herbicides are applied according to label directions. Control may vary depending on time and method of application, weather conditions, size of weeds, etc.

**Yellow nutsedge only.

F = 90%+ control; G = 80-89% control; F = 50-79% control; P = less than 50% control.

PRE = Preemergence; POT = Postemergence over-the top; PDS = Postemergence directed spray

RESIDUE MANAGEMENT, CROPPING SYSTMS, AND AN OVERVIEW OF NO-TILL AND CONSERVATION TILLAGE RESEARCH IN THE COASTAL PLAINS[1/]

R. B. Campbell, R. E. Sojka, and D. L. Karlen[2/]

Introduction

In 1981, 71,000 acres of field crops were planted under conservation tillage in Coastal Plain counties of South Carolina. Of this acreage, approximately 60% was planted to soybean and 36% to corn. The primary increase in conservation tillage acreage is the soybean-small grain double-crop which has followed a substantial increase in wheat acreage.

In the following discussion, we define conservation tillage to include all crop production systems that minimize tillage intensity, thereby retaining all or nearly all existing residue on the soil surface. No-till refers specifically to tillage systems that leave essentially all residues untouched and usually standing and in which a micro-seed bed is created only in close proximity to and beneath the planted seed, disturbing only a small percentage of the surface area. In this paper we discuss a variety of residue management approaches which encompass the entire spectrum of conventional, conservation tillage, and no-till systems.

Expansion of no-till or conservation tillage farming has' been slow to develop in the southeastern Coastal Plains, but this trend is not due to a lack of interest or capability in the farming community. The problem has been an inability to provide sufficient scientific manpower, answers to problems, and advice to the farming community to insure the expansion and success of conservation tillage.

Agricultural research related to conservation tillage tools and technology will continue to expand as we recognize the needs and problems that must be solved to insure successful conservation tillage farming. Some of the specialized tools developed for the management of crop residues include: in-row subsoil tools equipped with a cutting roulter ahead of the subsoiler, heavy duty planters for planting in dense surface residues, and no-till grain drills for solid seeding of various crops in previous crop residues.

1/ Contribution of the Coastal Plains Soil and Water Conservation Research Center, USDA-ARS, Florence, S.C. Presented at the 5th Annual Southeastern No-Till Systems Conference, July 15, 1982, Florence, S.C.

2/ Soil Scientist, Research Agronomist, and Soil Scientist, respectively.

Weed control is an extremely important aspect of no-till or conservation tillage farming, but a wide variety of spraying equipment has been developed ranging from common broadcast sprayers to precision shielded and directed sprayers. Every year new effective herbicides or combinations of herbicides and application techniques are being added to our compliment of weed control tools. Unfortunately, weed control will never be a routine operation since populations of easily-controlled weed species will be succeeded by populations of species that are more difficult to control. These competing weed populations, that spraying systems are least effective in controlling, are a significant threat to successful no-till or conservation tillage farming. The type and population of weeds will at times influence our choice of crop rotation or cropping system.

The challenge in no-tilling is not merely determining whether or not no-till farming is better or worse than conventional farming. The real question is "How well do we no-till"? Do we have control and are we able to manage the critical factors that control or modify yield? This paper will address soil strength and factors that control rooting and water availability in no-tillage system. The influence of standing residues, cool-season crop residues, and a few alternative double crop sequences will be discussed. Yield data for corn and soybean following a winter rye cover crop will be presented to compare no-till and conventional tillage system as influenced by standing residues and cool-season crop residues.

I. Soil Properties Affecting No-Till Farming Practices in the Coastal Plain

Research has consistently demonstrated higher yields for the major field crops due to subsoiling or deep tillage. This result provides the basic rationale for utilizing heavy tractors, tillage implements, and planting equipment in the Coastal Plains. The soils of the Coastal Plains are generally sandy at the soil surface and nay vary from well drained to poorly drained in the lower profile. The soil below the normal disking layer (8-14" deep) may either contain a tillage pan or a compact A_2 horizon which normally has a higher bulk density than either the tilled surface soil or the undisturbed B horizon (or subsoil). Tillage research has demonstrated that rooting patterns correlate very highly with soil strength. Furthermore, soil strength, because of its impact on root distribution, can restrict water availability to the plant. In soils with compact horizons, corn roots have been shown to penetrate predominantly those areas in the soil profile which are loosened by tillage tools. Consequently, corn roots remove water primarily from the soil in which rooting occurs. Capillary water movement to root systems in southeastern sandy soils becomes very slow as the soil dries beyond the 20 centibar matric potential range.

In general, many soils of the Southeast are partitioned into three zones: (1) the tillage zone, (2) a zone of compaction, either genetic or due to tillage and traffic, and (3) a subsurface horizon which is normally only slightly compacted, and into which roots are able to penetrate provided A1 concentrations are negligible. Research has shown that for a given soil type, strength can be largely explained as a function of water content and bulk density of the soil.

Figure 1 shows a family of curves obtained from a soil which is typical of the southeastern Coastal Plains (Norfolk loamy sand). The surface Ap horizon has an average bulk density of 1.58 g/cm^3 in which rooting could occur at matric potentials between −1.1 bar and −0.08 bar. Rooting is restricted at the wet limit by aeration and at the dry limit by soil strength. The A_2 horizon, however, which has an average bulk density of 1.78 g/cm^3 prevents root penetration at matric potentials dryer than −0.22 bars. After roots penetrate the tilled portion of the A_2 or permeate the A2 horizon through a root channel, they can grow ingo the B horizon which has an average bulk density of 1.48 g/cc. The E horizon does not restrict rooting due to strength until the soil reaches −0.77 bar soil rnatric potential. By utilizing these relationships we can better understand how soil strength can limit soil water use by plants.

This Norfolk loamy sand retains approximately 7.1 cm of water between the −0.05 to −1.0 bar range and to a depth of approximately 1 m. If water extraction is limited to that lateral portion of the root profile where soil strength is less than 20 kg/cm^2 of strength (within the moisture limits given above), then the effective storage volume is reduced to 6 cm to the 1-m depth. If storage is limited to only that portion of the lateral soil profile between rows which was observed to have roots under a mature corn canopy, the water retention reduces to 4 cm for the 1-m deep profile.

From these soil water retention data, one may conclude that soil strength in this soil significantly reduces the extent and development of the corn root system. With a limited root system that does not permeate the entire lateral profile between corn rows, some water may remain unused. Although some water flow from wet to dry regions within the soil profile occurs, this flow is very slow due to the sharp reduction in hydraulic conductivity as the soil water content decreases. Consequently, soils with compact root−restrictive layers must be managed to obtain maximum permeation by root systems, because limited root development influences nutrient utilization, especially in conservation tillage system where the fertilizer is not mixed into the soil by subsequent tillage operations. Incorporating in−row subsoiling into the conservation tillage program provides a partial mechanical solution to overcoming the restricted root permeation caused by the layers that are either mechanically or naturally compact.

II. <u>Double Crop Sequences for Conservation Tillage</u>

Conservation tillage research in the southeastern Coastal Plains has been centered on three crop sequences: (1) winter rye followed by corn, (2) winter rye followed by soybean, and (3) small grain (usually wheat) followed by soybean. Of these crop sequences, the small grain-soybean rotation is being used rather extensively under conventional and under conservation tillage. In 1981 approximately 60% of the

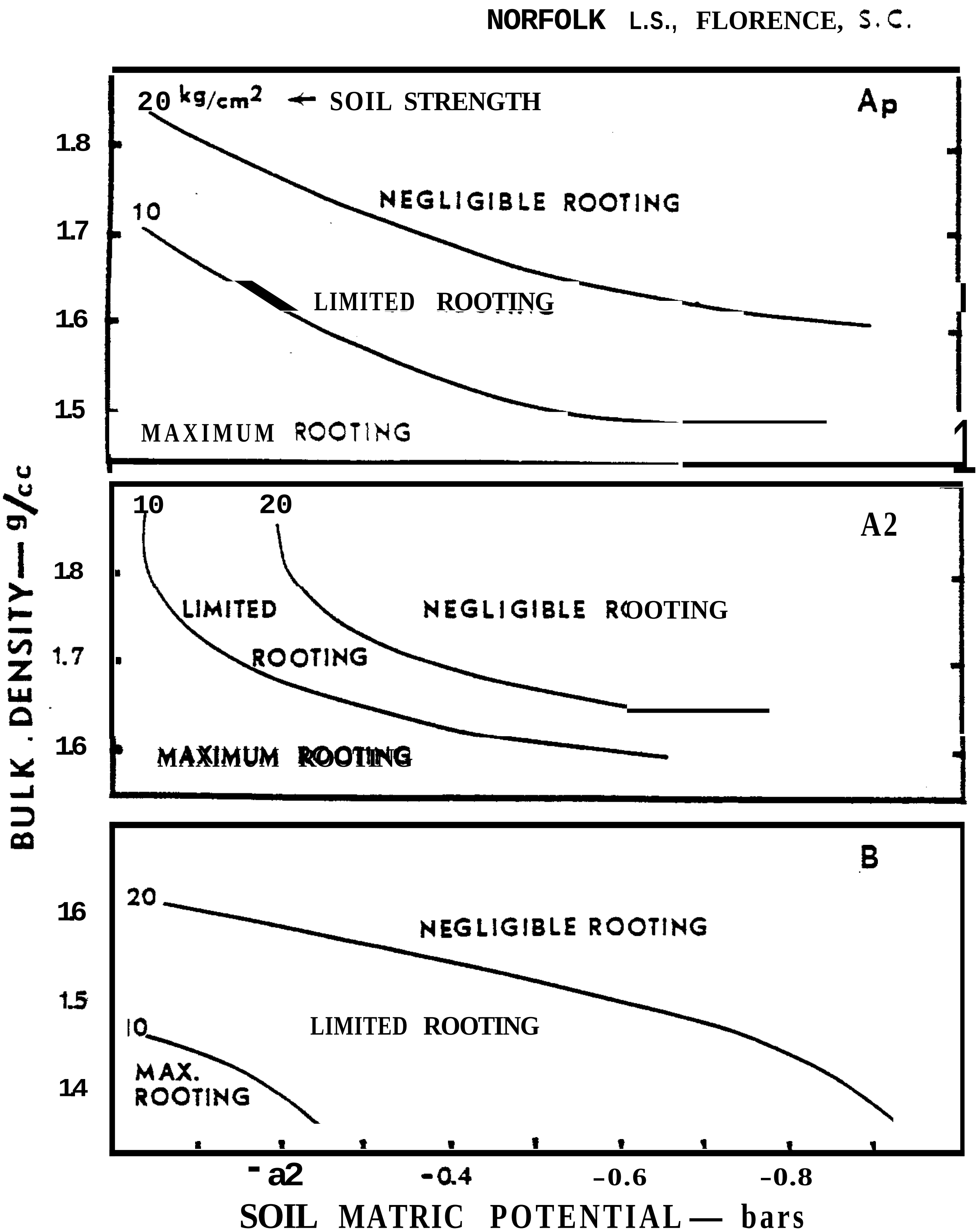

Fig. 1. Soil strength presented as a function of bulk density and matric potential (water retention) in relation to expected rooting in three soil layers, Ap, A_2, and B.

conservation-tilled acreage was planted to the small grain-soybean crop sequence. Approximately, 36% of the conservation tillage in the Coastal Plains involved corn which was planted into a cover crop or winter weeds growing in old corn or soybean residue.

Conservation tillage research in the Coastal Plains has progressed and is now in a position to consider using other cool season crops in the rotations. Economically, it is important for the cool-season crop to produce a return on the farmers investment beyond merely gaining the advantages of maintaining residue on the surface to reduce the hazard of erosion and soil loss. The use of late-season or cool-season crops may be grouped into four use categories: (1) to provide forage for grazing or hay (rye) (2) to fix nitrogen for subsequent crops (clover, vetch, or other legumes), (3) to grow oil seeds (soybean, sunflower, and rape) or (4) to grow small grains such as wheat, barley, oats, and rye. Research is underway to test the compatability of these cool-season crops with our major field crops such as corn and soybeans. At the present time, seven rotations given in Table I are being tested for compatability in conservation tillage farming.

Table 1. Potential double crop sequences for the Coastal Plains

1. Small grain followed by soybean
2. Corn followed by soybean
3. Legume followed by corn
4. Corn followed by sunflower
5. Corn followed by rape
6. Legume followed by sorghum
7. Rape followed by soybean

III. Advantages and Disadvantages of a Rye Cover

Cover crops provide many beneficial effects as well as incurring many risks in conservation tillage farming. Since cover crops are grown mostly during the cool season, they can provide forage for animals while maintaining a soil cover that stabilizes soil and reduces the hazard of soil erosion. A cover crop helps to control spring weeds (by competition) which are normally difficult or expensive to control by other means. A cover crop slightly reduce's soil temperature, but tends to increase the tilth of the soil. A cover crop provides better mechanical support for vehicles when soils are wet and hence may tend to minimize soil compaction in these instances.

There are risks and additional costs associated with conservation tillage farming in the southeastern Coastal Plain. Special considerations necessary to insure the success of conservation tillage farming with cover cropping include: (1) in-row subsoilers suited to operation in residue where subsoil compaction is a factor, (2) heavy disk-opening planters and higher seeding rates, (3) closer monitoring of insects, diseases and pests, (4) minimizing seed to residue contact to avoid phytotoxic effects of residues or exudates from plants in the weed or plant complex, and to avoid physical and disease related reductions in stand establishment of crops planted into unprepared soil, (5) adopting a fertilization strategy meeting the requirements of in-residue planted crops, (6) minimization of wheel traffic compaction arising from harvesting and other field operations that may accumulate over a period of time, increasing bulk densities and soil strength, and (7) specialized pesticide applicators for use in heavy residues.

IV. Soil and Water Management and Yield of Corn and Soybean in Conservation Tillage and No-Till Cropping Systems

Water removal by cover crops is a fundamental factor which affects crops following winter cover crops and influences the success of conservaton tillage systems. We evaluated the following winter rye residue management treatments which were established before planting corn on 16 April 1980: (1) disking the rye cover crop into the soil 20 days before planting, (2) applying a nonselective herbicide to the cover crop 20 days before planting, (3) double disking the cover crop 1 day before planting, and (4) applying a nonselective herbicide after planting, but before emergence. As the corn crop germinated and began to develop, it became obvious that in Treatment 1 (early incorporation) the corn was growing at a significantly higher rate than in tillage Treatment 4. The yield data (Table 2) show a reduction of 9-10 bu/A for Treatment 4 compared to 1. Corn yields decreased progressively, depending upon the degree to which water had been removed from the profile by the cover crop.

Table 2. Yield of corn as influenced by water extraction from soil by a winter rye cover crop-(Dargan Farm 1980)

Disposition of rye cover crop residue	Corn Yield bu/A
Incorporated 20 days before planting	102
Herbicide applied 20 days before planting	97
Incorporated 1 day before planting	92
Herbicide applied 1 day after planting	93

In a related study, corn was planted 4 April 1981. Measurements made 17 days after the crop was planted (Table 3) show that the quantity of water depleted from the soil profile reflected how the winter cover-crop had been managed. The treatments which were established prior to planting a cover crop included: (1) clean cultivation, where the soil was kept bare throughout the winter by periodic disking, (2) incorporating a rye cover crop by double-disking one day before planting, (3) applying a nonselective herbicide to the rye cover crop one day after planting, (4) applying a nonselective herbicide to the cover crop remaining after planting with a "Cole" 3/ system which buries about 50% of the previous crop residue at planting, and (5) planting with the "Cole" system, but applying no herbicide to kill the remaining cover crop.

In this experiment, most of the available soil water to a depth of 24 inches had been depleted in the treatments in which the rye cover crop achieved the greatest development. The soil water data shows significant water extraction in the 18-24" depth. The importance of adequate soil water during the early development of the corn was demonstrated from these soil water data and from the corresponding yield data also presented'in Table 3. The water profile deficit-was 0.83, 1.82, 2.20, 2.31, and 2.59 inches in the 24" profile for the five residue treatments listed in Table 3.

Corn yield correlated highly with the water deficit observed 17 days after planting. In 1981, 110 bu/A yield was produced in the clean-till treatment, but there was not sufficient rain to recharge the soil root zone to make up for the effects of the initial deficit during the growing season.

Table 3. Effect of five different cover crop management techniques on gravimetric soil water content, soil water retained 17 days after planting, and corn grain yield at harvest, 1981, Florence, S.C.

Crop Management	% Soil H O by Depth (in) 0-6	6-12	12-18	18-24	% Water Capacity	Yield bu/A
Clean-tillage (no cover)	8.9	9.9	19.4	21.4	73	110
Disk cover (before planting)	5.7	6.6	15.7	19.5	41	98
No-till (herb. at planting)	5.4	5.6	13.7	18.5	29	88
50% cover (w/herbicide)	4.6	4.6	14.2	18.9	26	90
50% cover (w/o herbicide)	2.4	3.9	14.1	18.2	17	70

The effects of both dead and green plant cover on corn yield at two sites in Florence, South Carolina in 1981 are presented in Table 4. The treatment entitled "no-till in corn stover" yielded 30% more than a clean-tilled plot. This relative yield is compared with the relative yield of corn data shown in the previous table.

3/ Mention of trademark, proprietary product, or vendor does not constitute a guarantee or warranty of the product by the U.S. Dept. of Agr. or the S.C. Agr. Exp. Sta. and does not imply its approval to the exclusion of other products or vendors that may also be suitable.

Table 4. Effect of various types of plant covers on corn yield, 1981, Florence, S.C.

Site	Plant cover treatment	Yield bu/A	% Relative yield
1	Clean-tilled	99	100
1	No-till in corn stover (w/o cover crop)	129	130
2	Clean-tilled	110	100
2	Rye cover incorporated	98	89
2	No-tilled w/herbicides	88	80
2	No-tilled w/50% cover (w/herbicide)	90	82
2	No-tilled w/50% cover (w/o herbicide)	70	64

Based upon data presented in Tables 3, and 4, one may conclude (1) that to have adequate water in the soil for the early development of corn is very important, (2) that green cover crops can utilize a considerable amount of water from the soil profile, which in effect competes for the water which would have otherwise been available for the succeeding crop, and (3) that planting in old corn stover in a dry spring helped to conserve water early in the crop history which produced a 30% increase over the yield produced under clean-tillage. While competition for and changes in availability of nutrients may also play a role, clearly soil-water was the single most dominant factor.

The proper seeding rate is essential to develop a stand of corn which will result in maximum yield. Data shown in Table 5 give the percent of seeds germinated when planted in incorporated rye residue and also when planted in standing rye. The results show a reduction of 13-14% germination in the standing rye residues compared to incorporated residues. These data were obtained in the spring of 1980 which was one of the Coastal Plains most recent severe drought years. We have since found that when soil moisture conditions for seedling establishment are favorable, germination reductions in conservation tillage systems may be as low as 6%. Data shown in Table 5, however, reflect germination under conditions where the water content of the surface soil was reduced by the presence of standing residue. Table 3 shows the highest extraction occurred in the surface horizon, which is the most critical zone for seed germination and seedling establishment.

Table 5. Stand of corn obtained in incorporated and standing rye at two seeding rates, 1980, Florence, S.C.

Seeding rate	Resulting Stand in Residue			
	Incorporated		Standing	
Seeds/A	Plants/A	%	Plants/A	%
31000	26600	84	22100	71
27000	23500	87	19400	72

Yields for various corn hybrids under no-till and clean-till cropping systems, with and without irrigation are given in Table 6.

Table 6. Yield (bu/A) of rainfed and irrigated corn hybrids under no-till and clean-till systems, 1981, Florence, S.C.

Hybrid	Monirrigated Clean-Till	Monirrigated No-Till	Irrigated Clean-Till	Irrigated No-Till
Coker 21	95	111	159.	165
DeKalb XL71	116	141	169	178
Northrup-King PX74	92	145	182	151
Pioneer 3382	103	140	168	159
Ring-Around 1502	88	109	193	181
Mean	99	129	174	167

The mean yield in the clean-till, nonirrigated system was 99 bu/A as compared to 129 bu/A mean yield in the no-till treatment which was planted in corn-stover with winter-weed residue. This yield increase appears to be due to the conservation of water by the stover cover on the soil surface. Under irrigated conditions, the clean-tilled treatment yielded 174 bu/A vs. 167 bu/A under the no-till system. Differences in yields among five corn hybrids within any tillage system under irrigated and nonirrigated conditions showed a wide range of response. This experiment is being continued in an effort to establish consistent differences between corn hybrids planted in the various types of tillage systems.

These data indicate that Northrup-King PX74 gave the highest yield under the nonirrigated no-till treatment, whereas Ring-Around 1502 gave the highest yield under the irrigated no-till treatment. This result is of special interest since Ring-Around 1502 gave the lowest yield of the five varieties in the nonirrigated no-till treatment. These data indicate that intensive screening of corn hybrids under no-till conditions would significantly improve corn production in no-till cropping systems.

Soybean has shown marked responses to drought stress during the germination, seedling development, and full canopy development. In 1980, data from Dargan Field #2 showed a reduction in seedling size at the 4-leaf stage in the no-till planting which continued throughout the growing season. Yet, as seen from the yield data in Table 7, the yield from the no-till soybean planted in rye residue was 30.9 bu/A as compared to 28.2 bu/A when rye cover was incorporated two weeks before planting. Soybean yields from several replicated large-scale incorporated vs. no-till plantings in winter rye cover are shown in Table 7. The average yield for several experiments conducted between 1978 and 1980 reflect a slight increase in yield in no-till planting behind a rye cover crop. The average yield for conventional tillage was 29.3 vs. 31.4 bu/A for the no-till in rye residue plantings. These data suggest that southern, determinate soybean is not as sensitive as corn to early-season growth reductions in no-till systems.

Table 7. Soybean yields for large-scale replicated conventional and no-till plantings in production fields with a winter-grown rye cover crop (bu/A).

Year	Field	Yield Incorporated	Yield No-till
-1978	Dargan 1	20.2	27.6
1979	Dargan 1	28.1	28.6
1979	Dargan 2	41.8	41.0
1979	Dargan 3	34.6	37.6
1979	Williamson	22.2	22.9
1980	Dargan 2	28.2	30.9
Average		29.3	31.4

In 1980 and 1981 a more comprehensive tillage-regime soybean test involving various methods of managing residues further supports this conclusion. The treatments compared were (1) clean-tillage where the field was disked periodically during the winter to control weeds, (2) disk-incorporated rye residue, 20 days before planting, (3) disk-incorporation just before planting; and two other treatments where a non-selective herbicide was applied (4) 20 days before planting, and (5) immediately after planting as a pre-emergent chemical (in the usual no-till manner).

Data from this experiment demonstrate effects of row spacing within these five tillage regimes. The mean yields (Table 8) show an increase for the 30" row in 1980 and an increase with a 38" row in 1981. These results indicate that row spacing interacts with the time and duration of drought. In 1981 severe drought occurred late in the

Table 8. Effect of row spacing on soybean yield for five tillage regimes (bu/A), 1980 and 1981, Florence, S.C.

Tillage System	30" Row Spacing 1980	30" Row Spacing 1981	38" Row Spacing 1980	38" Row Spacing 1981
Clean-till	17.1	27.2	14.0	29.7
Disk-early	14.7	29.6	14.4	28.8
Disk-late	15.8	31.0	14.9	31.0
Herb-early	15.5	24.4	12.9	29.4
Herb-late	14.0	29.4	14.7	29.4
Average	15.4	28.7	14.2	29.7

crop cycle, consequently soybeans which were slowest to develop a closed canopy survived' the drought best by conserving more moisture for the reproductive growth phase, thus producing the highest yields. Determinate soybean grown with adequate water, planted to a 30" row spacing normally produce slightly higher yields compared to 38" rows in full season crops.

The effect of variety on soybean yield within the five tillage regimes is shown in Table 9. In this experiment, Coker 338 produced a lower 2-year mean yield than the Bragg and Ransom. Water stress occurred in the later part of the production cycle for soybean in both 1980 and 1981, although late stress was more pronounced in 1981. Hence, the later varieties were affected more severely by drought than the earlier varieties of soybean.

Table 9. Effect of variety on soybean yield for five tillage regimes (bu/A).

Tillage System	Coker 338 1980	Coker 338 1981	Bragg 1980	Bragg 1981	Ransom 1980	Ransom 1981
Clean-till	14.3	28.5	15.6	28.3	16.8	29.1
Disk-early	14.8	29.2	14.5	28.3	15.6	30.1
Disk-late	13.6	29.4	16.0	30.6	16.5	33.1
Herb-early	13.2	26.0	13.9	28.7	15.5	27.9
Herb-late	15.4	28.4	13.3	29.2	14.4	30.6
Yearly Avg.	14.0	28.3	14.7	29.2	15.8	30.2
Variety Avg.	21.2		22.0		23.0	

The effect of tillage regime on soybean yield is presented in Table 10.

Table 10. Effect of tillage regime on soybean yield.

Tillage System	Yield (bu/A) 1980	Yield (bu/A) 1981
Clean-till	15.6	28.7
Disk-early	14.5	29.2
Disk-late	15.4	31.0
Herb-early	14.2	27.4
Herb-late	14.3	29.4

In 1981, yields were highest where the cover crop was undisturbed until shortly before planting. This occurred because a drier seedbed in the treatments where the cover crop was controlled late, slowed the early vegetative development of the soybean crop, conserving water for use in that year's late-season drought. Thus, under severe late drought, the disk-late and herbicide-late tillage treatments produced yields higher than conventional tillage and early cover crop control with herbicides or tillage. These data show that differences in water use and conservation by various canopy and residue conditions can result in water stress during the crop cycle itself or may experience stress due to water use by the preceding cover crop. Consequently, the time of water stress influences the effectiveness of row spacing and soybean varietal selection.

V. Summary and Conclusions

The results of conservation tillage research show that it is not a question of whether or not conventional tillage or no-tillage is better or worse than the other. The real question is how much do we know about the management factors that affect the various yield components within the various tillage systems and how well can these yield components be managed. Critical aspects of conservation-tillage and multi-cropping include the following considerations: (1) the timeliness of operations because one crop always follows another crop, (2) maintaining a favorable plant water status either by deep tillage and/or irrigation, (3) managing cool season crops to give an economic return on investment such as: pasture, oil-seed crops, legumes for nitrogen production, or small grains, (4) preventing disease and insect pests which are always a threat, (5) managing cool-season crops or spring weeds to conserve water, (6) achieving weed control through proper timing of the herbicide application, (7) developing long-term fertilization programs for no-till farming which have yet to be tested and recommended, and (8) selecting and developing cultivars which are best suited to a conservation-tillage planting environment.

No-till research in the Southeastern Coastal Plains is progressing, but is still in its infancy. Consequently, many cropping systems are being tested. Long-term effects of no-till cropping systems on Coastal Plain soils are only now being established and must continue to be studied, particularly in relation to disease and insect infestation and the synthesis of phytotoxic substances. Equipment and tools for no-tilling have been greatly improved and adapted to local farming conditions, but reduction in power requirements, seed placement, and residue displacement need improvement. Methods of managing and marketing the crops will continue to have the same kinds of problems associated with them under conventional tillage. No-tilling is destined to become a farming practice that will assure the success of double-cropping and multi-cropping programs in southern agriculture and will probably be the best method by which wind and water erosion can be controlled.