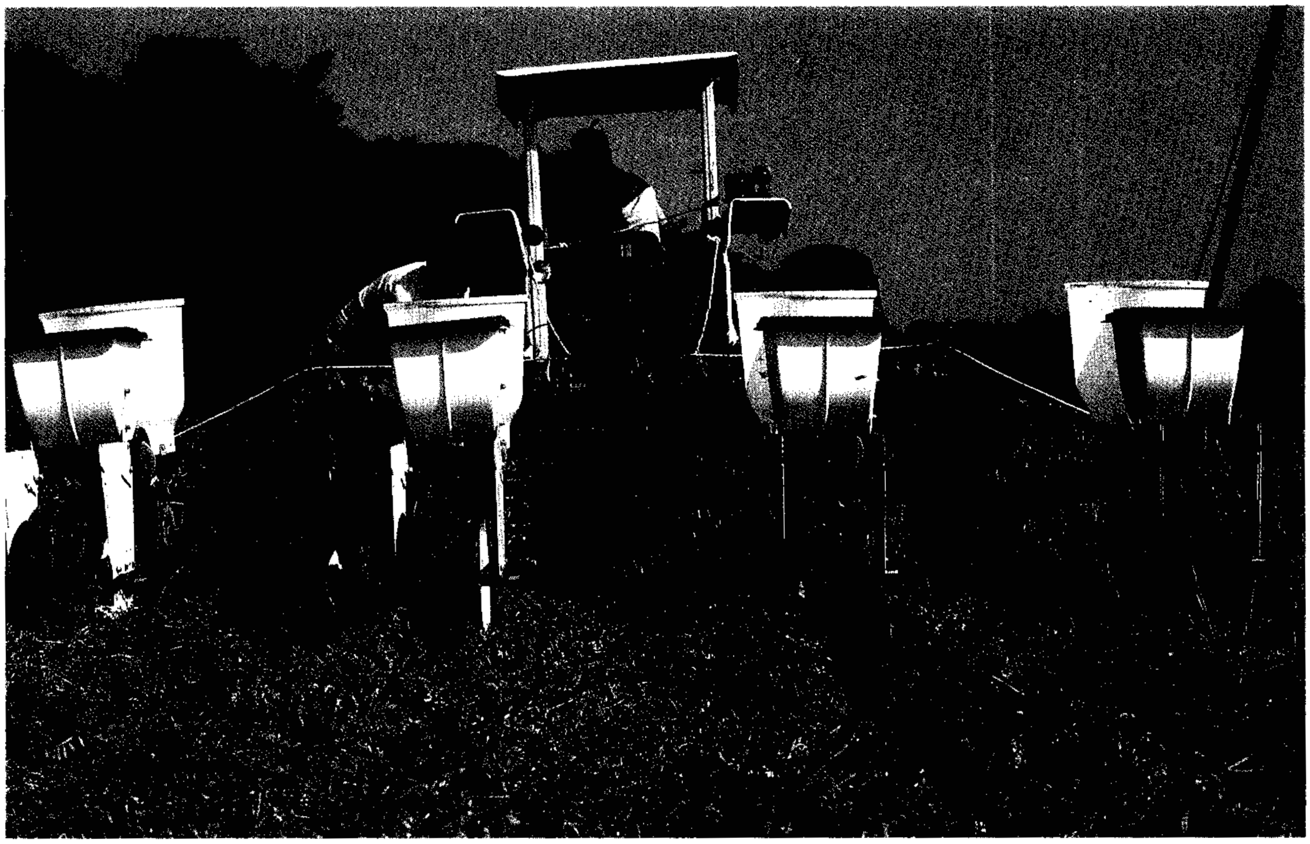
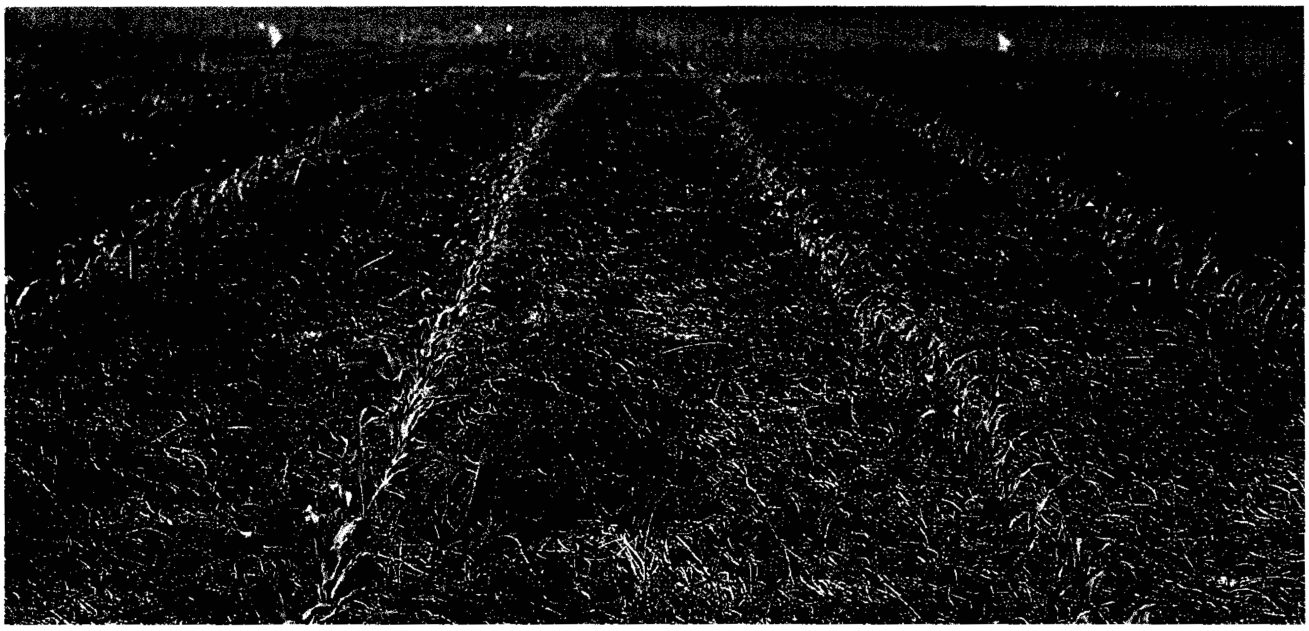
Proceedings SOUTHERN REGION June 18, 1986

No-Till Conference





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PROCEEDINGS OF THE SOUTHERN REGION NO-TILLAGE CONFERENCE

June 18, 1986

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PREFACE

We at the University of Kentucky welcome you to the ninth annual Southern Region No-Till Conference. The body of research on no-till crop production has grown dramatically since inception of the practice about 20 years ago. At that time, University of Kentucky scientists and farmers were among the first involved in development and spread of the practice. Following the early work by S. H. Phillips, now Associate Director for Cooperative Extension at the University of Kentucky, and Harry Young, an innovative Christian County farmer, acreage of no-till corn and soybeans has spread throughout Kentucky to where it presently represents about one-fourth of the total corn acreage and just over one-third of the total soybean acreage. Corresponding growth of the practice has also taken place in other states and no-till is now recognized in this country and around the world as an important planting and production technique for conservation of soil and water which often results in better yields than from traditionally prepared seedbeds, and as a fuel, time and labor saving practice of major importance.

Much has been learned about the principles and techniques of no-till farming during this short 20 years. This conference was designed to provide "state-of-the-art" discussions on some of the broader technical components of no-till farming by speakers widely recognized for their knowledge and experience about the practice. Proceedings of the conference contains the papers presented by those speakers, together with a summary of on-going research in no-till production by most of the southern states. We appreciate the opportunity to host this important annual conference and to show our on-going no-till field research with corn, soybeans, tobacco, small grains, and forages.

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April 24, 1986

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NITROGEN MANAGEMENT FOR NO-TILAGE CORN

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INTRODUCTION

Acceptance of no-tillage and reduced tillage crop production methods, often collectively referred to as conservation tillage, has expanded rapidly in many parts of the U.S. in recent years, particularly in the Mid-Atlantic and Southeastern regions. According to Peter C. Myers, chief of the Soil Conservation Service, "Conservation tillage is being adopted faster than any other practice in the history of farming. In 1972, (there were) 30 million acres. In 1982, (there were) more than 100 million acres. By the year 2010, as much as 95 percent of all U.S. cropland may be farmed with conservation tillage methods" (12). In Maryland, the extent of no-tillage and reduced tillage corn increased from less than 10,000 acres in 1970 to more than 350,000 acres by 1978 (1). A 1983 Maryland county-by-county survey showed that even in a year when the Federal Governnent's PIK (Payment-in-Kind) program encouraged an overall reduction in corn acreage, over 400,000 acres of corn were nevertheless reported in other Kid-Atlantic states where, on the average, conservation tillage corn acreage increased from less than 5% in 1970 to almost 30% in 1978 (1). No-tillage reduces costs for fuel, labor, and equipment. It can also reduce soil erosion losses on many soils by 50% to 90% percent and improve soil moisture retention (12,13,19).

Once it was recognized that no-tillage corn production was practical, it became apparent that many of the traditional lime and fertilizer practices long associated with conventional tillage might no longer be suitable or even possible. With the introduction of improved no-tillage planters, farmers foucd that they could establish excellent corn stands without prior soil tillage. It became obvious that traditional rates and methods of nitrogen application did not consistantly result in expected yields and acceptable nitrogen efficiency. A number of investigators have reported the need for increased fertilizer N for corn grown under no-tillage than under conventional tillage (3,10,11,16).

Some nitrogen management problems have resulted from the trend of the fertilizer industry away from ammonium nitrate and toward urea (9). Indications are that increased use of surface-applied urea or urea-based fertilizers in conservation ti1lage systems often present agronomical and subsequent economical problems for the farmer (2,17). It is well known that under favorable conditions, significant quantities of nitrogen can be lost to the atmosphere from surface-applied urea due to armmonia volatilization (5,9,18). The "bottom line" is that where urea or urea-based fertilizers are surface applied, particularly in the presence of organic residues, crop yields are often reduced (2,7,14,17). In some cases, ammonia losses from surface applied urea may be reduced by appropriate use of a nitrification inhibitor (6). Considerably improved N efficiency can be obtained by proper fertilizer placement (2,17), or if sufficient rainfall occurs at a fortuitous time. According to Fox and Hoffman (7), there is an apparent relationship between timeliness of rainfall after N application and possible N volatilization losses. They have suggested the following relationships: "(1) there was insignificant ammonia volatilization loss from unincorporated urea fertilizers if at least 10 mm (0.4 in.) of rain fell within *48* hours after fertilizer application; (2) if 10 mm or more fell 3 days after the urea was applied, volatilization losses are slight (<10%); (3) if 3 to 5 mm (0.1 to 0.2 in.) of rain fell within 5 days, or 7 to 9 mm (0.3 to 0.4) in.) within 9 days, volatilization losses could be moderate (10% to 30%); and (4) if no rain fell within 6 days, the loss could be substantial (>30%).

According to the 1984 FERTILIZER SUMMARY DATA published by the Tennessee Valley Authority (8), of the major direct applied nitrogen materials utilized on U.S. farms, 14.1% was attributed to urea and 27.8% to UAN solution. In Maryland, where no-tillage crop production has gained rapid popularity, 8.4% of the direct applied nitrogen came from urea, and 62.2% came from UAN solution. In Kentucky, another state with a high degree of farmer acceptance of no-tillage crop production practices, urea is reported to be the number one direct applied source of N. Urea accounts for 31.7% of the direct applied N, whereas UAN solution accounts for 12.6%. The relatively high popularity of UAN solutions in recent years is probably related to the fact that many herbicides and other pesticides can be tank-mixed with UAN, thus saving one or more extra trips across the field. The potential problems associated with surface applied urea and other urea-based fertilizers is already widespread, and will continue to grow as acreage of reduced tillage and no-tillage N management besides N source, include N rate, N placement and time of N application. These topics will be discussed in greater detail in the following sections.

NITROGEN RATE FOR MAXIMUM YIELDS

As no-tillage corn gained in popularity during the 1970's, one difference observed between no-tillage and conventional tillage was the "apparent" need for higher nitrogen levels in no-tillage fields. Unfortunately, some individuals incorrectly interpreted this difference as an indication that no-tillage corn is a less efficient utilizer of fertilizer N than conventional tillage corn. But, when properly managed, no-tillage corn actually provides a MORE EFFICIENT vehicle for fertilizer N utilization than does conventional tillage.

Long-term N rate by tillage experiments conducted in Maryland since *1973* have provided data relative to the nitrogen requirements of the two tillage systems. These tests substantiated that at sub-optimal N rates, N deficiency symptoms were more pronounced in no-tillage than in conventional tillage corn. Some of this work illustrated the major differences in N requirements between the two tillage systems. In these tests, N was applied to both no-tillage and conventional tillage corn at rates of 0, 80, 120, 160 and 240 lb/A. Yield data from one typical location-year are presented in Table 1.

From the response curves in Table **1, it** would appear that the 240 lb/A N rate resulted in highest yields for no-tillage and the 160 lb N/A rate resulted in highest yields for conventional tillage. However, neither of these curves actually "peaked" at these nitrogen levels. Using a statistical technique known as curvilinear regression, best fitting curved lines were selected for these data points. These lines showed that grain yields for both tillage systems continued to increase to some N rate(s) between 160 and 240 lb/A. Maximum yields should have occurred approximately 214 lb N/A for no-tillage and at approximately 183 lb N/A for conventional tillage corn -- approximately 31 lb/A more N for no-tillage than for conventional tillage corn in this case. These values illustrate typical differences in N requirements between the two tillage systems. Experience has shown that differences in maximum yield N requirements between typical no-tillage and conventional tillage corn systems average about 30 to 40 lb N/A more for no-tillage, but may vary from essentially 0 to more than 60 lb N/A. The magnitude of these differences depends upon many factors, such as soil type, past cropping history, seasonal rainfall and temperature, soil pH, etc. These are all factors which directly or indirectly influence the level of residual soil N available to the growing crop.

Despite no-tillage corn often requiring a higher fertilizer N rate than conventional tillage corn to obtain maximum yields, increased N levels on no-tillage corn are generally rewarded under Maryland conditions by higher yields than yields obtained on conventionally tilled corn at the same N level. For instance, in Table 1, no-tillage corn yields exceeded those from conventional tillage by approximately 20 to 36 bu/A at the more optimal N fertilization rates. When the amounts of fertilizer N required to produce a bushel of corn were calculated (Table 2), it was apparent that at N rates of less than 120 lb/A, no-tillage corn required about the same amount of N/bu as conventional tillage. But, at N rates of 120 lb/A or more, no-tillage corn required **LESS** N/bu than conventional tillage. For instance, at N rates of 120, 160 and 240 lb/A, each bushel of conventionally tilled corn required 1.0, 1.2 and 2.0 lb N/bu respectively compared to 0.9, 1.1. and 1.6 lb N/bu for no-tillage corn. At these higher N rates, conventional tillage corn required 1.1, 1.1 and 1.2 times more N respectively than similarly treated no-tillage corn. N efficiency relative to grain yields declined for both tillage systems as N rates increased. But N efficiency for no-tillage corn was always higher than that for conventional tillage corn at N rates of 120 lb/A or more.

Summarizing yield data collected over a 13-year period from as many as five Maryland locations (Table 3), showed that at sub-optimal N rates (below 80 lb N/A), conventional tillage corn out-yielded no-tillage corn 64% to 69% of the time. At the 80 lb N/A rate, the odds continued to be about evenly divided between the two tillage systems (46% for no-tillage and 54% for conventional tillage). But, at the more optimal N rates 120 lb N/A or more, the odds were reversed, and the probability for highest yields turned strongly in favor of no-tillage. No-tillage corn OUT-YIELDED conventional tillage corn 61% to 78% of the time at these higher, more optimal N rates.

Obviously, when managed properly and fertilized at the optimal N rate, no-tillage corn can be expected to deliver more efficient use of fertilizer N than conventionally tilled corn. No-tillage corn can be expected to normally return more profit per acre from properly applied N fertilizers than its conventionally tilled counterpart.

NITROGEN SOURCE

As discussed briefly in the INTRODUCTION, N fertilizers containing urea frequently are not as efficiently utilized when surface applied as ammonium nitrate or other materials less sensitive to volatilization losses. In a series of Maryland tests conducted from 1976 to 1979 at three locations, ammonium nitrate resulted in the highest and urea the lowest average no-tillage corn yields (2). Yields from UAN solution were intermediate between ammonium nitrate and urea (Table 4). Calculated response curves fitted to a summation of this data covering 12 location-years estimated that at the 160 lb N/A rate, urea utilization by no-tillage corn was 61% as efficient as amrmnium nitrate and 80% as efficient as UAN. Broadcast UAN solution was 75% as efficient as ammonium nitrate and 125% as efficient as urea in these tests.

In spite of the frequently erratic behavior of urea under no-tillage conditions, the importance of urea to agriculture cannot be discounted. Urea has the highest N content of any solid N fertilizer on the market. And because of more favorable economics in manufacturing, as well as the lack of many government restrictions on transportation and storage that have been imposed upon ammonium nitrate, urea has the potential to become a very important dry nitrogen material. Therefore, it becomes extremely important that more efficient methods of utilizing urea and UAN solutions continue to be investigated and refined.

If the cost per unit of N were the same for all N sources, amrmnium nitrate would appear to be a better value than either UAN or urea for surface application on no-tillage fields. UAN would also appear to be more economical than urea under no-tillage conditions. However, any cost differential between these materials must be taken into account when determining application rates. If the cost per unit of N from urea or UAN is significantly lower than that of ammonium nitrate, then it may be economically sound to increase the rate of application for urea or UAN to compensate for the lower efficiency of these materials. But since any nitrogen fertilizer should be considered as a valuable resource to be conserved and also as a potential pollutant of lakes, streams, rivers and ground water, a more practical approach to improve N efficiency might be to modify the application method or time of application.

NITROGEN FERTILIZER PLACEMENT

One proven technique for increased efficiency of urea-based fertilizers is soil incorporation. Since this technique requires special equipment if utilized under no-tillage conditions, a research project was initiated in 1979 at the University of Maryland in cooperation with the Tennessee Valley Authority to develop and test the effectiveness of an experimental apparatus for soil injection of liquid fertilizers under no-tillage field conditions. Subsequently, a tractor-mounted three-point-hitch soil injector was developed for use on small plots. Solutions of ammonium nitrate, urea or UAN were placed between the rows about 15 inches from the plant, and about 4 to 6 inches deep. A plow coulter in front of the injection knife cut through plant residues. Results from some of this research are presented in Table 5 (4).

Over the four-year duration of this experiment, surface broadcast N resulted in the largest yield differences among N sources. Ammonium nitrate resulted in the highest yields, and broadcast urea resulted in the lowest. Broadcast UAN resulted in yields intermediate between those from ammonium nitrate and urea. Corn grain yields from broadcast urea averaged 26.8 bu/A less than those from ammonium nitrate. For individual years, this difference ranged from 13.4 to 36.5 bu/A. Grain yields from broadcast UAN averaged 11.2 bu/A less than those from broadcast ammonium nitrate. Over the four-year duration of the test, yields after UAN were 8.4 to 15.9 bu/A lower than yields from ammonium nitrate.

Soil injection improves N fertilizer efficiency under no-tillage conditions. In those cases where all three N fertilizers were soil injected, no statistically significant grain yield differences occurred between N sources. considering only the N, injection is obviously the most efficient method available. but, there are also some disadvantages with this technique. For instance, few farmers are currently equipped to inject prilled or granular but is not as rapidly accomplished as other methods of fertilizer application. Soil injection requires more energy than surface application. Most farmers already own, or have access to, a sprayer. But many do not have access to an injection apparatus. Thus, injection may not be as convenient as other techniques. Another potentially serious problem is that the traditional anhydrous ammonia-type knife often used for injection causes soil disturbance which may create an erosion problem on more rolling topography. High pressure injection, or use of solid stream nozzle behind a straight plow coulter may remove some of these disadvantages. Field testing of some of these innovative techniques in cooperation with the Tennessee Valley Authority, USDA and the Arcadian Corporation is being conducted. Some preliminary results obtained at five Maryland locations in 1984 and 1985 are presented in Tables 6 and 7. It is important to recognize that the timely spacing of rainfall events at most locations in 1984 probably was a major reason why larger differences did not occur more frequently between application methods or materials. Greater stress was placed upon the treatments in 1985. Unfortunately, 1985 was severely dry at some locations causing stand reductions and reduced yields. On the average, broadcast ammonium nitrate and UAN injected either by anhydrous knife or by low pressure solid stream nozzle into a plow coulter slot resulted in highest yields. But UAN broadcast or dribbled were a close second. Broadcast urea and UAM injected by the high pressure NUTRI-BLAST 2000 resulted in lowest yields in the 1985 tests.

With proper equipment, soil injection of N solutions works very well, usually with a yield advantage. But, until significant improvements in machine availability occur, it is doubtful that many fanners will have injection available as a practical option. Since most growers either own or have access to a sprayer that could be used to apply fertilizer solutions, another application technique known as "dribbling", or surface banding, is being considered.

"Dribbling" of N solutions is a simple, low-cost procedure that can easily be accomplished by attaching a length of hose over the sprayer nozzle. This technique is effective for improving the efficiency of surface applied UAN under most normal growing conditions. Results from tests conducted at several

Maryland locations in 1982 are presented in Table 8.

In all four comparisons in Table 8, dribbled UAN was statistically superior to broadcast UAN. Increased yields from dribbling UAN compared to broadcast averaged 21.8 bu/A (17.8%) and ranged from 12.6 to 36.7 bu/A in favor of the dribble technique (9.2% to 30.6% increase). Even when corn is priced at only $2.00/bu, improved N efficiency from dribbling translated into an additional income of $25.20 to $73.40/A (average $43.60/A). Essentially, the only additional cost to this practice is for the purchase of a few lengths of hose, plus perhaps an extra trip over the field if the grower normally had been following the traditional practice of tank-mixing pesticides with UAN for simultaneous application. It would appear that surface banding (dribbling) UAN solutions on no-tillage corn is a reasonable alternative to the apparently large N losses otherwise experienced when broadcast application methods are employed.

TIMING NITROGEN APPLICATIONS

Proper timing of N applications on any crop is extremely important. But, it is doubtful that there has ever been a crop where proper N timing is more critical than it is for no-tillage corn. Proper N timing is particularly critical because of the many ways in which fertilizer N can be lost under no-tillage, many of which are not a serious concern under conventional tillage. A good “rule of thumb’’ is to ‘‘apply N fertilizer as near as possible to the time of plant need”. N leaching losses can be a problem on light-textured sandy soils regardless of the tillage system. But where no-tillage is practiced, a number of other factors nay also significantly influence N use efficiency if abused or ignored.

Under no-tillage management, N fertilizers may be lost from the soil by ammonia volatilization, denitrification and/or by biological immobilization. Or mechanisms include ammonia volatilization from surface applied urea or urea-based fertilizers, and denitrification, a process by which readily available nitrate N is chemically reduced (oxygen removed) until it is converted to a gas. Denitrification is believed to be a major source of fertilizer N losses from no-tillage soils and is most often a problem is wet soils where oxygen availability is limited. Denitrification can be serious during growing seasons in which wet soils are a problem, particularly when nitrogen was applied at times not coinciding closely with plant needs.

Another important mechanism that reduces fertilizer N availability is microbial immobilization, a process in which certain soil microbes decompose plant residues and convert them into soil organic matter (humus). Crop residues, such as old corn stalks, leaves, cobs, roots, etc. are relatively high in carbon and low in nitrogen. For soil microbes to convert such residues into protein relatively high in N, a readily available N source is necessary. Fertilizer N applied before needed by the crop could be consumed by microbes (immobilized), rendering it temporarily unavailable to plants. Most immobilized N remains unavailable to plants until the newly formed soil humus is broken down by oxidation (mineralized), releasing the immobilized nutrients. Cultivation, for instance, encourages mineralization by aerating the soil, allowing oxygen to react with the organic matter.

No-tillage corn production is an excellent example of a cropping environment in which N immobilization could be a serious problem. If N fertilizers are applied too early in the growing season, when N requirements of corn are minimal, then more biological N immobilization could occur than if N fertilizers were applied in a more timely manner. Corn requires very little N during its first 25 to 30 days. N applied during this period would not be in heavy demand by the crop. As plant dry matter increases, the crop's need for N also increases. N applied during this latter period could also be immobilized, but not likely to as great an extent as the early-applied N because there would be more intense competition for it by the rapidly growing plants. A good example of the possible combined effects of ammonia volatilization, denitrification and immobilization on corn grain yields, and the extent to which these effects can be minimized by N placement and timing of application is presented in Tables 9 and 10.

Relatively long term tests have been conducted at three locations across Maryland to test the effectiveness of nitrogen solution placement and time of application on nitrogen efficiency by no-tillage corn. Tests were established in 1980 on silt loam soils at two Coastal Plain locations (Poplar Hill Research Farm and Wye Research Center), and at one Piedmont location (Forage Research Farm) to compare the effects of broadcast versus injection of UAN solution on no-tillage corn yields. UAN solution was applied either within a few days of planting (early treatment) or about one month after planting (late treatment). These tests have been continued following the same treatment format through 1985.

After 18 location-years, a summary of the yield results as influenced by time of application and broadcast versus dribble (surface band) are given in the first half of Table 9. many corn growers have traditionally used the "early" broadcast technique as a standard method of application. Many like this method since it allows them to "tank mix" many of their pesticides with UAN, and apply everything with just one pass over the field. But is the time saved worth the risk of lower nitrogen efficiency and subsequent nitrogen losses? These tests were designed to help answer this question. With that objective in mind, we will consider the "early" broadcast application technique as the standard against which to compare the other treatments.

These data would indicate that although the efficiency of UAN (compared to broadcast) can be greatly improved by either injection or by delayed (late) rather than early (near planting) application, highest yields and highest nitrogen efficiency were obtained following a combination of correct placement and application timing. UAN injected near planting increased yields 7.4% over those obtained following broadcast UAM near planting (Table **10).** UAN broadcast about one month after planting resulted in about a 10.3% yield increase compared to the earlier broadcast application. However, by both delaying the application and by injecting instead of broadcasting, yields were increased 14.2%. Although the effects of time of application on grain yields following injection were relatively small (3.5%), the effects of the combined placement and time of application treatments obviously are additive.

The dribble technique was not initially included in these tests. The experimental design was modified slightly in 1983 to accommodate this surface banding method which many farmers prefer because it is easy to use, requires only a simple modification to equipment many farmers already own, and has been proven to be generally a more efficient method to apply UAN than broadcasting near planting. The nine location-years of data are presented in the second half of Table 9. These data show trends very similar to those for the 18 location-years of data in the first half of Table 9. In these tests, dribbling UAN near planting tended to he more efficient than broadcasting, and increased yields 4.7%. Injection near planting increased yields 19.8% compared to the early broadcast (Table 10). It is believed that more timely rainfall events in the spring soon after UAN was applied resulted in improved efficiency of broadcast UAN. Had more time elapsed between UAN application and the first significant rainfall, more of the broadcast UAN would probably have been lost. By broadcasting the UAN about one month after planting, grain yields were increased 12.5%. The delayed dribble application improved grain yields 7.7% over the early dribble and 12.8% over the early broadcast. The delayed UAN injection was about the same as early UAN injection with a yield increase of only 1.1%. Rut when grain yields from the delayed injection were compared to yields from the early broadcast, yields improved 21.1%. Some very important and useful observations from this work were that (l), for those growers who can inject UAN, there is more flexibility regarding time of application. And (2), for those growers who can delay their UAN application, there are more options available in method of application.

SUMMARY

An attempt has been made to demonstrate the importance of more careful nitrogen management on no-tillage corn. Factors that were of minimal importance under conventional tillage require more intensive management under no-tillage conditions. Special consideration must be given to N source, time of N application and N placement. Based upon current research and experience, a suggested fertilization program for no-tillage corn might be as follows:

***Use a starter fertilizer in a band near the row to supply 20 to 40 lb/A of N. Ideally, this fertilizer should also include P_2O_5 and K_2O in a 1:2:1, 1:3:1, or one of many other widely recommended ratios for starter fertilizers.

***Broadcast according to soil test any remaining P_2O_5 and K_2O requirements. Timing is not as critical for this operation as long as leaching and erosion are not problems. It is preferable that application be made sometime before planting.

***Apply the remaining N requirement about 4 to 6 weeks after planting, or when the corn has attained a height of 12 to 18 inches. If UAN solution is utilized, dribble (surface band) or inject between the rows.

***On the average, approximately 30 to 40 lb/A more N may be required for no-tillage than for conventional tillage corn. But, the amount may vary considerably from soil to soil, possibly from 0 to 60 lb/A or more. The difference in N requirement between the two tillage systems will depend upon soil conditions and past cropping history. But, experience in Maryland suggests that any extra N required is normally justified by the higher yield potential of no-tillage corn.

***For those growers who can inject UAN, there is considerable flexibility regarding time of application.

***For those growers who can split their UAN application and delay application of most of the N until three or four weeks after planting, more options are available in method of application.

DATA

Table 1. Grain Yields for Conventional tillage and No-Tillage Corn Following Variable Nitrogen Rates. Poplar Hill Research Farm. 1985.

Tillage	N (lb/A)** 0	80	120	160	240	Mean
	bu/A					
No-Tillage	23.3	97.3	128.8	153.0	155.9	111.7*
Conv. Tillage	37.7	102.3	108.0	126.2	119.9	98.8"
Mean	30.5	99.8	118.4	139.6	137.9	105.2

NOTE: LSD/.05:N Rate = 20.7 bu/A; LSD.lO: Tillage x N Rate - 24.3 bu/A.
* Tillage means are significantly different at the 5% level.
**40 lb N/A applied 4-29-85, remainder applied 6-7-85.

Table 2. Ratios of Fertilizer N to Grain Yield for Conventional Tillage and No-Tillage Corn Following Variable Nitrogen Rates. Popular Hill Research Farm. 1985.

Tillage	N (lb/A) 0	80	120	160	240	Mean
	bu/A					
No-Tillage	0.0	0.8	0.9	1.1	1.6	0.9
Conv. Tillage	0.0	0.8	1.0	1.2	2.0	1.0
Mean	0.0	0.8	1.0	1.2	1.8	-.-
Ratio: Conv. Till/ No-Tilalge	-.-	1.0	1.1	1.1	1.2	-.-

NOTE: Ratios calculated from points on best-fitting curvilinear regressions.

Table 3. Influence of Tillage on Probability of Obtaining Maximum Corn Yields from Variable Nitrogen Rates at Five Maryland Locations. 1973-1985.

Nitrogen Rate lb/A	No-Tillage1/ No. Tests	%	Plow Tillage/2 No. Tests	%	Total Tests
0	16	31	36	69	52
40	9	36	16	64	25
80	24	46	28	54	52
120	33	67	19	33	52
160	37	73	15	27	52
240	21	78	6	22	27

1/ Number of tests and percent of time in which no-tillage corn out-yielded conventional tillage corn.
2/ Number of tests and percent of time in which conventional tillage corn out-yielded no-tillage corn.

Table 4. Influence of Nitrogen Rate and Source on No-Tillage Corn Grain Yields at 3 Locations. 1976 to 1979.

N Source	N (lb/A) 0	40	80	120	160	Mean
	bu/A					
Ammonium Nitrate	85.6	107.0	130.5	141.4	147.7	122.4
Urea	85.6	100.6	119.6	126.9	135.8	113.7
UAN	85.6	97.3	120.7	134.3	141.9	115.9
Mean	85.6	101.4	122.6	132.4	140.3	117.4

NOTE: LSD/.05: N Source = 3.2 bu/A, N Rate =3.2 bu/A,
N Source x N Rate = 6.4 bu/A

Table 5. Four-Year Summary of the Influence of N Source and N Placement on No-Tillage Corn Yields. Poplar Hill Research Farm. 1979 to 1982.

Nitrogen Placement	N Source 1/ Ammonium Nitrate	Urea	UAN	Mean
	bu/A			
Broadcast	153.9	127.0	142.7	141.2
Injection	155.1	152.8	158.1	155.4
Mean	154.5	139.9	150.4	148.3

NOTE: N placement means significant at 5% level. 1/ N applied at 120 lb/A.
LDS/.05: N source = 4.2 bu/A, N source by N placement = 6.0 bu/A.

Table 6. Influence of N Source and Placement on No-Tillage Corn Grain Yields at Several Locations. 1984.

N Treatment	Poplar Hill	Wye Res. Center	Belts-ville	Forage Farm	Sharps-burg	Mean
	bu/A					
Check	49.4	51.2	82.0	144.9	109.6	87.4
Ammonium Nitrate	170.4	173.3	150.7	195.9	146.3	167.3
UAN Broadcast	140.6	135.1	143.5	197.3	146.0	152.5
UAN Dribbled	143.8	158.5	141.2	184.2	142.2	154.0
UAN Injected 1/	182.0	156.4	162.6	198.7	141.7	168.3
UAN Injected 2/	165.0	155.0	154.4	200.3	144.6	163.9
UAN Injected 3/	161.9	155.4	145.6	177.1	146.8	157.4
Urea Broadcast	----	115.8	123.1	163.1	148.6	137.6
LSD.05	12.1	26.0	21.1	25.4	16.7	

NOTE: 120 lb N/A applied near planting time. UAN injected by 1/ anhydrous ammonia knife, 2/ low pressure solid stream nozzle into plow coulter slot, or 3/ high pressure NUTRI-BLAST 2000.

Table 7. Influence of N Source and Placement on No-Tillage Corn Grain Yields at Several Locations. 1985.

N Treatment	Poplar Hill	Wye Res. Center	Belts-ville	Forage Farm	Sharps-burg	Mean
	bu/A					
Check	68.3	33.9	57.4	41.4	107.3	61.7
Ammonium Nitrate	127.6	138.0	108.0	179.1	166.2	143.7
UAN Broadcast	139.6	113.1	101.2	162.5	161.4	135.6
UAN Dribbled	134.3	109.7	83.7	162.1	167.5	131.5
UAN Injected 1/	143.8	144.2	99.6	178.3	163.4	145.9
UAN Injected 2/	142.6	118.0	98.2	185.2	160.8	140.9
UAN Injected 3/	137.6	96.6	84.6	116.2	----	108.8
Urea Broadcast	----	119.3	90.8	107.2	161.3	119.7
LSD .05	19.3	15.8	22.1	34.8	15.7	

NOTE: 120 lb N/A applied near planting time. UAN injected by 1/ anhydrous ammonia knive, 2/ low pressure solid stream nozzle into plow coulter slot, or 3/ high pressure NUTRI-BLAST 2000.

Table 8. Influence of N Source and Placement on No-Tillage Corn Grain Yields at Wye Research and Education Center and Poplar Hill. 1982.

N Treatment	Wye/1	Poplar Hill/1	Poplar Hill/1	Poplar Hill/2	Mean
	bu/A				
Check	33.3	31.1	42.3	42.3	37.2
Ammonium Nitrate	112.4	155.1	141.9	163.6	143.2
UAN Broadcast	99.0	119.9	136.3	159.0	128.6
UAN Dribbled	119.9	156.6	148.9	176.0	150.4
UAN Injected	124.2	167.2	156.2	178.4	156.5

NOTE: 1/ N rate = 120 lb/A, 2/ N rate = 160 lb/A.

Table 9. Influence of Nitrogen Placement and Time of Application on Average No-Tillage Corn Grain Yields at Three Locations. 1980-1985.

N Placement & Time	- - 1980 to 1985 - - May/1	June/2	********	- - 1983 to 1985 - - May/1	June/2
	- - - - - - - - - - - - -		bu/A	- - - - - - - - - - - - -	
Broadcast	135.6	149.6	********	124.4	140.0
Dribble	---.-	---.-	********	130.3	140.3
Inject	145.6	154.8	********	149.1	150.7
LSD.05	4.5			6.5	

NOTE: UAN applied at a rate of 120 lb N/A.
1/ UAN applied in May within 2-3 days of planting.
2/ UAN applied in Juen approximately 4 weeks after planting.

Table 10. Relative Influence of Nitrogen Placement and Time of Application on Average No-Tillage Corn Grain Yields. 1980 to 1985. May Broadcast = 100%.

N Placement &	- - 1980 to 1985 - - May/1	June/2	********	- - 1983 to 1985 - - May/1	June/2
	- - - - - - - - - - - - -		% /3	- - - - - - - - - - - - -	
Broadcast	100.0	110.3	********	110.0/3	112.5
Dribble	---.-	---.-	********	104.7	112.8
Inject	107.4	114.2	********	119.8	121.1

NOTE: UAN applied at a rate of 120 lb N/A.
1/ UAN applied in May within 2-3 days of planting.
2/ UAN applied in June approximately 4 weeks after planting.
3/ Relative to May Broadcast = 100.0.

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FARM MACHINERY DEVELOPMENT FOR NO-TILLAGE AGRICULTURE

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INTRODUCTION

No-tillage agriculture is a viable philosophy and practice for 1980's agriculture in the United States because of the interaction of many factors, illustrated by the following circle of interrelated needs, technologies, and results:

> → Needed erosion control for continued agriculture → Residues provide for erosion control → No-Till to maintain the residues → Reduced energy requirements because of No-till → Lower equipment costs from reduced energy requirements → More economical production because of lower equipment costs → Continued agriculture is possible with more economical production →

Agriculture is a business and agricultural management is driven by economic decisions. With no forseable trends toward sustained higher prices for agricultural products relative to the costs of production items, it appears that more economical production is required for continued agriculture in its present form. Such production economy must be for total farming enterprises and not just for one crop within an enterprise.

Unlike land, insurance, available family labor, seed, and fertilizer costs, farm machinery inventory and management are highly variable costs within an enterprise budget. With equal production, reductions in machinery-related costs produce increased profits. With re-evaluated production goals set to maximize net profits rather than yields, machinery-related costs might be reduced further.

Please note that herbicide weed control has not been mentioned. For this paper, weed control is considered to be part of the functional machine system with the application of herbicides being mechanical operations substituting for mechanical weed control. This is but one of several machinery selection and management options which must be evaluated to maximize the farm enterprise profits.

Farm machine systems are substantially based upon approaches to four basic functions:

1) Residue Management,
2) Fertilizer Application,
3) Crop Establishment,
4) Weed Control.

Conventional tillage philosophy says that residues must be completely buried so that a broadcast field surface can be tilled until the desired surface layer soil structure is produced for a seedbed. Weed control by mechanical cultivation is compatible with conventional residue management and seedbed preparation.

In contrast with conventional tillage, no-tillage philosophy says that residues must be kept on the soil surface year-around to conserve soil moisture and to protect soil from erosion. (At this point, we should admit that few farmers are going to make any change in production practices if there are not economic incentives; items such as "erosion control," reduced "groundwater pollution," and minimum "offsite impacts" are laudable environmental protection goals, but they will only be pursued if the practices which achieve them are also sensible, practical, manageable, and profitable). Therefore, the objective for development of farm machinery for no-tillage is to make available machines for the maintenance of surface residues while establishing crops, applying fertilizers, and controlling insects and weeds.

Machines For Residue Management

No-tillage field machines must be conceived and designed to either manipulate residues or minimize residue disturbance so that the following separate goals are achieved:

1) Soil cover is maintained for required level of conservation,

2) Subsequent machine operations which contact the residue and soil may be accomplished with reliable, uniform results,

3) Crop response and weed control are uniform.

Residue manipulation includes straw and stover chopper/spreaders on wide combines, shredders, and planter strip-tillers or strip-cleaners. Standard straw spreaders on combines will not spread evenly across the width of cut and actually separate the material according to size and weight, Fig. 1. This situation commonly results in high concentrations of chaff, spilled grain, and weed seed in the center of the combine path and only large, coarse pieces of residue at the outer edges (Allmaras et al., 1985). After making such a nonuniform residue distribution with a combine, no one would expect uniform performance by subsequent machines, fertilizers, herbicides, or crop plants. Machines adapted to and adjusted for one residue condition will encounter different types and sizes of residues across the field and different soil moisture contents under the different amounts of soil cover. Fertilizer performance will be different across the field depending upon the levels of nutrient availability resulting from various amounts of residues, soil moistures, and soil temperatures (Lohry, 1985). Volunteer crop plants will be concentrated in the path of the combine. Weed pressure and herbicide contact with the soil will vary with nonuniform residue spreading. Crop response, without row clearing, will vary between different soil moistures and temperatures as well as between different levels of available nutrients across the field. These influences on system performance should be sufficient to convince almost anyone that residues must be uniformly distributed over the surface of the field by harvesters. Chopper/spreader attachments should be adjusted to throw residues the full width of cut for each combine.

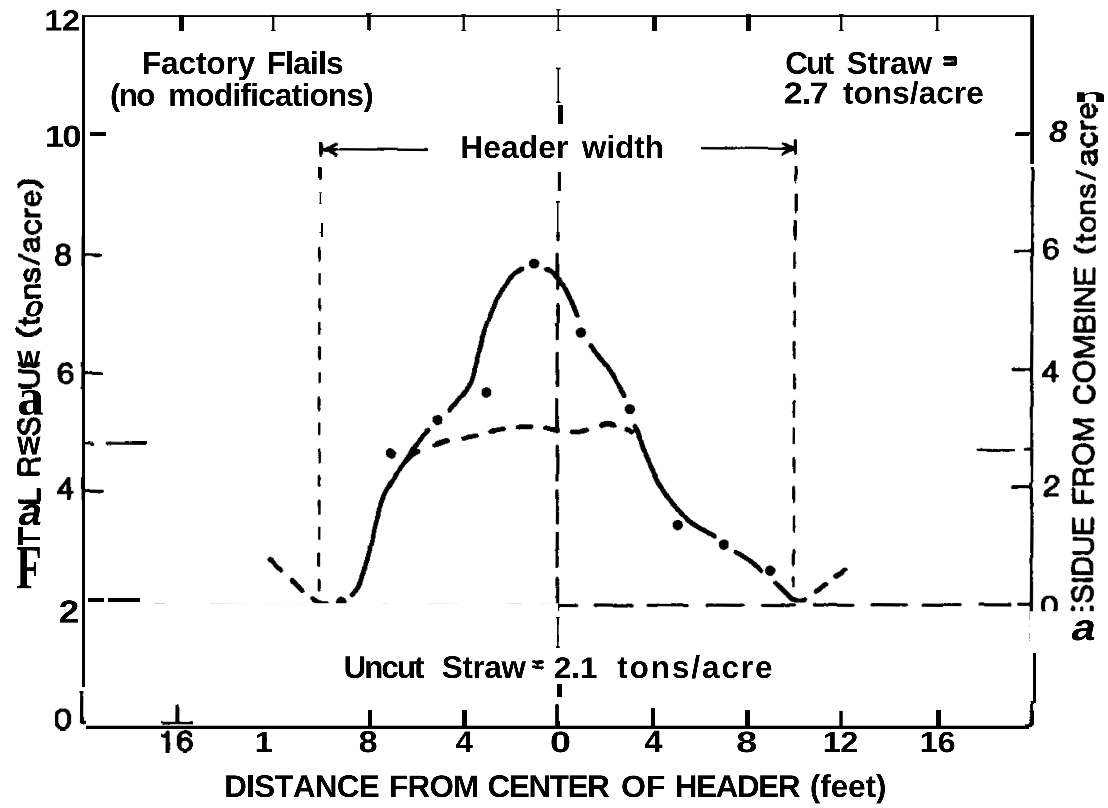

Figure 1. Combine straw spreader and chopper distributions of residues across the cut swath. Residues above the dashed curve line are chaff. (Unpublished, USDA-ARS, Pendleton, OR.)

Shredding of stalks and stubble remaining after harvest is one method used to produce the appearance of uniform residue spreading, but materials previously deposited on the soil surface by a combine are not measurably redistributed, only covered. Shredding may not be a desirable practice. When no-tillage field operations have been reduced to 5 or 6 trips per year the elimination of the stubble shredding operation is a significant reduction in the total machine operation budget. I will admit that we use a stalk shredder, but only once in 3 or 4 years and then only for the special case of immediately after cotton planting, so that standing residues will not be gathered by the cotton strippers at harvest, lowering lint quality.

Standing stubble remains intact longer, doesn't float away with overland water flow, and provides more protection from raindrop-impact induced erosion (Morrison et al., 1985). Fertilizer application and planting operations are much more reliable if the residues are anchored and are not lying on the soil surface requiring positive cutting for soil opening (Erbach et al., 1983).

Planter strip-tillers and strip-cleaners use powered tillers to incorporate residues into the soil or discs, shovels, or sweeps to move surface soil and residues out of the path of individual row planting units, Fig. 2. These devices are used both on the flat and on ridge-tillage. Strip tillage is used to improve planting performance and crop response uniformity.

In some ways, strip tillage is a "fix-it" approach to obtaining our goals. If residue distribution, weeds, and field traffic can not be adequately controlled to provide uniform conditions at planting time, then strip tillage may be necessary until those problems can be corrected. The limitations to strip tillage are accented when we need to effectively establish narrow-row or solid-seeded crops such as wheat or soybeans, within a particular residue management program. Strip-tillage with solid-seeding becomes total tillage and row cleaners deposit removed residues on adjacent rows; in short, it doesn't work. Narrow-row crops require as favorable growing conditions as do wide-row crops and narrow-row fertilizing and planting machines must perform adequately, therefore, we must use residue management technologies which do not limit profitable rotations and management of crops.

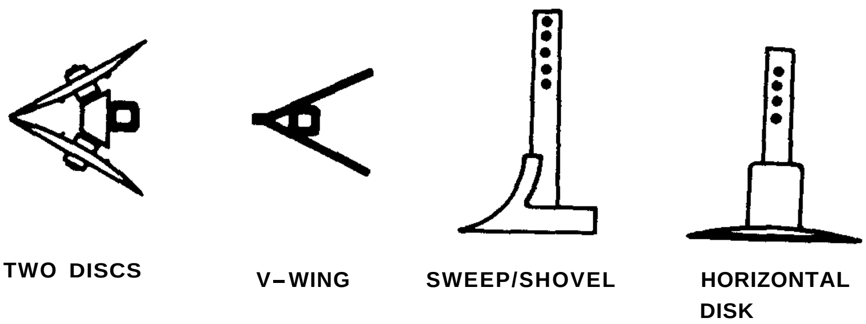

Figure 2. Strip tillage residue strip-cleaning tools for wide row crops.

Machines For Fertilizer Application

No-tillage fertilizer applicators can be grouped into four classes:

1) Applicators which place liquid or dry fertilizer materials on top of the soil and residue,

2) Applicators which penetrate the soil surface and place liquid and/or dry fertilizer materials in a slot,

3) Applicators which place dry, liquid, and/or vaporious fertilizer materials at predetermined subsurface depths,

4) Applicators which are in combination with individual planter row units to place fertilizer materials in, under, or beside the seed furrow.

The first three classes of applicators may be separate machines for pre- or post-planting operations, or mounted on planters, drills, or air seeders. The major differences in the various uses of these applicators are the applicable field and residue conditions and the expected crop utilization efficiency.

Surface fertilizer application is the most popular and the most inappropriate method for no-tillage fertilization. Surface broadcast application was developed for the distribution of fertilizers prior to incorporation by primary or secondary tillage. Without tillage incorporation, the fertilizer use efficiency is reduced, residues are prematurely decomposed, and surface soils become progressively more acidic (Mengel et a1., 1982; Blevins et a1., 1977). Surface dribble of concentrated bands of urea-ammonium nitrate solution were found to be 58% to 77% more efficient for plant N uptake than broadcast fertilization (Touchton and Hargrove, 1982). Both of these surface methods deposit fertilizer materials where they are vulnerable to losses by volatilization and runoff water flow, and also, contribute to offsite water pollution. Dribble banding is currently the better choice of surface fertilizer application techniques if subsurface application equipment is not available. Dribble banding may be the only appropriate method for spring topdressing of winter cereals. Dribbled liquid fertilizers are dispensed from tubes spaced along a lateral boom. Squeeze pumps, pressure pumps and nozzles, or elevated distribution manifolds are the liquid meters. Dry fertilizers may be dribbled from metering boxes, lateral auger tubes, or air-delivery tubes.

Slot injections are the newest fertilization technologies for conservation-tillage systems, Fig. 3. They all involve the creation of a cut, depression, or "slot" in the soil surface for deposition of liquid or dry fertilizer materials in a concentrated band. Advantages are minimum soil and residue disturbance, adaptation to a wide range of soil and residue conditions, protection from major volatilization and runoff losses, and subsurface placement below the highly biologically active soil surface layer. Each slot injection method achieves portions of these goals, as described below.

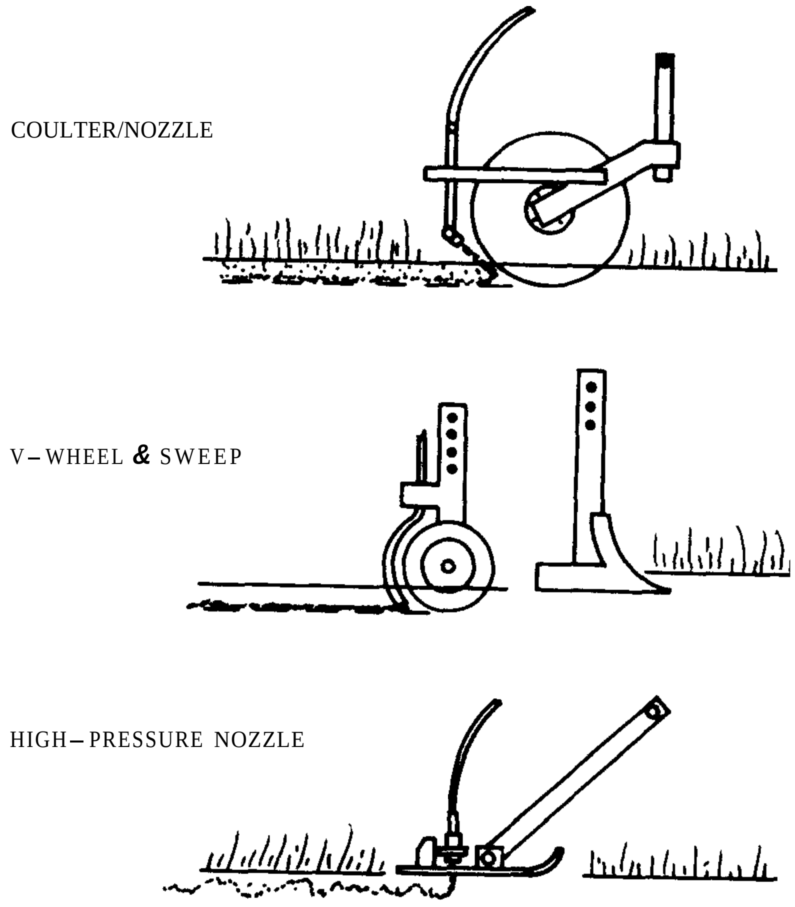

Figure 3. Slot injectors for no-tillage fertilization.

Rolling coulters with solid stream spray nozzles are slot injectors which shoot liquid fertilizer materials into the partially open slot directly behind the coulter. These "coulter/nozzle" applicators are relatively inexpensive, durable, and reliable devices. They can be mounted on a toolbar as a separate machine or on planters or drills to place fertilizer beside or between rows. We use coulter/nozzles as one alternative on our experimental applicators and include dual angled rear presswheels to close the fertilized slot, Fig. 4. The vertical distribution of the fertilizers and resulting plant use efficiency are under study at several locations, including Temple, Texas.

V-wheel type slot injectors have been introduced by one company to operate in residue-free conditions behind row trash cleaners. Their units are equipped with tubes to deliver metered liquid fertilizers into the slot pressed open by the thin V-wheel. We visualize the potential use of such V-wheels behind rolling coulters to cut no-tillage residues, penetrate firm soil surfaces, and open a wider slot than achieved with coulter/nozzles. V-wheel slot injectors deliver all of the fertilizer material below the soil surface and might also be adaptable to deliver dry materials.

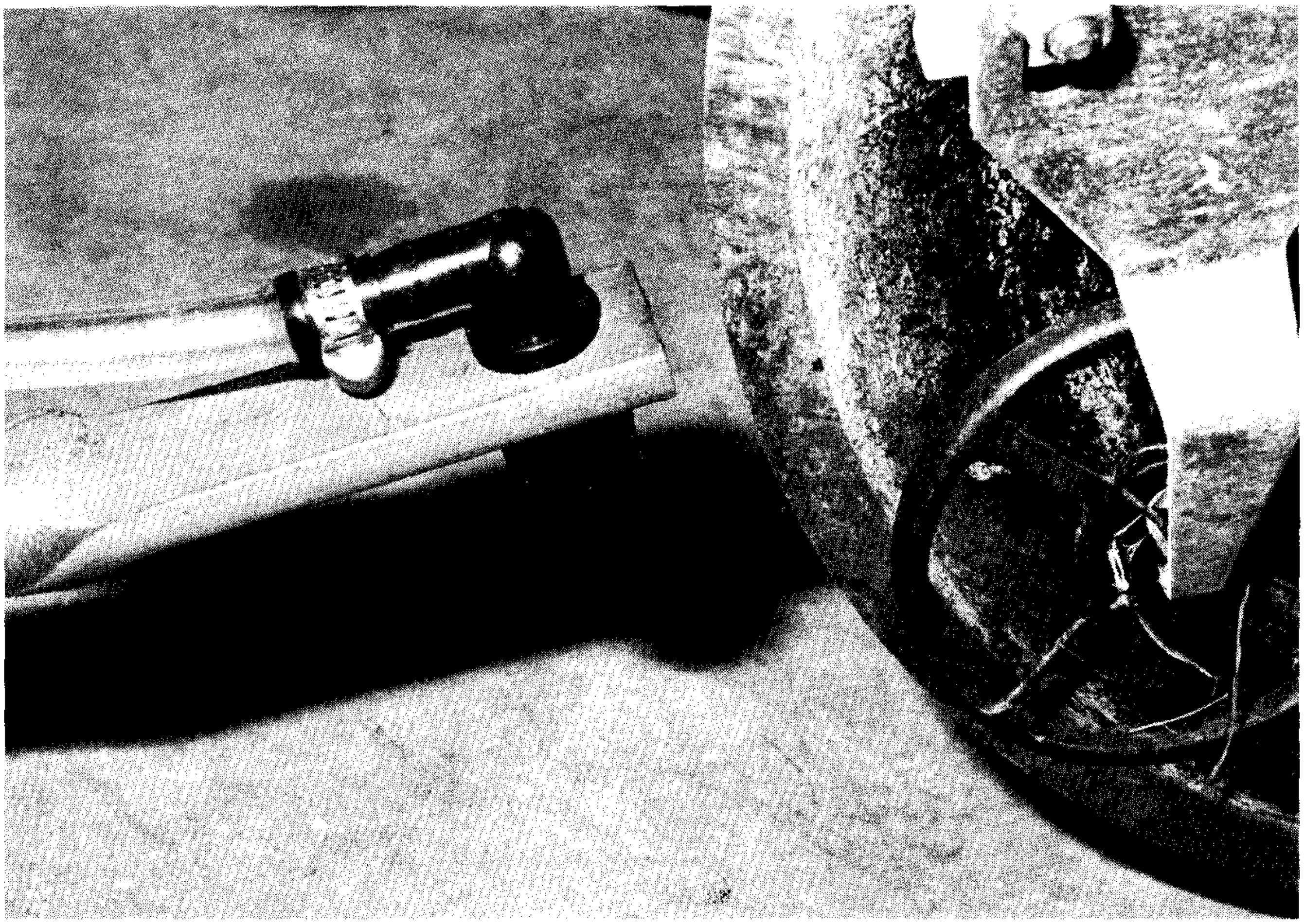

Figure 4. Experimental fertilizer application unit with a solid-stream nozzle directing a jet of solution into the slot behind the smooth rolling coulter. The nozzle replaces an applicator knife in this unit. (Unpublished, USDA-ARS, Temple, TX).

High pressure nozzle slot injection has been developed for no-tillage conditions. A trailing sled moves over the soil surface with a solid stream nozzle positioned just above the surface directing a stream of liquid fertilizer at pressures around 2,000 psi. The goal is to use the high pressure stream to cut a slot in the soil to place the bulk of the fertilizer material subsurface. Residue and hard surface soil reflect portions of the fertilizer material. In 1984 tests at Colby, Kansas, 50 to 70% of the fertilizer remained in the top 0.4 inch of surface soil (Sunderman, 1984). Performance was dependent on pressure, flow rate, and filtration of the liquid fertilizer.

Subsurface fertilizer applicators may be acceptable for no-tillage or they may be totally worthless, causing more damage than benefits. Benefits from subsurface applications include utilization of lower cost anhydrous ammonia nitrogen source. The materials are placed below the biologically active surface layer and into soil which may be moist enough for continued crop root uptake as the growing season progresses. This is due to surface residues maintaining higher soil moistures closer to the soil surface than in conventional bare soils (Lal, 1978), so that subsurface depths of 3 to 4 inches may be adequate.

Subsurface application problems occur when the surface residues are not completely cut and machine plugging causes stoppages. Problems also occur when applicator tools displace significant amounts of soil in their paths leaving deep, wide furrows (Chichester et al., 1985). These conditions occur during typical preplant and planting seasons when soils are moist, at low strengths, and adhesive. The wide bands of disturbed soil interfere with subsequent planting operations, cover needed surface residues, leave loosened soil more susceptible to erosion and micro-gully channeling of runoff, and expose buried weed seed for germination. Soil disturbance can be reduced by depth control and by selection of appropriate applicator designs (Chichester et al., 1985).

Several applicator knife designs are available for subsurface applicators. Conventional, thick, forward curved knives displace too much soil for no-tillage, especially at speeds above 4 mph, Table 1. Thin backswept knives minimize soil disturbance, but require significant downpressure and release fertilizers higher in the furrow than forward shanks. Shallow release may be unacceptable for sealing-in anhydrous ammonia vapors. Thin forward knives are a good compromise on knife designs.

Spoked-wheel point-injectors penetrate residues and surface soil layers to deposit pockets of fertilizer every 8 inches at Iowa State University (Baker et al., 1985), Fig 5. They can be used either as a separate machine or mounted on a planter. Experiments continue with both liquid and anhydrous ammonia applications. This applicator minimizes disturbances of both surface residue and soil.

Table 1. Eight fertilizer applicator knives ranked in order of minimum disturbance of soil surface cover (Chichester et al., 1985).

Knife Type	Shank Width	Toe Width	Mean Width of Soil Cover Disturbance?
	cm	cm	cm
Thick Backswept	1.5	1.5	20a
Thin Backswept	1.0	1.0	30b
Forward w/sealer	1.3	2.0	33bc
Thin Forward	1.1	2.4	36cd
Forward	1.3	2.0	38d
Thick Forward	1.5	3.6	40d
Forward w/point	1.0	4.5	46e
Thick Forward w/point	1.6	5.1	47e

† Data averaged overall treatment comparisons. Means assigned the same letter are not different by Duncan multiple range test at the 5% level of significance.

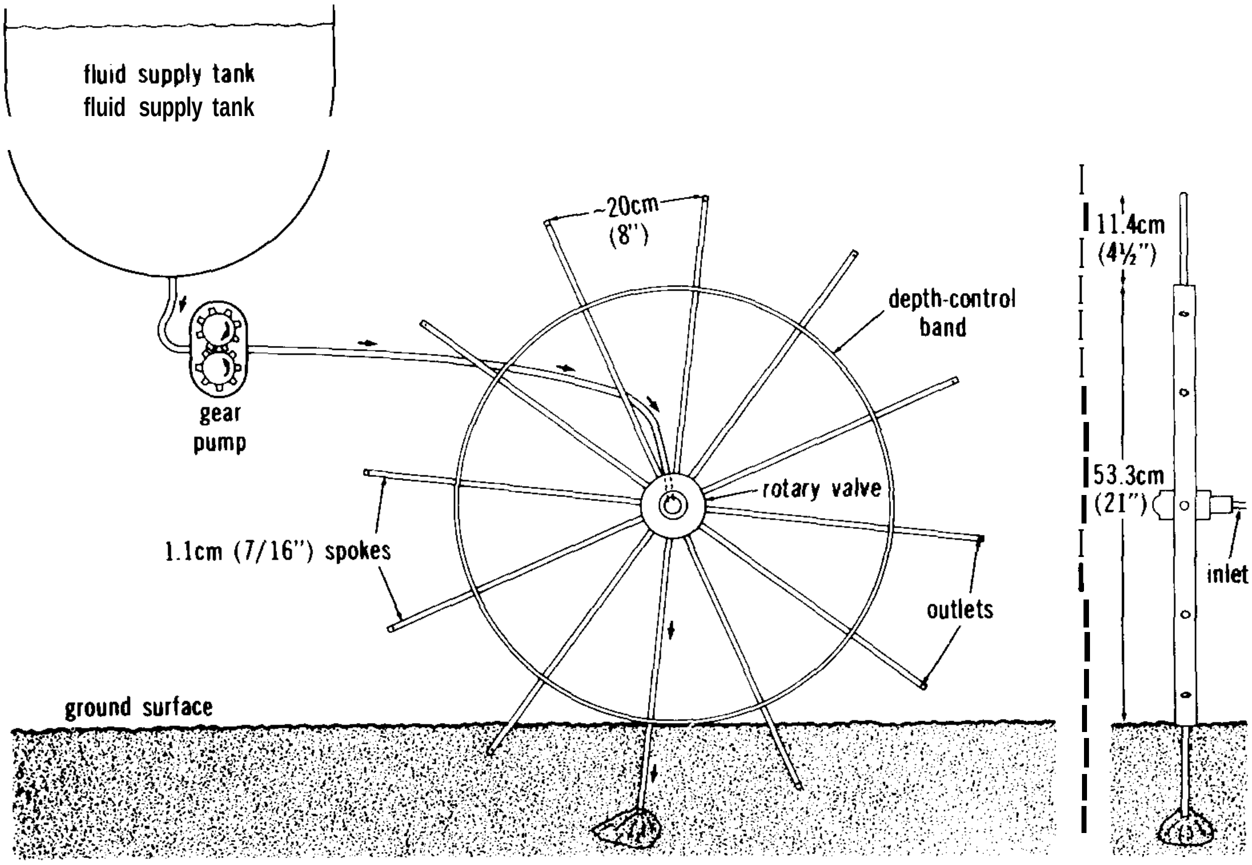

Figure 5. Experimental Iowa State University spoked-wheel applicator. (Baker et al., 1985).

Single and double discs have been used for years as subsurface fertilizer banding applicators on planters. Their main use has been for dry fertilizers, but liquids can also be used. These applicators require as much downpressure for soil penetration as do planter openers, so that their use as side banding attachments double the downpressure requirements for no-tillage planters. Total available downpressure for all openers is limited by the empty weight of the planter. The effect of shallow fertilization is not as damaging as crop stand establishnent failures due to shallow planting from inadequate downpressure. When such planting hazards are common, it would be better to eliminate such applicators from the planter and use them attached to a toolbar for a separate machine operation as either pre-plant or post-plant sidedress. We rarely see it done, but single or double disc openers can be used on a separate tool bar just like knife applicators.

Deep placement of fertilizers may be used when in-row deep chiseling or subsoiling is being conducted ahead of the planter opener to address a root or water penetration problem in the lower soil horizons. In these cases, any of the various fertilizer materials may be delivered down the backside of the deep tillage tool shank. This places fertilizer in soil zones which will be at higher moisture contents longer into the growing season and, therefore, should be more available for late season plant uptake than with any other method.

In-row starter, "pop-up," fertilizers are being overlooked by many no-tillers as an appropriate technology. We use liquid 10-34-0 starter fertilizer at 100 to 150 lbs/A with all of our no-tillage wheat, corn, grain sorghum, and cotton. We add liquid systemic insecticides for control of pests such as cutworms. In-row starter can provide part or all of the crop's phosphorous requirement, which is reported to enhance emergence and early growth during cool soil conditions (Moncrief and Schulte, 1979). Starter fertilizers are easily applied through a tube placed in the furrow opener, Fig. 6. Applicators such as split-boots and winged coulters are really starter fertilizer devices because most of them can not be used to apply the complete plant requirement rates. It may be just as good to limit the rate of application to allowable in-row values and deliver the materials directly into the seed furrow to avoid the cost, maintenance, and extra soil disturbing width of split-boots.

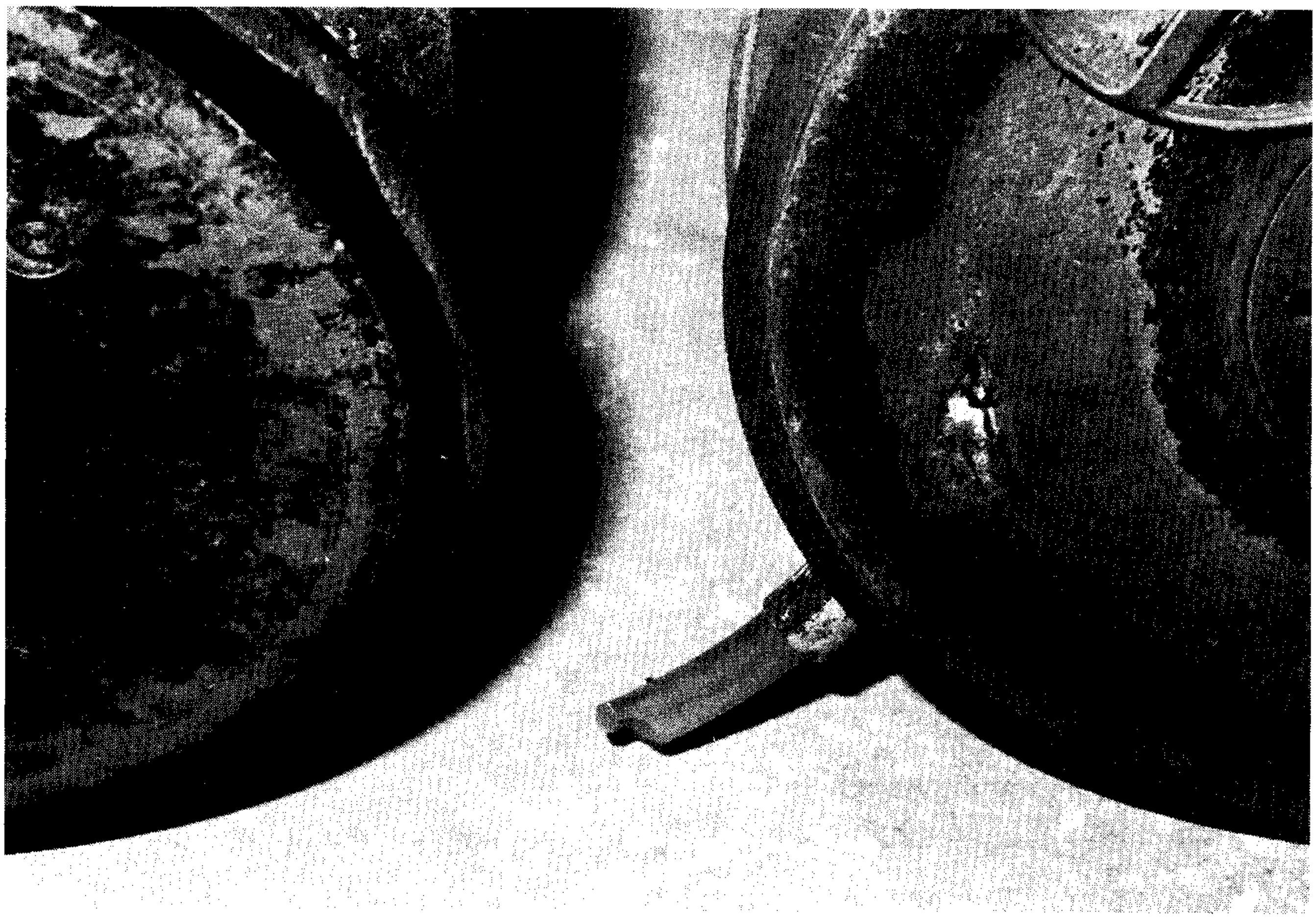

Figure 6. Starter fertilizer tube mounted in rear of a double-disc opener on an experimental no-tillage planter. (Unpublished, USOA-ARS, Temple, TX).

Machines for Crop Establishment

No-tillage crop establishment involves one pass of a planting machine. That machine may do several things in addition to depositing seed in the soil, including cutting residue, clearing a path, and applying fertilizers, insecticides, and herbicides. Performances of these machines have been closely linked to successes and failures of attempts at no-tillage cropping (Erbach et al., 1983).

Research and development efforts have concentrated on improving planting technology for row crops. Many innovations have been incorporated into machines which are quite acceptable for some no-tillage planting conditions. These machines are available with many options as seen in Table 2.   Of course, only a limited number of these options are available or needed for the intended use of different machines. Comprehensive strategies for selection of appropriate planter types and options are now being developed by the American Society of Agricultural Engineers and our laboratory at Temple. An “expert system” computer software package is being developed to serve as a guide to the selection of conservation-tillage planters, drills, and air seeders, Fig. 7.

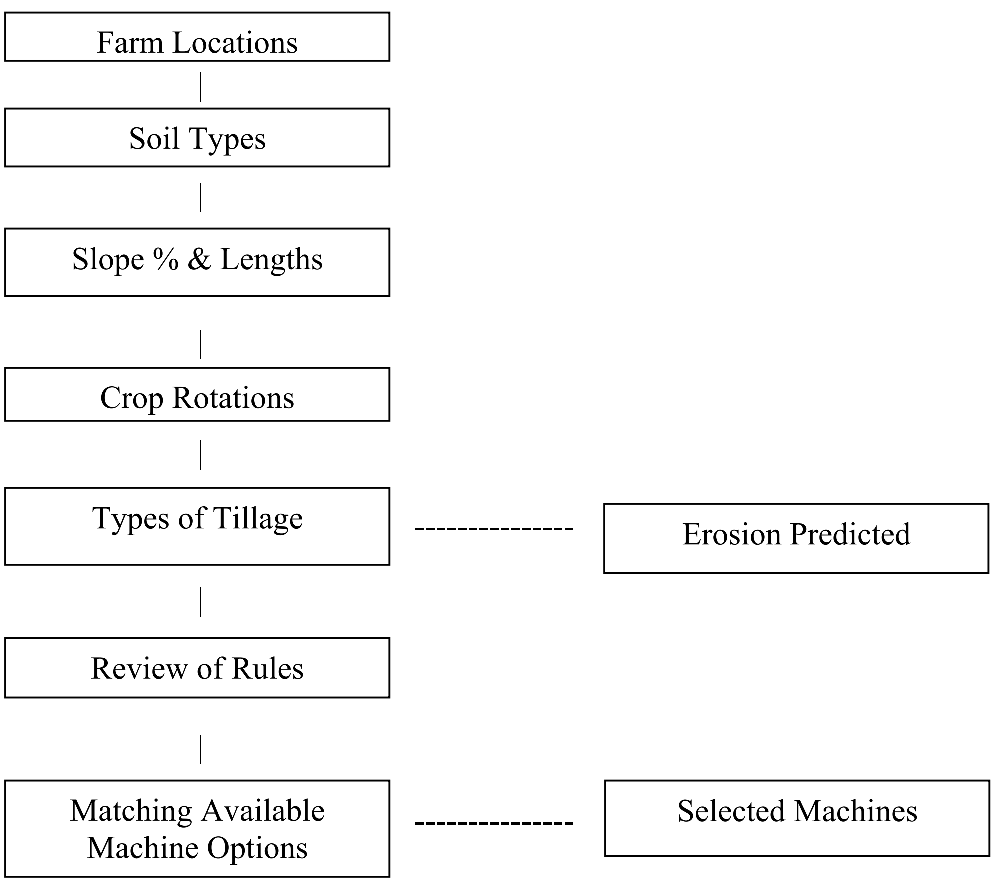

Figure 7.   “Expert System” computer flow chart for selecting appropriate machines and available options for conservation planting. (Unpublished, USDA-ARS, Temple, TX).

Table 2. Component options for conservation planters, drills, and air drills.

Initial Penetration Components	Row Preparation Components	Depth Control Components	Soil Opening for Seeding Components	Seed Firming Components	Seed Covering Components	Seed Slot Closure Components
Smooth coulter	*Sweep	Rear presswheels	Double disc	Rubber-tired wheel	Single covering disc	*Wide zero pressure wheel
Notched coulter	*V-Wing	*Side gauge wheels	Staggered double disc	Steel-plate wheel	Double covering disc	Single rib wheel
Rippled coulter	*Two-disc row cleaner	Skid plate on each opener	Runner		Paddles	Double rib wheel
Bubble coulter	*Horizontal disc row cleaner	Tandemed front wheels and rear presswheels	Stub runner			Narrow rubber wheel
Narrow fluted coulter	Wide fluted coulter	Frame lifting/guage wheels	Hoe			Narrow steel wheel
Wide fluted coulter	Ripple chisel	Depth rings on front leading coulter	Single disc			Dual angled rubber wheels
Powered blade or coulter	*Subsoil ripper		Coulter-boot			Dual angled steel wheels
Staggered double disc	*Dual angled residue-cullers		Chisel-boot			Split steel wheels
*Strip rotary tiller						Double covering discs
Smooth coulter w/depth bands						*Dual wide flat wheels

*Components which are too wide or which disturb too much soil to be effectively used on narrow-row, solid-seeding conservation drills.

There is no justification for using more exacting specifications for no-tillage row planting than for no-tillage drilling or solid-seeding. However, no-tillage drills remain crude and ineffective compared to current no-tillage row planters (Erbach et al., 1983). The drills generally have lower technology residue cutting, trash clearance, depth control, seed firming, furrow closure, flotation, and downpressure systems than do the best no-tillage planters. Air-drills only differ from conventional drills by using air delivery rather than gravity delivery of seed to the furrow openers. Drill component options are the same as for planters, Table 2, if applicable to narrow rows.

Air seeders deliver centrally metered seed to wide sweeps with multiple discharge ports. They can be used as conservation machines, but the use of full-width sweep tillage removes them from no-tillage practice.

Crop rows are getting narrower and narrower as fanners change from old technologies. The 30-inch minimum corn row spacing for combine corn headers is a major constraint to the use of narrow rows, approaching solid-seeded for all other major crops. At Temple, we plant no-tillage corn on 16-inch spaced rows and harvest at half speed with combine grain headers. Better harvesting solutions are needed for corn to allow narrower rows, so that the narrow row fertilizing, seeding, and spraying equipment for other crops on a farm will also fit corn rows.

General guidelines for the selection of planter and drills for no-tillage agriculture are as follows:

a) Use rolling components as much as possible to achieve self-cleaning and to minimize stoppages,

b) Cut residues with a rolling coulter or a staggered double disc opener,

c) Control the depth of the coulter in sticky soils,

d) Control planting depth as close to the location of seed drop as possible or by tandem front and back wheels,

e) Minimum disturbance of the soil surrounding the seed furrow is preferred,

f) Positive seed slot covering or closure is a must,

g) Use fertilizer, insecticide, and herbicide attachments only if they do not degrade seeding performance,

h) Use downpressure systems which allow individual row unit flotation,

i) Use downpressure systems which automatically adjust to changing field conditions,

j) Flotation and downpressure should be independent of variations in the weight of seed and fertilizer hoppers and tanks.

Machines for Weed Control

No-tillage weed control machines are herbicide sprayers. Sweep cultivators, rod weeders, and herbicide incorporation devices all perform tillage and are excluded from no-tillage systems. No-tillage herbicide sprayers are of five general types;

1) Band sprayers behind planter row units,

2) Broadcast spray booms on the rear of planters or drills,

3) Tractor-mounted or towed boom sprayers,

4) Self-propelled boom sprayers,

5) Directed sprayers for "chemical cultivation" of weeds.

Band sprayers only treat row areas and are more common for reduced tillage systems where mechanical cultivation is used for weed control between rows.

Broadcast sprayer attachments on planters and drills are very common and practical management tools. Herbicides are applied up to the end of the planting period eliminating the extra labor required to have a separate spraying rig following the planter and the hazard of leaving portions of a field without treatment. Conversely, on-board herbicide spraying requires additional down-time for refilling and mixing, and a large tank, pump, and controls on the planting tractor. If the mounted tank and pumps are being used for coincident fertilizer applications and the additional loads will require the purchase of a larger tractor, then separate planting and spraying operations may be the most economical procedures.

Every no-tillage farm is going to have broadcast spraying equipment. It will be used for insecticide as well as herbicide treatment. For those with front or saddle tanks on a tractor, the most economical sprayer is a 40-ft wide folding boom mounted on the tractor 3-point hitch. Alternatives are 3-point hitch mounted boom sprayers with tanks, and towed boom sprayers with a tank on a trailer.

Self-propelled boom sprayers are very convenient machines, but can be justified only if a tractor is not available, or if special chemical treatments must be made to tall crops and aerial spraying is not available or practical for those situations. Care should be taken in selecting a self-propelled sprayer so that the wheel tread widths match future needs. For controlled-traffic considerations and solid-seeded crops, four-wheel sprayers are preferable over three-wheel machines to confine all machine traffic to the same interrow traffic lanes.

A directed sprayer should be in every no-tillage farmer's shed, Fig. 8. Hopefully, he will never need to use it because his broadcast weed control programs will be adequate. But, for the times when the planting-time herbicides are not effective and there are no appropriate over-the-top herbicides, directed spraying between crop rows may be the only method of control. These machines consist of a toolbar with trailing sleds which position nozzles between rows. The nozzles are aimed at the base of the crop plants and the row middles, depending on the weed problem and the crop susceptibility to the herbicide. One nozzle is adequate between narrow rows. Users argue as to the merits of crop shields on directed sprayers. Shields may not be needed if low pressure, coarse sprays are used to avoid swirling herbicide mists in the plant canopy.

Manufacture's directions should be followed for matching sprayer tank, pumps, and plumbing sizes and materials for personal needs. Most no-tillage sprayers end up being used to pump corrosive fertilizers, so stainless steel fittings and nozzles are good investments. New easy-off sprayer nozzle caps and color-coded nozzles from several manufacturers aid good sprayer management. Electronic sprayer rate control and monitoring equipment may be practical investments for large acreage operators, especially for those who do all of their spraying and liquid fertilizer application work with one machine.

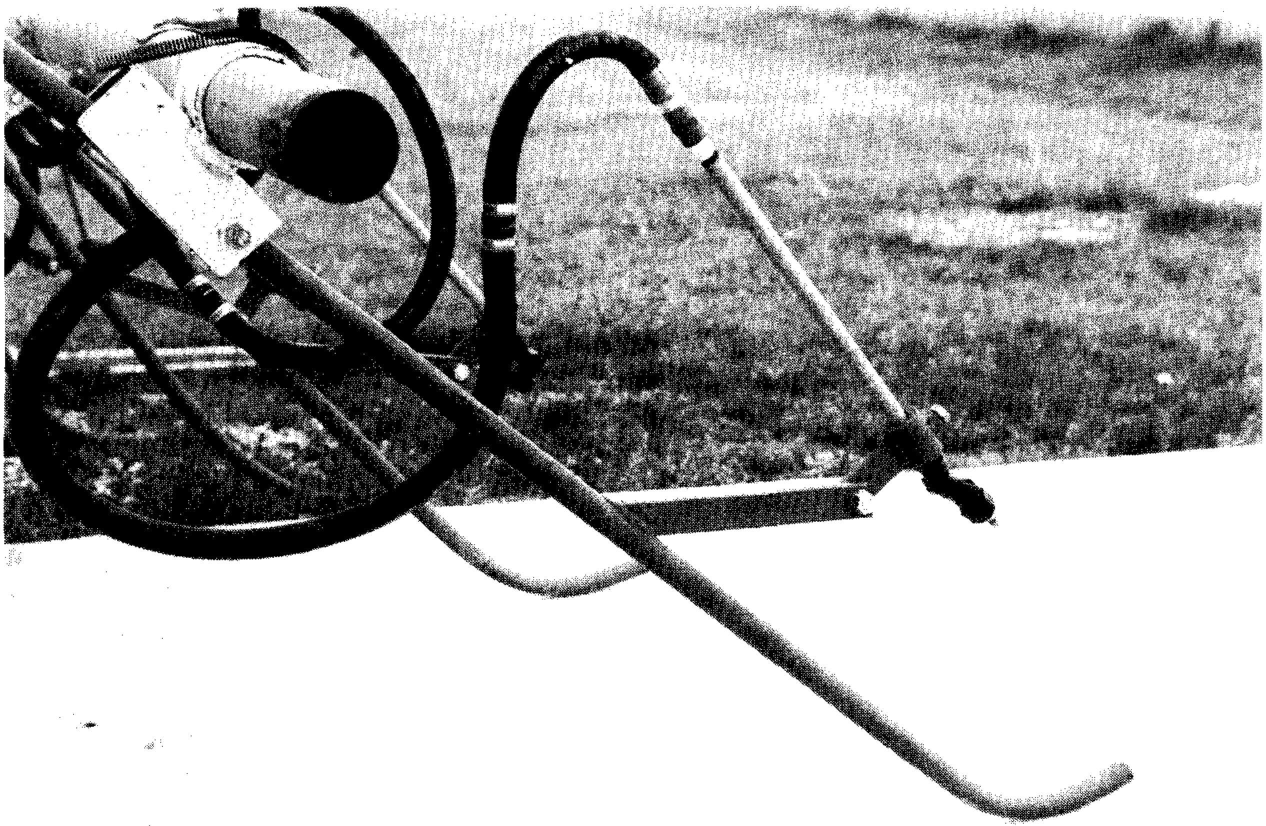

Figure 8. Simple sled-type directed sprayer unit without crop shields to operate between crop rows.

Other Machines

The only other field machines used in no-tillage agriculture are mostly connected with crop harvesting. In general, harvesting machines are interacting with above-ground plant material and do not require special specifications due to surface residue and undisturbed soil conditions. However, harvesting operations can impose objectionable soil compaction and wheel traffic ruts from random machine and truck traffic. For continued no-tillage, it is advisable to establish a common wheel track width for all machines and vehicles, eliminate dual wheels on tractors and combines, and manage year around controlled-traffic (Morrison, 1985).

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NO-TILL ALFALFA PRODUCTION IN VIRGINIA

Dr. Harlan E. White and Dr. Dale D. Wolf[1]

Most of the approximately 120,000 acres of alfalfa grown in Virginia are on sloping fields subject to erosion. Many fields contain rocks that when brought to the surface by tillage equipment, make it difficult to prepare fine seedbeds.

Producers have welcomed the opportunity to establish alfalfa on these fields using no-till procedures, especially since yields from no-till plantings have been equal to conventionally planted fields. Farmers especially like being able to seed without delay because of less time required for seedbed preparation and the ability to plant when prepared seedbeds are too wet or too dry. Essentially no alfalfa was seeded no-till until 1981 when the extension education program was initiated based on research conducted at Va Tech and by neighboring'state universities. In 1983 there were nearly 250 no-till drills available in Virginia which were used to plant 9,200 acres of no-till alfalfa that year and 9,080 in 1984.

Several requirements for successful no-till establishment are spelled out for producers:

1. Competition from other plants must be eliminated.
2. Heavy thatch and plant growth tall enough to shade the soil surface must be removed.
3. Seedlings must be protected from insects when seeding in sod.
4. Seedlings must be protected from diseases.
5. Seed should be placed in the soil no deeper than 1 inch.
6. Soil fertility must be medium to high with pH above 6.4.
7. Seeding must be done at the proper time of year.

The fertility program for no-till alfalfa is essentially the same as for alfalfa grown in tilled seedbeds. When seeding in soils testing medium for P_2O_5 and K_2O, apply 125 lbs per acre of each nutrient. On established stands in soils of above average productivity which test medium, topdress with 75 lbs of P_2O_5 and 165 lbs of K_2O per acre in late fall or after the spring harvest.

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One of the primary concerns with soil fertility in no-till seeding is the inability to incorporate needed lime and fertilizer into the soil prior to seeding. It is emphasized to producers that fertility must be raised to adequate levels in the cropping rotation at least one year in advance of no-till seeding.

In order to be useful a practice must be versatile enough to fit into the varied cropping and forage systems used on farms. No-till alfalfa is being established successfully in a number of different situations.

Seeding into sod

Spring seeding of alfalfa into a mixed perennial sod killed that spring is not recommended because of weed competition with the new seeding. A dense tall fescue sod is an acceptable situation for spring no-till seeding. Graze the tall fescue sod short (1-2 inches), apply 2 pints of paraquat per acre after the plants are actively growing, then wait 14-20 days and apply a second paraquat application of 1-2 pints per acre. Include 7 lb of 15G Furadan per acre with the seed. This procedure automatically results in a late spring seeding which is subject to severe weed competition in most situations except where the sod is very dense and has few weed seeds present.

A variation of this which works very well is to graze the sod in early spring or take a hay cutting and apply 2 pints of paraquat. Then seed a summer annual smother crop such as foxtail millet or sorghum-sudangrass. Harvest the smother crop for hay in early August, apply 1 pint of paraquat, and seed in the last 10 days of August. No Furadan is needed in this situation.

The producer may elect to simply utilize the sod for hay or pasture until about August 1, then apply the paraquat twice, and seed using Furadan. Another alternative gaining wide use is the application of paraquat in mid-October to kill the sod. In early March, apply a second application to kill winter annual weeds, and seed using Furadan. Perennial broadleaf weeds should be controlled before killing the sod by use of a suitable herbicide program.

In each of these situations where sod is being killed, Roundup at 2-3 quarts per acre may be substituted for the broadleaf weed control and the double application of paraquat.

Seeding after crops other than sod

Spring no-till planting of alfalfa may be successful in fields planted to corn the previous season. Long-residual herbicides should not be used on the corn when planning to follow with no-till alfalfa. Seedings in mid-March may not require paraquat if the field is free of germinated weeds, although there are usually enough winter annual weeds present to warrant an application of 1 pint of paraquat per acre.

There are several ways to successfully seed no-till alfalfa into small grain in the spring. One method is to spray the small grain with 1-2 pints of paraquat per acre when growth is 4-6 inches tall, then seed. The small grain will usually make regrowth which must be mowed when 5-6 inches tall to avoid competition with the alfalfa seedlings.

Alfalfa may also be seeded without tillage into standing (8-10 inches tall) small grain prior to harvesting for silage. Rye harvested for silage in the boot stage will normally produce Competition. Barley and wheat cut at the dough stage will produce little regrowth.

Forage may also be seeded into small grain stubble after a silage or grain harvest. If the silage harvest was made prior to dough stage, wait 5-10 days for regrowth to develop, then apply 1 pint of paraquat per acre to burn back the regrowth and kill weed seedlings. If the harvest was made at dough stage or later, apply 1 pint of paraquat per acre and seed immediately. Since harvesting for grain occurs late in spring, waiting until early August to spray with 1-2 pints of paraquat per acre and then seeding the forages is usually best. Volunteer small grain must be mowed after the seeding if it reaches a height of 5-7 inches.

Late August and early September seeded no-till alfalfa seedlings have been much less susceptible to heaving injury than seedlings established in prepared seedbeds. Seedlings emerge more quickly and make more rapid growth in no-till situations (Table 1). This is due partially to a more favorable moisture supply in the undisturbed soil and to better seed-soil contact. Crusting of the soil surface is also not a problem. Seedling survival and yields from conventionally established plantings in the first harvest the following year have been shown to decrease as planting is delayed beyond September 1 (Tables 2 and 3). Delay of 20 days beyond September 1 resulted in unacceptable stands the following year. On the other hand acceptable stands and yields at first harvest resulted from no-till plantings between September 1 and September 30. This makes it feasible to plant alfalfa after corn is removed for silage if using the no-till method. It also improves the likelihood of obtaining satisfactory stands when germination after planting is delayed due to dry soil conditions.

Table 1. Alfalfa Seedling Population and Weights Three Weeks After Planting on Four Fall Dates. D. D. Wolf, Blacksburg, VA.

Planting Method	Date	Population Plts/Sq. Ft.	Mg. Seedling Wt. Nov. 28 Top	Root	Total
conv.	2 Sept.	20	352	86	438
	18 Sept.	44	38	11	49
	28 Sept.	36	36	9	45
	10 Oct.	35	14	3	17
No-Ti11	2 Sept.	51	272	90	362
	18 Sept.	70	107	36	143
	28 Sept.	45	72	20	92
	10 Oct.	48	26	6	32

Table 2. Yields and Population of Alfalfa No-Till and Conventionally Planted on Four Dates in 1983 on North Facing Slope. D. D. Wolf, Blacksburg, VA.

Planting Method	Planting Date 9/1	9/10	9/20	9/30	10/10	LSD .05
	(1st Hay Yield (T/Ac)					
Conv.	0.95	0.46	0.00	0.00	--	
No-Till	1.75	1.34	1.86	1.54		0.45
	Total Season Yield (T/Ac)					
Conv.	3.10	1.60	0.00	0.00	--	
No-Ti11	4.45	3.31	3.88	3.78	--	0.42
	Plant Population Nov 1983 (No./Sq. Ft.)					
Conv.	33	44	28	35	--	
No-Till	45	46	50	39	--	10
	Plant Population April 1984 (No./Sq. Ft.)					
Conv.	20	12	0	0	--	
No-Till	39	42	35	39	--	8

Table 3. Yields and Population of Alfalfa No-Till and Conventionally Planted on Four Dates in 1983 on South Facing Slope. D. D. Wolf, Blacksburg, VA.

Planting Method	Planting Date 9/1	9/10	9/20	9/30	10/10	LSD .05
	1st Hay Yield (T/Ac)					
Conv.	1.38	1.19	0.84	0.12	0.00	
No-Till	1.74	1.48	1.85	1.41	0.72	.30
	Total Season Yield (T/Ac)					
Conv.	4.04	3.39	2.20	1.28	0.79	
No-Till	4.12	3.82	4.13	3.64	2.37	.46
	Plant Population Nov. 1983 (No./Sq. Ft.)					
Conv.	36	50	37	34	50	
No-Till	44	52	39	39	54	10
	Plant Population April 1984 (No./Sq. Ft.)					
Conv.	20	17	5	1	0	
No-Till	38	54	39	28	8	11

Disease Considerations

Sclerotinia crown and stem rot has long been present in Virginia. When fall weather conditions are favorable for its development, it has resulted in serious stand losses in conventionally fall seeded alfalfa and clover. In no-till fall seedings, it has become a serious problem in some fields when seeding into killed sods with clover present or in situations where clovers have been present in the sod in recent years. Since clover is a host for sclerotinia, many such sods apparently have large numbers of sclerotia present in the surface of the soil. Since these are essentially undisturbed due to lack of tillage, they are readily available to cause infection in no-till seedings. While most fall no-till seedings even under these conditions are successful, an alarming number of plantings are essentially "wiped out" by the disease.

Growers must be aware of this potential problem when making plans €or fall seeding into sod. The alternatives of killing the sod in spring and planting a summer annual smother crop before seeding or killing the sod in fall and planting in spring help to minimize the threat of sclerotinia.

Pythium or damping off is a seedling disease that can cause serious stand loss, particularly in cold, wet soils. While this has not been recognized as a serious overall problem there are instances, especially in spring no-till seedings where seedlings are lost due to this and perhaps phytophthora disease.

The availability of Apron as an inexpensive but effective seed treatment will be a great help in protecting new seedings from pythium and phytophthora diseases. As shown in Tables 4, 5, and 6, Virginia research has show it to be very effective.

Table 4. Alfalfa Germination in Pythium Infected Soil. D. D. Wolf. Blacksburg, VA.

Furadan lb./Ac.	Apron Treatment No	Yes	Avg.
	----------% Germination*		-------------
0	33	79	56
2	35	85	60
Avg	34	82	--

*Count made 5 days after emergence from soil.

Table 5. Alfalfa Seedling Germination in Sterilized and Non-Sterile Soil as Influenced by Seed Treatment with Apron Fungicide and Furadan Insecticide. D. D. Wolf. Blacksburg, VA. (Exp. 1).

Soil Sterilized	Furadan[2]	Apron Treatment[1] No	Yes	Avg.
		------% Germination		----------
Yes	No	53	82	68
	Yes	45	88	66
	Avg	43	85	67
No	No	33	79	56
	Yes	35	85	60
	Avg	34	82	58

[1]Two ounces/100 lbs. seed.
[2]Two lbs. active ingredient per acre sprayed over seed before covering.

Table 6. Alfalfa Seedling Germination in Sterilized and Non-Sterile Soil as Influenced by Seed Treatment with Apron Fungicide and Furadan Insecticide. D. D. Wolf. Blacksburg, VA. (Exp. 2)

Furadan	Soil Sterilized	Apron Treatment No	Yes
		---% Germination	---------
No	No	39	81
	Yes	88	89
Granular[1]	No	23	86
	Yes	87	a5
Spray2	No	51	81
	Yes	87	85

[1]One lb. a.i./acre in row with seed.
[2]Two lb. a.i./acre over seed before covering.

Seeding Rates

Recommended seeding rate in Virginia for seeding alfalfa in conventionally prepared seed beds is 20 lbs. of seed per acre. In no-till seedings the suggested rate is 15 lbs. per acre. Observations have indicated that when seeding in rows with the no-till drills into essentially undisturbed soil, the lower seeding rate results in adequate numbers of seedlings. High seeding rates result in high populations of weak seedlings that cannot all survive. These observations plus data such as those in Table 7 justify the lower seeding rates €or no-till establishment.

Table 7. Alfalfa yields from Four Different No-Till Plantings With Three Seeding Rates. D. D. Wolf. Blacksburg, VA.

Planting History	Harvest	Lb. Seed Planted/Acre 5	10	15
		---Yield (Tons/Acre)---		
1 Sept 84[1]	lst, 1985	1.08	1.19	1.14
28 Sept 84[2]	lst, 1985	1.23	1.13	1.19
	3rd, 1985	1.07	1.04	1.05
10 Oct 84[2]	lst, 1985	1.11	1.10	1.27
	3rd, 1985	0.95	1.03	0.99
24 Aug 84[3]	lst, 1985	0.85	1.45	1.38
	2nd, 1985	0.83	1.05	1.02
	3rd, 1985	0.87	1.06	1.04
	4th, 1985	0.84	0.99	0.89
	TOTAL	**3.40**	**4.24**	**4.33**

[1]Previous crop was millet.
[2]Previous corn crop removed for silage 20 Sept.
[3]Previous rye crop followed by millet smother crop.

Summary

In summary, the use of no-till establishment methods to establish alfalfa is rapidly becoming "standard procedure" in Virginia. No-till procedures are constantly being refined as new ideas and products emerge. The practice offers many practical advantages in terms of reduced soil erosion, less time and fuel required, more timely planting dates, and fewer rocks being brought to the surface. In spite of these advantages, there is no increase in cost and no decrease in yield or persistence when using no-till procedures.

NO-TILLAGE IN OUR FARMING OPERATION

Paul Beauchamp
Hardinsburg, Kentucky

The Beauchamp-Alexander farm located in Breckinridge County, Kentucky is operated as a family farm. My father Russell Beauchamp is retired but still has an active interest in the operation. My brother-in-law, Ova Alexander, Jr. is responsible for the day-to-day operation of the farm. The farm consists of 977 acres with between 400-500 acres in hay and pasture. A large portion of the farm is rolling and unsuited for row crops. This is one reason why, since 1975, we have been committed to an all forage-livestock operation with the exception of producing approximately 25,000 lbs. tobacco annually.

No-till farming is generally considered to be for row crops, such as corn and soybeans. I would like to comment on how our "all-forage'' program is also based on the no-till concept. Hay production is from 30 ac. alfalfa that was established no-till into existing orchardgrass sod using the chemical Paraquat to kill the grass. The alfalfa was then seeded with a no-till drill into the sod. This was done in spring with excellent results. Other hay and pasture is from the cool season grasses, fescue and orchardgrass, with clover being maintained in the stands using no-till seeding methods. Practices such as proper fertilization, control of competition from grasses and other practices recommended by the University are closely adhered to. We feel it is necessary to follow these principles for no-till establishment to be successful. In the fall of 1986, we intend to replace 30 ac. of KY 31 fescue with the Johnstone variety by killing the existing sod and then establishing the new stand by no-tilling the Johnstone into the killed sod.

Four no-till drills have been used by us with varying degrees of success. We chose the Moore Uni-Drill (now the G.T. Versa Drill) as the one we preferred. We like the close row spacing, the accuracy of depth control in addition to the accuracy of seed distribution.

We feel that our livestock program has benefit from maintaining legumes in our hay and pasture grasses. AS shown in Tables 1 and 2, both conception rates of the cows and weaning weight of the calves have increased. Our livestock program now consists of 200 cows, which we are planning to increase to 250, with their calves being backgrounded and sold in April at about 1 year old. At the present time, crossbreeding is practiced using Beefmaster bulls on predominantly Angus-Hereford cross cows. We are also developing a small purebred Beefmaster herd. We are doing this because of the tremendous interest in Beefmaster cross heifers for replacement females and the expressed interest in the desire for Beefmaster bulls, We feel that we can market our forages through a product that will sell at a premium over market price.

Table 1. Beef Cow Pregnancy Rate for Beauchamp-Alexander Farm.

Year	Pregnancy Rate, %
1980	67
1982	74.6
1983	--
1984	89
1985	92 (169/184)

Table 2. Calf Weaning Data for Beauchamp-Alexander Farm.

Year	Head No.	Weaning Date	Avg. Actual Weaning Wt., lb.	Adj. 205-day Wt., lb.
1981	91	Nov. 9	417	--
1982	113	Nov. 11	411	--
1983	128	Oct. 10	357	--
1984	88	Oct. 30	446	432
1985	126	Oct. 30	508	470

No-Tillage Update Report - Alabama

D.W. Reeves, D.H. Rickerl, C.B. Elkins, and J.T. Touchton

Slit-Tillage

Slit-tillage is the cutting of a narrow slit through a plowpan to promote deep rooting. One of the primary advantages of slit-tillage over subsoiling is that on coarse-textured soils slit-tillage produces a long-term residual effect, whereas the effects of subsoiling last only for one season. In 1985 we found 5-year-old slits that were still functional in promoting soybean root growth through a plowpan.

In the second year of an experiment on a Dothan soil at Headland, Alabama, yields of peanuts, corn, and soybeans grown with slit-tillage were equal to yields with in-row subsoiling. Yields with no-till were 62, 86, and 64 percent of maximum yields of corn, peanuts, and soybeans, respectively. It appears that on this soil, some form of tillage is essential for maximum crop yields.

Starter Fertilizer and Lime Placement For No-till Grain Sorghum

A field study was initiated in 1985 to evaluate the response of grain sorghum to starter fertilizer placement, in-row tillage to disrupt tillage pans, and deep injection of lime to amend subsoil acidity. The study was conducted on a Hartsells fine sandy loam. A factorial arrangement of 3 tillage-placement methods x 5 soil amendments was incorporated in a randomized complete block of 4 replications. The amendments included 1) starter fertilizer (20 lb/acre each of N and P_2O_5; 2) 700 lb/acre dolomitic limestone slurry in a water base with an anionfc'polymer to aid in suspension; 3) starter fertilizer + lime; 4) a polymer check; and 5) a water-only check. The amendments were placed either 1) in the subsoiler track (16-in depth); 2) in a narrow slit (3/16 in wide, 7 in deep) below the subsoiler shank; cr 3) incorporated with a fluted coulter 3-5 inches beside the row to a 3-inch depth.

Substantial increases in plant growth occurred only when starter or starter + lime were applied in conjunction with sore form of deep tillage (subsoiler or slit) (Table 1).

Table 1. Effect of amendment and application method on early season plant growth and grain yield.

Application	Amendment water	lime	polymer	starter	starter + lime
	------- g dry mt/lft row -----------				
Slit	5.7	6.7	5.3	13.3	11.9
Subsoil	5.9	6.4	6.6	i9.8	11.1
3 x 3	4.4	4.4	6.6	7.5	6.6
$LSD_{0.10}$ = 3.0					
	----- grain yield, bu/acre ---------				
Slit	58	61	62	69	74
Subsoi1	70	65	63	83	67
3 x 3	58	58	58	66	57
$LSD_{0.10}$ = 8.3					

Grain yield generally followed the same trend as plant growth (Table 1). Maximum grain yield (83 bu/acre) occurred when starter was applied in the subsoiler track. Averaged over amendments, yields were 59, 65, and 60 bu/acre ($LSD_{0.10}$ = 3.7) for subsoiliny, slit-tillage, and no deep tillage, respectively.

Previous research has shorn that soybean yield response to slit tillage improves with each successive season which is due to the cumulative effect of residual slits. After 3 seasons, yields from slit-tillages surpassed those of conventionally subsoiled plots. Whether the injection of lime into acid subsoils can further improve crop performance remains to be proved. The test will be continued on a number of coarse-textured, essily compacted soils with acid Bt horizons throughout the Southeastern Coastal Plain.

Tillage Systems for Double Cropped Wheat and Grain Sorghum

Research conducted from 1981 to 1984 demonstrated that the best tillage system for dcuble-cropped wheat and soybean was deep tillage prior to planting wheat and no tillage prior to planting soybean (Proceedinps of the Seventh Annnual No-tillage Systems Conference, pp. 146-150). Tillage systems prior to planting wheat were no tillage, disk, chisel plow, and turn plow. Soybean was planted with and without in-row subsoiling. Wheat yield differences between deep tillage systems (chisel and turn) were generally irsignificant. A key finding of this research was that yield of soybean following deep tillage for wheat was as high without as with in-row subsoiling even on soils with root restricting hardpans. The soils used in this research (Table 2) are typical coastal plain soils. The Benndale and Dothan soils had well defined root restricting tillage pans. Tillage pans existed in the Lucedale soils, but they were generally not well defined and yield response to in-row subsoiling was not consistant.

In 1984, the summer crop was changed from soybean to grain sorghum. Wheat yields in 1984 and 1985 followed the same treatment trends as previous years. Grain sorghum yields (Table 2), however, did not follow the same trends as soybean. Regardless of tillage system prior to planting wheat, in-row subsoiling was needed for top sorghum yields. On Benndale and Dothan sandy loam soils, deep tillage prior to planting wheat resulted in higher sorghum yields than no tillage prior to planting wheat, but this tillage did not substitute for in-row subsoiling at sorghum planting.

Table 2. No tillage sorghum yield (2 year average) as affected by tillage prior to planting wheat and in-row subsoiling at sorghum planting.

	Soil type and in-row subsoiling					
	Lucedale sl		Benndale sl		Dothan sl	
Tillaae before wheat.	SS[1/]	NSS	SS	NSS	SS	NSS
	---------------sorghum yield, bu/acre------------					
No-till	70	63	51	30	55	24
Disk	65	56	50	41	60	23
Deep	65	60	55	42	61	44

1/ SS = in-row subsoiled at sorghum planting; NSS = not subsoiled

Cropping Systems for No Tillage Corn Production

When winter cover crops are harvested for grain, cut for hay, or used for grazing, their use will generally off-set production costs and a cost free mulch is available for the summer crop. It is not always feasible, however, to use the winter cover crops as cash crops and the production costs have to be charged to the summer crop. When winter cover crops cannot be used as cash crops, planting annual legumes which produce N that can he used by subsequent grain crops can help off-set and sometimes eliminate costs of growing the legume.

Early maturing legumes, especially when planted early in the fall, can provide adequate mulch for conservation tillage and sufficient N for summer crops which have low N requirements and relatively late optimum planting dates. These legumes, however, generally do not provide adequate N for corn, which has to be planted early and has a high N requirement. Since soybean will sometimes provide up to 1/3 of the N needed by corn, growing corn in rotation with soybean in a cropping system with reseeding clover may eliminate the need for applying N fertilizer to corn.

This study was conducted on a Wynnville sandy loam soil at the Sand Mountain Substation in North Alabama and on a Dothan sandy loam soil at the Wiregrass Substation in the Coastal Plains of South Alabama. The two year cropping systems were 1) fallow-corn-fallow-corn, 2) clover-corn-clover-corn, 3) fallow-soybean-fallow-corn, and 4) clover-soybean-reseeded clover-corn. The clover was 'Tibee' crimson clover. Sidedress N rates for corn were 0, 60, 120, and 180 lb/acre. Irrigation was used at the Coastal Plain location but not at Sand Mountain.

At corn planting, higher clover yield and total N but lower N concentration at Sand Mountain than the Coastal Plain location (Tahle 3) are attributed to a later corn planting date at the Sand Mountain location (18 April vs 27 March). Higher yield and N production for clover following soybean than corn at both locations is due to reseeded vs planted clover. When corn was planted in the summer of 84, the clover was at the very early bloom stage and seeds had not been produced; but when soybeans were planted in May of 84 the clover was mature and had produced adeauate seeds for a self seeding system. The self seeded clover in the soybean canopy had established a stand in late August of 1984 while clover following corn was not planted until November.

Table 3. Above ground clover and N yield at corn planting in 1985 as affected by previous crop.

Previous summer Crop	Clover yield and N content					
	Sand Mountain			Coastal Plain		
	Weight	N	N	Weight	N	N
	1b/A	%	1b/A	1b/A	%	lb/A
Corn	3200	2.91	93	1100	4.19	46
Soybean	4240	2.86	121	2430	3.76	91

Corn yield (Table 4) at both locations was good. Judging from the 0 N rate at both locations, soybeans preceedinc corn will provide as much N to the corn as a winter legume. The clover-soybean-clover system however, was by far superior to any of the single legume crops preceedinp ccrn. Although the preceeding legume crops contributed N to the corn, they had no effect on the amount of N fertilizer required (120 lb/acre) for optimum yields at the Sand Mountain location. They did, however affect yields which were 110, 130, 130, 160 bu/acre for systems 1, 2, 3, and 4, respectively. At the Coastal Plain location, the preceedinp cropping systems did not affect yield potental but did affect N fertilizer requirement. When corn followed the clover-soybcan-clover system, 60 lb/acre of N fertilizer was adequate and 120 to 180 lb/acre were required for the other preceeding cropping systems.

Table 4. Corn grain yield as affected by previous crops and sidedress N.

Previous Crop			Sidedress N rate, lb/acre							
			Sand Mountain				Coastal Plain			
Winter 83/84	Summer 84	Winter 84/85	0	60	120	180	0	60	120	180
			1985 corn yield, bu/acre							
Fallow	Corn	Fallow	10	70	110	110	60	140	160	180
Fallow	Soybean	Fallow	40	100	120	130	90	130	170	170
Clover	Corn	Clover	50	100	130	130	90	140	150	170
Clover	Soybean	Clover	80	140	160	160	140	170	180	170
FLSD (.10)				14				26		

Tillage In-row Subsoiling, and Starter Fertilizer for Peanuts

This study was conducted for 3 years in the Coastal Plain (Wiregrass Substation, Headland) of Alabama. The soil which was a Dothan fsl, contained a root restricting hard pan 8 to 10 inches deep. Except for the starter fertilizer treatments, fertilizer and lime was applied according to soil test recommendations. Treatment variables consisted of tillage (disk-chisel-disk and no tillage into killed rye), fertilizer combinations, in-row subsoiling, and fertilizer placement. The liquid fertilizer combinations were: none, N alone, N-P, and N-P-K. Application rate was 150 lb/acre of total material and nutrient rates were 22 lb/acre N, 22 lb/acre P_2O_5 and 8 lb/acre K_2O. Subsoiling (10 to 12 inch depth) was with an in-row subsoil planting unit. For nonsubsoiled treatments, the same planting unit was used but without subsoilers. Fertilizer placement was deep and 3 X 2. For the deep placement, a tube was welded behind the subsoiler shank and the fertilizer was placed near the bottom of the track. The peanuts were planted on twin 7-inch rows on 36-inch centers and the 3 X 2 placement was directly between the paired rows and two inches deep.

Each year interactions occurred between tillage and in-row subsoiling (Table 5). Within the conventional tillage system, in-row subsoiling reduced yields, but it, increased yields within the no-tillage system. In 1983, yields were low and the only response to the starter fertilizers was a yield reduction from the 3 X 2 placed N-P-K. Yields were good in 1984 (3700 lb/acre) and excellent in 1985 (4900 lb/acre). Within the conventional tillage system, the starter fertilizers improved yields in 1984 (up to 900 lb/acre), but had no effect in 1985. In 1984, maximum response was obtained with the application of N alone. Within the no tillage system there was a positive yield response to starter fertilizers both years. The 3 X 2 placed starters were superior to the deep placed starters in 1984 (3660 vs 3300 lb/acre) but not in 1985. With the 3 X 2 placed fertilizer in conjunction with in-row suboiling (which was the superior treatment), N alone was as effective in improvina yields as the N-P and N-P-K combinations.

Table 5. Peanut yield on the Dothan soil at the Wiregrass Substation as affected by tillage, starter fertilizer, in-row subsoiling and fertilizer placement.

Starter fertilizer[1]	In-row subsoiling	Fertilizer placement	Year and Tillage[2] 1983 CT	1983 NT	1984 CT	1984 NT	1985 CT	1985 NT
			--------lb/acre--------					
None	Yes	--	2431	1830	2977	3176	3986	4301
	No	--	2817	1742	2946	2347	4392	3805
15-0-0	Yes	Deep	2512	2416	3131	3291	4192	4477
	Yes	3 x 2	2651	1815	3279	3630	3981	4677
	No	3 x 2	2939	2184	3860	2571	4101	3733
15-15-0	Yes	Deep	2425	2236	2862	3158	4162	4513
	Yes	3 x 2	1893	1771	3225	3757	4144	4628
	No	3 x 2	2707	2198	3781	2595	4380	3896
15-15-5	Yes	Deep	2300	2222	3104	3461	4274	4840
	Yes	3 x 2	2120	2163	3315	3600	3878	4858
	No	3 x 2	2288	1655	3721	2214	4646	3974
FLSD (0.10)			484		488		323	

[1] Application rate was 150 lb/acre.

[2] CT = conventional and NT = no tillage.

No-Tillage Research in Georgia

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Introduction

In this report, we summarize ongoing research on no-tillage in Georgia. Several disciplines are involved in researching the many aspects of no-tillage production. The project leaders are inaicated for each discipline.

No-tillage adoption (J. E. Dean, USDA-SCS)

The no-till acreage for 1985 is shown in Table 1. The amount of no-tillage remains a small fraction of the total crop production in Georgia, averaging only 4.2%. Conservation tillage makes up a much larger fraction averaging 23% of the total. No-tillage has actually declined somewhat in

Table 1. No-till acreage in Georgia, 1985.

Crop	Total Production	No-Till	Total[1/] Conservation Till	Conservation Till
	----------------	acres	---------------	% of total
Corn	1,130,552	43,967	328,899	29.1
Small grain	1,233,573	25,966	355,533	28.8
Soybean	1,993,698	111,386	528,197	26.5
Cotton	251,041	700	4,564	1.8
Sorghum	255,278	26,917	84,561	33.1
Vegetable Crops	156,654	1,205	7,154	4.5
Forage[2/]	124,233	9,601	21,717	17.5
Total	5,888,599	246,396	1,369,811	23.3

[1/] Includes no-tillage, ridge-till, strip-till, mulch till, and any other reduced-till system which leaves at least 30% residue cover.

[2/] Excluding permanent pasture.

the last 2 to 3 years as a result of the depressed farm situation arid the high cost of inputs. Soybean continues to be the number one no-till crop in Georgia. Of the total soybean acres, about 40% are double-cropped following small grains, and of the double-cropped soybeans, 11% and 36% are no-till and conservation till, respectively.

More row-crop acreage in Georgia needs to be in no-tillage production due to excessive soil erosion. Continued research and extension efforts, especially in weed control, should enable the amount of no-till production to increase.

Soil erosion research (G. W. Langdale, A. W. Thomas, and W. C. Mills, USDA-ARS)

The influence of cropping/tillage systems on soil loss probabilities from a southern Piedmont landscape was recently computed stochastically (Fig. 1). The model used was weighted with rainfall depth (100 years), rainfall energy (34 years), and observed runoff (12 years) from a 6.7 acre watershed with slopes up to 7.0%. This model suggests that a more than 80% probability is required for soil erosion, associated with double-cropped conservation systems, to exceed 0.5 tons/acre/year. At the same probability levels, soil losses associated with mono-cropped conventional tillage exceed 50 tons/acre/year. Coulter-in row chiseling grain sorghum into crimson clover residues virtually eliminated soil losses. Double-cropped conservation tillage systems also reduced total P loss from 3.6 to 0.09 lbs/acre/year on the same watershed, at the expense of increasing PO_4-P by 40%.

Soil fertility research (W. L. Hargrove and D. O. Wilson, UGA)

Research with legume cover crops showed that crimson clover continues to be the best adapted species to the soils and climate of Georgia. Yields of no-till corn were 180 bu/A following crimson clover with no fertilizer-N on a Cedarbluff silt loam soil. Yields of no-till grain sorghum were 100 bu/A following crimson clover with no fertilizer-N on a Greenville sandy clay loan soil. Crimson clover replaced as much as 120 lbs fertilizer-N per acre. Since fertilizer-N represents a sizeable portion of the fossil fuel energy required for non-leguminous row crop production, this represents a significant energy savings, enhancing the conservation value of a no-tillage production system.

The effects of legume cover crops on soil fertility status include: 1) a lower pH, 2) a redistribution of K^+ to the soil surface from deeper in the soil profile, and 3) a lower C/N ratio in soil organic matter.

Results from a study of nutrient uptake and yield of corn as affected by tillage showed that the redistribution and concentration of nutrients at the soil surface was not a disadvantage but appeared to be an advantage especially for P and micronutrient uptake. Though plant roots tended to be concentrated also near the soil surface with no-tillage, root activity was greater outside of the row and deeper in the soil profile under no-tillage management compared to conventional tillage.

Soil physical properties (D. E. Radcliffe, E. W. Tollner, and W. L. hargrove, UGA)

Results from studies of tillage and residue management practices for double-cropped soybeans at several locations in Georgia have shown that soil compaction and shallow tillage "pans" are serious problems on sandy Ultisol with poorly developed structure. By restriction of root proliferation, compacted soil layers can be detrimental to crop yields under no-tillage production. However, in long-term (10 years) no-tillage plots on a Cecil soil, crop performance has been maintained or improved in years 5 through 10 even though dense compacted layers are present. It is hypothesized that large continuous pores through the compacted layers have been established and preserved through no-tillage management, that allowed root proliferation into the subsoil. This hypothesis will be the subject of continuing studies.

Weed control and interference research (P. A. Banks, UGA)

Soybean yields were significantly greater when grown under a no-till, straw-mulched double-cropped system with wheat compared to a conventionally tilled double-crop system when both were infested with sicklepod (Banks et al, 1986). Yields under weed-free conditions were not different. The yield differences where sicklepod was present were attributed to soil-water content differences between the two systems; more water was available during the soybean reproductive stage of growth in the no-till system. It is also likely, ihat under the conditions of these experiments, the soybeans were better able to compete with the sicklepod under the nontilled conditions. This research demonstrates that weed interference studies conducted under conventionally tilled conditions cannot be used to predict the effects of weeds on soybeans grown under nontilled conditions.

Experiments to evaluate the influence of a wheat straw mulch on soil-active herbicides have been reported for rnetribuzin (Banks and Robinson, 1982), oryzalin (Banks and Robinson, 1984), acetochlor, alachlor, and metolachlor (Banks and Robinson, 1986). The chloroacetamide herbicides, (acetochlor, alachlor, and metolachlor) were retained more by the straw than the other herbicides following 0.5 inch of sprinkle irrigation. Oryzalin was least affected of the herbicides studied. The persistence of oryzalin in the soil was also less under the straw mulched conditions. The persistence of the other herbicides was not affected by the straw mulch. In the experiments with the chloroacetamide herbicides, it was documented that the herbicide retention by the wheat straw adversely affected herbicidal activity. Alachlor was most affected and acetochlor least affected. Metolachlor was more persistent than the other two herbicides. Research is continuing with other herbicides and also to determine the effect of straw-burning on herbicide persistence in these doublecropping systems.

The indeterminate soybean variety 'Duocrop' was show to provide an advantage in weed control over the determinate varieties 'Wright', 'Ransom', and 'Hutton' (Giraudo, 1986). Canopy closure was more rapid with Duocrop and the end of season weed weights were less compared to the other varieties. Research has continued to deterimine if the affect of soybean variety on weed interference is due totally to a 'physical' effect or if allelopathy nay play a part.

Numerous herbicides and herbicide combinations have been evaluated for weed control in nontilled soybean culture following small grain harvest. Regardless of what soil residual herbicide is used, the nonselective, foliar active herbicide applied at the time of planting is the most important component of the weed control program (Banks and Kvien, 1983). Several of these herbicides have been evaluated (paraquat, glyphosate, HOE-662, and SC 0224). For small, annual weeds all provided good control. Many times, weeds are several months old at the time of wheat harvest and paraquat has not provided adequate control of common ragweed, lambsquarters, horseweed, or large crabgrass.

In general, herbicides used in conventionally tilled soybean culture provide similar results under nontilled conditions with a few exceptions. Control of large seeded annual grasses and perennial grasses has been more difficult, although the new postemergence herbicides, sethoxydim and fluazifop, have provided excellent control when applied correctly (Hutchinson, 1985; Whiddon, 1985).

Several new broadleaf herbicides, imazaquin (Scepter), chlorimuron (Classic), and fomesafen (Reflex), have shown potential for use in nontilled culture. Research will continue with these, as well as with dimethazone (Command) and Canopy (metribuzin plus chlorimuron) to determine activity and potential residual hazards with fall-planted small grain or various rotational crops planted the following spring.

Entomological studies (J. N. All, W. A. Gardner, J. M. Cheshire, and D. Buntin, UGA)

Research over the past 12 years has revealed that the unique environments that are created in conservation tillage systems may have positive, negative, or neutral effects on insect pest potential. The lesser cornstalk borer, Elasmooalpus *lignosellus*, is a devastating soil pest of many southern field crops Infestations are significantly reduced in conservation tillage as compared to plow tillage systems. Reduced damage in conservation tillage is related to the saprophytic behavior of larvae which feed actively on the surface mulch in conservation tillage systems. In contrast, the southern corn billbug, Sphenophorus *callosus*, produces devastating infestations in conservation tillage corn and infestations appear to be enhanced by the increased cover provided by surface debris in these cropping systems.

The effects of wheat stubble management on Hessian fly (*Mayetiola destructor*) populations in winter wheat are being investigated. In a preliminary study, burning of wheat stubble had no significant ($P<.05$) effect on Hessian fly infestation. Conventional tillage significantly ($P>.05$) increased the percentage of uninfested tillers as compared with no-ti 11age.

In studies of the ecology and enhancement of entomoyenous pathogens in crop production systems, it has been found that tillage may distribute the overwintering inoculum of naturally-occurring pathogens, such as *Nomuraea* rileyi, in the soil, increasing the probability of contaminating plant surfaces where foliage-feeding larvae reside. Quantification of the vertical movement and persistence of an entomogenous fungus in response to tillage will be determined utilizing *Beauveria bassiana* as a model.

Soil microflora and plant diseases (C. S. Rothrock and B. M. Cunfer)

Microbial changes due to conservation tillage were examined in a long-term tillage experiment. No differences were found in the major groups of microorganisms (fungi, actinomycetes, and bacteria) in the upper 5 cm of soil. However, fungal, actinomycete, and bacterial populations were all lower from soil samples at the 5 to 15 cm depth under the no-tillage treatment compared to the conventional tillage treatment (moldboard plow).

Southern stem canker of soybean, caused by Oiaporthe phaseolorum var. caulivora, has increased under no-tillage, both in terms of severity and incidence. However, preliminary results from a study of cultivar x tillage interaction show no significant difference in yield of a resistant cultivar (Coker 368) between conventional and no-tillage. For a susceptible cultivar (Hutton), yield was 29% less than Coker 368 with conventional tillage, but 49% less with no-tillage. These data indicate that resistant cultivars can be incorporated into no-tillage systems to effectively control stem canker even under extreme disease pressure.

Take-all of wheat, caused by Gaeumannomyces graminis var. tritici, has been reported to be increased, decreased, or not affected by tillage. In our studies, take-all was found to increase in incidence and severity with conventional tillage. This increase in disease resulted from the movement of residues infested with the pathogen, spreading inoculum.

Wheat is one of the few crops where comparable yields have not been observed between no-tillage and conventional tillage systems. Research has demonstrated by fumigation that these reduced yields are associated with biotic factors. Research is also ongoing to develop disease-resistant small grain cultivars that can be used effectively in conservation tillage systems.

Ecological studies (P. F. Hendrix, D. A. Crossley, and K. W. Parmelee, UGA)

Recent studies by the Institute of Ecology suggest that organisms responsible for plant residue decomposition have shown distinct responses to tillage. Community structure of the soil biota suggests that microbial decomposition may be dominated by fungi in no-tillage and bacteria in conventional tillage. Earthworms and soil arthropods were more abundant in no-ti1lage, whereas enchytraeids and bactivorous nematodes were more abundant in conventional tillage. Insect herbivory on plant foliage has generally been higher in conventional tillage than in no-tillage, possibly due to greater abundance of predators in no-tillage systems and other unexplained agroecosysten dynamics.

Economic research (J. Allison and S. Ott, UGA)

Current economic research centers around:

1) Collection of production data from five local producers who use conservation tillage and/or legume cover crop production practices to estimate inputs and yields associated with conservation tillage ancl legume cover crops.

2) Estimate production response coefficients or surfaces of various crops grown in conservatio tillage/legume cover crop production systems.

3) Determine the economics (profit and risk) of various production systems using conservation tillage/legume cover crops.

4) Determine the value of reduced soil erosion, both to the producer and to society.

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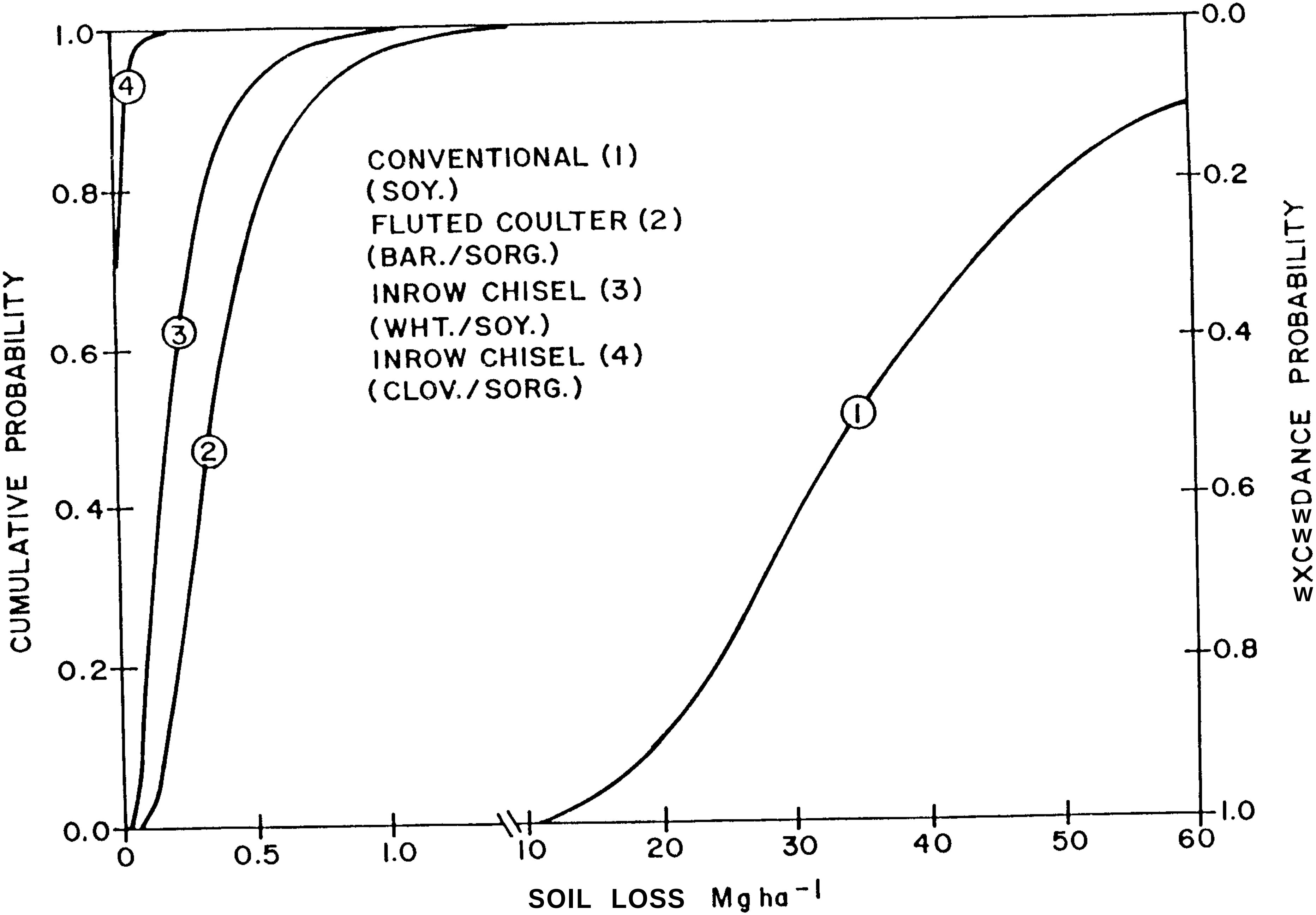

Fig. 1. Soil loss probabilities for various tillage/cropping systems.

Kentucky No-tillage Update[1]

Edited by W. W. Frye[2]

Kentucky farmers were among the first in the U.S. to adopt no-tillage, and the practice has grown rapidly in the state, particularly or production of corn and soybeans. Its inherent advantages in controlling soil erosion; conserving soil water; saving time, labor, tractor fuel, and machinery costs; and improving timeliness in planting double-cropped soybeans have been major factors accounting for the rapid adoption of no-tillage. The estimated acres of no-tillage corn and soybeans planted in Kentucky from 1969 through 1985 are show in Table 1.

The current no-tillage research projects in Kentucky are in several broad categories, including **(1)** long-term effects *of* no-tillage and other conservation tillage practices on soil properties and crop productivity, *(2)* role of legume cover crops in no-tillage, **(3)** N management for improved efficiency in no-tillage systems, (4) weed control for no-tillage crop production, (5) effects *of* tillage on soil erosion and runoff water quality, (6) production of burley tobacco using no-tillage and reduced tillage, and (7) no-tillage cropping systems and rotations.

Lona-term No-ti11aae and Conventional Tillaae

Corn has been grown continuously with no-tillage and conventional tillage on a Maury silt loam soil since 1970. Average grain yields during that time are shown in Table 2. After 15 years, there was a trend toward declining yields with all N rates and both tillage treatments, however, the

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Table 1. Estimated[†] Acres of No-tillage Corn and Soybeans Planted in Kentucky, 1969-1985.

Year	No-till corn: Acres no-till (X 1000)	No-till corn: % of all corn	No-till soybeans: Acres no-till (X 1000)	No-till soybeans: % of all soybeans	Corn and soybeans: Total acres no-till corn and soybeans (X 1000)
1969	80	7.4	30	6.2	110
1970	133	12.0	50	9.0	183
1971	213	16.0	110	15.0	323
1972	204	18.0	197	21.1	401
1973	250	21.6	300	28.9	550
1974	330	26.6	320	30.5	650
1975	300	22.6	350	30.4	650
1976	277	18.0	308	28.0	585
1977	248	15.0	338	25.0	586
1978	150	9.5	300	21.4	450
1979	173	12.0	464	27.0	637
1980	248	15.0	495	30.0	743
1981	316	18.8	570	34.0	886
1982	336	20.0	595	35.0	931
1983	265	23.1	545	34.0	810
1985	443	24.6	385	33.8	828

[†] Estimates by University of Kentucky Agric. Extension grain specialists for all years except 1981, 1983, and 1985, which were determined by a survey conducted by the Kentucky Crop and Livestock Reporting Service (1981) and estimates by Conservation Tillage Information Center (1983 and 1985).

Table 2. Average Corn Grain Yields During 16 Years of No-tillage and Conventional Tillage (1970-1985).

Tillage treatment	N rate, lb/acre: 0	75	150	300
	Grain yield, bu/acre			
No-tillage	71	114	125	128
Conventional tillage	84	118	120	126

most notable change was the reversal of the response of no-tillage and conventional tillage corn to the low N fertilizer rates. During the first ten years, conventional tillage treatments at the low N fertilizer rates always produced higher grain yields. However, since 1980 without N fertilizer, no-tillage corn yields have not been significantly different from yields of conventional tillage corn, and in 1984 and 1985, there was a strong trend toward higher yields with no-tillage. The higher organic matter and organic N levels observed with no-tillage now appear to be contributing more to the N needs of the corn crop than in the case of conventional tillage.

After 10 years, the organic matter content in the surface 2 inches of soil receiving annual applications of 150 lb/acre fertilizer N was 4.82% for no-tillage, 2.40% for conventional tillage and 5.1856 for the adjacent, nontilled bluegrass sod. The higher amount of organic matter near the soil surface with no-tillage than with conventional tillage can be attributed to the lack of mechanical mixing of plant residues into the soil and slower decomposition of organic matter.

The method of tillage did not affect bulk density (1.25 and 1.29 g/cm^3 for no-tillage and conventional tillage, respectively), but hydraulic conductivity was 0.75 inches/hour for no-tillage and 0.59 inche/hour for conventional tillage. This suggests greater pore continuity and possibly more large pores in the no-tillage soil.

Soil acidity increased more rapidly in no-ti1lage than conventional tillage and was closely related to the amount of N fertilizer applied. As acidity increased, exchangeable calcium and magnesium decreased, especially calcium, and exchangeable al uminum and manganese increased greatly. Exchangeable aluminum in the surface 2 inches of the unlimed soil ranged from 2 to 30 times higher under no-tillage than conventional tillage, making aluminum toxicity a serious threat to crop productivity. The high acidity and, probably to some extent the high organic matter, decreased activity of the triazine herbicides, resulting in poor weed control. The acidity problems were corrected by surface applications of lime.

Exchangeable potassium in the surface 2 inches was about twice as high under no-tillage as conventional tillage. The Maury soil on which this study was conducted has a very high labile phosphorous content, end we did not apply phosphorus fertilizer, but **if** we had, higher levels of soil phosphorus would be expected to accumulate near the surface as potassium did. This distribution pattern does not appear to be a problem in crop production and may actually increase availability of phosphorus. The higher soil water content near the surface under no-tillage enhances phosphorus diffusion and encourages root proliferation in that zone.

Another experiment was begun in 1983 to study the effects of disk tillage and chisel-plow tillage along with no-tillage and conventional tillage. Measured properties and yields to date suggest that the effects of disk tillage and chisel-plow tillage are between the extreme conditions of no-tillage and conventional tillage and are closely related to the amount of soil disturbance and residue left on the surface.

<u>Long-Term Sovbean Tillage Study</u>

A long-term study comparing tillage methods for single-cropped and double-cropped soybeans was initiated at Princeton in 1980 and continued through 1985. Tillage methods for both cropping systems include: **(1)** conventional tillage (plow, disk and roterra), (2) minimum tillage (chisel plow and field cultivate), and **(3)** no-tillage. Yields are shown in Table 3.

Table 3. Effects of Tillage on Yield of Single-Cropped and Double-Cropped Soybeans (Average of 1980-1985).

Cropping system	Tillage method	Yield
		bu/acre
Single-crop	Conventional tillage	35
	Minimum tillage	35
	No-tillage	36
Double-crop	Conventional tillage	24
	Minimum tillage	26
	No-tillage	27

After six years, there have been no apparent detrimental effects of reduced tillage on soybean yields. Soil data is currently being analyzed to determine the long-term effects on certain soil properties.

Leaume Winter Cover Crops in No-Tillage

To obtain maximum benefits from the advantages inherent in the no-tillage system, a winter cover crop is needed to produce additional residue for mulch. A legume mulch provides all of the advantages of a nonlegume mulch (e.g., erosion control, increased infiltration, and decreased evaporation), while also supplying a substantial quantity of N to the corn crop.

The effects of winter cover and N fertilizer on yield of no-tillage corn from 1977 through 1981 are shown in Table 4. Hairy vetch significantly increased corn grain yield, and its effect was still apparent with 90 lb/acre fertilizer N. Big flower vetch, crimson clover, and rye cover crops also increased yields of corn compared to corn residue, but their effects were much smaller than for hairy vetch. This difference was due in part to the yield and N content of the cover crops, as shown in Table 5. Hairy vetch outyielded and produced more N than the other cover crops, and in turn, enhanced corn yield the most.

Table 4. Effect of Cover Treatment and N Fertilizer Rates on No-tillage Corn Grain Yield (Average of 1977-1981).

	N rate, lb/acre		
Cover treatment	0	45	90
	--------Yield of corn, bu/acre---------		
Hairy vetch	102	108	143
Big flower vetch	67	105	105
Crimson clover	70	91	118
Rye	64	91	121
Corn residue	60	83	104

Table 5. Dry Matter Yield and N Content of Cover Crops at Corn Planting (Average of 1980–1981).

Cover crop	Yield of cover crops	% N	N content
	tons/acre		lb/acre
Hairy vetch	2.3	4.1	189
Big flower vetch	0.8	3.2	52
Crimson clover	1.1	2.4	52
Rye	1.5	1.15	35

In 1984, the plots of this experiment, which had been in continuous no–tillage corn, were split into conventional tillage and no–tillage treatments. The average grain yields for 1984 and 1985 are shown in Table 6. Without N fertilizer applied, yields were considerably higher with conventional tillage than with no–tillage. However, with N fertilizer, yields were about the same for both tillage methods, with a very slight tendency to be higher for no–tillage. Lower N mineralization probably accounted for lower yields under no–tillage with no N fertilization, and the better soil moisture conditions in no–tillage probably accounted for the trend toward higher yields at the higher N rate.

Table 6. Effects of Cover Treatments, N Fertilizer Rates, and Tillage Methods on Corn Grain Yield (Average of 1984-1985).

	N fertilizer applied, lb/acre					
	0		7E		150	
Cover treatment	CT	NT	CT	NT	CT	NT
	------Yield of corn, bu/acre------					
Hairy vetch	113	102	108	115	123	123
Big flower vetch	87	64	121	121	100	109
Rye	56	45	95	86	110	105
Corn residue	64	44	94	90	105	107

Grain yields with the hairy vetch cover crop treatment without N fertilizer were about equal to yields with the other cover treatments and 150 lb/acre fertilizer N. Our results indicate that N fertilizer application to the corn should not be decreased substantially following a legume winter cover crop because the effect of hairy vetch appears to augment corn yield rather than replace N fertilizer needs.

Cover crops may deplete available soil water and cause poor germination, slow seedling growth, and early water stress during a dry spring. Soil water at corn planting (May 14, 1985) is shown in Table 7). Clearly, the potential for a serious water stress existed, but timely rainfall averted any problems.

Table 7. Effect of Hairy Vetch Cover Crop on Soil Water at Corn Planting, May 14, 1985.

Soil depth	Corn residue		Hairy vetch	
	CT	NT	CT	NT
inches	----------------	% water by weight	----------------	
0–6	24.0	23.5	19.7	21.0
6–12	20.5	20.5	15.0	14.8
12–18	22.0	23.5	15.2	15.0
18–24	24.2	25.5	18.2	17.8

Shortly after being killed, the mulch formed by the cover crops with no-tillage began to conserve soil water. For example, in mid-July 1984, soil water in the 0- to 6-inch depth was 28% (weight basis) under the hairy vetch - no-tillage treatment and 23% with the hairy vetch - conventional tillage treatment. In mid-August 1985, soil water was still about 2.5 percentage points greater with hairy vetch - no-tillage than with hairy vetch - conventional tillage.

Nitrogen Fertilizer Management in No-tillage

The unique microenvironmental conditions and the application of crop residues and soil amendments at the soil surface with no-tillage greatly influence soil fertility relative to conventional tillage. Most of the research in Kentucky on improving N fertilizer efficiency has emphasized three management tecniques: (1) delayed or split application of N fertilizer, (2) subsurface band placement of N fertilizer, and (3) chemical inhibition of nitrification.

Time of Application. Denitrification and leaching are more likely to occur early in the growing season, because the higher soil water content at that time makes conditions more favorable for both losses. No-tillage also enhances potentials for both losses. By delaying most of the N fertilizer for no-tillage fields until after the greatest potential for denitrification and leaching has passed, N losses are largely averted. Additionally, availability of the major portion of N coincides more closely with rapid N uptake demand by corn. Approximately, 98.5 to 99% of the N uptake by corn during the growing season is taken up after 30 days following planting.

Our research has shown clearly that delayed application of N fertilizer improves N efficiency and increases corn yield with no-tillage, especially at the lower rates (Table 8). Yields were generally not increased by delayed or split application with conventional tillage (data not shown).

Nitrogen fertilizer recommendations for corn in Kentucky include the recommendation that the amount of fertilizer N can be decreased by 35 lb/acre for no-tillage corn on moderately well-drained soils, or for conventional tillage corn on moderately well-drained to poorly drained

Table 8. Effect of Delayed Application of N Fertilizer on Yield of No-tillage Corn at Nine Locations in Kentucky.

Soil	Drainage class[†]	Fertilizer N applied: 75 lb/acre, At plant	75 lb/acre, Delay	150 lb/acre, At plant	150 lb/acre, Delay
		----------Yield of corn, bu/acre----------			
Allegheny	wd	142	152	166	164
Baxter	wd	176	172	176	184
Lowell	wd	136	163	197	181
Pope	wd	121[‡]	147[‡]	--	--
Cavode	spd	138	140	156	148
Hampshire	mwd	--	--	104	131
Monongahela	mwd	111	127	169	134
Tilsit	mwd	106	119	132	126
Tilsit	mwd	107	129	129	156

† wd = well-drained; mwd = moderately well-drained; spd = somewhat poorly drained.

‡ 80 lb/acre N.

soils if as much as two-thirds of the N fertilizer is applied 4 to 6 weeks after planting. No-tillage is not recommended on poorly drained soils.

N Fertilizer Placement. Recent research at three locations in Kentucky showed that subsurface banding of N fertilizer for no-tillage corn was more efficient than surface broadcast application (Table 9). Since the N fertilizer was placed below the zone of high organic matter and high microbial biomass and activity, the advantage was probably due to a decrease in both immobilization and denitrification.

Table 9. Effect of N Fertilizer Placement on Corn Yield (Average of 2 Years).

Soil	N fertilizer	Method of application: Surface broadcast	Subsurface band
	lb/acre	---Corn yield, bu/acre----	
Donerail	100	114	124
Pope	80	108	141
Tilsit-Johnsburg	75	91	117

Denitrification and leaching losses of fertilizer N are probably most influential in less than well-drained soils during wet years. On the other hand, immobilization might be likely to decrease N fertilizer uptake and efficiency every year under no-tillage. Table 10 shows that, on a Maury silt loam soil, labeled fertilizer N lost, presumably by denitrification and leaching, was about the same in no-tillage and conventional tillage.

Table 10. Fate of Fertilizer N in No-tilled and Conventionally Tilled Maury Soil.

N rate	Tillage	Fertilizer N In grain	Immobilized	Lost
lb/acre		-------	%	-------
75	No-tillage	23	42	29
75	Conventional	40	27	26
150	No-tillage	29	39	25
150	Conventional	28	37	27

However, at the lower N fertilizer rate much more of the N was immobilized in no-tillage, consequently less was taken up by the plants.

If the N fertilizer contains urea, another potential loss is averted by subsurface banding. Ammonia volatilization from surface-applied urea may range from 0 to about 30% of that applied, depending on how soon it rains after the application.

Chemical Inhibitors. We have tested the use of the nitrification inhibitors, nitrapyrin (N-Serve) and dicyandiamide (DCD), as another means of improving the efficiency of N fertilizer in no-tillage corn production. In most of these studies, nitrapyrin was sprayed directly onto granular urea and ammonium nitrate just before broadcasting them on the soil surface at planting time. Averaged over several years at several locations in Kentucky, yield increases of no-tillage corn attributed to nitrapyrin were generally near 25% when used with suboptimum N rates applied at planting. We obtained no consistent response to nitrapyrin for conventional tillage corn.

In recent studies, nitrapyrin and DCD were applied with ammonium sulfate. Monitoring soil N throughout the growing season showed clearly that both chemicals functioned adequately as nitrification inhibitors, but neither affected corn yields significantly.

Other Nitrogen Management Studies

To determine whether substantial fertilizer N was carried over in a Pope silt loam soil from applications of 80 and 160 lb/acre N for no-tillage corn in 1984, an experiment was conducted in which no fertilizer N was applied in 1985. Also, a fertilizer N response curve was determined from broadcast applications of 80, 160, and 240 lb/acre N as ammonium nitrate.

The control treatment, which received no N fertilizer in 1985 nor during four previous years, yielded 32 bu/acre. Yields from plots which had received either 80 or 160 lb/acre in 1984 were no greater than the control, indicating no carryover N effect on corn yields in 1985. Fertilizer N broadcast at planting at 80, 160, and 240 lb/acre resulted in yields of 89, 148, and 172 bu/acre, respectively.

Tillage and Soil conservation

In 1984, a set of erosion plots was established at Lexington, Ky. on a Maury silt loam soil with 8 to 9% slope to study the effects of conventional tillage, chisel-plow tillage, and no-tillage on runoff, erosion, and water quality in corn production. Some of the results from 1985 are shown in Table 11.

Table 11. Runoff, Erosion, and Corn Yields with Conventional Tillage, Chisel-Plow Tillage, and No-tillage on Maury silt loam soil (1 January - 31 December 1985).

Tillaae	Runoff loss	Soi1 loss	Corn Yield
	acre-inch	ton/acre	bu/acre
Conventional tillage	1.16	8.00	125
Chisel-plow tillage	0.34	0.18	126
No-tillage	0.48	0.16	133

Conventional tillage resulted in the highest runoff and soil loss by far, while there was little difference in soil loss from chisel-plow and no-tillage treatments. The chisel-plow treatment had somewhat lower volume of runoff, probably because of the rough surface left by chisel-plowing. Soil loss under conventional tillage exceeded by about two times the tolerance limit for the Maury soil established as T = 4 tons/acre/year by the universal soil loss equation (USLE). Soil loss was far below the T value with no-tillage and chisel-plow tillage. Nitrates, phosphates, and atrazine in the runoff were greatest for conventional tillage; nitrates and phosphates were least for no-tillage, but atrazine was slightly higher in no-tillage runoff than in chisel-plow runoff. Most of the differences in water quality factors, however, were not statistically significant because of wide variations in the data collected.

A similar study was begun in 1985 at Princeton, Ky. with five different tillage and cropping systems for soybeans on a Zanesville silt loam soil with 7 to 9% slope and T value of 3 tons/acre/year. Table 12 shows the average runoff and soil loss during the 1985 growing season (15 May–28 October). No-tillage with full-season soybeans decreased soil loss from about 4 tons/acre to about 0.20 ton/acre or lower. Double-cropping soybeans with wheat was also effective in decreasing soil loss. Soil loss was not directly proportional to water loss.

Tillage-soil erosion research has been conducted since 1982 on a Lowell silt loam soil with 8 to 15% slope in Clark County, Ky. Four corn tillage treatments were applied, each on a different small watershed. Results are shown in Table 13 for 1982–1984. Corn yield was significantly highest from no-tillage, and soil loss was significantly higher from conventional and chisel-plow tillage than from no-tillage and disk tillage. Soil loss from the watersheds with conventional tillage and chisel-plow tillage slightly exceeded the tolerance limit (T) of 3 tons/acre/year. No-tillage and disk tillage kept soil loss far below the T value.

Table 12. Effect of Soybean Tillage and Cropping System on Runoff and Soil Loss on Zanesville silt loam soil.

Cropping and tillage system	Runoff loss†	Soil loss†
	acre-inch	ton/acre
Full season soybeans:		
Conventional tillage	7.5	4.04
No-tillage	2.8	0.19
No-tillage into wheat cover crop	3.0	0.12
Double-crop wheat--soybeans:		
Conventional tillage	5.5	0.51
No-tillage	4.2	0.08

† 15 May–28 October 1985.

Table 13. Three-Year Average Seasonal Soil Loss and Corn Yield on Lowell silt loam soil (1982-1984).

Tillage treatment	Soil loss	Corn Yield
	ton/acre	bu/acre
No-tillage	0.10	141
Chisel-plow tillage	3.24	113
Disk tillage	0.17	127
Conventional tillage	3.68	115

Burley Tobacco Production Using No-tillage

An experiment including no-tillage and conventional tillage techniques for production of burley tobacco was initiated in 1984. In no-tillage, the tobacco plants were transplanted directly into killed bluegrass-fescue sod (at Lexington) or into killed wheat cover crop (Grant County). Transplant survival was 96 to 100% in both no-tillage and conventional tillage. Yield and average market value of leaf are shown in Table 14. Leaf quality, as indicated by the support price of federal grade, tended to be higher for no-tillage tobacco than for conventional tillage tobacco.

Table 14. Effect of Tillage on Yield and Market Value of Burley Tobacco.

	Leaf yield		Market value	
	Lexington†	Grant Co.‡	Lexington†	Grant Co.‡
	--------lb/acre--------		---------$/acre---------	
Conventional tillage	2,575	3,175	4,550	4,800
No-tillage	2,588	3,375	4,650	5,150

† Average of 1984 and 1985.
‡ 1985 only.

We concluded that no-tillage could be a viable management tool in the production of burley tobacco, since equal yields and value were obtained with no-tillage and conventional tillage in both a dry year (1984) and a wet year (1985).

No-tillage Weed Research

Research in Kentucky on weeds and herbicides in no-tillage has emphasized four main areas: (1) weed management systems, (2) herbicides and their persistence and movement, (3) weed population dynamics, and (4) weed biology and ecology.

Development of Weed Management Systems. An intensive program of identifying herbicides that perform satisfactorily in no-tillage is being conducted. Foliar herbicides applied either before or after crop emergence and soil active herbicides are being tested in tall fescue sod, small grain cover crops, wheat stubble, and corn residue for weed control in corn, soybeans, and grain sorghum. Associated with these studies, we are evaluating low-volume applications and various formulations in an effort to develop as many weed control options as possible for no-tillage conditions.

Effect of Tillage on Herbicides and Their Persistence and Movement. During the past 5 years, alachlor, linuron, metolachlor oryzalin, pendimethalin, and trifluralin have been studied under conventional tillage and no-tillage soybeans to determine their effectiveness in weed control and persistence and movement in the soil. Weed control has genrally been as good under no-tillage as conventional tillage, but the depth that these herbicides moved in the soil was generally greater with no-tillage. The persistence has varied depending on the herbicide and tillage system.

Effect of Tillage on Weed Population Dynamics. A long-term study to evaluate no-tillage, minimum tillage, and conventional tillage on weed populations is in its seventh year. More winter annual and biennial species have been present in the minimum tillage, and johnsongrass has been more prevalent under no-tillage and minimum tillage than under conventional tillage. No differences in perennial or annual broadleaf species have been noted among tillage systems. Slightly fewer species have been found in a corn and soybean rotation compared to either crop grown continuously.

Weed Bioloav and Ecoloay. Velvetleaf was found to be equally competitive in both conventional tillage and no-tillage corn, even though the emergence of velvetleaf was delayed in no-tillage. The requirements for germination of eastern black nightshade, cutleaf groundcherry, and smooth groundcherry are such that they have the potential to establish equally well in either no-tillage or conventional tillage.

No-tillaae Grain Croppina Svstems

Wheat After Corn. Wheat is often established after corn in Kentucky. Nitrogen management of the previous crop, as well as the residue management system used in wheat seeding, may be an important consideration in N management for the wheat crop. No-tillage management offers growers the opportunity to improve the timeliness of wheat establishment, but fertilizer N losses from the early spring applications to wheat are likely to be larger under no-tillage residue management.

An experiment was conducted on a Maury silt loam soil to evaluate tillage, corn N fertllizer rates, and wheat N fertilizer rates on N nutrition and yields of wheat. Average wheat yields for 1983 and 1984 are shown in Table 15. At lower levels of N availability, conventional tillage wheat outyielded no-tillage wheat. At realistic corn N fertilization rates, however, no-ti11age wheat equaled or outperformed conventional tillage wheat. The optimum level of applied N, however, was generally higher for the no-tillage wheat. No-tillage wheat appears to require more N than conventional tillage wheat when N availability in the soil is low. On the other hand, when an excessive soil N supply combines with the environment to increase lodging pressure, no-tillage wheat seems less likely to succumb to that lodging pressure.

Table 15. Wheat Grain Yield Response to Tillage, Applied N, and Prior Corn N Fertilization Rate (Average 1983 and 1984).

		Wheat yield	
Corn	Wheat	No-ti11	Conv. til1
--------lb/acre--------		------------bu/acre------------	
0	0	34	50
	40	53	69
	80	63	70
100	0	45	57
	40	67	62
	80	63	58
200	0	58	52
	40	64	52
	80	59	50

Double-Cropped Wheat and Soybeans. Higher levels of fertilizers are often recommended to growers who double-crop. Fertility requirements have been evaluated under continuous no-tillage double-cropping for 3 years on a Maury silt loam soil. When managed in split application, only 60 lb/acre N was required for wheat. Wheat yields were increased, but not greatly *so,* by increasing soil test P to the 'medium-high' range. Application of K according to soil test recornmendation influenced soybean yields very substantially but only when soil test K was increased from 'low' to 'medium' test levels.

It is apparent that fertilization for double-cropping should be based on the needs of individual crops in the system. Wheat is more responsive to P, therefore, the P fertilizer rate should come from the recommendation guide for that crop. Similarly, the K fertilizer rate should be based on the needs of the soybean crop. These data suggest that **it** is not appropriate to add together the two single-crop fertilizer rate recommendations for either P or K. All P and K fertilizer may be applied prior to wheat planting.

Update of No-tillage in Louisiana

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Despite encouraging results from research by Louisiana Agricultural Experiment Station (LAES) scientists[1] and the operation of a demonstration conservation farm near Cade, La., by the University of Southwestern Louisiana (USL), only a small acreage in Louisiana is planted with no-till or conservation-tillage planting techniques. The Conservation Tillage Information Center (CTIC) and the No-Till Farmer Acreage Survey estimated that 50,000 to 65,000 acres were planted no-till, and 215,000 to 230,000 acres were planted with reduced-tillage planting techniques in Louisiana in 1985. In these categorizations "no-till" refers to "slot-planting" or planting into soil left undisturbed prior to seeding with planting completed in a narrow seedbed usually 1 to 3 in wide; and "reduced-tillage" to any planting system in which tillage is more extensive than no-till but which leaves at least 30% residue cover on the soil surface after planting. The ASCS cost shared no-till planting on 2600, 3000, and an estimated 7300 acres in Louisiana during 1984, 1985, and 1986, respectively (J. B. Louray, personal communciations).

Soybean-Wheat Double Cropping

Soybeans is the row crop with the largest acreage in Louisiana, and soybean-wheat double-cropping systems have received the widest no-till research attention. Table 1 identifies the factors investigated in LAES experiments conducted in 1984 and/or 1985 which included soybeans no-till planted after wheat. Several of these experiments have compared factorial combinations of: tillage vs no-tillage before soybean planting, wheat straw burning vs not burning, and differential irrigation treatments. Other management factors which have been investigated include: sole-crop soybeans vs double-crop soybeans, soybean row spacing, soybean variety, herbicide combination, lime application, and P_2O_5 and K_2O fertilizer rate and timing.

Investigations of straw management ahead of soybeans in double-crop systems have yielded mixed results. The effect of stubble height was investigated at the Rice Research Station, Crowley, and Northeast Research Station, St. Joseph, during 1982 and 1983. Neither wheat straw stubble heights from 3" to 20", nor straw spreading or removal, consistently affected soybean yields. Similarly, straw burning has not had a consistent effect on yield. A straw mulch appears to be beneficial on soils prone to drought

[1] Dabney, S. M. et al. 1984. Reduced tillage research in Louisiana. Louisiana Agricultural Experiment Station Bulletin 8765.

stress. For example, the Winnesboro branch of the Northeast Research Station is located on soils with an acid fragipan beginning at depths of 14 to 18 inches. At this iocation straw burning has lowered yields of non-irrigated soybeans in 3 out of 4 years (Table 2). The lack of response in 1983 coincided with an especially dry year. In contrast, the St. Joseph branch of the Northeast Research Station is located on deep soils derived from recent Mississippi alluvium. At this location from 1976 to 1984 yields of no-till planted soybeans were increased in 3 years, unaffected in 5 years, and decreased in 1 (the driest) year by straw burning. In the absence of tillage, large amounts of straw residues can interfere with some types of no-till planting equipment and can reduce the efficacy of certain herbicides. Thus while a straw mulch may under some circumstances increase available soil moisture, on deep soils and in south Louisiana where rainfall is usually well distributed or even excessive, this benefit may be marginal. Long term effects of straw burning on soil properties and soil erosion rates may be more important than short term yield effects, but these aspects have not been measured in Louisiana.

Preplant tillage for double-cropped soybeans has yielded mixed results. At the Dean Lee Research Station, Alexandria, La., over 4 years no-till and reduced-till double-crop soybeans yielded 35 bu/acre while conventionally-tilled sole-crop beans planted the same day yielded 44 bu/acre. Over 5 years in similar study at the Iberia Research Station, Jeanerette, both no-till double-crop beans and conventional-till sole crop beans averaged 46 bu/acre. At the St Joseph location, tillage increased the yield of non-irrigated double-crop soybeans an average of 5 bu/acre over 9 years, although the decrease has averaged only 2 bu/acre during the last 3 years. No significant difference in yields have been noted due to tillage before double-crop soybean planting at Baton Rouge over 5 years, at the Rice Research Station over 4 years, at the Red River Research Station, Bossier City, over 7 years, or at the Winnesboro location over 4 years. Recent improvements made in no-till planters have rendered no-till planting more reliable where weed control is adequate and compacted soil conditions are avoided.

No significant interactions have been reported between tillage and soybean varieties, herbicide combinations, fertilizer rates or timing, lime application, or irrigation treatments examined. Narrow row spacings (20 inches or less) appear to be superior to wide rows (40 inches) if chemical weed control is good. Irrigation has increased soybean yields at the Red River and Northeast Research station locations in northern Louisiana, but no response was seen in Baton Rouge from 1983 to 1985. Entomological studies[2] have indicated that bean leaf beetle and banded cucumber beetle are found in higher populations in tilled than in no-ti11 double-crop soybeans, while threecornered alfalfa hopper and green clover worm are more abundant under no-till conditions.

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[2] Troxclair, N. N. and D. J. Boethel. 1984. Influence of tillage practices and row spacing on soybean insect populations in Louisiana. J. Econ. Entomol. 77:1577-1579

Other No-Till Systems for Grain and Silage Production

Other no-till cropping systems which were investigated during 1984 and/or 1985 are identified in Table 3. Soybeans, corn, sorghum, rice, and forages have all received attention. Three systems which have been studied for several years or at several locations will be discussed.

Mono-crop soybeans

Sole-crop soybeans planted with reduced tillage have received limited attention. One study at the Red River Research Station indicated that there were no effects due to tillage, while at the Southeast Research Station, Franklinton, no-till was demonstrated to be superior. At the Northeast Research Station conventionally planted beans proved to be superior. As with all no-till studies, results are highly influenced by the available planting equipment, its adjustment, soil conditions at planting, and weather conditions after planting. At the producer level there appears to be considerable interest in adopting a "stale seedbed" form of planting. In this system, the soil is worked and smoothed well ahead of planting. Weeds are then allowed to germinate. Planting is done without further tillage and weeds are desiccated with a herbicide applied at a low rate.

Cover crops

Several studies have investigated using winter cover crops ahead of no-till planted summer-crops. Corn, sorghum, soybeans and rice have all been tested following legumes, ryegrass, and/or wheat cover crops. Stand establishment of corn, sorghum, and soybeans has been poor following several legumes and re-planting has often been necessary. Rice has successfully been established with no-till drill planting following legumes. Limited data indicate only a small response of sorghum following legumes to fertilizer N. Rice following clover has responded to 50 lbs N/acre and yield and total N uptake has been higher than with rice receiving higher rates of N fertilizer without a cover crop. In 1984, subterranean clover successfully reseeded following both flood and sprinkler irrigated rice crops yielding over 140 bu/ac.

Corn silage production in perennial grass sods

Research has been conducted at the Southeast Research Station to develop and evaluate methods of no-till planting of corn and sorghum for silage production on coastal plain soils. Several no-till planter arrangements have been evaluated for planting these crops into dormant bermuda and bahia sods, into ryegrass stubble, and into non-sod areas. In the perennial-sod plantings, the objectives are to manage the timing of seeding and the timing and rate of herbicide application to suppress the sod sufficiently to allow the silage crop to dominate, and yet leave the sod alive and capable of producing grazing or hay after silage is removed. Results indicate that no-till production of silage from corn planted in sod or non-sod and from sorghum planted in ryegrass stubble offers much promise. Three years continuous no-till silage production has been found to effectively eliminate an established bahia sod, with its replacement by common bermudagrass. A summary of corn silage dry matter production during 7 years of field plantings is presented in Table 4.

No-till Establishment of Forages for Winter Grazing

Winter annuals are an important component of Louisiana's livestock industry. Conventionally, winter annuals are planted into a prepared seedbed. Seedbed preparation, however, poses a serious erosion hazard on many areas devoted to grazing. Research at the Dean Lee Research Station demonstrated that ryegrass could be successfully relay planted into soybeans by aerially seeding it into the beans at one-half leaf drop. Sod seeding winter annuals into summer perennial grass sods has received attention at the Rice, Southeast, and Rosepine Research Stations. Factors examined include: summer perennial grass species, winter forage species, herbicide use, residue mowing, residue burning, drill vs. broadcast planting, and tillage. Bahiagrass, bermudagrass, and dallisgrass sods have been evaluated. In general, it has been found that seeding winter annuals into summer-perennial sods can increase total annual forage production 50-100%. Rye, oats, and ryegrass fertilized with N has usually produced more and earlier dry matter production than legumes. Ryegrass has produced the most total cool season dry matter, but rye and oats produced forage earlier. Legumes usually yielded more digestible dry matter during late spring than ryegrass. Ryegrass and legumes have their peak productivity after the normal initiation of sod regrowth in the spring. They can thus suppress regrowth although the decrease is usually more than offset by cool-season forage production. Reduced tillage planting methods often result in less early season (Fall) growth than that attained by the same species planted into a prepared seedbed. Drilling winter annual seed has been shown to be superior to broadcasting seed with or without subsequent disking. No real advantage has been shown between the use of clipping, herbicides, and/or burning prior to drilling winter annual forages into sod.

Future Directions

A number of different planters have been used in no-till studies, but these have seldom been directly compared. Several available planters and alternative tillage systems will be evaluated in future research. Recently a comparison of a John Deere "Max-emerge" and two in-row subsoiling planters was initiated at the Southeast Research Station. Other systems under consideration include the use of the Paraplow without subsequent disking, ridge tillage planting systems, and controlled traffic field management systems. Because of past recommendations relative to the value of deep plowing to prevent hardpan formation, many people feel regular tillage is needed. Questions are being asked on how long, in the absence of severe rutting, can a soil may be subjected to minimum or no-till procedures before soil physical conditions begin to cause decreased crop yields. An integrated state-wide effort is needed to determine the effectiveness of our several planters and tillage techniques on different soil types in different resource areas. Ridge tillage, for example, may afford too little erosion control on some rolling soils, but may be beneficial on some heavy, imperfectly drained soils in Louisiana where soil loss seldom exceeds tolerance values even with conventional tillage.

Cotton will receive a larger no-till research effort in the future. Development of conservation tillage systems for cotton was identified as the number one research priority by the Delta Area Soil Conservation Service Research Needs Committee in 1983. Research by L. W. Sloane at the Northeast

Research Station in the early 1970's demonstrated cotton could be successfully no-till planted into hairy vetch. There has been little follow-up research. Studies are planned to evaluate the combination of ridge tillage and legume cover crops for cotton production in Louisiana.

Future research efforts in Louisiana will be increasingly interdisciplinary. A need is recognized to monitor not only yield but also weed, insect, disease and nematode pressures; physical and chemical soil properties; and the nutritional status of our crops. Questions of how to take soil samples and how to interpret soil test results and make fertilizer recommendations for no-till culture will be addressed.

Table 1. Factors examined in reduced-tillage soybean-wheat double-crop experiments in Louisiana during 1984 or 1985.

Researcher Location	Till vs. no-till	Burn vs. nc burn	Irrig. vs. none	Row spacing	Soybean variety	Lime or fertil.	Weed control
Baton Rouge	X				X		
Baton Rouge	X						X
Baton Rouge	X	X	X				
Baton Rouge	X		X			X	
Baton Rouge	X					X	
Dean Lee	X			X			
Iberia	X						
N.E. (St. Joseph)	X	X	X				
N.E. (Winnsboro)	X	X	X				
Red River	X	X	X				
Red River					X		

Table 2. Effects of burning wheat residue, tillage and irrigation on yield on doublecrop Centennial soybeans, Winnsboro, La. 1982-1985.

Treatment	Yield, bushels/acre 1982	1983	1984	1985	4-year average
Irr-Burn-Till	39.0	39.0	37.6	26.6	35.6
Irr-Burn-No Till	40.5	40.6	35.4	21.4	34.5
Irr-No Burn-Till	39.1	39.8	39.0	29.4	36.8
Irr-No Burn-No Till	39.0	39.0	40.2	27.6	36.5
Non Irr-Burn-Till	25.9	19.0	26.6	18.1	22.4
Non Irr-Burn-No Till	25.1	20.6	24.3	15.7	21.4
Non Irr-No Burn-Till	32.4	17.3	30.3	25.4	26.4
Non Irr-No Burn-No Till	32.7	20.6	32.6	29.8	28.9

Table 3. Factors examined in experiments involving no-till grain and silage production for cropping sequences other than soybean-wheat double-crop in Louisiana during 1984 or 1985.

Researcher Location	Crop¶	Cover Crop	Irrig.	N Fertil.	Crop Rotation	Deep Tillage	Weed Control
Baton Rouge	c	X		X			
Baton Rouge	gs	X		X			
Baton Rouge	r	X		X			
aaton Rouge	r		X		X		
Baton Rouge	s,gs	X			X		
N.E. (St. Joseph)	s						X
N.E. (St. Joseph)	s,gs	X		X			
Rice	s,gs	X					X
Rice	r	X	X	X			
Southeast	c	X				X	X
Southeast	fs	X					

¶ c=corn, fs=forage sorghum, gs=grain sorghum, r=rice, s=soybean.

Table 4. Mean effect of seeding method, averaged over hybrids, on silage yield of corn, Franklinton, La. 1979-1985.¶

Seeding method,§ field condition	Dry yield, tons/acre 1979	1980	1981	1982	1983	1984	1985	7-yr. mean
Prepared bed	3.1	2.6	5.5	4.6	4.9	4.2	5.3	4.3
No-till, non-sod	5.5	3.0	7.0	3.8	5.1	5.6	5.5	5.1
No-till, sod#	3.8	3.0	6.0	3.4	2.9	3.3	5.7	4.0

¶ Data from field plantings of multiple acreages of several hybrids each year.
§ Seedings on prepared bed made with conventional 4-row planter. No-till seedings in 1979, 1980, and 1981 were made with 3-row Brown-Hardin Superseeder, in 1982, 1983, and 1984 with 4-row Cole no-till planter, and in 1985 with a 4-row John Deere Max-emerge adapted no-till.
# Averaged over plantings in bahia and bermuda sods.

Mississippi No-tillage Update Report

Edited by

James E. Hairston and Keith Remy

No-tillage systems of crop production have not been as widely accepted by farmers in Mississippi as in the midwestern farm states or even in some neighboring southern states. Mississippi had 161,171 acres in no-till in 1985 as compared to 749,727 and 4,791,354 in minimum and conventional tillage, respectively, according to the mid-March issue of No-Till Farmer (Vol. 15, No. 6, No-Till Farmer Inc., 260 Regency Court, Waukesha WI 53186). Adoption of complete no-till has been slowed by a number of primary factors, including unique soil resources, drainage characteristics, topography, and crop mix in major farming areas -- and by a number of studies indicating significant yield reductions in crops grown without some form of tillage. A closer look at Mississippi reveals why no-till farming has not been widely used and points to areas of the state where it has potential.

Mississippi encompasses a total land area of approximately 30 million acres. Major land resource areas of the state (shown in Fig. 1) are as follows: Southern Mississippi Valley Alluvium (Delta), Southern Coastal Plain, Southern Mississippi Valley Silty Uplands, Mississippi Blackland Prairie, and Gulf Coast Flatwoods. The loess deposits or Silty Uplands, commonly called Brown Loam, and Coastal Plain are further subdivided on a state level. General land use in the state is as follows: cropland 24 percent; pasture 13 percent; forest 56 percent; other agricultural lands 2 percent; urban and built up areas 4 percent: and small water areas (7 to 40 acres in size) 1 percent. The state's population is approximately 2.5 million and is 55 percent rural and 45 percent urban. The standard of living in Mississippi as measured by per capita income is just over two-thirds that of the U.S. average, and the overall economy is highly dependent on agriculture and forest products.

Average annual rainfall across the state ranges from 50 to 64 inches with the highest values near the Gulf Coast. Mean annual temperature ranges from 62°F in the extreme north to 68°F in the extreme south with an average of 194 and 264 frost free days, respectively. Thus, much of the state has a long growing season and is suited to a variety of doublecropping systems.

Approximately 22 million acres of land in Mississippi have an erosion problem. Of this total there are about 1.8 million acres, primarily in the Mississippi Valley Silty Uplands, which have a critical erosion problem. At least 2.5 million acres of productive agricultural land have a problem related to excess surface water during most years.

Acreages and recent changes in acreages of five major crops are given in Table 1. Soybean acreage peaked at 4.2 million in 1979 and has declined

Table 1. Acreages of major crops planted in Mississippi, 1978 to 1984.

Crop	1978	1979	1980	1981	1982	1983	1984
	1000 acres						
Soybean	3,900	4,200	4,000	3,800	3,700	3,200	3,300
Cotton	1,200	1,090	1,150	1,230	1,000	687	1,045
Wheat	100	150	375	650	1,100	7?0	770
Rice	220	210	250	340	250	162	195
Corn	215	190	170	180	150	100	120
Grain Sorghum	35	35	27	20	25	24	30
Total	5,670	5,885	5,972	6,270	6,225	4,893	5,460

Source: Mississippi Agricultural Statistics, 1978-1984, Supplement No. 19, Mississippi Crop and Livestock Reporting Service and USDA Statistical Reporting Service, Jackson, Mississippi.

by almost a million acres since that. time. Cotton and wheat rank second and third in total acreage, with approximately three-fourths of the wheat doublecropped on the same land base with soybeans. Other crops of importance include rice, corn, and grain sorghum, but the combined acreage of soybeans and cotton has made up 80 to 90 percent of the total cropland during the past 5 years. Grain sorghum increased by a factor of 10 or more in 1985 and 1986 acreage is expected to be near 0.5 million acres.

Most tillage research in Mississippi during recent years has been conducted on soybeans, under both monoculture and doublecrop situations. Tillage effects on cotton, wheat, corn and grain sorghum have been studied, but not to the same degree as with soybeans. Agronomic and short-term economic aspects of tillage intensity have been studied most, followed by engineering and physical aspects associated with compaction, soil density, runoff, and erosion. Both agronomists and weed scientists are familiar with the potential impact that weeds, especially perennials, may have on minimum-till and no-till systems and this problem has been researched thoroughly with a large variety of chemicals. However, little information has been collected on how tillage and specific chemicals impact not only plants, but insect and disease related ecosystems as well. Some studies currently underway or planned will look at selected soybean insect pests and their natural predators under a variety of tillage systems. This type of information is important in pest management programs within any cropping system.

Although climatic patterns in Mississippi are similar to those of other states in the Southeast and Midsouth, soil materials, topography and drainage characteristics of the most, commonly used agricultural soils in Mississippi are somewhat different from those of some neighboring states in the Region. The highest concentration of cropland in Georgia and Alabama, for example, is on medium to coarse textured soils in the Southern Coastal Plain and Southern Piedmont. In Mississippi, the highest concentration of cropland is found in the Mississippi Alluvial Floodplain, or Delta as it is commonly called, and the Blackland Prairie. Both of these land resource areas are dominated by soils which have fine to very fine texture. However, sizable acreages of cropland are found in the Interior Flatwoods of the Coastal Plains as well as in the flatter areas in the Silty Uplands (Brown Loam) and Upper Coastal Plain. The Lower Coastal Plain and Gulf Coastal Flatwoods in the southern third of the state are dominated by timberland. Soils of the Interior Flatwoods are predominantly of a silt loam texture and overlay acid shale that is impervious to water movement, thereby causing many of these soils to be waterlogged for long periods since most of the area has level to gently sloping topography.

Soybeans are grown throughout the state but predominantly in the Delta and Blackland Prairie. Cotton is grown primarily in the Delta but is still an important crop in some areas of the Brown Loam and Upper Coastal Plain. Wheat and grain sorghum are widely dispersed but grown primarily in the Delta and Blackland Prairie. Corn is grown everywhere but the Delta, while rice is grown only in the Delta.

Corn acreage is low in Mississippi (making up less than 5 percent of the cropland), and has decreased in recent years as has soybean acreage. Rice and sorghum acreage has fluctuated somewhat, but present acreages are similar to those of 5 years ago, with both making up about 5 percent of the total cropland. Wheat acreage has increased substantially in recent years, going from 100 thousand acres in 1978 to 1.1 million in 1982.

Although many soybean tillage practices, developed and supported by research, have been adopted by farmers throughout the state, few farmers have gone to complete no-till farming systems. The major reason for this can be related to results of field research conducted on fine and very fine textured soils in the Delta and Blackland Prairie, and other results from silt loam soils in other parts of the state. A number of researchers have found that complete no-till monocrop soybeans produce lower yields and lower net returns on fine and very fine textured soils most years and on silt loam soils of the Silty Uplands some years, in comparison to systems that use primary tillage. A similar trend has been found for doublecrop soybeans following wheat, although the differences are not as dramatic. On fine and very fine textured soils, soybeans planted no-till in standing wheat straw usually yield lower than those planted in a prepared seedbed. Several researchers have found that doublecrop soybeans planted no-till after burning wheat straw usually out yield those planted into straw on the fine and very fine texture soils in Mississippi. However, these beans do not usually perform as well as those planted in a prepared seedbed after burning wheat straw when moisture is adequate at planting. Although burning is not a practice recommended by most agronomists due to certain hazards associated with wild fires, smoke, and loss of organic matter, many farmers of fine textured soils utilize burning as a cheap and easy method of handling wheat straw regardless of whether they plant doublecrop soybeans no-till or in a prepared seedbed.

With good weed control, no-till monocropped soybeans generally compare favorably with or give improved yields over those of conventionally tilled soybeans on the coarser textured soils in the Coastal Plain. Any mulch, including wheat straw, appears to improve moisture use efficiency on coarser textured soils. This gives no-till doublecropped soybeans a favorable response over conventional soybeans some years. Even with comparable yields, net returns from no-till in the short term have not always been better than those for conventional methods. In many cases, the extra costs of chemicals needed for adequate weed control have more than offset the decrease in fuel consumption and equipment costs associated with no-tillage. However, if dollar values are placed on topsoil and nutrient losses due to erosion, no-till systems compare more favorably on many upland soils. Current research in Mississippi will evaluate the effects of various tillage intensities on long-term productivity of major upland soils in the Mississippi Blackland Prairie.

A large number of researchers and farmers now believe that any tillage practice which does not return more than it costs by increasing yield or improving soil conditions should be eliminated. Although thera are those who still adhere to and follow proven traditional practices because less risk is involved, the number who believe any tillage activity beyond that needed to assure optimum crop production and weed control has no value is steadily increasing. Tillage research conducted throughout Mississippi, thus far, indicates that the tillage requirement for optimum soybean production is variable and highly dependent on soil texture.

No one doubts that no-till or many forms of reduced tillage decrease soil erosion in summer row crops like cotton and soybeans, especially on upland soils. Mississippi data supports this fact. However, cotton is usually grown as a monocrop and a preferred practice is burying all residue with fall plowing. Fall plowing in the Delta and bottomland areas is also used to facilitate earlier planting the following spring. These areas are not usually prone to high erosion. However, during recent years more residue has been left on upland sites during winter months, and interest has increased in reduced tillage and the use of legume cover crops for nitrogen and erosion control in upland cotton.

Most cotton is grown on ridges to facilitate machine harvest. These ridges and the woody nature of stalks and roots interfere with no-till planting in the same row even after residue has been shredded. More research is needed to study the potential of no-till or reduced tillage in upland cotton. No-till cotton yields from upland Coastal Plain soils in north Mississippi have been comparable to yields from conventional planting methods.

Tillage research on fine textured soils with corn and grain sorghum is somewhat limited since neither is a major crop in Mississippi. However, grain sorghum seems to be replacing part of the acreage previously used to grow soybeans. General trends however, show that reduced tillage on the fine textured soils limits growth and yield of both crops most years in comparison to systems receiving primary tillage. However, these reductions are not as severe as those for soybeans and appear to be eliminated during years of good rainfall distribution. The fine and very fine textured soils of the Blackland Prairie appear to limit root growth and uptake of water and nutrients when primary tillage is eliminated. This is brought about by the high density and mechanical impedance associated with smectite type clays which exhibit tremendous forces during wetting and drying cycles due to shrinking and swelling. Apparently these soils can self compact to a density near 1.5 g/cm^3 as water is removed. Many of the fine textured soils in the Delta have similar clays. Primary tillage prior to planting prevents this self compacting effect during most of a single growing season, but by the next growing season the effect of primary tillage from the previous year has disappeared. Corn and grain sorghum have generally responded favorably to no-till on coarse textured soils, provided weed control has been adequate. Recently, there has been renewed interest in using legume cover crops in reduced tillage or no-till systems with corn or grain sorghum.

Very little research has been conducted on how tillage intensity affects wheat yields in monocrop on doublecrop systems. Little research data are available on the effects of fertilizer placement in minimum-till and no-till systems. Most tillage studies in Mississippi have been conducted without irrigation, and there is some indication that a strong interaction may occur between irrigation and tillage on the finer textured soils. If this is the case, many earlier conclusions would have to be re-evaluated. Irrigation could expand no-till production in the future, especially in association with doublecropping systems.

This brief overview and summary of no-till in Mississippi was prepared with input from the following scientists who are among some three dozen federal and state research workers involved in tillage studies at Mississippi State University Agricultura1 and Forestry Experiment Station and its outlying Branch Experiment Stations.

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Ned Edwards, Agronomist, Brown Loam Branch Station, Raymond, MS
Carl Hovermale, Agronomist, South Mississippi Branch Station, Poplarville, MS

MAJOR LAND RESOURCE AREAS OF MISSISSIPPI

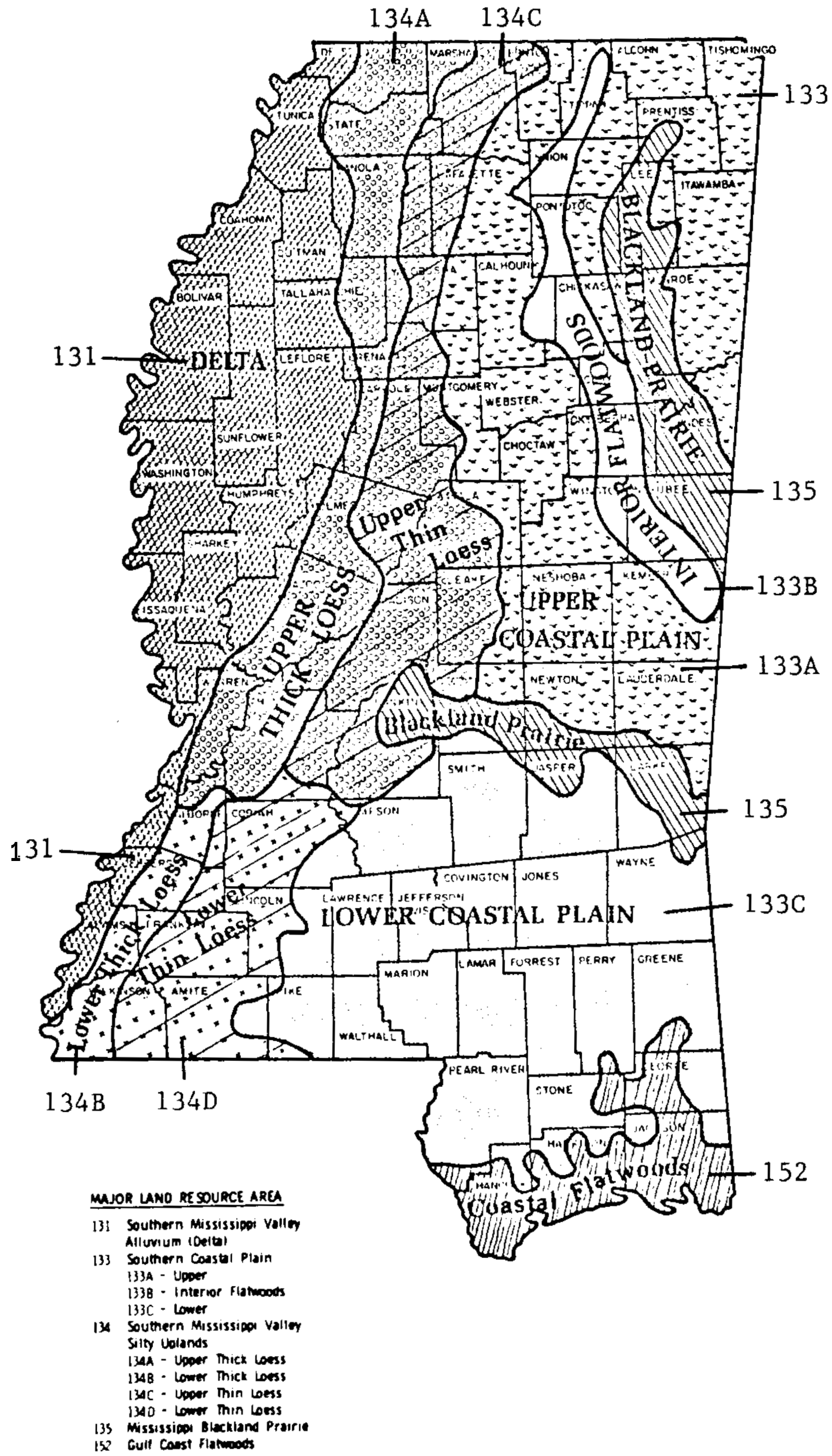

Figure 1.

NO-TILLAGE RESEARCH UPDATE - NORTH CAROLINA[1]

Edited by A. Douglas Worsham
Crop Science Department, North Carolina State University

EFFECTS OF TILLAGE SYSTEMS AND CROP ROTATION ON CROP PRODUCTION

Long-term experiments were established in 1984 at one Coastal Plain location and one Piedmont location to evaluate the effects of tillage system and crop rotation on certain soil chemical and physical properties and their relationship to crop growth and development. The 1985 growing season marks the completion of one cycle of each rotation (10). The first experiment consisted of two rotations (continuous corn and corn-soybeans) and three tillage systems (continuous conventional tillage, continuous no-tillage, and annually alternating conventional tillage and no-tillage). A second experiment consisted of a corn-wheat-soybean rotation with four tillage systems: 1) no-tillage for all crops, 2) conventional tillage for all crops, 3) no-tillage for soybeans only, and 4) no-tillage for corn and soybeans. All tillage and rotational sequences were fully established in 1985, consequently, only 1985 results will be discussed. Corn yield was significantly increased by no-tillage at the Piedmont location but was unaffected by tillage at the Coastal Plain location (Table 1). Full-season soybean yields were also unaffected by tillage at both locations. Both corn and soybeans showed no response to tillage in the previous year. Although data are not presented, corn yields were not influenced by the previous crop as well. Grain yield results for the three-crop rotation at the Piedmont location are shown in Table 2. As with the two-crop rotation, the corn yield response was highly significant in favor of no-till (9.1 vs 5.6 Mg ha^{-1}). Double-cropped soybean yields were also increased by no-tillage. In contrast, the only significant decline in grain yield due to no-tillage was with the wheat crop in the rotation (7.5 vs 4.0 Mg ha^{-1}). Tillage in the previous crop did not appear to have any effect on 1985 grain yield results. The effect of tillage system on soil compaction was also monitored in selected treatments and some of these results are presented in Table 3. After two years of maintaining various tillage systems and controlled traffic patterns, soil in the untrafficked interrow area was compacted to a greater degree in the no-till system compared to conventional tillage at both locations. However, on the basis of

[1] Authors contributing to this report were: J. R. Anderson, G. R. Bathke, U. Blum, R. L. Davis, H. P. Denton, R. P. Ewing, G. J. House, G. D. Hoyt, J. P. Lilly, T. J. Monaco, L. A. Nelson, D. P. Schmitt, T. J. Sheets, W. D. Smith, M. G. Wagger, R. H. White, J. S. Wilson, and 4. D. Worsham. The contributions of each author are appreciated very much and acknowledgement of each contribution is made by reference citation. Addendum - Contributing author, T. R. Konsler.

equal. or superior yield results in the no-till systems, it is not likely that these increased bulk density values were much of a limiting factor to crop performance and overall grain yields. It is of great interest to continue monitoring this particular aspect of these studies (10).

Table 1. Effect of tillage *on* corn and soybean yields.

1985	1984	Location		Location	
Tillage	Tillage	Coastal Plain	Piedmont	Coastal Plain	Piedmont
		----------Corn----------	Mg ha^{-1}	----------Soybeans----------	
NT	NT	9.7	7.4	1.7	2.5
NT	CT	9.9	7.1	1.8	2.5
CT	NT	10.1	5.2	2.0	2.4
CT	CT	10.1	4.6	1.8	2.4
		....	sig. level	------------------------	
NT vs. CT		NS	0.05	NS	NS

Table 2. Effect of tillage on grain yields in the three crop rotation.

Tillage Sequence	Corn	Wheat	Soybeans
	------------------	Mg ha^{-1}	------------------
NT Corn–NT Wheat–NT Soybeans	9.0	3.5	2.9
NT Corn–CT Wheat–NT Soybeans	9.2	4.1	2.9
CT Corn–CT Wheat–NT Soybeans	5.6	4.0	2.9
CT Corn–CT Wheat–CT Soybeans	5.5	3.8	1.9
	----------------	sig. level	----------------
NT vs. CT	0.01	0.05	0.01

Table 3. Soil compaction as affected by tillage system and row position.

1995	1984	Interrow Area		Interrow Area	
Tillage	Tillage	Trafficked	Untrafficked	Trafficked	Untrafficked
		------------------------	D_b, Mg m^{-3}*	------------------------	
		Coastal Plain		Piedmont	
NT	NT	1.64	1.47	1.62	1.52
NT	CT	1.66	1.76	1.67	1.44
CT	NT	1.57	1.24	1.51	1.22
CT	CT	1.58	1.25	1.46	1.70

* Sample area represents the surface 2-10 cm of soil

SUBSOILING AND COVER CROP INTERACTIONS IN CORN

In the Southeastern Coastal Plain, subsoiling is done to increase the access of plant roots to available subsoil water. Winter cover crops can also aid in conserving soil water during the growing season. This experiment examined the interaction of subsoiling and cover crops on water use, growth, and yield of corn. Three cover conditions at planting (bare, wheat, or crimson clover) were tested with and without subsoiling (4). During early spring the cover crops depleted surface moisture substantially, and corn planted into cover grew more slowly. However, by the onset of tasseling (day 59), dry matter accumulation in cover crop plots which were subsoiled was nearly that of the bare plots, and tasseling was delayed only 2 days as compared to 4 days for nonsubsoiled cover cover plots. Final yields were not affected by cover in the subsoiled plots, but were substantially reduced by cover in nonsubsoiled plots. Data are summarized in Table 4 (4).

Table 4. Soil water at planting, above-ground plant dry weights, and grain yield.

Cover Condition	Sub-Soiling	Soil water* at planting kg/kg	Plant dry weight, g/plant ---days after planting--- 31	59	102	Grain yield Mg/ha
Bare	Yes	0.107a	8.0a	86.7a	258.6a	6.5a
Bare	no	0.107a	9.1a	80.1a	264.0a	5.7b
Wheat	Yes	0.076c	3.3c	64.6b	264.5a	6.4a
Wheat	no	0.076c	2.7c	57.8b	207.4b	4.5c
Clover	yes	0.081b	4.2b	79.0a	304.9a	6.4a
Clover	no	0.081b	4.0b	58.9b	209.4b	4.3c

* Represents soil water content in the upper 90 cm of soil.

WINTER-ANNUAL LEGUMES AND FERTILIZER PLACEMENT METHODS IN NO-TILLAGE CORN

Since 1982, efforts have been made to evaluate the potential of winter-annual legumes as nitrogen sources and mulches for no-tillage corn production systems in the North Carolina Coastal Plain. In six experiments, hairy vetch, Cahaba White vetch, Austrian winter pea and Tibbee clover produced adequate dry matter and top growth nitrogen to function successfully as mulches for no-tillage corn in comparison to fallow systems supplied with fertilizer nitrogen. Hairy vetch consistently produced the highest corn yields; fifty pounds per acre of fertilizer N was the optimum fertilizer nitrogen rate for legume systems. Incorporation of a hairy vetch cover crop prior to corn planting produced yields equivalent to the corn planted without tillage into undisturbed vetch (in a two-year study where soil moisture was plentiful during grainfilling periods). In-row subsoiling for corn was required for maximum yields in the winter-annual/corn rotation. Removal of the vetch for forage reduced corn yield unless additional fertilizer nitrogen was supplied. Planting of corn into killed strips of the hairy vetch cover crop reduced corn yields whether the remaining cover crop was killed at two or four weeks after corn planting or allowed to mature in the row middles. Three years of experimentation indicated that starter fertilizers may improve no-tillage corn yields in some seasons. Placement of UAN solutions in dribbled surface bands close to the corn row (approximately 6" to one side) produced higher corn yields than surface bands placed in the row middle (on 36" row spacings). This effect may be offset, in some situations, by use of a starter fertilizer in 2 x 2 placement. Many N.C. corn growers have adapted the no-tillage plus subsoiling implements to their corn production systems and wish to place a starter fertilizer in the subsoiler track. In 1985, a device was developed that uniformly distributes fluid fertilizers in the subsoiler track. Preliminary experiments indicate that uniform distribution of fertilizer in the subsoiler track produces a "starter" response equivalent to that observed with 2 x 2 placement (1).

SOIL STUDIES OF TILLAGE SYSTEMS FOR CORN PRODUCTION

Nine tillage systems for corn production have been tested for two years at two Piedmont locations (3). The tillage systems are fall moldboard plow-spring disk, spring moldboard plow-spring disk, fall chisel plow-spring disk,

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spring chisel plow–spring disk, spring disk only, fall chisel plow only, spring chisel plow only, no-till, and no-till with in-row chiseling. In 1984, a wet year, there were no yield differences between systems at one location. At the other location, poor stands and serious weed problems resulted in lower yields in no-till than in conventionally tilled treatments. In 1985, a drier year, no-till and chisel plowing without disking resulted in higher yields than the conventionally tilled systems at both locations. Bulk density measurements indicated no compaction problems in any system in untrafficked areas. All systems had high bulk densities (1.60 - 1.55 g/cm^3) in trafficked areas, indicating a possible compaction problem in continuous no-till if traffic is not controlled (3).

ROLF OF LEGUME COVER CROPS IN NO-TILL CORN

The use of legumes in conservation tillage production systems may provide significant quantities of fixed nitrogen while conserving soil and water resources. Research has been conducted the past two years to determine the influence of winter cover crops in a conservation tillage corn system with regard to: 1) N cycling and 2) soil-plant-water relationship (8). Another objective was to evaluate the adaptability of various legumes to North Carolina soil and climatic conditions. In this study, the experimental design consisted of four cover crop treatments (no cover, rye, crimson clover, and hairy vetch), three cover crop-corn/time of burndown-planting combinations (early kill-early plant, early kill-late plant, and late kill-late plant), and three rates of fertilizer N (0, 100, and 200 kg ha^{-1}). There was approximately a 2-week interval between the early and late corn planting dates. Grain yield results (2 yr. avg.) are shown in Table 5 and represent mean values averaged across all burndown-plant combinations. The soil water status in the no-cover treatment appeared to limit the yield response to fertilizer N, as grain yield only increased up to the first 100 kg of N In contrast, with rye as cover crop, grain yield increased with increasing N rate. The wide C:N ratio of this cover crop and associated N immobilization potential was most likely a contributing factor in this response pattern. even with no fertilizer N applied, grain yields for the legume cover crop treatments were comparable to yields obtained with the no cover and rye cover treatments receiving 180 kg N(8).

Table 5. Effects of cover crop and N rate on corn grain yield, 1984-85.

Cover Crop	N Rate (kg ha^{-1}) 0	100	200
	----------Yield, Mg ha^{-1}	----------	----------
No cover	5.9	7.6	7.9
Rye	4.4	7.1	7.9
Crimson clover	7.6	8.3	8.6
Hairy vetch	8.1	8.6	8.6

TILLAGE-CROP ROTATION INTERACTIONS ON WEEDS, NEMATODES AND NUTRIENTS

A long-term. tillage-crop rotation study involving corn, soybeans and wheat was established at the Tidewater Research Station on a high organic: soil (14). Tn the fifth year of the experiment, 1955, all plots were planted to soybeans. Tillaqe treatments on corn and wheat in 1984 previously af fected lesion and stunt nematode population levels. Lesion populations tended to be greatest in plots continuously tilled, whereas their numbers were lowest if corn was planted no-till in 1984. The fewest of these nematodes occurred in plots planted no-till to corn but plowed, disked and planted to wheat. This latter treatment also gave low population densities of the stunt nematode. Tn contrast to the lesion nematodes, greatest population densities of the stunt nematode were found after continuous no-till. In 1985, each plot was subdivided, half treated with aldicarb and half left untreated. The stunt and lesion nematode populations were lower in aldicarb treated subplots than in untreated ones at 74 and 69 days after planting. The number of plots with detectable populations of the soybean cyst nematode increased from planting of soybeans in 1985 to 69 days later. Increases in incidence of various life stages were: juveniles -from 5% to 65%, cysts - from 45% to 50%, and eggs - from 40% to 50%. Late-season data will be needed to determine the impact of aldicarb on population resurgence. Weeds were still not a major problem in any of the treatments. The herbicide program for soybeans in 1985 was: linuron + paraquat was used preemergence and aciflurofen + crop oil concentrate was used as an early-post-emergence treatment for broadleaf weeds. There was more morning glory in the tilled plots as compared to the no-till. All plots were relatively clean in late-season. Grass control was not a problem. In 1985, there were no differences in stratification of P and K with regard to tillage. P and K were higher at the surface in all treatments. According to the P and K index, P was about 80% higher in the surface and K was 65 to 75% higher at the surface than lower depths. Nutrient cycling is probably responsible for no more changes in stratification than this. Differences in soil pH were very small. There were no differences in plots that were bottom plowed. pH in chiseled and disked plots was 0.13 lower in the surface as compared to deeper and pH in no-till plots was 0.1 lower in the surface as compared to deeper (14).

NEMATODE CONTROL IN CONVENTIONAL AND NO-TILL DOUBLE-CROPPED SOYBEANS

Efficacy of nematicides to control selected nematodes, with emphasis on Heterodera glycines, was determined in no-till and conventional-till planted soybeans over a 3-year period from 1981-87 (8). Greatest numbers of H. glycines eggs were recovered in conventionally-tilled plots. Population of Tylenchorhynchus claytoni were lowest in in-row subsoiled no-till treatments and highest in no-till, nonsubsoiled treatments. Nematicide effects were not consistent across years as mensured by population densities. Yields were greatest in in-row subsoiled no-till plots treated with EDB. The soil characteristics which influence water movement seem to be important for nematicide performance (8).

CONSERVATION TILLAGE FOR VEGETABLES AND TOBACCO

Conservation-tillage research involving vegetables and tobacco have mainly focused on the use of various cover crops as residue in a strip-til1 system (5). Experiments with the various commodities have shown that cover crop residues do influence growth parameters and yields (Table 6). The strip-till tobacco production system yields well when rye and Austrian winter peas have been used. The various vegetable crops, however, seem to yield better when legume cover crops are used than when grass cover crops are utilized. All commodities were produced under optimum conditions (including fertilizer) except for irrigation. Various tillage systems have also been established to measure the yield potential and constraints of conservation tillage on seeded and transplanted vegetable and tobacco crops. Yield results indicate that production under conservation tillage can compete competitively with conventional culture (6). Conventional tillage does appear to yield better when early season varieties or commodities are grown, but full-season or "normal" season crops yield similarly regardless of tillage methods (Table 7).

Table 6. The effect of cover crop on tobacco and vegetable yields.

Cover Croe	Tobacco lbs/A		Cabbage T/A	Broccoli T/A	Tomato T/A	Potatoes T/A
	Brevard Soil	Dyke Soil				
Bare		1988	29.4	6.2	78.3	19.3
Cultivated	2605		31.1			
Rye	2921	2207	26.9	6.6	34.4	17.8
Barley	2680	1989	25.7			16.9
Ryegrass			24.6			
Wheat	2646		25.0			
Crimson clover		2046	28.9	6.5	38.9	18.0
Vetch		1950	29.7	6.9	79.1	17.8
Peas	2918					

Mean yields from two years data.

Table 7. The effect of tillage on various vegetables and tobacco yield.

	Marketable Yield by Commodity, Ton/A							
				Squash	Broccoli		Sweetcorn	Tobacco
	Tomatoes	Cabbage	Snap Beans	Acorn	Spring	Fall	ears/A	lbs/A
Conventional	46.1	'54.0	18.6	18.8	6.6	4.8	22172	2425
Strip-till	50.8	33.4	15.5	15.2	5.5	4.1	22058	2225
No-till	49.4		15.5	20.9	5.4	3.9	19970	2244
LSD(.05)	NS	NS			.9	.6	NS	NS

SOIL CONSERVATION AND TILLAGE SYSTEMS FOR TOBACCO

In 1984, a year characterized by intense storms and greater than normal precipitation (170mm during July through Sept.) runoff and erosion losses from tobacco planted on Cecil soil with a 6% slope were 42.1 mm and 16768 kg/ha from conventional tillage (CT) (fall moldboard plow, spring disc and ridge, cultivation), 40.7 mm and 18615 kg/ha for conventional tillage without cultivation (NC), and 35.9 mm and 1757 kg/ha from reduced tillage (RT) (fall moldboard plow, disc and ridge, and a cover crop) (2). A higher percentage of fines, though lower in actual mount, were eroded from the RT treatment. Tobacco yields were reduced 10% by NC (2360 kg/ha) and 14% by RT (2274 kg/ha) treatments compared to CT (2630 kg/ha). In 1985, a year characterized by less intense storms and near normal precipitation levels (202 mm from May to Sept.), runoff and erosion losses from tobacco on Appling soil with a 5.5% slope were 29.0 mm and 9361 kg/ha for CT, 36.1 mm and 9629 kg/ha for NC, and 35.5 mm and 1502 kg/ha for RT, respectively. As in 1984, a greater percentage, but less in actual amount, of fines were eroded from the RT plots. The erosion event characteristics changed markedly as the growing season progressed, with very large storms near the end of August producing large amounts of runoff but very little soil loss, with the RT treatments producing the least soil loss. Texture of the sediments varied between treatments and varied across time, with the NC and CT plots producing coarser sediments than the RT plots. The NC treatment reduced tobacco yield 7% (2634 kg/ha) compared to the RT (2807 kg/ha) and CT (2818 kg/ha) treatments. Detailed analysis of soil physical properties and plant characteristics of these and 9 more treatments are being done at this tine (2).

NO-TILL TOBACCO WEED CONTROL RESEARCH

Weed control in no-till tobacco was variable in 1985 (I3, 15). Plots with good weed control yielded well. No-till tobacco in one test on a clay soil yielded 38% less than conventional, one test on a sandy loam soil, 32% less and in another test, 20% less. No-till burley tobacco yielded as much as conventional. Over the last 4 years, no-till burley yeild has been equal to conventional yields. In a variety test in no-till flue-cured tobacco, higher yields (7015 and 3085 Ib/A, respectively), were obtained with K-326 and NF-28 over C-319, NF-22, 5-70 and NC-82 (averaging 2502 lb/A). Most no-till plots where registered herbicides were used had to have some hand weeding to attain acceptable weed control. A fertility test site was infested with morningglory and control was poor. All conventional tobacco out-yielded the no-till and had a higher price per lb., although grade index was not different. In the conventional and no-till tobacco, the higher rates of fertilizer tended to increase yields. This resulted in lower quality in the conventional but not in no-till. Two on-farm no-till tests in flue-cured tobacco were heavily affected by drought and all no-till treatments yielded about 400 lb/A less than conventionally tilled and fertilized tobacco. In general, the no-till tobacco seemed to be more adversely affected by drought than conventionally tilled tobacco. This might have been caused by the water shedding effect of the firm, untilled soil plus the funneling of water by the raised row ridges and early depletion of soil moisture by the cover crop of rye. Tillage and fertility treatments in the on-farm tests which included: in-row subsoiling, injected fertilizer, and surface applied fertilizer to no-till tobacco did not result in mensurable differences in cured leaf yield or quality and all treatments yielded less than conventionally grown tobacco (13, 15).

CONTROL OF BARD-TO-CONTROL WEEDS IN NO-TILL CORN AND SOYBEANS

Field studies were initiated in 1985 to evaluate the combined tankmix interactions of several broad spectrurn contact and systemic herbicides relative to individual burndown treatments alone for hard-to-control weeds (12). Results in corn indicated paraquat plus 2,4-D gave better control of horseweed and Virginia pepperweed than paraquat alone. Glyphosate or glyphosate plus 2,4-D) gave better control of the weeds studied than paraquat or paraquat plus 2,4-D. Glyphosate or paraquat plus 2,4-D gave significantly better yields than either glyphosate or paraquat alone. Results in soybeans indicated that glyphosate, paraquat plus linuron, glyphosate plus 2,4-D, glyphosate plus dicamba and glyphosate plus alachlor were excellent on common lambsquarters and horseweed. The addition of 2,4-D to paraquat improved control of all weeds over paraquat alone, although 2,4-D rates may need to be higher than 0.56 kg/ha to obtain better control. The addition of dicamba to paraquat or glyphosate improved control, but caused crop injury. Subsequent studies revealed that soybeans planted two weeks after dicamba applications of 0.15 or 0.28 kg/ha were not injured. Paraquat plus linuron, glyphosate plus 2,4-D, glyphosate plus alachlor gave significantly better yields than all other treatments (12).

CONTROL OF LEGUME COVER CROPS IN NO-TILL AND ALLELOPATHIC EFFECTS

Field studies were initiated in 1985 to investigate different herbicide combinations and rates of application to improve initial kill of legume cover crops prior to planting corn and cotton (11). Consistent with other legume cover crop studies, corn and cotton planted into hairy vetch outyielded that which was planted into crimson clover (by 926 kg/ha and 149 kg/ha, respectively). Plots treated with combinations such as glyphosate or paraquat/2,4-D or dicamba generally produced greater yields than plots treated with the former two separately (612 kg/ha more for corn and 256 kg/ha more for cotton); plots treated with paraquat usually had higher yields than those treated with slower-killing herbicides. Overall, hairy vetch was more easily killed than crimson clover. Throughout the growing season, corn and cotton plants were taller in the vetch whole plots. Nitrogen differences and allelopathy were suspected. Although vetch had 187 kg/ha total N in the above-ground biomass versus 136 kg/ha N for clover, crop tissue analysis for N, however, did not reveal higher N levels in plants from the vetch plots. Differences in yield of corn between vetch and clover were correlated to differences in stand, with poorer corn stand in clover. Differences in yield of cotton between vetch and clover are not explained. To investigate possible allelopathic interactions, germination studies using water extracts of each legume at full (5g dry wt./150 ml water) one-half and one-third strength concentration levels were conducted; corn, cotton, wild mustard, morningglory and goosegrass were used as bioassay test species. Reductions of 25-90% in germination rates and seedling dry weights were found. Debris studies also revealed significant inhibition of emergence and growth of corn and cotton planted in pots in which 4 levels of legume dry matter (0, 1.67, 3.77 and 6.67 mg/g soil) were incorporated. Plants grown in pots with legume remaining on top of soil showed no reductions in seedling emergence, plant height, or dry weight. Future studies will examine possible allelopathic interactions between legume roots and the test species. It is planned to repeat the field studies in 1986 (11).

WEED CONTROL IN NO-TILL STAKED TOMATOES

Preemergence and postsmergence herbicides were evaluated in no-till and strip-till plantings of tomatoes in a rye cover crop which had been killed with paraquat (7). Diphenamid, napropanide and cinmethylin provided excellent control of goosegrass (Eleusine indica) and common lambsquarters (Chenopodium album) in both the no-till and striptill systems. The same was true for tank-mix combinations used in both systems. Trifluralin at 1 lb/A applied prior to tillage in the strip-till planting did not provide adequate weed control. Chloramben followed by either sethoxydim or fluazifop a month later provided good weed control in the no-till system. However, chloramben csused significant injury initially. Two months following application no injury was apparent. However, chloramben treated plants were delayed in maturing fruit. Overall, none of the herbicide treatments reduced yield in either system. ?he weedy check in the no-tillage planting yielded in the same range of all other treatments, whereas the weedy check in the strip-tillage planting did not. The rye mulch in the no-tillage weedy check provided approximately 50% weed control perhaps accounting for the better yield obtained. In general, a trend towards higher yields was observed with the strip-tillage planting compared to the no-tillage planting *(7)*.

HERBICIDE AND TILLAGE EFFECTS ON SOIL ARTHROPODS

Studies have been initiated to elucidate the effects of two commonly used herbicides, glyphosate and paraquat, on soil arthropod number and activity in nc-tillage systems and to quantify the impact of conventional and no tillage practices on the soil arthropod community (5). For the first gear tillage had a greater impact on soil microarthropod numbers than herbicides. Treatments without tillage, regardless of the kind of herbicides applied, supported higher numbers of microarthropods (e.g., Collembola and mites) than tilled treatments. Length of time without tillage had a significant ($p<0.05$) effect on microarthropod density. Soil microarthropod numbers were 10-fold higher in treatments two years without tillage than in those one year without tillage. In no-tillage systems, differences between herbicide treatments were detected for surface crop residue-dwelling microarthropods. On two sampling dates, higher microarthropod numbers were collected from the surface crop residue of nonherbicide than herbicide treated no-tillage plots, probably as a consequence of a more moist litter layer due to the dense weed and crop canopy. However, in the soil surface (0-3 cm depth), similar numbers of microarthropods were collected from both herbicide and nonherbicide treated plots. Soil macroarthropods (e.g., spiders, ground beetles) were most abundant under weedy, no-tillage conditions. Clean (i.e., herbicide-treated) no-tillage treatments often sup ported fewer arthropods than nonherbicide no-tillage treatments. Indirect effects of herbicides on habitat modification, especially floral diversity, are implicated. Decomposition (weight loss) of nonherbicide surface crop residues may be more rapid than herbicide-treated as a consequence of different microclimatic effects within the treated soil-litter subsystem (5).

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OKLAHOMA TILLAGE UPDATE REPORT
BY

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A series of tillage studies were initiated in Oklahoma in 1981-82 as the result of renewed interest by farmers and the Oklahoma Wheat Commission. Historically reduced tillage for wheat production in Oklahoma had been associated with reduced yields. Weed control, stand establishment, dieseases, insects and fertilization each had been suggested as potential causes of the reduced yields. New equipment, herbicides, emphasis on energy conservation, and renewed emphasis on erosion control resulted in a necessity to investigate the advantages and disadvantages of reduced tillage systems.

Plots were set up with different tillage systems designed to evaluate the impact of different levels of prior wheat crop residue remaining on the soil surface after planting. In Oklahoma the majority of wheat acreage is planted where wheat is grown every year for decades. Thus, these plots were designed as a monoculture yearly wheat production system with the same tillage practice remaining on each plot for the duration of the study.

Table 1 lists the treatments, ground cover and yield data from the residue management studies. These studies are in the fourth year at three locations. We have been encouraged since yields in the minimum tillage plots have been equivalent to clean tillage except for two locations in the third year. At one location the wheat was planted under damp conditions and many of the seed were deposited in straw rather in firm soil. This has been our only planting or stand establishment problem. We have not determined the reason(s) for the low yields in the minimum tillage plots at the second location in 1984-85. Overall, yields of no-till and subsurface tillage have been competitive.

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Table 1. Ground Cover And Grain Yield For Different Tillage Systems.

Tillage System	Residue Level	Ground Cover* (%)	3 Yr. Ave. Yld.** (Bu/A)
Moldboard Plow, disc.	minimal	8	38
Disc	low	25	39
Subsurface	intermediate	80	37
No-Till	maximum	95	36

*Ground cover average of three locations after planting the fourth crop of wheat.

**Grain yield average of three locations across three years. Subsurface tillage was accomplished with a 6-8 foot v-blade followed by a single treader.

Wheat tillage plots at four Oklahoma locations have consistently shown significant reductions in greenbug numbers where residues were left on the surface. The southwest Oklahoma location showed the greatest difference between tillage practices. At this location the moldboard plow plots had a mean number of greenbugs of 250 per row foot and the no-till plots had only 10. At another location, adding straw to existing conventionally tilled plots substantially prevented greenbug increases. No-tilled plots with residues removed by burning or raking had a reduced number of greenbugs when compared to conventionally tilled plots, indicating that more than just residues are responsible.

Sorghum plots have also shown that greenhugs are reduced under a reduced tillage situation. Continuous sorghum and wheat-fallow-sorghum-fallow plots both showed a reduction in greenhug numbers from 900 per plant when these treatments were conventionally tilled to less than 300 per plant under a no-till situation. In another study a significant reduction in greenhug damage occurred even though one-half of the residue had been removed.

Apparently, surface residues act as a reflective mulch. This reflective situation either repels the immigrating migratory greenbugs or masks the attractiveness of the soil surface. Soil condition and canopy, perhaps acting as a reflecting background, also have an influence on the number of greenhugs. We are continuing to observe the responses on large fields, however, plot or field size will probably not be a factor since this is a behavioral response of to the greenbug. At this point, residue management and other reduced tillage practices appear to be effective tools for managing greenbugs.

Diseases and nematodes have been monitored in these tillage studies. Initially some people predicted gloom because diseases and insects might be much more problem in minimum tillage monoculture wheat. However, as noted above, we have already seen that greenbugs responded exactly in reverse. It is a general opinion among wheat workers that reduced tillage practices increase the incidence and severity of the foliar diseases septoria tritici blotch and pyrenophora tan spot. Initial infection of wheat in Oklahoma by the blotch pathogen, Mycosphaerella graminicola (anamorph, Septoria tritici), occurs during fall rains. Since only the Septoria state of the pathogen has been observed in Oklahoma, asexual spores released from fruiting structures in old leaf lesions are the presumed primary source of inoculum. The tan spot-inciting fungus, Pyrenophora tritici-repentis (anamorph, Dreschlera tritici-repentis), produces both sexual fruiting bodies and asexual spores on infected straw and stubble. Since some level of these diseases develops in the crop each year, tillage practices that leave infected leaf and straw tissue above ground expectedly would increase their incidence in the following wheat crop. To determine effects of tillage modes on septoria tritici blotch and tan spot, we counted septoria lesions per gram of flag-2, and penultimate leaves; and tan spot lesions per gram of flag-2 and flag leaves. The leaves were randomly collected from plants grown in the same tillage plots described earlier.

Results indicated that tillage method had little or no effect on development and severity of septoria tritici blotch. Among eight data sets, only two (collections made in April and May 1983 at Stillwater) indicated that plowing under plant refuse significantly reduced the number of lesions that developed in flag-2 and penultimate leaves.

The number of tan spot lesions which developed in leaves of plants grown in plowed and disked plots were similar in all but one instance (collection made in May 1983 at Altus) (Table 2). The data strongly support the hypothesis that covering infected straw with soil will significantly reduce the incidence of tan spot. We believe that the lack of discretely different levels of infection between plants grown in clean and near-clean tillage plots (plowed and disked) and those grown in subsurface and no-tillage plots resulted in part from contamination by spores carried by wind from one plot to another.

Table 2. Effect of tillage systems on tan spot levels in winter wheat.

Tillage System	Lesion/Gram of Leaf Tissue					
	Flag -2 Leaf		Flag Leaf			
	Altus		Altus		Stillwater	
	4-11-83	4-9-85	5-23-83	5-10-85	5-24-84	5-17-85
Moldboard	2a*	85a	70a	175a	115a	735a
Disc	6ab	114ab	92b	227ab	118a	881ab
Subsurface	9bc	194c	110bc	276ab	117a	1364b
No-till	11c	123ab	16c	347c	142a	898ab
C.V.(%)	78	24	14	29	39	39

*Lesion numbers followed by the same letter indicate that the treatments are not significantly different according to either an LSD test or Duncan's multiple range test.

On these same plots the effects of surface straw residue on microbial populations are being studied. Soil fungi, actinomycetes, bacteria, and total microbial population were determined in 1984-85 crop season as part of the pre-, post-plant and at harvest soil sampling. At Stillwater, subsurface tillage resulted in significantly greater post-plant and harvest total soil fungal populations (includes pathogenic and nonpathogenic fungi) than in the plow treatment. Similarly at Altus, total soil fungal populations were significantly higher at harvest for the subsurface tillage compared to plow tillage, and the soil fungal populations were higher, but not significantly at post-plant sampling.

Soil actinomycetes, bacteria, fungi and total microbial populations at both locations were directly affected by soil moisture. At Altus, microbial counts increased from post-plant to harvest sampling periods reflecting the post-plant (12%) to harvest (22%) increase in soil moisture (gravimetric 0-4 cm depth). No fluctuations in populations were seen over this period at Stillwater because soil moisture (14%) was the same at both sampling periods.

At both locations, soil bacterial populations decreased as surface residue levels increased, as contrasted with the general tendency for increased soil fungal populations. At harvest, populations of soil bacteria were higher regardless of treatment at Altus than at Stillwater as a result of the wetter soil conditions at this location. We will be looking at these effects with regard to the rhizosphere populations and root populations in the next season.

Populations of pin, Paratylenchus projectus, stunt, Merlinius brevidens and root lesion, Pratylenchus spp. nematodes are also being monitored. To date neither biologically nor statistically significant differences have been measured in the tillage studies.

No pest discussed thus far has developed as a distinct problem in minimum tillage contrasted with clean tillage. However, the first problem which became apparent was the higher population of cheat, Bromus spp., in the subsurface and no-till plots. In these plots the cheat levels have been held to a noncompetitive level with careful variety selection and herbicide applications. For a farmer to do this he can use only two herbicides and four wheat varieties and then only if the soil pH is not too high and the soil texture not too coarse. Thus, cheat control remains as a limitation to widespread use of minimum tillage for wheat production in Oklahoma.

Another attempt to control cheat has been with triazine herbicides. These herbicides, such as atrazine and cyanazine (Bladex), can effectively control cheat and are relatively inexpensive. However, wheat has little relative selectively to these herbicides. A research program was initiated to develop a no-till drill to improve crop safety by providing placement selectively at planting.

To provide placement selectivity, triazine herbicides are applied as a broadcast spray prior to planting wheat with an experimental no-till hoe drill. This drill consists of an air seeder metering unit mounted on a frame attached to the three point hitch of a tractor. A coulter with depth bands for gauging, hoe opener, and Vee press wheel are mounted on a box beam which is attached to the drill with a 4-bar linkage. The specially design hoe opener moves the triazine treated soil, along with cheat seed, out of the drill rows and into the middles. The Vee press wheel firms the furrow walls, preventing the cheat seed and the herbicide treated soil from falling back into the furrow. The triazine herbicide and cheat are concentrated between the rows, leaving the rows free of cheat, and providing a herbicide free zone in which wheat can germinate and emerge.

First year's research showed that placement selectively could be obtained for atrazine with modified hoes or with concave discs to move atrazine treated soil from the row. The second year's research will refine the drill design, investigate use of cyanizine as well as atrazine to control cheat, and evaluate effect of application rates and soil type on cheat control and wheat injury. Yield data from the first year and crop injury and weed control ratings from current experiments indicate that this system will provide good cheat control without yield reduction under no-till conditions.

We have also been particularly interested in any changes in fertilization requirements as we change tillage systems. Currently, we suggested that when much of the straw is left on the soil surface that farmers apply 30-40 pounds of additional nitrogen. Phosphorus studies have also been conducted and placement seems to have little affect as long as it is placed in the soil rather than on the surface. The exception to this occurs in situations where phosphorus soil test is quite low. Under these conditions placement close to the germinating seed has been beneficial. Effects of tillage on ammonia volitization is also being studied but these studies have not been concluded.

Soil moisture has also been monitored on these residue management studies. Differences have been apparent in the top two to three inches where higher levels of soil moisture have frequently been observed in the mulched plots, allowing us to establish a wheat stand at earlier dates on no-till plots than on clean tilled plots. This has been important in Oklahoma where wheat is grazed in the fall, winter and early spring if enough growth is obtained. It was hoped the earlier establishment would result in greater forage yields. However, forage yields have not consistently been better even when establishment occurred one month earlier on no-till than moldboard plow plots. Wheat grain yields have not been improved by water conservation as a result of leaving mulch on the soil surface. This has surprised us and we are not sure of all the reasons yet. One reason is that the mulch has not given us the large differences in soil moisture which has been reported by others.

Economics is a very important factor in farmer acceptance of management changes. Because yields have been equal between the tillage systems, profit potential has been controlled by input costs. No-till costs more than moldboard or discing and therefore profits have not been as good. Some of the one and two tillage systems have been economically competitive, but because of cheat control limitations are not widely used in Oklahoma.

Farmers are aware of erosion in Oklahoma and see the benefits of minimum tillage for erosion control and a small acreage is managed in this manner because of erosion, but much more would be if there were more economic benefits and cheat could be controlled more reliably.

Effects of Conservation Tillage on Weed Succession and Crop Yield on a Coastal Plain Soil

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Reduced tillage has gained much favor in the Southeastern Coastal Plain from the standpoint of time, labor, and soil conservation, but no-tillage has generally not been accepted due to poor stands, high weed pressure, and associated lower yields when compared to a more conventional tillage and weed management regime. In order to assess the interaction of crop rotations, tillage systems, and weed management levels, on insects, weeds, diseases, and crop yield, a long-term interdisciplinary study was established at the Edisto Research and Education Center in 1983. This project involves personnel from the Departments of Agronomy and Soils, Entomology, Plant Pathology, Agricultural Economics, Agricultural Engineering, and Experimental Statistics. The objectives of this research are:

1. To determine weed growth, herbicide efficacy, and population dynamics encountered under various levels of management, tillage, and cropping schemes for soybeans;

2. To determine changes in insect, nematode, and disease levels under each agroecosystem studied;

3. To prepare crop production budgets for each agroecosystem and determine profitability of each.

Although there are data available dealing with discipline-oriented research on specific pests, there are essentially no pulished papers dealing with this type of integrated approach.

Three different tillage systems, representing those commonly in use, or which could be readily adapted by soybean growers, are under study:

1. Conventional tillage--to include discing, subsoiling, and cultivation as needed:

2. Minimum tillage--discing once prior to planting and subsoiling at planting;

3. No-till--plots are disced and chisel-plowed before wheat planting, but are only subsoiled prior to planting the summer crop.

Cropping systems include continuous soybeans, wheat followed by soybeans, or wheat/soybeans followed by corn the following year. A low level of weed management (preemergence herbicides plus cultivation only) is being compared to a high level of weed management (preemergence plus postemergence herbicides as needed plus cultivation).

At the conclusion of the third year of the study (one complete crop rotation cycle) there have been no differences observed among treatments (tillage system, rotation, or weed management level) on effects on beneficial or harmful insects or diseases. There also have been no significant shifts in nematode populations, but one rotation cycle may be too short to see any effects with this pest group.

Weed infestation levels have been higher under all rotations and herbicide levels in the no-tillage systems. The biomass of grassy and perennial weeds also appears to increase as tillage is reduced. With the use of preemergence and postemergence herbicides, weed infestation can be reduced to a non yield-reducing level. Minimum tillage systems appear comparable to conventional tillage in terms of weed biomass except in the continuous double-cropping of wheat and soybeans. In this system biomass is significantly higher than in all other rotations. Soybean yields for the no-till treatments declined in 1984 and were significantly lower than for conventional or minimum tillage treatments in 1985, Corn stand and yields have been reduced in the no-till plots compared to conventional or minimum tillage. Rotation has had no effect on soybean yield, but wheat yield seems to improve in the system with corn in the rotation.

Crop producing budgets are currently being prepared to compare the economic impact of these practices. The project will continue through the 1987 growing season.

Conservation tillage research is also being conducted in South Carolina by USDA-ARS scientists at the Coastal Plains Soil and Water Conservation Research Center (CPSWCRC) near Florence, SC. The scientists conducting this research are D.L. Karlen, W.J. Busscher, M.J. Kasperbauer and P.G. Hunt. The objective of their research program is to improve soil tilth and productivity by optimizing conservation tillage systems, cropping sequences, plant and microbial manipulations, and water management practices for the predominant soil associations in the southeastern Coastal Plains. They have found that currently, conservation tillage is not being used in the southeastern Coastal Plains because yield penalties often reduce the profitability of those systems compared to conventional tillage practices. For corn, conservation tillage apparently causes a yield penalty because seedbed characteristics for germination, growth, and development are poorer than for conventional tillage systems. This occurs even though in-row subsoiling is used to alleviate soil strength problems for both tillage systems.

To increase the use of conservation tillage systems, alternative commercial and experimental tillage implements, planters, and weed control equipment are being evaluated and modified for southeastern Coastal Plain soils. Fertilizer practices for improved plant nutrition are being studied and related to inherent soil productivity and nutrient leaching. The effects of alternative tillage practices on soil color (bare vs residue covered), light environment, and seedling growth are being evaluated. The basic studies are providing valuable information regarding the effects of soil color on transmission of light to the root zone and its effect on root growth, soil microorganisms, nodulation, and other micorhizal processes. Field studies are being conducted with and without supplemental irrigation so that the most profitable conservation tillage system can be determined for this region.

Several conservation tillage publications have been written by CPSWCRC scientists (1-9). Research has also been conducted to evaluate tillage systems for wheat on Ardilla, Dothan and Norfolk soils. Summarizing eight site-years of research that were conducted between 1983 and 1985 has shown that no-till treatment yields were significantly lower than where the seedbed was prepared by disking in 2 of 4 years. The best tillage treatment for wheat, however, utilized deep tillage with a moldboard plow. This treatment significantly increased grain yield by an average of 6 bu/acre in 4 of 5 site-years compared to using disk tillage to prepare the seedbed. A N variable was included in these tillage studies because of the known reduction in available N for no-till wheat systems compared to conventional tillage systems. Tillage and **N** both increased grain yield by increasing head number and weight per unit area. Increased N compensated for tillage in 50% of the experiments, but the interaction between tillage and N was neither strong or consistant.

Another conservation tillage study was conducted to assess the effectiveness of four deep tillage implements in encouraging corn germination and in developing and maintaining a proper rooting environment throughout the growing season. The implements, which included a Brown-Harden Super Seeder (SS), BushHog Ro-till (RT), Howard Paratill (PT), and Kelley Manufacturing Co. (KMC) systems, were evaluated with and without surface disking to incorporate soybean residue and with and without irrigation. Germination and stand establishment for the conservation tillage treatments (79%)was significantly less than for the disked treatments (93%). Achieving good soil-seed contact in these systems appears to be a major limitation at this time, because when irrigation water was applied within 48 hours after planting, stand establishment for both tillage systems averaged 24,400 plants/acre.

This research also showed that at the begining of the growing season, overall soil strength for the SS and PT implements was about 0.35 MPa lower than for the RT and KMC implements in both conservation and conventional tillage systems. This was due to a larger area of disruption by the SS and PT implements, although all four units broke through the root-restricting E horizon. Conservation tillage treatments maintained a softer medium for root growth and did not recompact as much during the growing season as the conventional treatments. This may be the most important reason for adopting conservation tillage systems in the southeastern Coastal Plains. Furthermore, it suggests that for Coastal Plain soils which have been subsoiled, compaction is not the factor causing lower grain yields in conservation tillage systems.

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Tennessee No-Tillage Update

George J. Buntley

No-till acreage in Tennessee dropped from 563,200 acres in 1984 to 451,000 acres in 1985 according to the NACD-CTIC 1985 conservation tillage survey data. No-till corn (162,280 acres) and no-till soybeans (214,871 acres) accounted for about 84 percent of the total 1985 no-till acreage. Small grain (32,360 acres), grain sorghum (29,980 acres) and forage crops (10,960 acres) made up the bulk of the remaining no-till acreage in 1985.

The 1985 decrease in no-till acreage was due primarily to conditions resulting from an extremely wet 1984 fall season. Wet soils restricted the amount of wheat sown which resulted in wheat acreage being down 43 percent. This in turn drastically reduced the acreage of no-till soybeans that would have followed wheat in double-crop systems. In addition, fields that normally would have been no-till planted into crop residues of the previous crop were so deeply rutted by 1984 harvesting operations that they could not be planted no-till in the spring of 1985. However, all indications are that no-till acreage again will be on the increase in 1986.

Results of research in grass-legume cover crops for corn and in no-till cotton are reported below.

Nitrogen-fixing legume cover crops have the potential to protect the soil from erosion and to supply nitrogen to a following grain crop. Yields of various cover-tillage treatments for conventional and no-tillage corn are shown in Table 1.

Corn yields did not increase much above the 100 lbs. N/A fertilizer rates when corn was planted into soil incorporated wheat-vetch or chemically-killed wheat-vetch. When corn was planted in a conventional seedbed with no winter cover or planted no-tillage in killed wheat, yields increased up to the 150 lbs. N/A rate. A nitrogen contribution to the corn crop of at least 50 lbs. N/A from the vetch is indicated whether the vetch was incorporated or used as a no-tillage mulch.

Table 1. GRASS-LEGUME COVER CROPS FOR CORN
(6 YR. AVG.) (1980 - 1985)

	N Rate (lbs/A)			
	0	50	100	150
	Corn Yield bu/A			
NO Winter Cover (conv.)	17	59	86	99
Wheat-Vetch (conv.)	48	83	99	103
Wheat-Vetch (no-till)	42	70	93	98
Wheat (no-tiil)	13	44	75	94

Don Tyler and Bob Duck

Vetch as a mulct. for no-tillage cotton has also been compared to other cover-tillage treatments at various nitrogen rates. Yields of cotton at two locations for the various treatments are shown in Tables 2 and 3.

Table 2. NO-TILL COTTON (MES)
(5 YR. AVG.) (1981 - 1985)

	No-till Lbs N/A			Conventional Cbs N/A		
	0	30	60	0	30	60
	Lint Yield (lbs./A)					
No Cover (Previous Cotton Stubble)	624	747	797	742	797	817
Rye	528	586	762	648	794	804
Rye-Vetch (Vetch 3 yrs. Crimson Clover 2 yrs.)	578	591	724	708	700	762
Vetch	638	601		715	681	

Don Tyler, Phil Hoskinson and Bob Hayes

TABLE 3. NO-TILL COTTON (WTES)
(5 YR. AVG.) (1981 - 1985)

	No-till Lbs N/A				Conventional Lbs N/A			
	0	30	60	90	0	30	60	90
	Lint Yields (lbs/A)							
No Cover (Previous Cotton Stubble)	752	931	898	921	839	1175	1015	915
Rye	629	807	809	880	864	972	999	915
Rye-Vetch (Vetch 3 yrs. Crimson Clover 2 yrs.)	621	716	678	584	893	973	716	871
Vetch	747	675	652	565	906	884	849	928

Don Tyler, Phil Hoskinson and Bob Hayes

Yields of cotton planted no-tillage into heavy mulches such as rye, rye-vetch (vetch 3 yrs.- Crimson clover 2 yrs.), or vetch were lower when planted no-tillage as compared to conventional tillage. When planted in previous cotton stubble yields were about the same between tillage systems.

Cotton responded to more fertilizer nitrogen when planted no-till into rye as compared to when it was no-till planted into the stubble of the previous cotton crop. Yields were reduced at high fertilizer nitrogen rates where cotton was no-till planted into vetch.

Yields at the Milan Experiment Station location were similar for cotton planted either no-till or conventional in previous cotton stubble. Yields were lower at the West Tennessee Experiment Station location at Jackson when the cotton was planted no-till in previous cotton stubble as compared to conventional tillage.

No-tillage cotton in a limited mulch residue is being recommended to Tennessee growers. Heavy mulches have tended to result in cooler than optimum soil temperatures. Cotton maturity also has been delayed when no-till planted into heavy mulches.

No-till alfalfa was recommended for the first time in Tennessee in 1985. There was considerable interest and a small acreage planted in 1985. The number of no-till drills increased with a much larger acreage seeded in the spring of 1986, probably 1,000 to 1,500. Interest is increasing daily, and with the need to kill fungus infected fescue pastures, no-till alfalfa fits the situation nicely.

The fescue endophyte fungus problem is being discussed statewide. A concerted program for killing the infected fescue will be put into operation in the fall of 1986. The new diagnostic lab will be completed in September and will provide facilities for testing for the endophyte fungus in fescue.

Research indicates that the best methods of killing 100 percent of the infected fescue are:

1. Use a rotation crop such as corn, sorghum X sudangrass, grain sorghum or alfalfa. All of these crops can be seeded no-till.

2. Kill the fescue in late summer or early fall and reseed with fungus free fescue seed. Two spray applications two to three weeks apart are needed for 100 percent kill. Fescue is much easier to kill in fall than in spring.

3. One spray application can be used in late fall with another spray in spring after fescue turns green and is growing, with the fescue seeded in spring after the last spray application. No-till reseeding of the fescue and rotational crops is being stressed.

No-till alfalfa seeding and no-till reseeding of fungus-free fescue demonstrations will be given special emphasis at the Southeastern Forage and Grassland Expo '87 to be held at Greeneville, Tennessee, June 18-19-20, 1987.

CONSERVATION TILLAGE RESEARCH IN TEXAS

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INTRODUCTION

The agricultural diversity across Texas is indicative of widely varying precipitation, temperature and soils. Average annual precipitation ranges from 18 to 51 inches from west to east. The number of frost-free days range from 180 at Amarillo in the Texas Panhandle to 346 at Brownsville in the Rio Grande Valley. This produces a wide variety of farming systems from a continuous winter wheat and summer fallow rotation in semi-arid West Texas to double cropping rotations of corn, cotton or sorghum with winter vegetables (lettuce, onion, carrots, etc.) in the Rio Grande Valley and creates a heterogenity in our tillage and cultural practices.

Research programs in Texas concerning conservation tillage farming systems reflect the climatic and edaphic variability in the state. Fourteen scientists from the Texas Agricultural Experiment Station, Texas A&M University System, or USDA-Agricultural Research Service have ongoing studies to improve soil-tillage farming practices for optimum crop productivity. Research topics receiving prominent attention in Texas are: soil compaction, soil erosion and residue management, methods to increase plant available soil water, fertilizer use efficiency and plant nutrition, and weed competition and control methods. Descriptions and results of ongoing studies are given below. Footnotes are used to identify the research activity with the respective scientist, location and research agency.

Soil Water Conservation. Tillage methods that increase rainfall catchment and infiltration and reduce soil evaporation are being investigated. Studies at Corpus Christi conducted during a 7 year period on a clay soil demonstrated significant difference in rainfall catchment with regards to the type of primary tillage performed (8). Soil water infiltration rates were greater for soil treated with a chisel or moldboard plow when compared to reduced tillage or no-tillage. However, soil water contents during the peak crop demand period (April-May) were not different among tillage methods during each of the 7 years. Grain yields of sorghum were not different between tillage methods when rainfall was adequate, but were significantly greater for no-tillage or reduced tillage when soil moisture was limited.

In semi-arid West Texas, cropping systems using no-tillage were found to increase soil water contents and grain yield of sorghum compared to methods requiring tillage on clay and loamy soils (7,12). Yields for 8 crop years averaged 3,150 and 2,190 pounds per acre for no-tillage and disk tillage, respectively. Yields of sunflower and corn were also greater under no-tillage, but yield differences were not as great as that of sorghum (12). On a weakly structured sandy loam soil, yields of cotton and grain sorghum were not different between reduced and conventional tillage methods in irrigated or rainfed situations for the last 4 years (1,11). However, yields of reduced till irrigated wheat were slightly but significantly reduced 1 out of 4 years, whereas yields of reduced till dryland wheat were slightly but significantly reduced 2 out of the 4 years (1).

Micro-catchment (furrow dikes) construction to reduce water runoff has been reported to increase sorghum and cotton yields in the semi-arid regions of Texas (4, 10). In 1981 and 1982, conventional tillage yields increased 32 and 108% by furrow diking cotton and sorghum, respectively. Furrow dikes in 1985 increased cotton and sorghum yields 11 and 14%, respectively. Combination of furrow dikes with reduced tillage practices are in the process of being investigated.

Soil Fertility. Studies are being conducted to determine the effects of tillage and cropping sequence on yield and nitrogen use efficiency of grain sorghum, wheat, soybean and cotton (2,5,6,8,9). On coarse-textured soils, significant tillage x nitrogen rate interactions occurred for yields of wheat and grain sorghum (6). For wheat, conventional tillage produced higher grain yields at lower N application rates whereas no-tillage had the highest yield at the largest N rate. No-tillage grain sorghum yields, however, were decreased at lower N rates compared to conventional tillage treatments at the higher N rates. On a fine-textured clay soil, grain sorghum yields were found to be generally higher, though not always statistically significant, for conventional tillage compared to no-tillage for any given N application rate (2,5,9).

Significant cropping sequence x N-rate interaction has been found for winter wheat (6). Continuous wheat produced higher grain yield than wheat in a sorghum-wheat-soybean rotation at the low N rates whereas wheat grown in the rotation had the highest yield at the higher N rates. Wheat yields in a wheat-soybean double crop rotation produced lower yields than continuous wheat at all N rates.

The use of winter annual legumes as a nitrogen source in double crop sequence with grain sorghum was investigated. Grain sorghum following a green manure treatment of sub-clover outyielded no-tillage treatments where clover residues remained on the surface and conventional tillage which had no clover but received N fertilizer (60 kg/ha). Decomposition of clover residues on the soil surface may be too slow to meet the N demands of sorghum. Studies indicate that rainfall levels and chemicals (glyphosate) applied to eliminate competition between a crop like sorghum and the winter legume significantly affect the rate of decomposition and nitrogen release from the legume residue (2,5,9).

Soil Compaction. Soil structural properties related to conservation and conventional tillage have been studied for varied soil textures (3,4,13). Results indicate that antecedent soil moisture significantly affected the saturated hydraulic conductivity of sandy 1oam soils (14). Slow soil drying resulting from low air temperature (25°C) or straw mulch increased the soil strength and bulk density. Incorporated residues, however, reduced bulk density and increased organic matter content (4). Although conservation tillage can reduce evaporation and increase moisture storage, these properties also modify the structure of the fragile soils and may contribute to reduced plant growth and crop yields (3,4,13).

Soil structural deterioration from wheel compaction can adversely affect root growth and crop development. Because of the concern of compaction, this research was conducted to determine the effect of controlled traffic lanes on soil physical properties and crop rooting for no-tillage and conventional tillage cropping systems on a swelling clay soil (2,5,9). Soil strength, bulk density and total porosity were not different between tillage treatments in areas not trafficked during the crop growing season. In areas subject to wheel traffick during the crop growing season, soil strength and bulk density were higher for the no-tillage treatments. Both soil strength and bulk density in the areas where wheel traffic was confined reached values reported to inhibit root growth to the 0.15 m depth. Measured crop rooting densities were not different with respect to the presence or absence of wheel traffic or tillage treatment. The data suggest that soil moisture and nutrients in controlled-traffic lanes will be available for crop use.

Weed Control. The herbicides AAtrex (atrazine), Milogard (propazine), Bladex (cyanazine), Cotoran (fluometuron), Igran (terbutryn), Glean (chlorsulfuron), Ally (metsulfuron) and Treflan (trifluralin) were evaluated with respect to tillage for herbicide toxicity and persistance (14). Available results do not give a clear indication of whether no-tillage affects herbicide toxicity and persistence. In a 1984 dryland sorghum stubble study, weed control was best after incorporation and poorest when herbicides were applied on bare soil. No-tillage results were intermediate. Herbicides persisted longest following incorporation. In a 1984 wheat stubble study, spraying herbicides on bare soil gave the best weed control and the herbicides persisted the longest. In a 1985 dryland wheat stubble study, control of volunteer wheat was equally effective between no-tillage and conventional tillage, but control was reduced when herbicides were sprayed on bare soil without incorporation. In contrast, results on sorghum stubble were just opposite of results obtained on wheat stubble in 1985. Control and persistence with Glean and Ally were approximately the same with no-till ore bare soil. This did not hold true for Treflan and AAtrex because they gave poor control and did not persist under no-tillage. Irrigation immediately after application did not effect initial toxicity or persistence of the herbicides in the soil even though it did not rain on the dryland part of the study for two months. At 0.012 lb/A, Glean and Ally persisted longer than AAtrex at 1.5 lb/A or Treflan at 0.75 lb/A regardless of the method of incorporation method. Soil samples evaluated in the greenhouse indicated that Glean and Ally leached into the 3 to 6 inch soil depth. Other herbicides remained in the 0 to 3 inch depth.

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NO-TILL SEEDING OF ALFALFA, TALL FESCUE, AND OTHER FORAGES

Dale Wolf, VIRGINIA TECH

No-till alfalfa establishment continues to be widely accepted and successful. Surveys made in recent years have shown that there are more than 300 hundred no-till drills available in Virginia and more than 9,000 acres successfully established in 1984. This represents an estimated 45% of the alfalfa planted in the state was established with no-fill practices. Recommendations for successful establishment have been prescntcd frequently but we must realize that farmers need to know the importance of following these recomrnendations to the last detail. Additionally, there are some new twists or modifications that can cxtcnd the usefulness of current no-till alfalfa establishment procedures. New areas include late-season planting for establishrncnt of alfalfa after removing corn for silage, fall suppression of grasses for early spring planting, and surface applied lime for correcting low pH soils.

Keep up the good work. We are fortunate in Virginia that personnel in a wide range of agencies are telling the same story and are acquainted with the basic principles of no-till establishment of forages. Whcn talking with prodccrs who are interested in beginning to use no-till forage establishment or working with those who already have had experience, we must continually impress on them the importance of following necessary procedures. Extension publication No. 18-007 regarding "So-till Seeding of Forage Grasses and Legumes" is an excellent reference to obtain procedures. I want to emphasize two things where we must be very aware of possible problems. One involves planning ahead in selecting the field for planting. Weeds are a very critical problem dealing with alfalfa production whether for conventional or no-till plantings. Making an effort to clean a field of weeds in the year or two before planting alfalfa will be very helpful. If sclccting a field that is in sod or an old hay area, you will most likely have weed problems when sod kill and planting is attempted in the spring. For example, you must wait long enough bcfore the first paraquat application for greenup then two to three weeks for a second paraquat application which delays planting until late in April which allows summer annual weeds to be very competitive. Your best recommendation in this situation maybe to plant a summer smother crop of millet, sorghum sudan, or soybeans which can be removed for hay in early August bcfore a late August. Atlernatively, a summer hay crop could be removed in late July with a split paraquat application being made in August and plant in late August.

A second critical emphasis that we need to stress concerns the amount of old dead residue remaining on the surface. Farmers arc tcmptcd to plant into areas that have far to much accumulation of old accumulated growth. This creates a problem in planting and competition for the gcrminatcd seedlings. Ideally, sod should be grazed or cut very close with a two-inch or less stubble height so that about 50% of the land area is visible.

Late fall suppression with early March planting. As mentioned above, old hay fields or pastures often have weedy problems if all establishment operations arc conducted in the spring. We have found excellent results by suppressing the sod with chemicals in the fall bcforc seeding the following March. Proper herbicides should be used in late September to kill broadleaf weeds Graze the area or make hay so that growth accumulation is minimal by mid to late October. In early November apply two pints paraquat per acre. If thcrc is considerable greenup of grass in late Sovcmber or early December, you might consider application of one additional pint of paraquat. Then in late February or very early March apply one pint paraquat and make the alfalfa no-till planting. This procedure suppresses the original sod and winter helps to do an additional kill.

Alfalfa is planted early and has good growth for competition with weeds before the warm summer months.

Planting after removing corn for silage. Our tests at Blacksburg have shown that no-till alfalfa can be planted successfully three to four weeks later than can be recommended for conventional alfalfa establishment. In most of the state we are not able to harvest silage, prepare a conventional seedbed, and have time for a conventional establishment to be successful. However, with no-till, the planting can be made very soon after remvoing corn for silage with the firm soil causing rapid germination and firm anchoring of the seedlings during the winter to avoid heaving and plant damage. You must plan ahead and use a hcrbicide problem that has no toxic carryover and have a corn seedbed that is level enough to be used for a hay field in the future years. Immediately after removing the silage, spray with one pint per acre paraquat and plant the alfalfa.

Surface applied lime for no-till alfalfa. Current recommendations often specify that pH for alfalfa should be 6.5 or above. Generally if pH is between 6.0 to 6.5 we recommend application of lime before plowing to incorporate the lime. If the pH is less than 6.0 then lime should be incorporated and crop grown on the area before planting alfalfa. I still think this is the ideal recommendation where the land is suitable for plowing. This however limits alfalfa production and excludes many area that will grow alfalfa yet can not be successfully plowed.

We are told that 80% of the nitrogen that is fixed by alfalfa occurs in the top two inches. The primary reason for having a pH of 6.5 or above is to favor the nitrogen fixation by bacteria. This means that the most important region of the soil to have a modified pH is the top two inches. We know that alfalfa roots, if supplied nitrogen from bacteria, can penetrate deep into soil that has pH of less than 5.5, otherwise, alfalfa rooting and water utilization would be limited to only the plow layer in most fields This is not the case, since we have deep penetration of alfalfa roots into acidic soils. Our research indicates that we can apply lime to the surface of *soils* with pH as low as 5.0 and expect excellent yields. Current lime recommendations are based on uniform distribution of the lime through the plowed layer. With surface application we maybe able to use a different basis for recommendation. If a field needs lime (pH of less than 6.5) then add lime as recommended but never more than 2 ton per acre. For economical reasons such as cost of spreading, why put out less than 2 ton per acre for a valuable perennial crop like alfalfa. So it about comes down to a decision of whether to add lime. If we decide to add lime, then go with 2 ton per acre.

RELATIONSHIP OF CORN SEED VIGOR TO PERFORMANCE UNDER NO-TILLAGE PRODUCTION.

D. M. TeKrony and D. F. Miles[1]

No-tillage research over the past two decades has shown that corn can be produced successfully without yield loss in the southern and south-central United States (Blevins. 1970; Moody, et al., 1961; Shear and Moschler. 1969) while yield reductions frequently occur following minimum tillage planting in the more northern areas of the corn belt (Griffith, et al., 1973; Ritchey, et al., 1977; Mock and Erbach. 1977). Early investigations in Kentucky and Virginia reported that corn could be no till planted into grass sod and produced without yield losses. However. few acres of perennial grass remain in the major grain production areas and establishment of sod is not feasible for grain producers. Fortunately winter cover crops such as small grains, annual ryegrass andfor legumes have also shown excellent potential for no-tillage planting (Mitchell and Teel, 1977; Frye et al., 1980). It appears that these cover crops will reduce soil erosion and provide an excellent alternative to sod for no-till planting of corn.

Much evidence has accumulated showing that the surface mulch associated with no-tillage lowers soil temperatures at depths ranging from 2.5 to 10 cm. The mulch reduces the diurnal fluctuation in soil temperature with the greatest difference compared to bare soil occurring in the daily maximum temperature (Phillips, 1974; Moody et al., 1963). Lower emergence and growth rate of corn seedlings have been directly related to reduction in soil temperatures in no-till production (Griffith et al., 1977; Moody et al., 1963 and Burrows and Larson. 1962). Even though, slower initial growth of corn has been shown under mulch, Moody. et al. (1963) concluded that later in the growing season growth rates were superior for no-tillage (mulch) compared to bare soil.

Seedling vigor in corn is commonly measured in the laboratory by the cold test (Funk, et al., 1962; Burris and Navratil, 1979) andfor seedling dry weight evaluation (Eurris, 1975) with both tests able to detect vigor differences among seed lots. Dungan and Koehler (1944). using naturally-aged (carryover) corn seed, found that both stand and yield declined as the seed aged. They reported that with identical field stands, three year old seed was weaker and less vigorous than 1 year old seed and caused a 4.8; reduction in yield. Similar studies, with uniform field stands, reported lower yields using low vigor seed that had been naturally or artificially aged prior to planting compared to high vigor seed (Grabe, 1967; Funk, et al., 1962). Funk et a1.(1962) concluded that the low vigor seed were slow to emerge, had less seedling vigor and lower competitive ability and were of greater concern in some hybrids than others. After several investigations Burris (1975) concluded that no consistent response due to vigor could be demonstrated for corn seedling emergence or yield.

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The studies reported here were conducted to investigate the influence of seed vigor on seedling emergence, growth and yield in no-tillage planting systems. If seed vigor relates directly to improved performance in no-tillage systems, this parameter could be used by seed companies when evaluating genotypes for no-tillage use. Seed vigor can also be used by seed companies as an "in house" marketing tool to determine the ultimate destination of seed lots, with high vigor seed lots being sold in areas where early planting stress might be a problem. Knowledge gained may also be used by plant breeders when identifying genetic traits for improved planting seed performance.

METHODS:

Several corn seed lots were selected from the single cross **B73** X M017 that had acceptable germination but a range in seed vigor. The seed were tested for vigor using the cold test and seedling dry weight (AOSA. 1983) and for germination using the standard germination test (AOSA, 1982). Four seed lots were planted in 1982 and 1984 under four tillage systems and at three planting dates in a Maury silt loam soil on Spindletop Experimental Farm near Lexington, KY. The experiment was arranged in a split, split plot design with tillage treatments as main plots, planting dates as sub plots and seed vigor as sub, sub plots with three replications.

The three planting dates were April 15, May 5 and May 25, 1982 and April 21, May 12 and June 5. 1984. The four tillage systems used were:

1. Conventional tillage (CONV) - Soil was fall plowed and a seedbed prepared in the spring by discing and planted using conventional cultural practices.
2. No-till corn stalks (CSNT) – Corn was produced the previous year and the stalks were chopped after harvest to form a mulch. The soil was not tilled prior to no till planting of corn the following spring.
3. No-till wheat (WNT) - Soil was fall plowed, and planted in mid-October to soft red winter wheat at the rate of 2 bu/A and disced to cover the seed. Corn was no-till planted into standing wheat which was sprayed 1-3 days before planting, except for the last planting date which was sprayed with paraquat approximately 20 days prior to planting to conserve moisture.
4. No till tall fescue (TFNT) - The area where the plots were established had been in tall fescue sod for at least three years prior to planting. Corn was no-till planted into sod which had been sprayed at the same time intervals as described above for WNT.

A tank mixture of Lasso, Atrazine and Paraquat plus spreader was used to kill cover crops and control weeds in all tillage treatments. All seed lots were treated with the fungicide Captan. Mesural and Furadan were applied at planting to control rodents and soil insects. Soil samples were taken in the fall and lime was applied as recommended in November of each year. Ammonium nitrate was applied by hand to each treatment at the rate of 175 lb N/A 1 to 2 days prior to planting. Potassium was applied to the entire plot area as potassium chloride at 250 lb/A in mid-April of each year.

A two row Allis-Chalmers planter equipped with fluted coulters and cone planting units was used to plant all the plots. All treatments were extablished in four row plots 40 feet long with a 38" row spacing. The planting depth was 2 inches and the planting rate was 26.000 viable seeds per acre.

The following field evaluations were made for each treatment:

1. Soil temperature - Prior to and after each planting date for each tillage system, soil temperature was monitored at the seed planting depth with copper-constantan thermocouples with a minimum of 3 thermocouples in each planting date-tillage system.
2. Field Emergence – Emergence counts were made at first emergence and at regular intervals until 50% emergence. Those seedlings that had the first plumule unrolled from the emerged coleoptile were considered emerged.
3. Stand - Final stand counts were made for all treatments approximately two weeks after 50% emergence.
4. Growth rate - Three samples were taken for the measurements of plant height, dry weight and leaf area at the following growth stages: Sample 1 - Fourth collar growth stage according to Hanway (1963); Sample 2 - When one-half of the growing degree days (GDD) between 50% emergence and anthesis had accumulated for each treatment (not taken in 1984); and Sample 3 - When 50% of the plants had silks exposed. Ten consecutive plants were harvested in each vigor level for the first sample date. Five consecutive plants were harvested for the other sample dates.
5. Soil Moisture - Soil samples were taken at planting, at weekly intervals until 50% emergence and at each sample date for growth rate measurements at a depth of 0-3" (emergence period) and 0-6" (growth stages).
6. Grain Yield – Determined by hand harvesting a 15 foot section of two middle rows in each treatment. The number of ears per plant was recorded, the ears were dried. weighed, the moisture determined and the yield adjusted to 15.5% seed moisture.

RESULTS AND DISCUSSION

A range of environmental conditions occurred following the three planting dates in four tillage systems in both years with a wide range in 1982. Soil conditions varied from cool and wet at the April 15, 1982 planting date to warm and dry at later plantings in both years (especially WNT in 1982 and CSNT in 1984). Excellent seed placement was achieved in all plantings and in all tillage systems allowing adequate stand establishment under favorable conditions. All significant differences presented for field emergence, plant growth and yield treatment means are at the a = 0.05 level using the Least Significant Difference (LSD) test.

Seed Vigor

Four seed lots were selected in 1982 and 1984 which had acceptable standard germination (≥ 88%) but a range in seed vigor (Table 1). All seed lots in both years were of similar seed size (220–270 mg seed^{-1}) and shape (medium flat). In 1982 seed lot 1L had a low cold test germination (68%), low seedling growth, and a vigor rating of 5.3 which was classified as low vigor. Even though seed lot 2M had a slightly lower cold test germination (64%). it had a much higher seedling growth rate and a medium vigor rating of 6.3. Seed lots 3H and 4H had high vigor ratings (10.0 and 9.7. respectively) because of high cold test and seedling vigor results. In 1984, seed lots 2L and 4L had the lowest cold test germinations and seedling growth rate scores and were both classified at low vigor (Table 1) In contrast, seed lots 1H and 3H had high cold test germination and seedling growth rate which resulted in high vigor ratings of 9.7 and 9.0 respectively.

Table 1 Seed lots of the single cross B73 x M017 used in 1982 and 1984

Seed lot (Vigor)[1]	Standard Germination	Cold Test	Shoot and Root Weight	Vigor Index
	---------- %	------	mg/seedling	Rating
		1982		
1L	88	68	47	5.3
2M	94	64	62	6.3
3H	96	94	81	10.0
4H	94	94	83	9.7
		1984		
1H	98	97	78	9.7
2L	93	45	39	3.3
3H	94	97	71	9.0
4L	88	57	47	4.7

[1] Relative vigor was determined used vigor rating system previously described by TeKrony et al., 1977 where High(H), Medium(M) and Low(L) vigor seed lots had a rating of > 8.0, 610 to 8.0 and < 6.0 respectively.

Soil Temperature

The pattern of soil temperature at planting depth was similar in both 1982 and 1984. Maximum! ranges in the mean maximum and minimum soil temperature were seen at the first planting date both years. The fluctuations in temperature decreased while the average minimum and maximum temperature increased with each successive delay in planting each year. Since the first planting date had the greatest effect on seedling emergence and the temperature pattern was similar in 1982 and 1984 only soil temperature data recorded for an 8 day interval following the April 15, 1982 planting will be presented (Figure **1)**. The average soil temperature of CONV, CSNT, and WNT was 13C for the period from April 20 to April 28, 1982 (time to mean 50% emergence across tillage systems and seed lots) while the average soil temperature of TFNT was 12C. The minimum soil temperature of CONV on April 20 was 1OC and remained below this level for the next four days (Figure 1). During the same period the maximum soil temperature of CONV ranged from 13 to 22C. Minimum soil temperature in TFNT was higher than CONV and varied less ranging from 7 to 12C over the period from April 20 to April 28 while maximum soil temperature in TFNT varied from 12 to 16C over the same period. Soil temperatures recorded in WNT and CSNT were similar to CONV (Figure 1).

Decreased average soil temperature under mulch and in no-tillage has been reported by several workers (McCalla and Duley, 1946; Van Wijk et al., 1959; and Lal, 1974), and the magnitude of the decrease observed was related to the amount of mulch present. Burrows and Larson (1962) reported an average decrease in soil temperature of 0.4C for each 811 lb/A of mulch added to the soil surface. The amount of mulch present in TFNT in 1982 was 1924 lb/A which would correspond to an average 1C decrease in soil temperature compared to COMV according to Burrows and Larson. There was less mulch in WNT (1175 lb/A) and the mulch was less dense than the tall fescue sod so the amount of mulch present did not affect soil temperature as much as in TFNT.

Field Emergence

A wide range in final field emergence was observed between and within vigor levels, tillage systems and planting dates. The widest range in final emergence was seen in 1982, from 36% for the low vigor seed lot (1L) planted into tall fescue on April 15 to 96% for the two high vigor seed lots (3H and 4H) planted into CONV on May 25 (Table 2). In 1984 field emergence ranged from 55% for the low vigor seed lot (2L) planted into TFNT on April 27 to 95% for the high vigor seed lot (1H) planted into CONV on May 12 (Table 3). The range in field emergence decreased with each successive delay in planting in 1982 while the narrowest range in field emergence was observed at the second (May 12) planting date in 1984.

The lowest final field emergence averaged across tillage systems and vigor levels was observed at the first plating date each year which indicates a negative response of all seed lots to the stressful planting conditions. Differences in both soil temperature and soil moisture contributed to the differences seen between the final field emergence results across planting dates and tillage systems. TFNT had the most stressful planting conditions at the first planting date each year which resulted in the lowest, average final emergence for all vigor levels. Conversely CONV had the most favorable planting conditions for each planting date each year which resulted in the highest field emergence for all vigor levels. Soil temperature in WNT and CSNT was similar to CONV and average time to 50% emergence was also similar (14and 12 days, respectively). These results agree with previous studies which showed that lower field emergence and slower rates of emergence were related to reduced soil temperature in no till production (Griffith et al., 1977; and Moody et al., 1963).

Low soil moisture at planting and during the period from planting to 50% emergence contributed to the low final stands observed for WNT at the May 5 planting date in 1982 and for CSNT and TFNT at the June 4 planting date in 1984. Soil moisture for WNT was 10% at the May 5, 1982 planting due to moisture depletion in the root zone by the actively growing wheat crop. This extremely low soil moisture at planting reduced the final stand for WNT. The TFNT and CSNT treatments had soil moisture levels of 19 and 206, respectively, compared to 23% for WNT and 25% for CONV one week after the June 4 planting date in 1984. This lower soil moisture combined with poor rainfall distribution during the emergence period reduced the final stands for TFNT and CSNT at the third planting date in 1984.

Final emergence of the low vigor seed lots averaged across tillage systems was less than 80% and significantly lower than the medium and high vigor seed lots at all three planting dates both years (Table **2).** Similar results were found in 1984 for the low vigor versus the high vigor seed lots. The range in field emergence averaged across tillage systems for the low vigor lots over all three planting dates was 66 to 14% compared to a range of 82 to 87% for the high vigor lots (Tab1e 3). These results are similar to previous reports which show that high vigor seed lots have a better emergence potential than low vigor lots in both stressful and more optimum emergence conditions (Funk et al., 1962; Johnson and Wax, 1981).

Plant Growth

Plant height, dry weight and leaf area were measured at three plant growth stages (fourth collar, one half of GDD to anthesis (1982 only) and 50% silking). Plant growth was measured at these growth stages rather than at a certain time interval after planting to reduce the effect of differences in emergence rate on growth measurements. Since the results of all three measurements followed similar trends, only the average of plant height and dry weight across seed lots will be presented (Tables 4 and 5) and the seed vigor levels will be compared only for the April 15, 1982 planting date. Plant dry weight will be reported as weight per meter^2 to examine the relationship of seed vigor to plant dry weight over a given area which reflects plant stand as well as plant size.

In 1982 the greatest difference in plant height between seed lots and tillage systems at the fourth collar growth stage occurred in the first (April 15) planting date. The plant height when averaged across seed lots was significantly lower than the other tillage systems for WNT at the first and second sampling stages (Table 4). Differences in dry weight in 1982 were also most evident at the April 15 planting date and WNT was significantly lower than most other tillage systems when averaged across seed vigor levels at all three sampling stages (Table 5). The lower plant height and dry weight for WNT was also evident at the 2nd and 3rd sampling dates for the May 5 planting date. The average soil temperature of WNT was slightly less than CONV. but not as low as TFNT in 1982, thus, decreases in plant height and dry weight were not related to soil temperature. Even though there was little difference in soil moisture between tillage systems at the April 15 planting date in 1982, the soil moisture in WNT was approximately **5** percentage points lower at the May 5 and May 25 planting dates. Since little rainfall occurred prior to the first and second sampling stages in 1982, the lower plant growth of WNT may be due to less soil moisture due to the growth of wheat prior to planting.

In 1984 at the first sample date (fourth collar stage) there were consistent trends for both plant height and dry weight to be lowest for CSNT when averaged across all seed lots at all three planting dates (Tables 4 and 5). Inversely, plants in TFNT were consistently taller and cf greater dry weight than all other tillage systems at the same growth stage for the April 27 and May 12 planting dates. Since there was less difference in soil temperatures between tillage systems in 1984 than in 1982, the differences in early plant growth were again primarily related to differences in soil moisture. The average soil moisture for approximately one month prior to the fourth collar sample was 3 to 5 percentage points higher for TFNT than CSNT with WNT at an intermediate level across all planting dates.

Few differences in plant height were recorded at the third sampling date (50% silking) between tillage systems or seed lots at any planting date in 1982 or 1984 (Table 4). There were also few differences in dry weight at 50% silking between tillage systems and seed vigor levels in 1982 and 1984 across the three planting dates (Table 5). In 1984 when averaged across seed lots the dry weight of TFNT was significantly greater than all other tillage systems at the last two planting dates. The increased growth at 50% silking in TFNT was primarily related to increased soil moisture in both years.

It has previously been reported that soil moisture under killed tall fescue sod is greater than in conventional tillage to a depth of 20 inches and has been related to yield increases over conventional tillage (Hill and Blevins, 1973). Moody et al. (1963) found that corn grown in mulched plots was taller at silking than that in conventional tillage, while Jones et al. (1969) found average plant height to be greater under mulch and attributed it to increased soil moisture under the mulch. In these experiments no significant differences in plant height were recorded at 50% silking between seed lots in any tillage system. Glenn et al. (1974) also observed that differences in plant height due to initial differences in seedling vigor usually decreased as the plants matured.

Plants from the low vigor seed lots were shorter and lower in dry weight at the first sampling date (fourth collar stage) in both years. This difference was largest at the first and second planting dates, however, it was still evident at the last planting date. Since similar trends occurred between seed vigor levels in both years only the 1982 results will be presented for the April 15 planting date (Figures 2 and **3).** Even though these differences occurred early in growth, there was little difference in plant height between vigor levels at the last sampling date (50% silking) and low vigor seed lots also had higher dry weight per plant than medium and high vigor seed lots. However, when expressed as total dry weight on a area basis (g m^2) the low vigor seed lots had lower dry weight especially at the first and second planting dates of TFNT and WNT where stands were slightly lower than for medium and high vigor levels.

Yield

Average grain yield of all tillage systems (across seed lots and years) ranged from 85 bu/A for late planted CONV to 145 bu/A for the early planted TFNT (Table 6). The highest average yields across both years occurred for TFNT followed by WNT and CSNT with CONV having the lowest yields. In 1982 there was no significant difference in average yield (across seed lots) between the three no-till planting systems at any planting date (Table 6) and all were consistently equal to or higher than CONV. In 1984 there was no significant difference in average yield between CONV and CSNT, however, both were significantly lower than TFNT at the April 27 and May 12 planting dates. The lower yields in WNT at the May 5, 1982 planting date and in CSNT at the April 27 and May 12, 1984 planting dates were primarily associated with moisture stress in these tillage systems. In the WNT treatment in 1982 the wheat plants were killed just prior to the May 5 planting date and little rainfall occurred immediately before and after planting. In 1984 there was less mulch in CSNT than in TFNT and WNT. however, the differences were similar to 1982. Thus, the lower soil moistures in the CSNT in 1984 may possibly be related to soil compaction in the previous plot area and the extremely dry conditions which occurred during corn production the previous year. Since the CSNT treatment was not tilled in the fall or spring prior to no-till planting, there may have been less movement of water into the soil profile following rainfall in 1984 than for the other tillage treatments. Thus, later in the growing season as moisture become limiting there was less soil moisture available for plant growth which eventually resulted in lower yields for CSNT than occurred in 1982.

Grain yields of the four seed lots were variable across the two years, however, they were generally influenced more by planting date and tillage system than seed vigor. The greatest differences in yield between seed lots was recorded in WNT and TFNT at the early planting date in 1982 where yields of seed lot 1L were 91 bu/A which was significantly lower than medium and high vigor seed lots which ranged from 132 to 157 buIA. Similarly the greatest difference in yield in 1984 occurred for seed lot 2L in TFNT which was 22 and 40 buIA lower than the high vigor seed lots 1H and 3H which yielded 144 and 162 bu/A, respectively. Little to no difference in yield occurred between seed vigor levels at the second and third planting dates across all tillage systems in either year, except that seed lot 1L was significantly lower than all other seed lots in WNT at the May 5, 1982 planting date.

The reductions in yield of the low vigor seed lots (1L in WNT and TFNT in 1982 and 2L in TFNT in 1984) were associated with decreased stands of these seed lots at the earliest planting date. Stands of both low vigor seed lots were reduced to less than 16,000 plants/acre in both WNT and TFNT in 1982 and to less than 17,000 plants/acre in TFNT in 1984, which caused a significant reduction in yield. There was little difference in yield between vigor levels at other planting dates and tillage systems when stands were similar. Except for seed lot 1L of WNT at the second planting date in 1982, there was little difference in stand or yield between vigor levels within the second and third planting dates in either year. These results agree with Burris (1975) who found that there was little effect of seed vigor on grain yield in conventionally planted corn when stands were equal. Thus, while seedling emergence was reduced for the low vigor seed lots under the more stressful planting conditions, reductions in final stand that could affect yield were avoided in most cases due to the high initial seeding rate of 26,000 seed per acre. At lower seeding rates (i.e. 22,000 seed per acre) it is possible that the plant stands of low vigor seed lots could have been reduced to a level that yield reductions would occur.

SUMMARY

The results of this investigation indicate that there was no relationship of seed vigor to yield if stand differences were not recorded. However, stands of low vigor seed lots were lower than all other seed lots at the early planting date in certain no-till systems and these reduced stands caused lower yields. Therefore, the use of high vigor seed would be beneficial to achieve adequate stands if no-tillage corn was planted early especially into tall fescue or wheat. There is presently no requirement to label corn seed for vigor, thus the purchaser cannot assess the vigor of the seed at the time of purchase. There are several reasons for not labelling seed vigor on the seed tag as is done with standard germination. There is no standardized vigor test for use on corn seed due to variability in methods and materials used to test for vigor. This lack of standardization complicates the interpretation of vigor testing results between different seed laboratories and makes the information less useful to the purchaser.

Although the vigor information is not printed on the tag, the purchaser can have the seed tested for vigor at a public or private agency and use the results to help make decisions about planting rates and tillage options. Results of vigor tests could also be used by plant breeders and seed companies to identify genotypes and seed lots that will be more tolerant to cold soil. Mock (1982) has identified cold tolerance as one of the most important characteristics for profitable no-tillage corn production, thus, the use of seed vigor testing could become an important tool in the future success of corn no-tillage systems.

The results of this study indicate that no-tillage corn can be planted as early as conventionally tilled corn without reductions in yield if adequate stands are achieved. The use of wheat as a cover crop appears to be a viable alternative to conventional tillage. However, the wheat needs to be managed carefully to assure adequate soil moisture for the corn crop. Planting corn with no-tillage directly into corn stubble from the previous crop is also an alternative to conventional tillage, however, disease and insect problems can occur when using this practice.

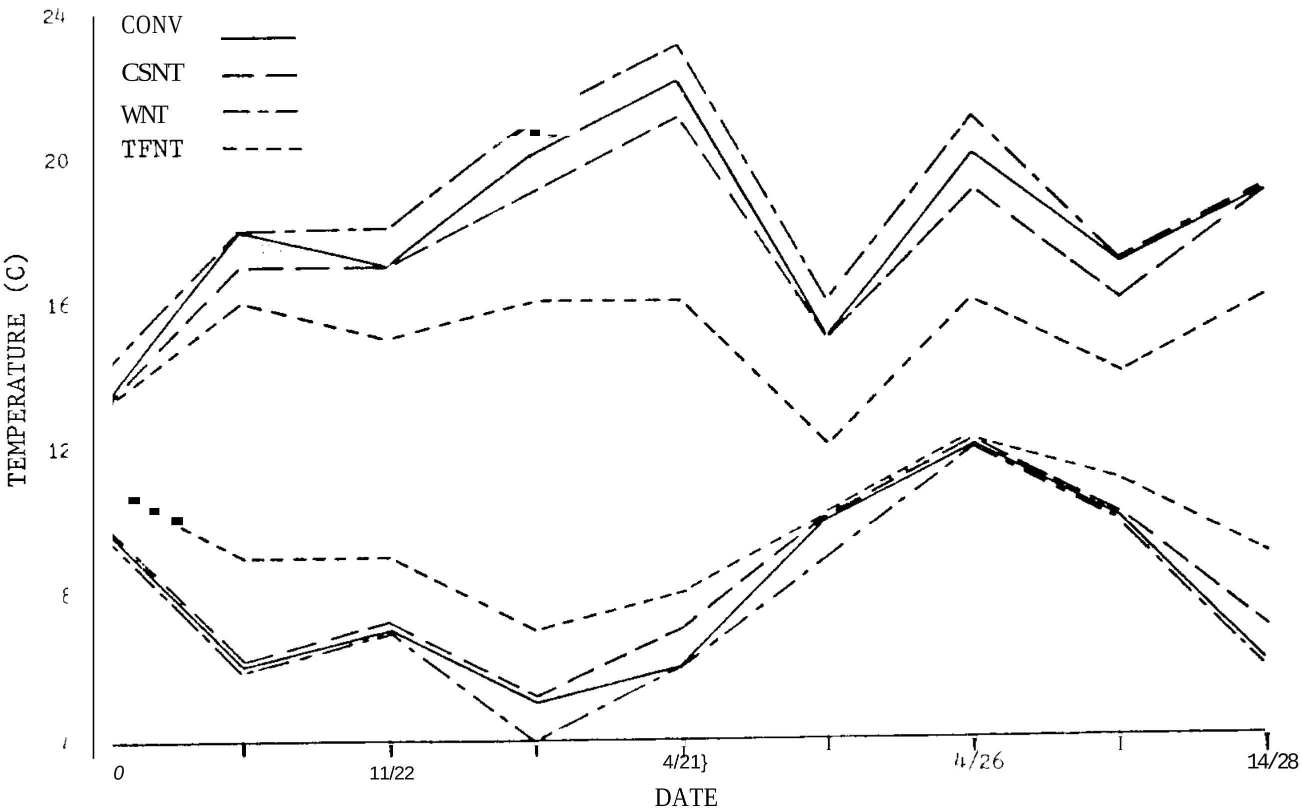

Figure 1, Minimum and maximum soil temperatures in four tillage systems for the period from April 20 to April 28 following planting on April 15, 1982.

Table 2. Final emergence of four seed lots in four tillage systems at three planting dates in 1982.

Planting Date	Tillage System	Seed Lot[‡][§] 1L	2M	3H	4H	Tillage Mean[†]
		----------	%	----------		
April 15	CONV	49	85	89	93	79
	CSNT	61	78	87	91	79
	WNT	37	61	67	73	60
	TFNT	36	69	81	82	67
	Mean	46	73	81	85	
May 5	CONV	64	88	91	92	84
	CSNT	55	80	81	80	74
	WNT	46	63	68	76	63
	TFNT	57	87	88	91	81
	Mean	56	80	82	85	
May 25	CONV	70	95	96	96	89
	CSNT	70	88	93	94	86
	WNT	72	85	89	93	85
	TFNT	63	84	88	89	81
	Mean	69	88	92	93	

[†] LSD 0.05 = 5 Comparing tillage system means averaged across seed lots.

[‡] LSD 0.05 = 7 Comparing seed lots in the same tillage system at one planting date.

[§] LSD 0.05 = 3 Comparing seed lots averaged across tillage systems at one planting date.

Table 3. Final emergence of four seed lots in four tillage systems at three planting dates in 1984.

Planting Date	Tillage System	Seed Lot[‡] [§] 1H	2L	3H	4L	Tillage Mean[†]
		-----	-----	%	-----	-----
April 27	CONV	95	71	91	75	83
	CSNT	88	75	88	73	81
	WNT	77	64	77	73	73
	TFNT	85	55	74	61	69
	Mean	86	66	82	70	
May 12	CONV	95	80	93	82	81
	CSNT	84	68	79	66	74
	WNT	78	72	87	69	77
	TFNT	91	77	92	75	84
	Mean	81	74	88	73	
June 4	CONV	91	82	93	79	86
	CSNT	73	66	82	71	73
	WNT	89	76	91	74	83
	TFNT	88	61	83	67	15
	Mean	85	71	81	73	

† $LSD_{0.05}$ = 5 Comparing tillage system means averaged across seed lots.

‡ $LSD_{0.05}$ = 10 Comparing seed lots in the same tillage system at one planting date.

§ $LSD_{0.05}$ = 5 Comparing seed lots averaged across tillage systems at one planting date.

Table **4** Plant height averaged across four seed lots in four tillage systems and three planting dates in **1982** and **1984.**

Tillage System	Planting Date †	Sampling Dates ‡ 1	2	3	1	3
		----------	----------	cm	----------	----------
CONV	1	54	125	241	61	249
	2	53	141	239	70	253
	3	49	129	252	73	253
CSNT	1	52	125	261	51	252
	2	52	143	254	64	245
	3	43	139	219	55	---
WNT	1	39	94	241	68	257
	2	53	99	243	74	218
	3	54	121	213	74	261
TFNT	1	52	129	215	85	289
	2	59	128	269	93	296
	3	51	152	286	67	212
LSD 0.05		7	14	14	6	32

† Planting dates were: **1982** (April **15,** Hay **5** and May **25).**
1984 (April 27, May **12** and June **4).**

‡ Sampling dates: 1–fourth collar leaf stage, 2–one half of GDD and **3-502** silking.

Table 5 Plant dry weight (g m^{-2}) averaged across four seed lots in four tillage systems and three planting dates in 1982 and 1984.

Tillage System	Planting Date†	Sampling Dates‡ 1982 1	2	3	1984 1	3
		g m^{-2}				
CONV	1	31	211	843	25	912
	2	25	211	907	31	926
	3	26	258	993	38	1046
CSNT	1	28	210	993	21	1002
	2	21	251	870	14	787
	3	25	214	1011	23	---
WNT	1	16	105	195	29	900
	2	19	124	135	29	982
	3	21	201	949	40	1052
TFNT	1	27	210	1119	31	946
	2	28	234	993	52	1122
	3	26	218	913	32	1256
LSD 0.05		9	50	170	7	115

† The planting dates were: 1982 (April 15, May 5 and May 25)
1984 (April 27, May 12 and June 4)

‡ Sampling dates: 1– fourth collar leaf stage, 2–one half of GDD and 3-50% silking.

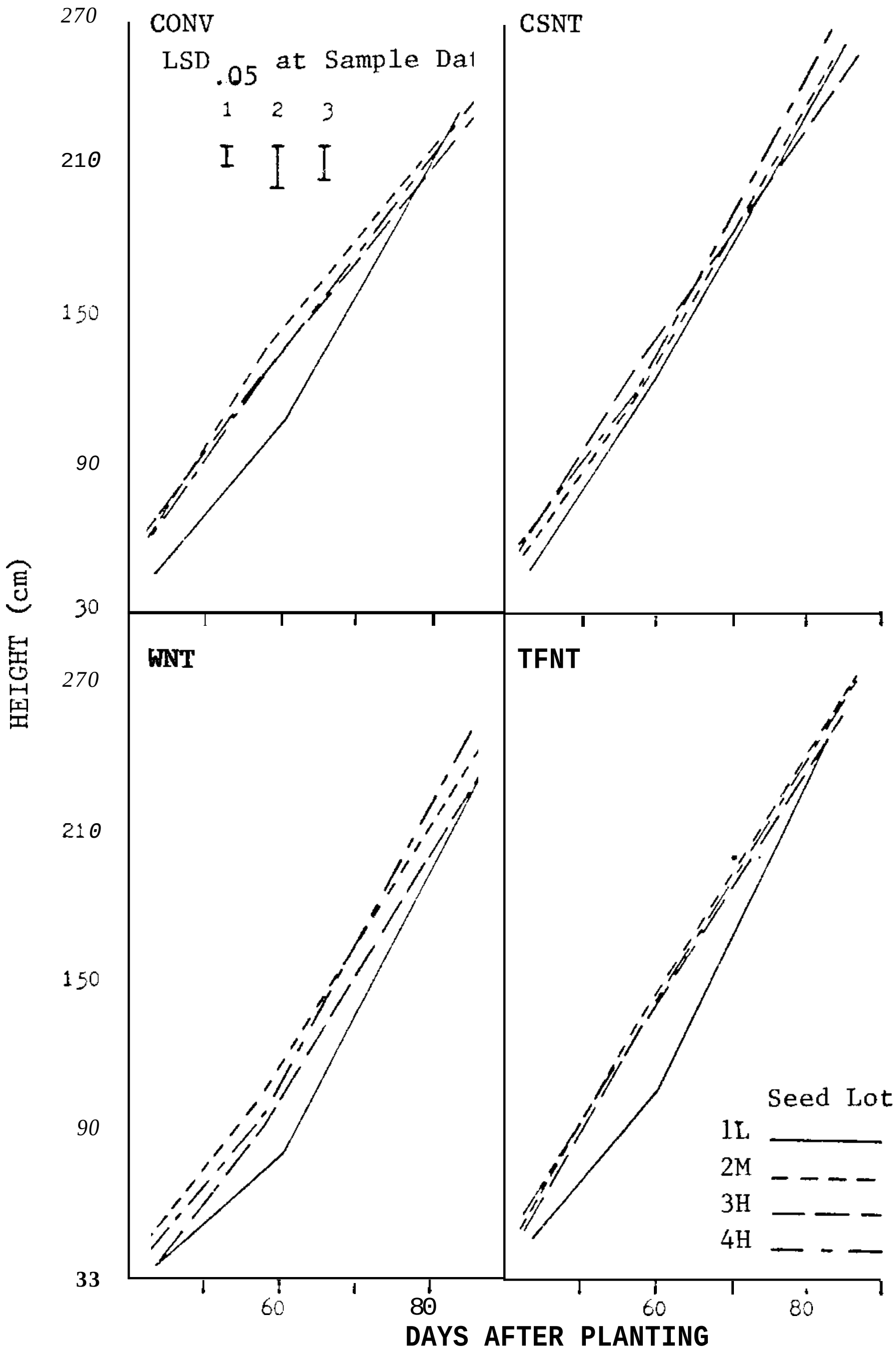

Figure 2. Plant height of four seed lots in four tillage systems of the April 15 planting date in 1982 at three sample dates.

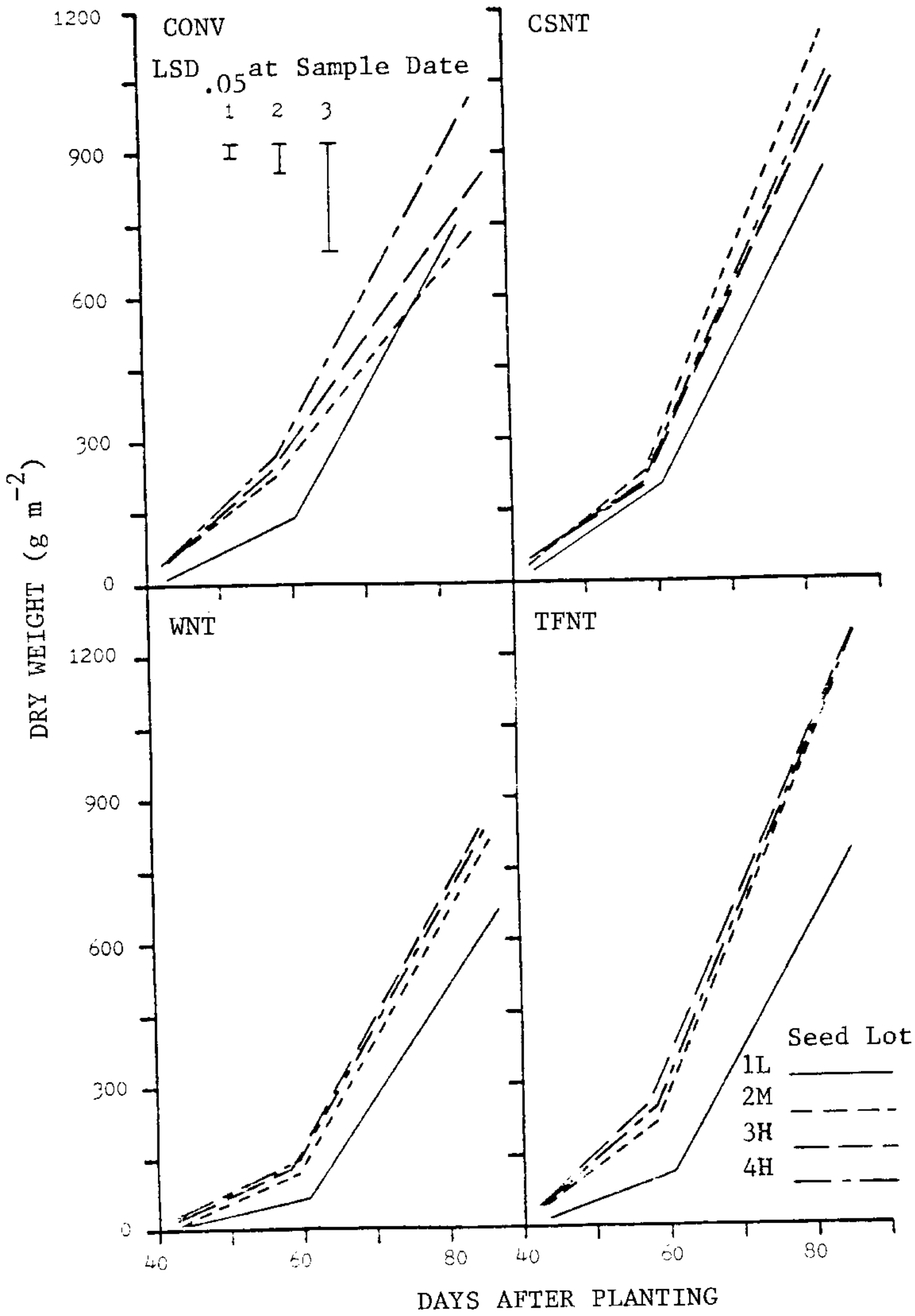

Figure 3. Plant dry weight (g m^{-2}) of four seed lots in four tillage **systems** of the April 15 planting date in 1982 at three sample dates.

Table 6 Grain yield averaged across seed lots in four tillage systems at three planting dates in 1982 and 1984.

Tillage System	Planting Date †	Yield 1982	1984	2 YR Mean
		-------- Bu/A	--------	
CONV	1	129	110	119
	2	132	112	112
	3	99	72	72
CSNT	1	154	102	128
	2	146	102	124
	3	112	---	---
WNT	1	149	121	135
	2	132	133	133
	3	131	82	106
TFNT	1	144	146	145
	2	151	134	142
	3	129	82	105
LSD 0.05		22	18	

† The planting dates were: 1982 (April 15, May 5 and May 25)

1984 (April 21, May 12 and June 4)

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