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Jackson and Milan, Tennessee
July 21-23, 1992

Conservation Tillage For Profitable Farming and Environmental Quality

M.D. Mullen and B.N. Duck, Editors

Tennessee Agricultural Experiment Station
Institute of Agriculture
The University of Tennessee, Knoxville

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Knoxville, Tennessee
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Forward

The first no-till conference was hosted by the Georgia Experiment Station at Griffin in 1978 with seven Southeastern States participating. The conference was expanded to include all 13 states in the Southern Region in 1985. In 1987, the Steering Committee voted to change the conference title to Southern Conservation Tillage Conference. The primary objective of the Conference became the promotion of conservation production systems, not just no-till, by providing a communication link between various agencies and personnel interested in resource conservation.

The use of conservation tillage has grown rapidly since the concept was first practiced in the 1960's. Its success is due, in large part, to the perception that it is a cost effective means of achieving both agricultural production objectives and soil and water conservation goals.

The 1992 conference theme "Conservation Tillage for Profitable Farming and Environmental Quality" was chosen to target the economics of changing to conservation tillage (weed control, fuel, labor, equipment, management, etc.) and preserve our land base resource as well as address conservation compliance. It is intended to include (1) farmers who are practicing conservation tillage, (2) research, Extension and Soil Conservation Service professionals studying and teaching conservation tillage, and (3) agribusiness consultants, farm suppliers, and commodity representatives.

This year's conference is being held in conjunction with the Milan No-till Crop Production Field Day at The University of Tennessee Milan Experiment Station. The conference includes a full day of oral and poster presentations at the West Tennessee Agricultural Experiment Station in Jackson, TN, followed by a tour of the Milan No-till Crop Production Field Day. It is hoped that by combining these two events, the important message of conservation tillage will be amplified and dispersed to a much larger audience than would otherwise be possible. Certainly, we at The University of Tennessee welcome the opportunity to host this important conference, and we sincerely welcome you to Tennessee.

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Contents

Tillage and Cover Crop Effects on Nitrate Leaching

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INTRODUCTION

In no other part of the United States is the erosion potential worse than in the western parts of Kentucky and Tennessee. It is an area of sloping loessial soils, with high rainfall intensities, and a high proportion of the area in row crops. No tillage (NT) has been adopted by many farmers in the area to control erosion. The no-tillage system has proven its effectiveness in reducing overland flow and sedimentation (Blevins, et al., 1989; Shelton, et al., 1983).

There is a tendency for macropores to form under NT. These macropores may be root channels, cracks between soil ped faces or earthworm burrows (Thomas et al., 1973; Thomas and Phillips, 1979; Edwards et al., 1988). Macropores potentially increase the amount of water entering the soil. This infiltration increase combined with lower evaporation from the soil surface under NT potentially leads to higher leaching. The effect of tillage on macropores and the flow of water and chemicals through macropores has been shown to be important (Thomas et al., 1973; Quisenberry and Phillips, 1976; Edwards, et al., 1988). In earlier lysimeter work at Lexington, Ky, Tyler and Thomas (1979) showed a tendency for more NO_3-N and Cl loss from no-tillage during the spring, but practically no difference during winter. However, Kanwar et al. (1985) concluded that increased macroporosity under NT results in decreased nitrogen leaching when the nitrogen source is within micropores. Under the latter scenario, new water entering the soil during storm events by-passes the solute-rich micropores via macropore flow.

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No-tillage cropping is especially important with double-crop soybeans (48 and 80% planted to no tillage in Tennessee and Kentucky, respectively) and to a lesser extent with corn (Anon., 1988). The use of no-tillage cultural practices for cotton production is relatively new and little is known about how tillage systems influence nitrate movement in the soil and its potential to pollute the groundwater. The general objectives are to determine the effects of cropping systems and tillage practices on nitrate movement. Specifically we are comparing nitrate leaching under (i) NT and CT (conventional tillage) cotton with no-cover in Tennessee, (ii) NT and CT soybean-wheat-corn rotation in Tennessee and Kentucky, (iii) continuous NT corn planted in wheat, hairy vetch, and no cover in Tennessee, and in hairy vetch and no cover in Kentucky, and (iv) alternating NT corn-soybean in Kentucky. An additional objective is to evaluate the preferential flow under such systems by comparing leachate measurements from three size lysimeters and by comparing infiltration properties and dye staining patterns under saturated and unsaturated conditions.

PROCEDURES

Tension-free pan lysimeters were used to collect water draining from the soil profile. Three sizes of lysimeters (75 x 60 cm, 45 x 35 cm, and 30 x 13 cm) were used in the NT corn with hairy-vetch cover in Tennessee. The large pans were used in all other studies in Tennessee arid Kentucky. Pans were installed under undisturbed soil at 90 cm depth by digging a trench into each plot and excavating laterally from the trench into the plot. A lysimeter was inserted into the excavated area with the outer edge at least 15 cm from the trench face into the plot. Each lysimeter was filled with sand and crushed marble to establish continuity with the soil profile. Tygon tubing was connected to the lysimeter to route water collected into a buried 60 L polypropylene carboy. Installation of all lysimeters was completed in May 1990 and leachate has been collected following storm events since that time. Nitrate concentrations and the quantity of subsurface flow has been recorded. Soil samples were collected at 15 cm intervals to a depth of 107 cm under each cropping system and resident nitrate and ammonium concentrations analyzed. Nitrate concentrations were determined by IC and ammonium by a colormetric method.

RESULTS AND DISCUSSION

Preliminary findings in Tennessee reveal that 81% of all the leachate samples had NO_3-N concentrations below the 10 mg L^{-1} maximum contaminant level (MCL) (Table 1). Samples exceeding the MCL typically occurred during the growing season shortly after fertilization when flow out of the root zone was generally small (Fig.l). The general pattern observed was high preferential flow out of the root zone during winter and early spring periods when nitrate-N concentrations were low. Nitrate-N concentrations were generally high during periods following fertilization, however, preferential flow during these summer periods was low or non-existent. Nitrate-N concentrations were generally higher under hairy vetch than under wheat or no cover during the winter period.

Table 1. Percentage of Tennessee samples with **NO_3-N concentrations above 10, 5, and 1 mg/L.**

Cropping System	10 mg/L	5 mg/L	1 mg/L
		%	
No-till Corn			
No-cover	4	12	65
Wheat	14	21	43
Hairy vetch	17	33	70
Cotton			
No-till	6	17	69
Chisel	14	42	72

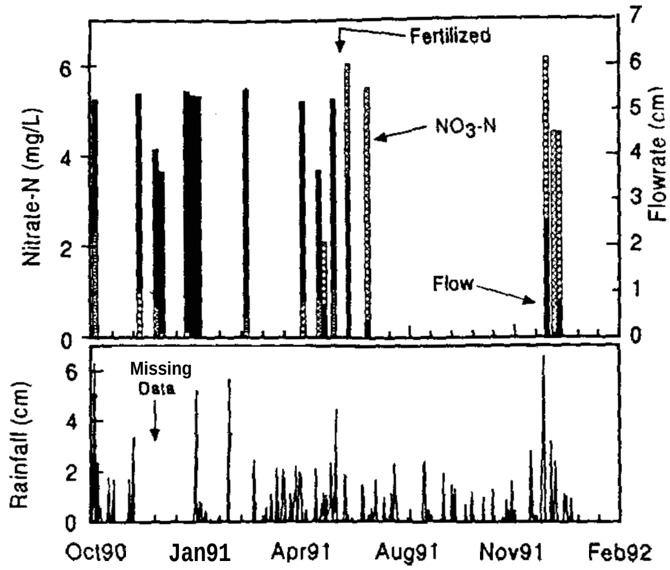


Fig. 1. Typical temporal variability of flow and nitrate-N concentration illustrated for NT corn with hairy vetch winter cover.

No-tillage appeared to reduce nitrate leaching under cotton (Fig. 2) and under the soybean-wheat-corn rotation during the wheat-corn period (Fig, 3) as compared to chisel plowing. Between 1 October 1990 to 31 September 1991 there were 30 and 20 kglha of N03-N leached for conventional and no-tillage cotton, respectively, and 14 and 5 kg/ha leached for conventional and no-tillage wheat-corn system, respectively. For no-tillage corn (Fig. 4), average losses of nitrate-N were greatest under hairy vetch ($\approx$ 17 kgha), intermediate for winter wheat ($\approx$ 10 kglha), and lowest under no cover ($\approx$ 6 kg/ha). Nitrate-N losses ranged from 3 to **53** kg/ha with the 12 lysimeters under hairy-vetch cover. The small size lysimeter exhibited the greatest variability and greatest average loss ($\approx$ 20 kglha), and the medium size had the lowest average loss ($\approx$ 9 kg/ha).

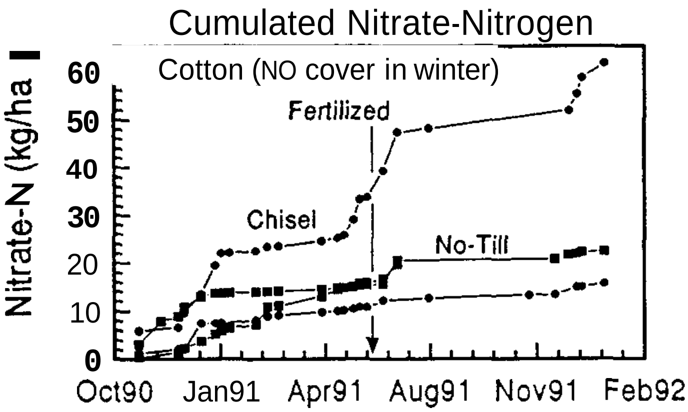


Fig. 2. Cumulative mass of nitrate-N transported out of the root zone per hectare under NT and CT cotton with no winter cover crop in Tennessee.

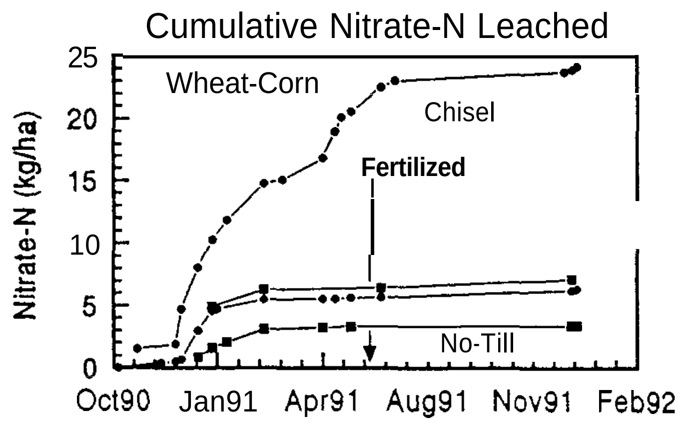


Fig. 3. Cumulative mass of nitrate-N transported out of the root zone per hectare under NT and CT soybean-wheat-corn rotation system in Tennessee.

First year results in Kentucky show that 80% of all leachate samples had N03-N concentrations below the 10 m,g/l MCL (Table 2). Corn with winter wheat that was fertilized with 150 kg N ha-1 during the summer lost about 40 kg ha^{-1} under no-tillage and 65 kg ha^{-1} under conventional tillage through the winter (Fig. 5). Conventional tillage exhibited greater nitrate leaching than NT until fertilization of wheat. When wheat was top-dressed in March with 75 kg ha^{-1} of nitrogen as ammonium nitrate and a rainstorm occurred the following night, both no-tillage and conventional-tillage wheat showed very large losses of 50 and 30 kg ha^{-1}, respectively, in a single storm. These results illustrate how highly susceptible nitrate is to leaching immediately following application. Losses of nitrate-N were small in the case of conventionally-tilled soybeans (≈ 15kg ha^{-1}) and considerably higher with no-till soybeans (≈ 35 kg ha^{-1}), Fig. 6. However, these differences were not apparent in the concentration data shown in Table 2.

CONCLUSIONS

For Tennessee and Kentucky, 81% and 80%, respectively, of leachate samples had NO,-N concentrations below the 10 mg L^{-1} MCL. Samples exceeding the MCL occurred during the growing season shortly after fertilization when flow out of the root zone was generally small. When large rainstorms occurred immediately following fertilization, as much as 50 kg/ha of NO_3-N was leached. Flow was greatest during the winter and spring when concentrations were below the MCL in Tennessee. In Kentucky, NO_3-N concentrations above 10 mg L^{-1} were observed on occasions throughout the year. No-tillage appeared to reduce nitrate leaching under cotton in Tennessee, and under corn systems in Tennessee and Kentucky. In Tennessee we observed that infiltration rates were relatively low with no significant differences between CT and NT. Thus, no-tillage not only improved surface water quality but did not increase the potential for leaching of chemicals toward groundwater due to greater infiltration. Losses

Table 2. Percentage of Kentucky samples with NO_3-N concentrations above 10, 5, and 1 mg/L.

Cropping System	10 mg/L	5 mg/L	1 mg/L
		%	
<u>Corn-Wheat</u>			
No-ti11	18	50	84
Conventional	26	43	90
<u>Soybean</u>			
No-till	2	25	95
Conventional	33	64	97

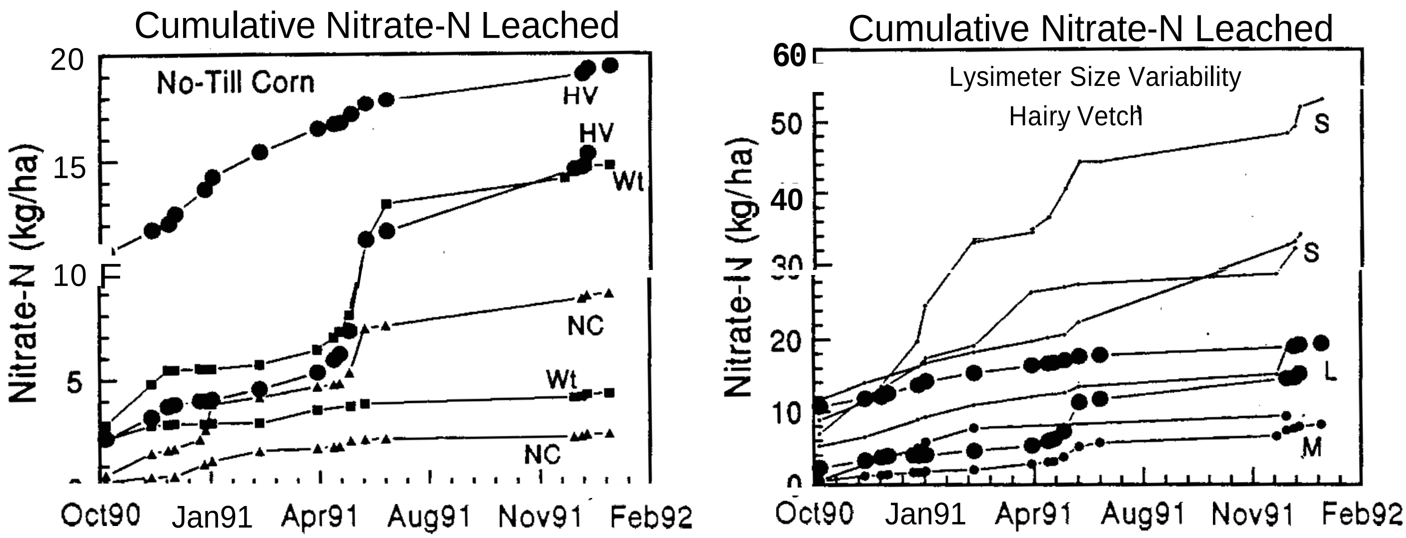


Fig. 4. Tennessee. Transport into a) large lysimeter pans under NT corn with hairy vetch (HV), winter wheat (Wt), and no cover (NC), and b) into large (L), medium (M) and small (S) pans under hairy vetch.

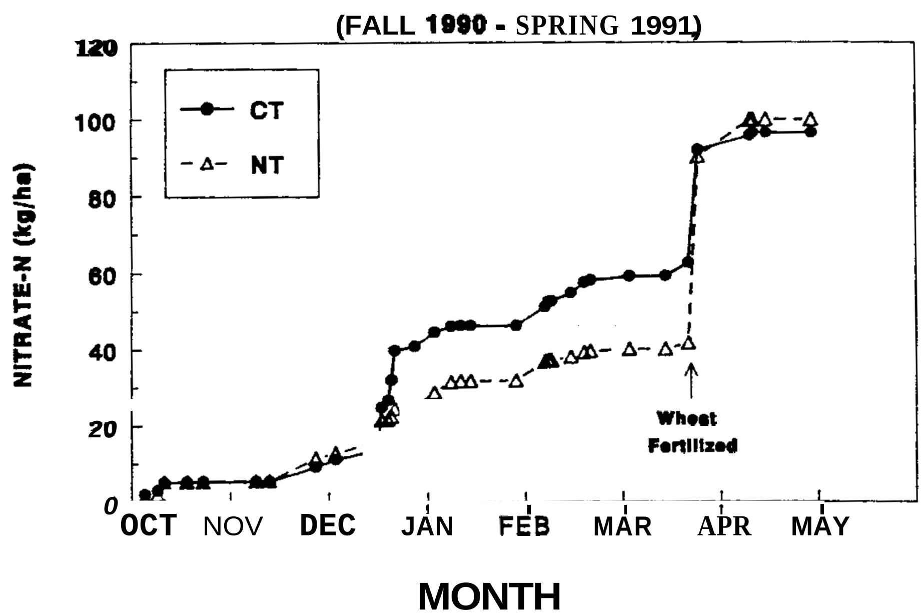
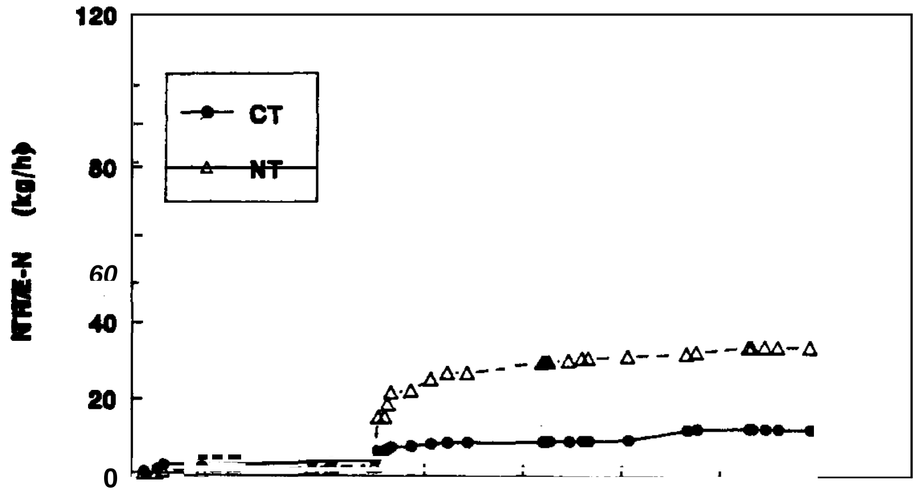


Fig. 5. Mass of nitrate-N transported out of the root zone per hectare under NT and CT Corn in Kentucky.



of NO_3-N under soybean systems were generally low, however, losses were higher with no-tillage than with conventional tillage.

ACKNOWLEDGEMENTS

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LITERATURE CITATIONS

1. Anonymous. 1988. National survey: Conservation tillage practices. Conservation Technology Information Center. 144 pp.

2. Blevins, R.L., W.W. Frye, P.L. Baldwin, and J.D. Robertson. 1989. Soil erosion and soluble nutrient losses from soil under conventional and conservation tillage. J. Environ. Qual. (in press).

3. Edwards, W.M., M.J. Shiptalo, and L.D. Norton. 1988. Contribution of macroporosity to infiltration into continuous corn no-tilled watershed: Implications for contaminant movement. J. Contam. Hydrol. 3:193-205.

4. Kanwar, R.S., J.L. Baker, and J.M. Laflen. 1985. Nitrate movement through the soil profile in relation to tillage system and fertilizer application method. Trans. ASAE 28:1802-1807.

5. Quisenberry, V.L., and R.E. Phillips. 1976. Percolation of surface-applied water in the field. Soil Sci.Soc. Am. J. 40:484-489.

6. Shelton, C.H., F.D. Tompkins, and D.D. Tyler. 1983. Soil erosion from five soybean tillage systems. J. Soil and Water Cons. 38:425-428.

7. Thomas, G.W., R.L. Blevins, R.E. Phillips, and M.A. McMahon. 1973. Effect of a killed sod mulch on nitrate movement and corn yield. Agron. J. 65:736-739.

8. Thomas, G.W., and R.E. Phillips. 1979. Consequences of water movement in macropores. J. Environ. Qual. 8:149-152.

9 Tyler, D.D., and G.W. Thomas. 1979. Lysimeter measurement of nitrate and chloride losses from conventional and no-tillage corn. J. Environ. Qual. 6:63-66.

Horizontal and Vertical Distributions of Soil C, N, P, K and pH in Continuous No-tillage Corn Production.

M.D. Mullen and D.D. Howard[1]

INTRODUCTION

Long-term no-tillage crop production often results in the accumulation of organic matter and inorganic nutrients, particularly broadcast P and K, AT the soil surface due to a lack of soil mixing (Howard and Mullen, 1991, Karlen et al., 1991). The stratification of nutrients due to the lack of tillage can result in erroneous soil test results if soil sampling techniques are not carefully monitored (Kitchen et al., 1990; Tyler and Howard, 1991). The objective of this research was to determine the effect of long-term no-tillage corn production with broadcast applications of P and K fertilizers on extractable P and K concentrations within and between corn rows. In addition, total soil C and N and soil pH were evaluated.

MATERIALS AND METHODS

A field experiment was established at the Milan Experiment Station, Milan, TN. in 1983 and continued through 1989 on a Loring silt loam soil (fme-silty, mixed, thermic, Typic Fragiudalf). During this time, no-tillage corn ('Pioneer brand 3389') was planted early- to mid-April each year in 30-inch rows.

The experimental design was a randomized complete block with a split-plot arrangement of treatments replicated five times. Main plots were P_2O_5 and K_2O rates with sub-plots consisting of different starter N-P_2O_5-K_2O combinations. For the purposes of this investigation, only the main plot treatments are considered. The P and K rates (P/K hereafter) were 0-0, 56-28, 112-56 and 168-84 kg ha^{-1}. The P/K treatments were broadcast applied in mid- to late-March using 0-46-0 and 0-0-60. Nitrogen, applied as UAN, was injected approximately 2 inches deep and 4 to 6 inches to the side of the row immediately after planting at a rate of 168 kg ha^{-1}.

Soil samples were taken between and within the corn rows. The between row samples consisted of seven soil cores taken 22 cm from two corn rows for a total of 14 subsamples per treatment. Likewise, 14 subsamples were taken directly over two corn rows. The soil cores were divided into three sections corresponding to the 0-7.5, 7.5-15, and 15-30 cm soil depths. Surface residue was removed from the soil surface prior to sampling. Extractable P and K were determined using the Mehlich I double-acid extractant followed by phosphovanadate colorimetry procedures for P determination and atomic absorption for K determinations. Total C and N were determined by dry combustion methods. Soil pH was determined by glass electrode in a 1:l soi1:water suspension. All data were analyzed using the ANOVA procedures of the Statistical Analysis System (SAS) computer program (SAS Institute, 1988). Mean separations were done using the LSD test.

RESULTS AND DISCUSSION

As expected, both C and N have preferentially accumulated in the top 7.5 cm of soil. In addition to this vertical stratification, we also observed a horizontal stratification in C and N concentrations (Table 1). The trend was not strong for total C, however, total C concentrations were consistently higher within the corn rowsthan between the rows. The interaction between sampling position and soil depth was significant at $\alpha = 0.10$. This result

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is not surprising when considering that an accumulation of roots would occur in the row and this effect would tend to fade with distance from the row.

The effect of sampling position was much more evident for total N concentrations; N concentrations were 37%, 26%, and 15% higher within than between the row in the 0-7.5, 7.5-15, and 15-30 cm segments, respectively (Table 1). This is likely due in part to accumulations of fertilizer N since UAN was injected close to the row. The increase in N may also be root derived, however, this contribution would appear to be less important with depth, based on total C data. Microbial biomass N may also be higher in this zone, but the microbial biomass-N pool was not evaluated in this study. Previous work has found increases in biomass C and N under no-tillage conditions (Follett and Schimel, 1989). and conditions which promote increased organic C and N are likely to also promote higher biomass.

The C:N ratio in each soil segment was also significantly narrower within rows than between rows (Table 1). This narrowing is primarily due to the higher N within the row, as C concentrations differed only slightly between sampling positions at any depth.

Table 2 illustrates the effect of planting rows in the same location from year to year on Mehlich I extractable P and K. Extractable concentrations of both P and K were significantly affected by P/K application rates, as well as sampling position and soil depth. As P rate increased, P concentrations in the surface 7.5 cm also increased. There were no differences in P concentration in the 7.5-15 or 15-30 cm segments at any P_2O_5 rate. The vertical stratification of P at the soil surface in no-tillage has been previously documented (Howard and Mullen, 1991; Karlin et al, 1991; Tyler and Howard, 1991). Horizontal stratification of extractable P was also observed in the surface 7.5 cm of soil at the 112 and 168 kg P_2O_5 ha^{-1} rates where P concentrations were higher between rows than within. These high rates evidently allowed for the accumulation of extractable P at the soil surface between rows over the seven year period. Tyler and Howard (1991) did not observe the horizontal stratification of P in these plots at the 112 kg ha- rate after three years, indicating that these extractable P concentrations have built over a relatively long period of time. We hypothesize that some of the P at the higher rates may be tied up in the organic P fraction, since organic matter also tended to be higher within the row. However, total P and organic P were not determined on these samples. Uptake of P within the row and subsequent removal with the grain would also be a factor, due to the relative immobility of P in soils.

Table 1. Total carbon, total nitrogen, and C:N ratios between and within rows by sampling depth.

Depth (cm)	Total C (%)		Total N (mg kg^{-1})		C:N Ratio	
	Between	Within	Between	Within	Between	Within
0-7.5	1.06 b*	1.10 a	850 b	1166 a	12.61 a	9.47 b
7.5-15	0.65 c	0.69 b	690 c	866 b	9.47 b	7.97 c
15-30	0.39 d	0.38 d	508 e	582 d	7.68 c	6.52 d

* C means followed by the same letter are not significantly different by LSD at a = 0.10. N or C:N ratio means followed by the same letter are not significantly different by LSD at a = 0.05.

The pattern for K accumulation in the soil was different than observed for P (Table 2). In contrast to the P data, K in the 0.7.5 cm segment was lower between rows than within rows at all K_2O rates. The K concentrations also were numerically greater within rows in the 7.5-15 cm segment at all K_2O rates, with the difference being significant at the 84 kg ha^{-1} K_2O rate. The horizontal segregation of K between and within rows was also observed after three years of continuous no-tillage by Tyler and Howard (1991). A possible explanation for this concentration may be that K is being recycled from plant and root tissue remainiig near the row after crop harvest. The corn rows were planted within several centimeters of the original row each year, which would support this explanation, Potassium concentrations were numerically greater within rows at the 15-30 cm depth for all K rates; however, these differences were not significant.

Extractable P and K were also evaluated for the 0 to 15 cm depth to evaluate differences relative to a standard soil test sample depth. Table **3** give soil test P concentrations *in* kg ha^{-1}.

Table 2. Mehlich I extractable P and K as affected by P_2O_5 and K_2O application rates, depth of soil sample, and sampling position.

P/K Rate (kg ha^{-1})	Depth (cm)	Extractable P (mg kg^{-1}) Between Rows	Extractable P (mg kg^{-1}) Within Rows	Extractable K (mg/kg) Between Rows	Extractable K (mg/kg) Within Rows
0/0	0-7.5	4.4*	5.0	73.4	91.2
	7.5-15	3.8	2.1	48.4	54.8
	15-30	2.9	2.1	50.6	54.6
56/28	0-7.5	16.7	17.1	85.2	96.0
	7.5-15	4.8	3.1	52.4	59.0
	15-30	2.8	2.0	50.0	55.1
112/56	Q-7.5	45.9	38.2	92.0	103.2
	7.5-15	5.6	4.4	50.2	62.4
	15-30	3.6	3.5	51.3	51.5
168/84	0-7.5	93.5	66.4	94.4	141.6
	7.5-15	6.6	4.9	56.6	77.2
	15-30	3.8	3.8	51.8	56.9

* The rate x depth x position interaction was highly significant at $P < 0.0001$ for both extractable *P* and K concentrations. The $LSD_{0.05}$ for the P means is 4.9 mg kg^{-1} and the LSD, for the K mean6 is 9.8 mg kg^{-1}.

Table 3. Mehlich I extractable P and K in the top 15 cm of soil between and within corn rows.

P/K Rate ($kg\ ha^{-1}$)	Extractable P: Between Rows	Extractable P: Within Rows	Extractable K: Between Rows	Extractable K: Within Rows	Yield** (bu/ac)
	$kg\ ha^{-1}$				
0/0	9.3*	8.0	136.4	163.5	135 c
56/28	24.1	22.7	154.1	173.6	143 b
112/56	57.7	47.7	159.3	185.5	146 a
168/84	112.1	80.0	169.1	245.1	147 a

* The P/K rate by sampling position interaction was significant at $P < 0.01$ for both P and K. LSD,, for P is 10.2 kg ha" and for K is 21.6 $kg\ ha^{-1}$.

** Yields are means for three cropping seasons, 1987-1989. Means followed by the same letter are not different by LSD at $\alpha = 0.05$.

The within row and between row differences in soil test P concentrations were not significant at any rate other than the 168 $kg\ ha^{-1}$ application rate. University of Tennessee Soil Testing Laboratory guidelines indicate that the soil test P level between and within rows is low in the check plots, medium in the 56 $kg\ ha^{-1}$ treatments, and high at the 112 and 168 $kg\ ha^{-1}$ rates. Although differences in soil test P were observed at the high P rates, these differences would not have any significant impact at this time with respect to P application recommendations for these soils.

Soil test K concentrations in the top 15 cm were significantly greater within rows than between rows except at the 28 $kg\ ha^{-1}$ rate (Table 3). Again, depending on the K rates used and accumulation patterns, disparities in soil test K classifications occurred. At this time, the only soil test level differences occur in the 56 and 84 $kg\ ha^{-1}$ treatments, where soil test K is rated as high within and medium between the rows.

Average corn yields over the three year period from 1987 to 1989 were significantly lower in the 0/0 and 56/28 treatments than at higher rates (Table 3). Both K and P may have limited yields in these treatments. The vertical and horizontal stratification of P at the low application rates, coupled with the low soil test P concentrations likely contributed greatly to these lower observed yields. Certainly the 22.7 $kg\ ha^{-1}$ P soil test P concentration within the row in the 56 $kg\ ha^{-1}$ treatment would provide less available P to a growing crop over time than the levels found at the higher rates.

In addition to C, N, P and K, soil pH was also evaluated. There were no significant effects of P/K rate or sampling depth on soil pH in this study. However, the sampling position did affect the pH. The within-row pH of 6.0 was significantly less than the between-row pH of 6.2. This is a small difference; however, the plots used in this study were limed regularly. It is conceivable that larger differences would become apparent with time if proper liming practices were not followed.

CONCLUSIONS

The data from this experiment illustrate the potential variability which may be encountered in routine soil testing of no-tillage cropland. The continued planting of rows in the same relative position over a number of years in a no-tillage system may result in both horizontal and vertical stratification of nutrients in the soil. Even at high P/K application rates, this stratification becomes obvious and may, in time, lead to yield limiting conditions in no-tilled soils. When soil sampling, attention may need to be given to the technique used to minimize soil test variability.

REFERENCES

Follett, R.F., and D.S. Schimel. 1989. Effect of tillage practices on microbial biomass dynamics. Soil Sci. Soc. Am. J. 53:1091-1096.

Howard, D.D., and M.D. Mullen. 1991. Evaluation of in-furrow and banded starter N P K nutrient combination for no-tillage corn production. J. Fert. Issues 8:34-39.

Xarlen, D.L., E.C. Berry, T.S. Colvin, and R.S. Kanwar. 1991. Twelve-year tillage and crop rotation effects on yields and soil chemical properties in northeast Iowa. Commun. Soil Sci. Plant Anal. 22:1985-2003.

Kitchen, N.R., J.L. Havlin, and D.G. Westfall. 1990. Soil sampling under no-till banded phosphorus. Soil Sci. Soc. Am. J. 54:1661-1665.

SAS Institute, Inc. 1988. SAS/STAT User's Guide, Release 6.03 edition. Cary, NC. p. 1028.

Tyler, D.D., and D.D. 'Howard. 1991. Soil sampling patterns for assessing no-tillage fertilization techniques. J. Fert. Issues 8:52-56.

Nitrogen Management of Tropical Corn in a Reseeding Crimson Clover Conservation-tillage System

D.W. Reeves[1]

Introduction

Despite the known benefits of growing corn following a winter legume, the practice is currently not sufficiently economically advantageous for growers to adopt due in large part to the cost of annual reseeding of the legume (1). New corn hybrids, originally bred for the tropics, can be planted late enough to allow a winter legume cover crop to mature seed (3, 5). These hybrids, known to farmers as tropical corn, could therefore be grown in a conservation-tillage system with winter annual legumes without incurring the yearly costs of establishing the winter legume cover crop.

Few studies have addressed the response of tropical corn hybrids to N fertilizer management (4). Although winter annual legumes like crimson clover *(Trifolium incarnatum* L.) can supply 60 to 90 lb or more N A^{-1} to a corn crop, the N released is generally not available until tasseling for temperate hybrids (2). It is likely, however, that the late planting date for tropical hybrids is more synchronized with the N release from a winter legume cover crop than the planting window of temperate hybrids.

The objectives of this field study were: to determine if tropical corn, with its late planting date, can be grown with a reseeding winter annual legume; to determine the optimum N rate and application time for tropical corn hybrids grown following a winter legume; and to determine the feasibility of this cropping system as an alternative for grain/silage production.

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MATERIALS AND METHODS

The study was initiated in 1989 at the Alabama Agricultural Experiment Station's substation at Crossville, AL. Crossville is located in the northeastern region of the state, in the Appalachian Plateau; the soil type is a Hartsells fine sandy loam (Typic Hapludult). In 1990, the study was also established on a Norfolk sandy loam (Typic Kandiudult) at the E. V. Smith Research Center in east-central Alabama. 'Tibbee' crimson clover was seeded into the experimental area in the fall prior to initiation of studies at each location (1988 and 1989, at Crossville and E. V. Smith, respectively). The clover has naturally reseeded every year since then. A Bush Hog Ro-till'' was used to subsoil in the row prior to planting tropical corn hybrids. A John Deere Flex planter with cone planters was used to seed the tropical corn into the strip-tilled area. Paraquat, atrazine and metolachlor were applied at recommended rates immediately following planting of the corn. Planting dates were June 28, June 5, and June 5 in 1989, 1990, and 1991, respectively, at Crossville, and May 31 and June 4 in 1990 and 1991, respectively at E.V. Smith. Three weeks after planting, stands were thinned to final plant populations of 18,000 A' in 1989 and 1990. Stands were thinned to 26,000 plants A^{-1} in 1991. The higher population was chosen in 1991 in order to better determine silage as well as grain yield potential of the hybrids.

The experimental design was a strip-split design of 4 replications. Horizontal plots were mulch cover, either winter fallow or reseeded crimson clover. Vertical plots were N rates of 0, 45, 90, or 180 lb A^{-1}. Subplots within the mulch cover and N rate plots were a factorial arrangement of tropical corn hybrids and N application time. Nitrogen application times were either all N applied at planting or N split

(1/3 at planting and the remainder when corn was 12-16 inches tall, 5-6 wk after planting), Tropical corn hybrids used in 1989 and 1990 were Pioneer hybrid 304C and Dekalb hybrid 678C. The hybrids used in 1991 were Pioneer hybrids 304C and 3072. These two hybrids were chosen because recent research in Alabama and Florida identified Pioneer hybrid 304C as a top silage producer while Pioneer hybrid 3072 was identified as a top grain producer.

RESULTS AND DISCUSSION

In 1989 at Crossville, yields were reduced due to severe drought in July and September, and the earliest frost ever recorded. The frost stopped development of grain when it was at 1/3 milk line. Grain yields averaged 57 bu A" for the Dekalb hybrid regardless of N application time. Pioneer hybrid 304C averaged 50 bu A^{-1} when all N was applied at planting, and 57 bu A^{-1} when N was split ($LSD_{0.10}$ = 4.1 bu A^{-1}). In the clover system, N application time was not critical, averaging 60 and 62 bu A^{-1}, respectively, when N was applied at planting or split. In the fallow system, however, yields were reduced from 53 to 46 bu A^{-1} when N wa applied at planting rather than as a split application ($P \leq 0.14$). The beneficial effect o f the clover mulch on both grain and silage yield: is seen in Table 1. Equivalent grain and silage yields were obtained with 45 lb N A^{-1} following clover as compared to 180 lb N A^{-1} following winter fallow.

Table 1. Effect of applied N and crimson **cover** cover **crop,** averaged over hybrids **and** N **application** time, on **grain** and silage yield **of tropical corn at** Crossville, *AL* **in 1989.**

	N (lb A^{-1})			
Cover **Crop**	*0*	45	90	180
	— grain, bu A^{-1} —			
Clover	45	59	60	64
Fallow	11	39	51	59
$LSD_{0.10}$=5.8 bu A^{-1}				
	— silage', **tons** A^{-1} —			
Clover	14.5	17.8	17.7	18.7
Fallow	7.1	12.6	15.9	16.4
$LSD_{0.10}$= 1.1 tons A^{-1}				

*35% dry matter

In 1990, a severe drought and heavy infestations of fall armyworm *(Spodoptera fugiperda* J. E. Smith) caused crop failures at both E. V. Smith and Crossville. Ear development was so poor that grain yields were not determined at either location. Silage yields were determined at Crossville, but the crop was so poor at E. V. Smith that no data were taken. At Crossville, Dekalb® hybrid 678C yielded 13.8 tons A' and Pioneer® hybrid 304C yielded 12.4 tons A^{-1} ($LSD_{0.10}$=0.94 tons A^{-1}). The severe drought negated any N responses, however, silage yields were increased from 11.9 tons A^{-1} following fallow to 14.2 tons A^{-1} following clover ($LSD_{0.10}$= 1.78 tons A^{-1}). This increase was likely the result of improved soil moisture under the clover mulch.

In 1991, timing of N application did not affect grain production for either hybrid at E. V. Smith or Crossville. Silage production for Pioneer® hybrid 3072 was similar to PioneeP hybrid 304C in 1991. Maximum yield (35% dry matter) was 24.8 tons A^{-1} for both hybrids at Sand Mountain. At E. V. Smith, maximum yields were 18.3 tons A' for Pioneer@304C and 19.7 tons A^{-1} for Pioneer® 3072. Averaged over both locations, Pioneer@ 304C yielded more silage when N was split applied (20.7 tons A^{-1}) rather than applied at planting (19.1 tons A^{-1}) while yields of Pioneer® 3072 were greater when N was applied at planting (20.8 tons A^{-1}) rather than split (18.9 tons A^{-1}) ($P \leq 0.11$).

Pioneer@ hybrid 3072 had a higher grain yield potential than the widely commercially available hybrid Pioneer® 304C (Fig. 1). At both locations, Pioneer® hybrid 3072 increased grain yield with N rate up to 180 lb A^{-1}. Pioneer® hybrid 304C, however, did not respond to N fertilizer as well as Pioneer® 3072,

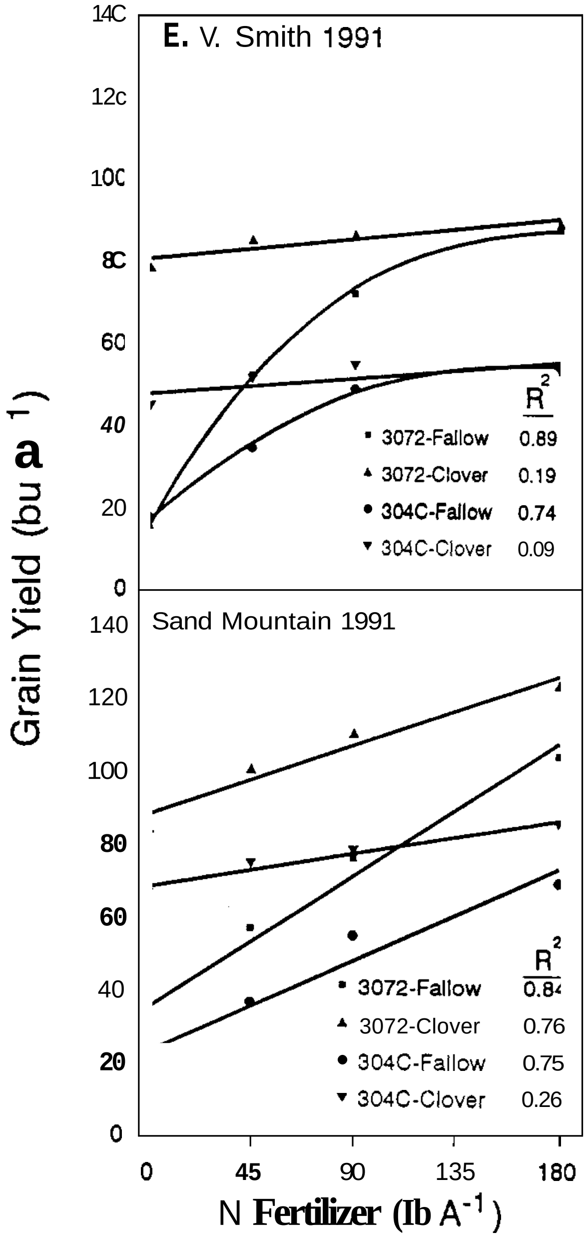

Fig. 1. Grain yield response of tropical corn hybrids to applied N as affected by cover crop, averaged over N application time.

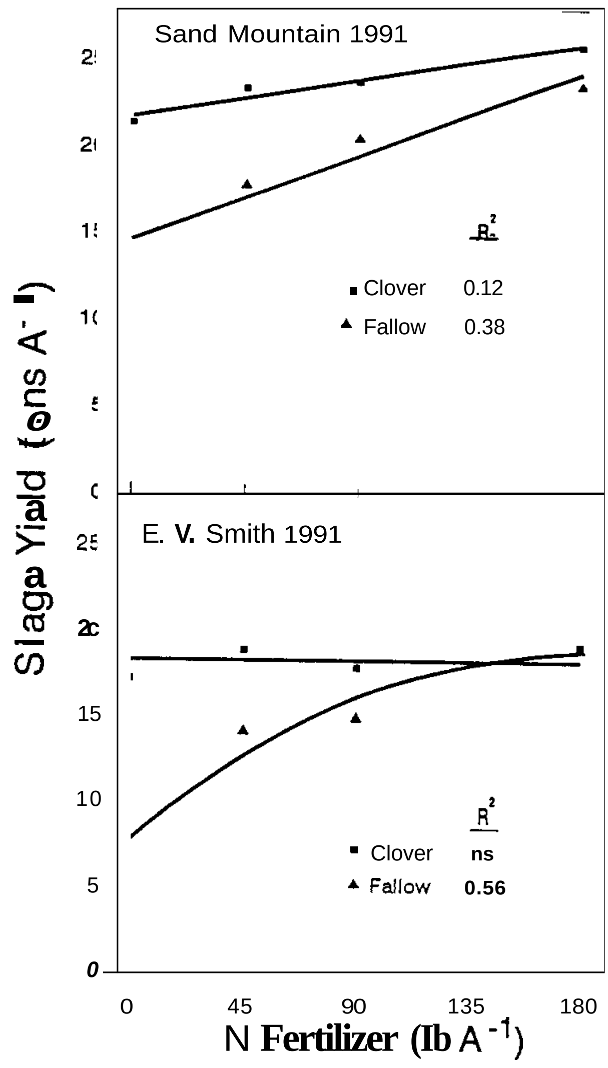

Fig. 2. Silage yield (35% dry matter) response of tropical corn to applied N as affected by cover crop, averaged over N application time and hybrids.

especially at E. V. Smith.

The reseeded crimson clover increased grain yield of both hybrids from 32 to 69% (Fig. 1). The response of Pioneer@ hybrid 3072 to the cover crop, however, was greater than that of Pioneer@hybrid 304C. At both locations, 45 lb N A^{-1} following clover produced equivalent or greater grain yields as 180 lb N A^{-1} following fallow. Silage yield following clover was similar for both hybrids. Yield following clover increased only 2 and 11% at E. V. Smith and Sand Mountain, respectively, when applied N increased from 45 to 180 lb A^{-1} (Fig. 2). Following winter fallow, however, silage production increased **35%** at E. V. Smith and 35% at Sand Mountain when N fertilizer was increased from 45 to 180 lb A^{-1}.

Although more research is needed for control of fall armyworm in tropical corn, grain yields obtained with newer hybrids like Pioneer® 3072, as well as the silage yield potential of other hybrids, shows that tropical corn has great potential in conservation-tillage systems with reseeding winter annual legumes like crimson clover. Respectable grain and silage yields in such a system can be obtained with as little as 45 lb N A^{-1}. Such a system should provide an economical alternative for growing a late season grain or silage crop that meets soil conservation guidelines.

REFERENCES

1. **Allison, J. R. and S. L. Ott. 1987.** Economics of using legumes as a nitrogen source in conservation tillage systems. p. 145-150. *In* J. F. Power *(ed.)* The Role of Legumes in Conservation Tillage Systems. Proc. **of** a national conference, University of Georgia, Athens,, GA April 27-29, 1987. Soil Conservation Society of America.

2. **Huntington, T. G., J. H. Grove,** and **W. W. Frye.** 1985. Release and recovery of nitrogen from winter annual cover crops in no-till corn production. Commun. in Soil Sci. Plant Anal. 16(2):193-211.

3. **Mask P. L. and D. W. Reeves. 1991.** Tropical corn in Alabama. p. 27. *In* I. D. Teare (ed.) Proc. of the Southern Regional Tropical Corn Symposium . Quincy, FL. June 27-28, 1991. PPI/FAR Technical Bulletin 1991-3.

4. **Reeves, D. W., D. L. Wright, and G. L.** Mullins. Soil fertility and no-tillage management of tropical corn. p. 55-58. *In* **I.** D. Teare (ed.) Proc. of the Southern Regional Tropical Corn Symposium . Quincy, FL. June 27-28, 1991. PPI/FAR Technical Bulletin 1991-3.

5. **Wright, D. L., R. N. Gallaher, and I. D. Teare.** Tropical corn as a grain crop. p. 28. *In* I. D. Teare (ed.) Proc. of the Southern Regional Tropical Corn Symposium . Quincy, FL. June 27-28, 1991. PPI/FAR Technical Bulletin 1991-3.

Sustaining Soil Organic Matter in No-tillage Corn Production

W. W. Frye and R. L. Blevins[1]

INTRODUCTION

Soil organic matter imparts many beneficial qualities to soils. These include higher cation exchange capacity; enhanced labile soil fertility, especially N and S; greater buffering capacity; improved structure and with it higher infiltration rate, lower runoff and erosion, and higher water supplying capacity.

One of the most important relationships is between soil organic matter and soil erosion. Soil organic matter decreases soil erosion and soil erosion decreases soil organic matter content (5). This relationship has important implications in the effects of tillage on soil organic matter. Controlling soil erosion with conservation tillage not only conserves soil organic matter but further decreases soil erosion. Conversely, when tillage accelerates soil erosion it accelerates both the loss of soil organic matter and the erosion process.

Tillage systems affect soil organic matter in another way also. Soil disturbance and manipulation and mixing of plant residues into the soil by plow tillage and the secondary tillage normally associated with it increase the rate of decomposition of soil organic matter. In no-tillage, on the other hand, little soil is moved or mixed. Plant residues and soil amendments are applied to the soil surface and are not mechanically mixed into the soil. Plant roots tend to concentrate near the soil surface. The surface few centimeters of soil usually are cooler, wetter, less oxidative, and more acid than in conventional tillage soil (3). These conditions in no-tillage tend to cause the soil organic matter content to increase near the surface and to decompose at a slower rate relative to conventional tillage.

Finally, crop yields are not only affected by soil organic matter content, but in turn, affect it. The improved soil conditions and increased plant nutrients from soil organic matter usually increase crop yield, as does increased nitrogen fertilizer. As crop yields increase, more residue is returned to the soil, increasing soil organic matter content (5). To a point, there is a self-perpetuating relationship between soil organic matter and soil productivity.

Our objective was to determine the effects of tillage, N rate, and time on the soil organic matter content under continuous corn starting with an old (50 to 60 years) bluegrass sod.

EXPERIMENTAL PROCEDURES

This paper reports data from a tillage field experiment at Lexington, KY. The soil was a Maury silt loam. The experiment was established in 1970 and has been in continuous no-tillage (NT) and conventional tillage (CT) corn production since then. Soil samples reported on here were taken after corn harvest in the fall of 1989, and the results are compared to results from similar samples taken before tillage in the spring of 1975 (2).

The CT plots were plowed to 8 to 9 inches depth in late April to early May each year. Corn was planted about May 10 to 15 each year with a no-tillage planter. The seeding rate was aimed at obtaining a final stand of about 20,000 plants/acre. All plots were sprayed at planting with recommended rates of a mixture of herbicides (2) for burndown of the rye cover crop and for seasonal weed control. Muriate of potash (KCI, 60% K_2O was applied broadcast at the rate of 100 lb K/acre. No P was applied because the soil is naturally high in phosphate. Corn was harvested from the two center rows of each plot. Soil samples were collected fiom 0-

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to 2-, 2- to 6- and 6- to 12-inch depth increments and analyzed for organic carbon using a wet digestion procedure in 1975 and a dry combustion procedure in 1989. The organic carbonvalues were multipliedby 1.72 to convert to soil organic matter values. Bulk density was determined by the method of Radcliffe (unpublished M.S. thesis, Univ. of Kentucky). Soil organic matter was calculated to a depth of 12 inches for each treatment.

RESULTS AND DISCUSSION

Soil organic matter in 1989, after 20 years of continuous corn, was greater in NT than CT soil (Table 1). This was consistent with previous observations on these plots (2) and consistent with the results obtained by other researchers at different locations (1, 4, 6, 8). The effect, however, was greatest at 0 to 2 inches and was limited to the 0 to 6-inch depth. Below 6 inches (6 to 12), soil organic matter was greater in CT than NT. Several factors may contribute to this phenomenon. Plant residues accumulate at the soil surface in NT and are not mechanicallymixed throughout the plow layer as they are in the case of CT. When mixed into the soil, the residues are in a more favorable environment for decomposition and humification than when left on the soil surface. Moreover, soil disturbance associated with tillage generally increases the rate of organic matter decomposition and carbon mineralization by increasing aeration and exposing heretofore protected soil organic matter (3, 7).

The effect of N fertilizer rate on soil organic matter was apparent in both tillage treatments (Table 1). There are two possible reasons for higher soil organic matter with higher N rates. First, higher N rates produce greater biomass, adding more plant residue to the soil. A possible second reason is the retarding effects of soil acidity on the rate of organic matter decomposition. During the earlier stages of our experiment, the soil pH decreased to nearly 4.0 on the unlimed, high N plots (2). Soil organic matter tended to be higher in plots with lower soil pH values (2); however, whether or not the relationship was causal is unclear.

Soil organic matter declined sharply from 1970 to 1975 but increased substantially in the 15 years from 1975 to 1989 with both CT and NT (Tables 1 and 2). The soil organic matter content under bluegrass sod appeared to increase slightly during that time, from 40.2 to 43.5 tons/acre in the 0 to 12-inch depth. The 38%

Table 1. Soil organic matter after 20 years (1970-1989) of no-tillage and conventional tillage corn.

	Soil organic matter to 12 inches		
N rate	Conv. tillage	No-tillage	Bluegrass sod
lb acre[-1]	ton/acre[1]		
0	37.6	42.6	43.5
75	43.3	44.9	
150	43.4	45.2	
300	47.2	51.1	
Average	42.9	46.0	

[1] Average of four replications and sum of three depths (0-2, 2-6, 6-12 inches).

Table 2. Soil organic matter to 12 inches after 5 years (1970-1975) of no-tillage and conventional tillage corn. From **Blevins et al. (2).**

	Soil organic matter to 12 inches		
N rate	Conv. tillage	No-tillage	Bluegrass sod
lb acre[-1]	ton/acre[1]		
0	28.0	33.0	40.2
75	30.6	34.9	
150	32.0	35.1	
300	33.4	40.6	
Average	31.0	35.9	

[1] Average of four replications and sum of three depths (0-2, 2-6, 6-12 inches).

average increase with CT and the 28% increase with NT were probably a result of a gradual rebuilding of soil organic matter following the rapid decline that was observed in both tillage systems after the first 5 years of the experiment (Table 2). By 1989, all plots except CT without N fertilizer had returned to the original level (or higher) of soil organic matter. At the 300 lb N/acre rate, soil organic matter appears to have exceeded that of the bluegrass sod. All corn residue and a rye cover crop were added to the organic matter pool each year during the 20-year study period, which, along with N fertilizer, is probably responsible for most of the increases observed in soil organic matter.

SUMMARY

When an old bluegrass sod was converted to corn production, the organic matter content decreased rapidly during the first 5 years with both CT and NT, however, more so with CT than NT. Soil organic matter increased substantially for all treatments between the 5th and 20th years of the study, with all but one treatment (CT, no N) returning to near or above the original level of the bluegrass sod.

Clearly, row cropping decreases soil organic matter content, if initially high, especially with CT. However, if initially low or depleted to a relatively low level, soil organic matter can be increased through nitrogen fertilizer, crop residue, and cover crop management. The increase is greater and probably faster with NT than CT.

LITERATURE CITED

1. Baeumer, **K.,** and W.A.P. Bakermans. **1973.** Zero tillage. Adv. Agron. 25:77-123.

2. **Blevins, R. L., G.W. Thomas, and P.L.** Cornelius. 1977. Influence of no-tillage and nitrogen fertilization on certain soil properties after five years of continuous corn. Agron. **J.** 69:383-386.

3. Doran, J.W. 1980. Soil microbial and biochemical changes associated with reduced tillage. Soil Sci. Soc. Am. J. 44:765-771.

4. Elliott, **L.F., R.I.** Papendick, and **D.F.** Bezdicek. 1987. Cropping practices using legumes with conservation tillage and soil benefits. p. **81-89.** In J.F. Power (ed.) The role of legumes in conservation tillage system. Soil Conserv. Soc. Am., Ankeny, IA.

5. **Frye, W.W., O.L. Bennett, and G.J.** Buntley. 1985. Restoration of crop production on eroded or degraded soils. p. 335-356. In R.F. Follett and B.A. Stewart (ed.) Soil erosion and crop productivity. ASA, CSSA, and SSSA, Madison, WI.

6. Giddens, **J. 1957.** Rate of loss of carbon from Georgia soils. Soil Sci. Soc. Am. Proc. 21:513-517.

7. Rice, C.W., **M.S.** Smith, and **R.L.** Blevins. 1986. Soil nitrogen availability after long-term continuous no-tillage and conventional tillage corn production. Soil Sci. Soc. Am. J. 50:1206-1210.

8. Utomo, **M.,** W.W. **Frye,** and **R.L.** Blevins. 1990. Sustaining soil nitrogen for corn using hairy vetch cover crop. Agron. J. 82:979-983.

Cotton Response to Vetch, Pix, and N Rates

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INTRODUCTION

Cotton is an important economic crop that has potential for expansion in Mississippi and the southern United States. Farmer compliance with the conservation compliance provision of the 1990 Food Security Act, however, may limit its expansion, especially on highly erodible soils. Therefore, the development of profitable productions systems which meet conservation compliance is essential for the future of cotton in Mississippi and the southern United States.

Research (Mutchler and McDowell, 1990) on highly erodible soils indicated that no-tillage and reduced tillage were effective in reducing soil erosion to within tolerance levels only when winter cover crops were included in the production systems. The use of winter cover crops in different cotton-tillage production systems, however, have shown highly variable yield results (Brown et al., 1985; Hoskinson et al., 1988; Hurst, 1989; Williford, 1985; Hutchinson et al., 1990; and Touchton et al., 1984). In the Mississippi Delta (Hurst, 1989). cotton lint yields for the winter fallow (no cover crop), averaged over tillage-herbicide systems, were higher than the wheat cover crop 2 of 5 years. Lint yield following vetch 4 of the 5 years, however, was equal to no cover crop and was more than following a wheat cover crop 2 of 5 years. All treatments (cover crop/tillage) which included herbicides produced from 409 to 1800 lb/acre more seedcotton than treatments with no herbicides. Another delta study (Williford, 1985) on a Bosket silt loam soil indicated that neither cover crops (mustard, subclover, and rye) nor tillage (no-till, minimum and conventional) systems showed a clear advantage as a cotton production system. The subclover cover crop in the check treatment (fall subsoil plus bed and rebed in spring), however, produced 200 lb/acre (3 yr av) more seedcotton than the check treatment with a natural winter cover. In contrast, Hutchinson and Shelton in 1989 reported that cotton in no-tillage and ridge-tillage both with winter wheat as a cover crop were comparable in yield to conventional tillage with no cover crop.

Winter cover crops, to become an acceptable practice in cotton production, must produce some added return (e.g. seed, nitrogen or increased yield) to offset seed and planting costs. Several reports indicated that winter legumes, especially vetch, provided sufficient N for the cotton crop (Hoskinson et al., 1989; Brown et al., 1985; and Touchton et al., 1984). Vetch, however, has been reported (Stevens et al, 1992) to delay maturity.

Pix (mepiquat chloride), a cotton plant growth regulator, has been shown to be effective in controlling cotton plant height and boll retention and increased cotton yield (Cothren et al., 1977 and Gausman et al., 1979). Recently, low rate multiple applications of Pix have been shown to be effective in reducing plant height and increasing earliness (Livingston et *al.,* 1990; McCarthy et al. 1990, Metzer and Wilde, 1990). The effect of Pix and N rates on the maturity, lint yield, and plant height of no-till cotton grown in a killed vetch sod has not been established.

A three-year (1989-91) field study was conducted on the Northeast Branch of the Mississippi Agricultural and Forestry Experiment Station, Verona, MS. The objective of this study was to evaluate cotton growth and yield response to Pix and fertilizer N applied to cotton planted in conventional tillage without vetch and planted no-till in a killed hairy vetch cover crop.

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METHODS AND MATERIALS

The field study was initiated in the fall of 1988 on an Ora fine sandy loam soil. Plots were located on the same site for the duration of the study, The study was conducted as a randomized complete block design with four replications. Plot size was four rows (38 inch wide) x 40 ft long. The Pix treatments were applied across selected N rates (0, 40, 80, and 120 Ib N/acre) applied to no-till cotton planted in killed vetch sod and to conventional tillage cotton (subsoil +disk with no vetch).

In early November of 1988-90, hairy vetch at 30 lb seed/acre was planted no-till in mowed cotton stubble with a no-till grain drill. Vetch biomass samples for dry matter yield and N content analysis were harvested in the no-till cotton (without Pix) N application treatments of 0, 40, 80, and 120 lb N/acre. Vetch samples were harvested from four 1.1 ff randomly selected areas in each plot in mid-April prior to the burndown herbicide application. The samples were dried in an oven dryer at 140°F for 72 hr before dry weights were determined. A composite sample of each treatment was sent to the MCES soil testing laboratory for N analysis.

The conventional tillage plots were subsoiled 12 to 14 inches deep in March of each year, disked in April and then do-alled prior to cotton planting. Cultivars DES 119 in 1989 and 1990, and DPL 50 in 1991 were planted (5 seed/ft row) no-till into a killed hairy vetch sod and in conventional tillage treatments on 2 May 1989, 24 April 1990, and 24 May 1991 with a four row planter equipped with a coulter and cast iron soil-slit closing wheels. Due to inadequate stands in the vetch treatments, the whole study was replanted on 17 May 1989, 8 May 1990, and 4 June 1991.N rates as ammonium nitrate (Table 4) were applied surface broadcast to both vetch and conventional tillage plots on 16 June 1989, 30 May 1990, and 12 June 1991.

Vetch burndown and cotton weed control during the growing season were accomplished with selected burndown, preemergence and post-directed herbicides. Glufosinate + metolachlor at 0.75 + 2.0 lb ai/acre were applied as a tank mixture on 14 April 1989 followed by fluometuron at 1.0 lb ai/acre applied preemergence at planting on 2 May 1989. Glyphosate at 11.0 lb ai/acre was applied prior to replanting on 17 May 1989. In 1990, paraquat + metolachlor + fluometuron + surfactant at 0.5 + 2.0 + 1.5 lb ai/acre +0.25% v/v in a *tank* mixture were applied as a burndown application to vetch on 12 April 1990. Paraquat + surfactant at 0.5 lb ai/acre + 0.25% v/v also were applied at planting on 24 April 1990 and repeated prior to replanting on 8 May 1990. In 1991 paraquat + surfactant at 0.5 lb ai/acre + 0.25% v/v were applied on 16 April 1991 and repeated on 20 May 1991. Metolachlor + fluometuron at 1.5 + 1.0 lb ai/acre were applied preemergence on 24 May 1991. Glyphosate at 0.75 lb ai/acre was applied prior to replanting on 4 June 1991.

Weeds in all treatments were controlled during the cotton growing season with appropriate herbicides applied preemergence and as post directed sprays. No treatments were cultivated during the growing season. Southern crabgrass [Digitaria scillaria (Retz)] yellow nutsedge Cyperus esculentus), and spiny pigweed (Amaranthus spinosus) were the major weeds present in all plots during the cotton growing seasons of 1989-91. Fluometuron + MSMA at 0.8 + 2.0 lb ai/acre or MSMA + methazole at 2.0 + 0.75 lb ai/acre were applied each year as a post directed spray to cotton plants 4 to 6 inches tall and repeated 2 to 3 wk later. All herbicide treatments were made with water as the carrier and applied at 20 gallons per acre (gpa) volume. Cotton insects were controlled with insecticides applied as needed based on weekly insect scouting reports. Eight to ten insecticide applications were made each year during the growing season.

Pix plant growth regulator applications (4 oz formulated product/acre) were initiated at the match-head (M.H.) square and repeated three times at 2 wk intervals, and the 8 oz/acre application at the mid-bloom cotton fruiting stage of growth (Table 1) was repeated one time

2 wk later. The Pix mid-bloom treatment was initiated when white blooms were present on the 8th to 9th node of the plant. The Pix as-needed treatment (treatment 3) was applied when personal observations indicated above normal soil moisture and rapid plant growth conditions. All Pix treatments were applied with 0.25% (v/v) surfactant in 20 gpa spray volume using SX-12 cone nozzles.

Cotton defoliant, tribufos, was applied at 1.13 lb ai/acre in 1988 and 1990, and tribufos + ethephon at 1.3 + 0.33 lb ai/acre were applied in 1991 when at least 65% of the bolls were open on all treatments. Defoliant application dates were 18 October 1989, 12 September 1990, and 30 September 1991. Ten plants in each treatment replication were mapped about 7 days prior to harvest. Five plants were selected at random from each of the two center rows of a 4-row plot of 4 replications. Each plant was mapped for plant height, number of fruiting branches, total number of bolls/plant, bolls in the first and second fruiting positions, first fruiting branch node, and nodes/plant. Seedcotton was harvested from the two center rows of each 4 row plot with a 2-row cotton picker (modified for plot harvest) on 30 October 1989, 23 September 1990, and 18 October 1991.

Analysis of variance (ANOVA) was conducted to evaluate treatment effects. Least significant difference (LSD) at the 5% probability level was used to separate treatment mean differences.

RESULTS AND DISCUSSION

Hairy vetch average dry matter yield ranged from 2849 lb/acre in 1989 to 1409 lb/acre in 1991 (Table 2). Vetch dry matter production for 2 of the 3 years was not affected by N rates applied to the previous cotton crop. In 1990, however, the 80 Ib N/acre treatment produced less dry matter than the 0 and 120 lb N/acre rate. There is no explanation for the 80 lb N/acre lower dry matter yield than the zero N rate. The N content of the vetch dry matter ranged from 4.30 to 5.28% N (Table 3). Averaged over cotton N application rates, vetch dry matter N ranged from 131 Ib N/acre in 1989 to 73 Ib N/acre in 1991 with a 3 year average of 99 Ib N/acre.

All three years of the study, the first planting in the killed vetch sod resulted in cotton stand failures. This was in contrast to good stands in the conventional tillage (subsoil + disk) treatments. Personal observations indicated that stand failure was not a result of seedling disease, but was possibly due to soil surface compaction from the planter cast iron soil-slit closing wheels. In addition, under the vetch surface mulch, the soil surface was wetter than the conventional tillage treatment. The unfavorable environmental conditions (wet and cool) for good emergence that existed during the seedling emergence period also may have had a more negative influence on emergence in the vetch sod than in conventional tillage. Plant population (data not shown) variability between vetch and conventional tillage and between years was noted with the second planting. Populations ranged from about 20,000 plants/acre in 1989 and 1990 to 50,000 in 1991. Vetch plots had higher populations than conventional tillage in 1989, lower populations than conventional tillage in 1990, and no difference in 1991.

Personal observation indicated that neither vetch nor Pix had any effect on cotton maturity. However, at the 120 lb N rare, the vetch plots had fewer bolls open in mid-September than other treatments and the data indicated a trend for fewer bolls (plant mapping data not shown) and lower seedcotton yield (Table 4).

Cotton planted in vetch and in conventional tillage showed variable yield response to additional N (Table 4). Although multiple low rates of Pix shortened plant height (Table 5), seed cotton yield for both vetch and conventional tillage showed no response to Pix all three years of the study. Cotton planted in vetch with no added N and no Pix produced yield equal to conventional tillage + 80 Ib N/acre each year with a three year average of 2074 Ib seedcotton/acre. These results are in agreement with other reports (Hoskinson et al., 1988; Brown et al., 1985; and Touchton et al., 1984) which indicate that vetch supplied sufficient N for cotton production. Vetch + 80 lb N/acre with Pix (4 oz/acre x 4 times) or without Pix, however, produced higher yield than conventional tillage + 80 lb N/acre in 1991 with no difference in 1989 and 1990. The three year average seedcotton yield for vetch + 80 lb N/acre (no Pix) was 2379 lb/acre. Although not significant, this was 408 lb/acre more than conventional tillage + 80 lb N/acre (no Pix) and 294 lb/acre more than vetch with no N and no Pix, Conventional tillage without Pix showed no yield difference between 80 and 120 lb N/acre. However, both vetch and conventional tillage showed trends for lower yield with the 120 lb N/acre.

Pix usually resulted in shorter plant height at maturity with conventional tillage than vetch treatments (Table 5). Multiple low rate Pix applications (4 oz/acre x 4 times) in both vetch and conventional tillage, however, were more effective in shortening plant height and internode length than the two 8 oz/acre application treatments initiated at mid-bloom or 4 oz/acre applied as needed (data not shown). These results are in agreement with other reports that Pix reduced plant height (Cothren et al., 1977; Livingston et al., 1990; McCarthy et al., 1990; and Metzer et al., 1990). Pix generally reduced the number of nodes/plant in both vetch and conventional tillage (data not shown). Multiple low rate applications of Pix, however, reduced total nodes/plant more in conventional tillage than in vetch.

Pix had no significant effect on total bollslplant (data not shown). Across Pix treatments, total bolls per plant for all vetch/N treatments generally were equal to or more than conventional tillage + 80 lb N/acre. Vetch + 120 lb N/acre (with and without Pix) in 1989, however, had fewer bolls/plant than the conventional tillage (no Pix) with 120 and 80 lb N/acre treatments. The percent of bolls in the first and second fruiting positions were not affected by vetch, Pix and N rate in 1989 and 1991 (data not shown). The first fruiting branch node location was not affected by vetch, Pix, N rate, and conventional tillage all three years (data not shown).

SUMMARY

Vetch planted no-till into cotton stubble in early November of each year produced a biomass of 1978 lb/acre (3 yr av) with N content equivalent to 99 lb N/acre. First planting date (2 to 3 wk after burndown herbicide application) stand failures each year in the killed vetch sod may have been due to soil compaction caused by the planter cast iron soil-slit closing wheels and the surface soil being wetter under the vetch mulch than conventional tillage. Replanted stands were acceptable in both vetch sod and conventional tillage. Multiple low rate Pix applications (4 oz/acre x 4 times) initiated at match head square was more effective in reducing plant height than two 8 oz/acre applications initiated at mid-bloom. Multiple low rate applications also shortened plant height more in conventional tillage than vetch treatments but had no effect on earliness, location of the first fruiting branch node, number of bolls/plant, and seedcotton yield. Yield varied from year to year, but vetch with no N produced yield equal to the conventional tillage + 80 lb N/acre. Although not significant, vetch + 80 lb N/acre with no Pix produced 408 lb/acre (3 yr av) more seedcotton than conventional tillage + 80 lb N/acre and 305 lb/acre more than vetch + no N. In conventional tillage, 40 to 80 lb N/acre was sufficient for maximum yield. Although the vetch cover crop system + 80 lb N/acre produced sufficient increased yield (3 yr av, 408 lb/acre more seedcotton) to more than pay for the vetch seed and the associated planting costs. Further research, however, is needed on the influence the type of planter soil-slit closing wheel system and the length of the delayed planting period following the burndown herbicide application has on cotton seedling emergence planted no-till in a killed vetch sod.

Table 1. Pix application rates and times of application made in 1989-91 to conventional tillage cotton and no tillage cotton planted in a killed vetch cover crop at the MAFES Northeast Branch.

Pix rates and times of application	1989	1990	1991
1. Check (no Pix)			
2. Pix applied at 4 oz/acre x 4 application dates initiated at Match Head (M.H.) square.	6/28 & 7/06 at 2 oz/acre	6/27	7/03
	7/28 at 4 oz/acre	7/12	7/17
	8/10 at 8 oz/acre	7/27	7/31
		8/10	8/19
3. Pix applied at 8 oz/acre x 2 applications, initiated at mid-bloom and repeated at 2 wk.	6/28 at 4 oz/acre	7/20	8/02
	7/28 at 8 oz/acre	8/08	8/19
	8/10 at 4 oz/acre		
4. Pix at 4 oz/a applied as needed based on soil moisture and plant growth	6/28 & 7/06 at 2 oz/acre	7/20	7/17
	7/18 & 7/28 at 8 oz/acre		
	8/10 at 4 oz/acre		

Table 2. Vetch dry matter yield in a no-till cotton study in 1989-91 at the MAFES Northeast Branch, Verona, MS

Cotton Production System	Applied N -lb/acre-	-------- Dry matter yield ---------- 1989	1990	1991	AV
		--------------- lb acre		---------------	
1. Vetch: NT cotton	0	3072	1892	1361	2109
2. Vetch: NT cotton	40	2578	1614	1356	1849
3. Vetch: NT cotton	80	2936	1282	1547	1922
4. Vetch: NT cotton	120	2810	1910	1372	2031
	AV	2849	1675	1409	1978
	LSD .05	NS	430	NS	
	CV %	19	19	10	

Table 3. Vetch dry matter N content in a no-till cotton study in 1989-91 at the MAFES Northeast Branch, Verona, MS

		%	lb/acre	%	lb/acre	%	lb/acre
1. Vetch: NT cotton	0	4.73	145	5.42	102	5.02	68.3
2. Vetch: NT cotton	40	4.60	119	5.17	83	5.28	71.6
3. Vetch: NT cotton	80	4.30	128	5.61	72	5.20	80.4
4. Vetch: NT cotton	120	4.64	131	5.73	109	5.28	72.4
	AV	4.57	131	5.48	92	5.20	73.2

Table 4. Seed cotton yield response to Pix time and rate of application on cotton grown no-till in a killed vetch sod and conventional tillage in 1989-91 at the MAFES Northeast Branch, Verona, MS.

Pix Rate Tillage/Cover Crop	1989	1990	1991	AV
A. No Pix	---------- Seedcotton Yield lb/acre ----------			
	0 lb N/acre			
1. Vetch	2023	1657	2541	2074
	40 lb N/acre			
2. SS + Disk	1892	1688	2119	1900
3. Vetch	1997	1662	2596	2085
	80 lb N/acre			
4. SS + Disk	2085	1588	2239	1971
5. Vetch	2477	1720	2940	2379
	120 lb N/acre			
6. SS + Disk	1713	1461	2102	1759
7. Vetch	2597	1476	2428	2167
B. Pix 4 oz/acre x 4 applications (M.H. square and repeated at 2 wk intervals)				
	0 lb N/acre			
1. Vetch	2752	1690	2631	2358
	40 lb N/acre			
2. Vetch	2411	1676	2406	2164
	80 lb N/acre			
3. SS + Disk	2031	1682	2230	1981
4. Vetch	2364	1608	2901	2291
C. Pix 8 oz/acre x 2 applications (mid-bloom and repeated 2 wks later)				
	0 lb N/acre			
1. Vetch	2186	1584	2583	2118
	40 lb N/acre			
2. Vetch	1845	1596	2475	1972
	80 lb N/acre			
3. SS + Disk	1674	1854	2605	2044
4. Vetch	2008	1562	2469	2013
	120 lb N/acre			
5. Vetch	2047	1243	1698	1663
D. Pix 4 oz/acre as needed based on soil moisture and plant growth				
	0 lb N/acre			
1. Vetch	1961	1768	2763	2164
	40 lb N/acre			
2. Vetch	2488	1493	2463	2148
	80 lb N/acre			
3. SS + Disk	2054	1567	2183	1935
4. Vetch	1620	1573	2918	2037
	120 lb N/acre			
5. Vetch	1527	1496	2626	1883
AV	2083	1602	2472	
LSD .05	792	379	620	409
CV %	23	21	18	12

Table 5. Effect of Pix and N rates on height at maturity of cotton grown no-till in a killed vetch sod and conventional tillage in 1989-91 at the MAFES Northeast Branch, Verona, MS

Pix Rate Tillage/Cover Crop	1989	1990	1991	AV
A. No Pix		height at maturity (in)		
		0 lb N/acre		
1. Vetch	43	40	33	39
		40 lb N/acre		
2. SS + Disk	46	33	29	36
3. Vetch	42	40	36	39
		80 lb N/acre		
4. SS + Disk	42	36	32	37
5. Vetch	47	39	36	41
		120 lb N/acre		
6. SS + Disk	46	39	34	40
7. Vetch	52	39	33	41
B. Pix 4 oz/acre x 4 applications (M.H. square and repeated at 2 wk intervals)				
		0 lb N/acre		
1. Vetch	--	34	28	31
		40 lb N/acre		
2. Vetch	--	37	29	33
		80 lb N/acre		
3. SS + Disk	--	28	22	25
4. Vetch	--	37	31	34
C. Pix 8 oz/acre x 2 applications (mid-bloom and repeated 2 wks later)				
		0 lb N/acre		
1. Vetch	32	40	34	36
		40 lb N/acre		
2. Vetch	34	38	34	38
		80 lb N/acre		
3. SS + Disk	38	39	33	36
4. Vetch	33	35	36	38
		120 lb N/acre		
5. Vetch	35	35	34	36
D. Pix 4 oz/acre as needed based on soil moisture and plant growth				
		0 lb N/acre		
1. Vetch	33	36	32	33
		40 lb N/acre		
2. Vetch	35	37	32	34
		80 lb N/acre		
3. SS + Disk	37	35	30	34
4. Vetch	42	30	32	32
		120 lb N/acre		
5. Vetch	39	34	32	34
AV	40	36	32	
LSD .05	5	6	5	
CV %	11	12	10	

REFERENCES

Brown, S. M., T. Whitwell, J. T. Touchton, and C. H. Burmeister. 1985. Conservation tillage systems for cotton production. Soil Science Society of American Journal 49(5): 1256-1260.

Cothren, J. T., P. R. Nester, and C. A. Stutte. 1977. Some physiological responses of cotton to 1,l dimethylpiperidinium chloride. Fourth Annual Meeting Plant Growth Regulation Working Group Proceedings. Hot Springs, AR.

Gausman, H. W., L. N. Namken, M. D. Heilman, H. Walter, and F. R. Retting. 1979. Physiological effects of a growth regulator (Pix) on the cotton plant. Beltwide Cotton Production Research Conference Proceedings, Phoenix, AZ.

Hoskinson, P. E., D. D. Tyler, and R. M. Hayes. 1988. Long term no-till cotton yields as affected by nitrogen. Beltwide Cotton Production Research Conference Proceedings.

Hurst, Harold R. 1989. The influence of winter vegetation on seedbed preparation and weed control in cotton. MAFES Bulletin 958.

Hutchinson, R.L. and W. L. Shelton. 1990. Alternative tillage system and cover crops for cotton production on the Macon Ridge. Louisiana Agriculture 33(4) 6-8.

Livingston, Stephen D. and Larry B. Wilde, Jr. 1990. The effects of Pix multiple applications on fiber quality and boll position in irrigated cotton. Beltwide Cotton Production Research Conference Proceedings, Las Vegas, Nevada.

McCarthy, W. H., A. Blaine, J. R. Rhea, S. Wise, and D. Varner. 1990. Cotton response to multiple applications of Pix - Mississippi field results. Beltwide Cotton Production Research Conference Proceedings.

Metzer, R. B. and Larry Wilde. 1990. Evaluation of multiple applications of Pix in central Texas. Beltwide Cotton Production Research Conference Proceedings.

Mutchler, C. K. and L. L. McDowell. 1990. Soil loss from cotton with winter cover crops. Transactions of the ASAE 33(2): 432-436.

Stevens, W. E., J. R. Johnson, J. J.. Varco, and J. Parkman. 1992. Tillage and winter cover crop management effects on fruiting and yield of cotton (Gossypium hirsutum L.) J. Production Agric. (in press).

Touchton, J. T., D. H. Rickerl, R. H. Walker, and C. E. Snipes. 1984. Winter legumes as a nitrogen source for no-tillage cotton. Soils and Tillage Research 4:391-401.

Williford, J. R., and R. S. Barker. 1985. Impact of cover crops on cotton production. Beltwide Cotton Production Research Conference.

Effect of Nitrogen Rate, Tillage Method and Cover Crop on Biomass Yield of Kenaf

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ABSTRACT

Everglades 71 kenaf was planted May 29, 1991 at 8 Ib/acre. Before planting 73 lb/acre each of P_2O_5 and K_2O was applied. Nitrogen (N) was applied sidedress when kenaf was 4 inches tall. Tilled plots were roto-tilled prior to planting. Analvsis 1. Eleven treatments consisted of 5 N rates (0, 34, 68, 102, and 136 Ib/acre) on prepared seedbed, 4 N rates (34, 68, 102, and 136 Ib/acre) and two legume cover crops on no-till plots. Highest yields were obtained with 102 lb N/acre with both till and no-till. Lowest yields were with no-till planted in legume cover crops. Kenaf yield from 0 N treatments was not different from highest N treatments. Final plant heights showed no differences due to treatment. Analysis 2; (split plot). In order to more closely study the effect of N rate and tillage method both legumes and the 0 N were deleted. Treatments consisted of two tillage methods and four N rates. No-till planted kenaf had lower initial and final populations than till. There were no differences in final plant height, yield, or lodging due to N rate or tillage.

INTRODUCTION

Kenaf is not a new crop in the United States, but it is experiencing a rebirth of interest. In the early 1970s it was introduced to south Mississippi but lack of effective storage methods made commercialization impossible (2). Solutions to this problem have been found, bringing commercialization closer.

The recommended cultural practice for planting kenaf is a well prepared seedbed. Preparing a seedbed increases production cost and has the potential to increase soil erosion (1).

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Limited information is available on the response of kenaf to Iegume N or tillage method. Research in Florida and Georgia showed that fertilizer N rates greater than 103 kg ha^{-1} did not increase yields (4). In Kansas ,research has shown that N rates over 51.5 kg ha^{-1} do not increase yields (5). In Alabama, cotton, which is in the same family as kenaf, planted after legume cover crops produced lint yields comparable to cotton fertilized with inorganic N rates up to 68 kg ha^{-1} (3).

METHODS

Kenaf was planted conventionally and no-till at a rate of 8 lb/acre. Four N rates (34, 68, 102, and 136 lb/acre) were applied to each tillage treatment when the kenaf was 4 inches tall. Three additional treatments were: no-till planted after two cover crops (Tibbee crimson clover and Cahaba white vetch) and a 0 N tilled treatment. Plot size was four 40-inch-wide rows 20 feet long. Cover crops were planted November 1, 1990. Potash **and** phosphorous were applied at a rate of **73** lb/acre prior to planting. Cover crops were killed with herbicides in early May and kenaf planted May 29 using a John Deere Model 7100 conservation tillage planter equipped with rippled coulters.

Ten plants per plot were measured from the ground *to* the tip of the stalk and averaged to get plant height. Plant population was determined by counting plants per 12 feet of row at emergence and harvest. Lodging was rated on a value scale at harvest (1=all plants erect, 10=all plants prostrate). Plants from thirteen feet of row were cut two inches above the ground October 13, weighed, and moisture samples taken to determine biomass yield.

Two analyses of this experiment were made:

one as a randomized complete block, and a second as a split plot comparing N rates between till and no-till after eliminating the cover crop and 0 N treatments.

RESULTS AND DISCUSSION

Analvsis 1. RCB design. There were differences in plant height early in the season which continued through mid-season (data not shown) but at harvest there were no significant differences ($P<0.05$) in height attributable to treatments (Table 1). The highest rates of **N** did not produce the fastest growing or tallest plants.

There were differences (NS) in plant stand at emergence with more plants per acre in the tilled plots with 0 N and lower N rates than in the other treatments (Table 1). There was a greater percentage loss of stand in the kenaf planted no-till in crimson clover than in plots planted till with the highest N rates.

The greatest lodging was in the no-till planted legume plots. The lowest occurred in the no-till treatment with the three highest N rates and the highest till N rate (Table 1). It appeared that there was a greater incidence of collar rot (Sclerotium rolfsii) in the legume cover crop plots.

The lowest yielding treatment was kenaf no-till planted in both legume cover crops (Table 1). This was attributed to disease problems. The yield from the 0 N treatment was not different from either the lowest or highest yielding treatments.

Analvsis 2. Split plot design. During the early season plants in tilled plots were taller than those in no-till and plants fertilized with 68 lbs of N were taller than those with 136 lbs (early season data not shown). In both instances as the season progressed differences disappeared. There was no interaction between tillage method and N rate (Table 2).

There were differences in final plant stand attributable to both N rate and tillage method. Kenaf fertilized with 68 lb/acre of N had more plants per acre than that fertilized with 136 lb/acre but these were not different from the other treatments (Table 3). Kenaf planted no-till had lower plant stands than on a prepared seedbed. There was no interaction between tillage method and N rate.

Lodging ratings ranged from 1.9 to 4.8 but there were no differences attributable to N rate or tillage method. There was no interaction between N rate and tillage method (Table 4).

Yields ranged from 11,000 to 14,000 lb dm/acre but there were no differences in yield attributable to N rate or tillage method (Table 5). There was no interaction between tillage method and N rate.

CONCLUSIONS

These data indicate that kenaf can be a viable crop if a market can be established. Kenaf yield was not adversely affected by no-tillage culture in this study. Kenaf appears to be a crop that is not a heavy user of N makiig it an even more attractive crop. Cultural practices must be developed which reduce cost, produce economic yields, and conserve soil.

LITERATURE CITED

1. **Dempsey, J.M.** 1975. Fiber Crops. The University Presses of Florida.

2. **Spiers, J.M., and C.W. Thurman.** 1971. Kenaf tested as pulp crop in Mississippi. Mississippi Farm Research, Nov. 1971.

3. **Touchton, J.T., D. Rickerl, R.H. Walker and C.E. Snipes.** 1984. Winter legumes as a nitrogen source for no-tillage cotton. Soil & Tillage Research 4:391-401.

4. **White, G.A., D.G. Cummings, E.L. Whiteley, W.T. Fike J.K. Greig, J.A. Martin, G.B. Killinger, J.J. Higgins, T.F. Clark. 1970.** Cultural and harvesting methods for kenaf. . . an annual crop source

of pulp in the southeast. USDA Production Research Report No. 113.

5. **Williams J. H.** 1966. Influence of row spacing and nitrogen levels on dry matter yields of Kenaf (Hibiscus cannabinus L.) Agron. J. 58:166-168.

Table 1. Effect of nitrogen rate, tillage method and cover crop on kenaf plant stand, plant height, lodging and yield.

N Rate	Cover crop	Tillage	Plant Counts init.	Plant Counts final	Plant Counts % Loss	Plant height	Lodging	Yield
			plants/12 ft			inches	rating'	lb/acre
34	none	NT	24	21	15	106	5.0	9996
68	none	NT	36	32	15	107	1.8	12722
102	none	NT	21	17	22	110	3.2	13862
136	none	NT	15	12	17	109	2.0	9896
0	clover	NT	23	15	36	110	7.7	6916
0	vetch	NT	23	17	25	108	7.0	7904
34	none	T	45	38	15	102	4.5	12135
68	none	T	54	43	19	103	4.2	12785
102	none	T	31	28	8	110	3.5	14754
136	none	T	22	22	2	108	1.8	13188
0	none	T	58	45	21	102	5.0	10107
		Mean	32	26	17	107	4.2	11280
		LSD(.05)	16	13	19	NS	3.1	3997
		CV%	35	35	74	6	52	25

1 1=all plants erect 10=all plants prostrate.

Table 2. Effect of nitrogen rate and tillame method on kenaf final plant height.

Nitrogen rate (lb/acre)	No-till	Till	Average
	inches		
34	106	103	104
68	107	103	105
102	110	110	110
136	109	108	108
Mean	108	106	

Table 3. Effect of nitrogen rate and tillage method on kenaf final plant stand.

Nitrogen rate	No-till	Till	Average
(lb/acre)	plants/12 ft		
34	21.5	37.8	29.6ab
68	31.3	42.5	36.9a
102	17.0	28.5	22.8ab
136	11.8	22.2	17.0b
Mean	20.4b*	32.8a	

* Means followed by the same letter are not significantly different ($P<.05$) according to Duncans Multiple Range Test.

Table 4. Effect of nitrogen rate and tillage method on kenaf lodging.

Nitrogen rate	No-till	Till	Average
(lb/acre)			
34	5.0	4.5	4.8
68	1.8	4.3	3.0
102	3.3	3.5	3.4
136	2.0	1.8	1.9
Mean	3.0	3.5	

Table 5. Effect of nitrogen rate and tillage method on yield of kenaf.

Nitrogen rate	No-till	Till	Average
(lb/acre)	lb/acre		
34	9996	12135	11066
68	12721	12784	12753
102	13862	14574	14218
136	9896	13188	11542
Mean	11619	13171	

No-tillage Planted Tropical Corn Yield Response to Nitrogen Fertilizer

R.N. Gallaher[1], T.A. Lang[1], K. Gallaher[1], and E.L. Ashburn[1]

ABSTRACT

The widespread use of tropical corn *(Zea mays* L.) in sustainable farming systems necessitates the continued study of its requirements of N fertilizer. The objective of this research was to determine the inorganic N requirements of tropical corn hybrid, 'Pioneer Brand X304C' in no-tillage management systems under environmental conditions at one location in Tennessee and one location in Florida. Leaf analysis showed that N fertilizer provided sufficient concentrations in tissue for the Tennessee study but apparently N leaching in the Florida experiments resulted in deficiency levels in the leaves. Highest grain (about 100 bu/acre) and forage yields (about 20 tons/acre) were achieved with about 120 pounds N/acre in Tennessee but even 180 pounds N/acre was not adequate in Florida. More efficient use of N should occur with four or more split applications in Florida, but this will require additional research to verify.

INTRODUCTION

Tropical corn (Zea mays L.) was estimated to have been grown, mostly for silage, on over 50,000 acres in the southeastern USA in 1991 (Wright et al., 1991). Gallaher et al. (1991) found that double cropping of tropical corn for silage could provide both profits and high quality forage. Precise inputs of N fertilizer are important not only *to* reduce pollution of surface and ground water but also to the economic well being of tropical corn producers (Lord and Gallaher, 1991). One way to monitor N fertilizer needs is by leaf analysis followed by comparisons with sufficiency concentration ranges (Jones, 1974). The objective of this research was to determine the inorganic N requirements of tropical corn in no-tillage management systems under environmental conditions at one location in Tennessee and one location in Florida.

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MATERIALS AND METHODS

One experiment was conducted at the Gallaher Angus Farms, Waynesboro, Tennessee on an Ennis cherty loam (46% sand, 34% silt, 20% clay) (Fine-loamy, siliceous, thermic, Fluventic Dystrochrept). 'Pioneer Brand X304C was planted on 5 May 1989 to achieve a population of 17,000 plants per acre in four row plots 30 inches wide and 30 feet long. Rows were laid off using **a** no-tillage planter in a 25 year-old fescue (Festuca arundinacea Schreb) pasture and planted by hand using a crowbar to punch equally spaced holes in the sod. Seed were dropped in the holes and covered with a mallet. Preemergence herbicides were Gramoxone (paraquat) plus X77 surfactant and atrazine. Six N rates of 0, 40, 80, 120, 160, and 200 pounds N/acre were applied in a randomized complete block design with four replications. Split applications of the N were at planting and at 12 inches. Youngest mature leaves were collected two weeks before tasseling for N analysis. Plant dry matter and grain yield were determined at black layer. Based upon soil test and Florida recommendations no additional fertilizer was applied. However, the fescue pasture had been fertilized with 45 lbs. N, 45 lbs. P_2O_5 and 45 lbs. K_2O per acre three months prior to planting the corn.

The second experiment was conducted for 2 yr at the Green Acres Agronomy Farm near

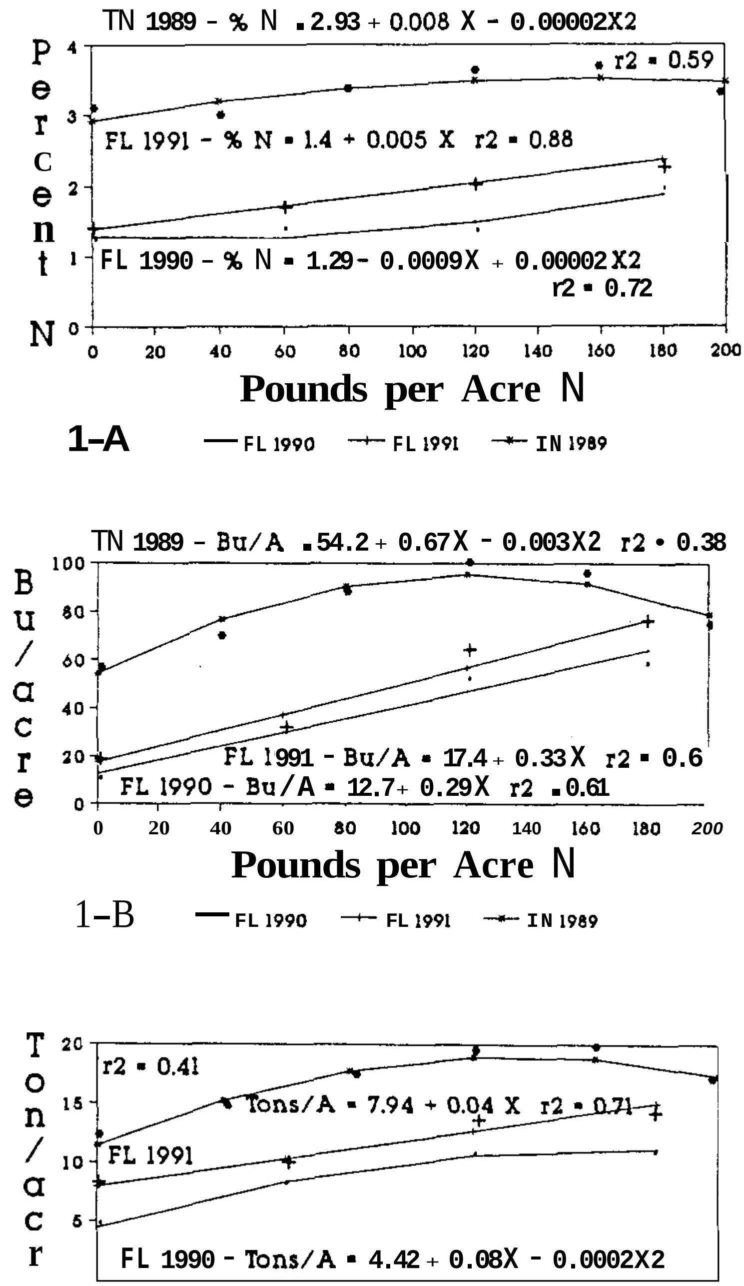

Fig. 1. No-tillage tropical corn for 1989 in Tennessee and for 1990 and 1991 in Florida: 1-A is leaf N concentration; 1-B is grain yield at 15.5% moisture; and 1-C is forage yield at 35% dry matter.

Gainesville, Florida. The soil was an Arredondo fine sand (94% sand, 2% silt, 4% clay) (sandy, siliceous, thermic, Grossarenic Paleudult). Pioneer Brand X304C was planted with an in-row subsoil no-tillage planter into no-tillage drilled rye (Secale cereale L.) residue on 20 May 1990 and 18 May 1991. The four row plots were 30 inch wide and 16 feet long to achieve 31,000 plants/acre. Four N rates were 0, 60, 120, and 180 pounds N/acre in a randomized complete block design replicated five times. Nitrogen was applied in two equal splits in 1990 and in three equal splits in 1991. Dual (metolachior) plus atrazine was applied to corn at planting. Gramoxone plus X77 surfactant was sprayed preplant. Furadan (#15g) (carbofuran) was applied at the rate of 2 pound a.i./acre at planting. Lannate (methomyl), at the labeled rate, was sprayed overtop corn one time to control insects. Water was applied every four days (1.2 inches) from tasseling through rapid grain fdl depending on rainfall. Soil samples were collected from the top 3 inches depth. Each year 450 pounds of 0-10-20/acre plus 300 pounds of K-Mag were broadcast at planting. Ear leaf samples were taken at early tasseling and silking for diagnostic N analysis. Grain yield forage yields were determined at black layer.

Leaf samples were dried at 70 °C in a forced air oven and ground to pass a 2 mm stainless steel screen in a Wiley mill and stored in air tight sterile plastic bags. Micro-Kjeldahl techniques were used to determine leaf N levels (Gallaher et al., 1975; Gallaher et al., 1976).

RESULTS AND DISCUSSION

Based on sufficiency ranges for N in corn leaf just below the whorl 3.00% N would be low and **>3.50%** N would be high (Jones, 1974). Leaf N from the Tennessee study was below 3.00% in the control plots and slightly above 3.50% with 160 pounds N/acre (Fig. 1-A). Based on sufficiency ranges for N in corn ear leaf, values below 2.60 % would be low and >4.00 % would be high. Ear-leaf N for both years of the Florida study was low at all N rates. Only at the highest N fertilizer rate of 180 pounds/acre in 1991 did ear-leaf N even approach the lowest value for sufficiency. Data show that in all studies leaf N concentration increased from increasing rates of fertilizer N except at the highest rate of N in the Tennessee study. Leaching of N was likely the reason for the low concentration of N in the ear leaf in the Florida studies. Applying the N in more than three splits should help overcome N losses and enhance N level in corn leaf.

Grain and forage yield response were positively related to increasing rates of fertilizer N application as well as N concentration in the corn leaf tissue (Fig. 1-B and 1-C). The no-tillage corn yield at the Tennessee location was greater at a lower rate of fertilizer N as compared to the Florida studies. It appears that best grain yields were obtained at about 120 pounds N/acre for Tennessee and at about 180 pounds N/acre or more for the Florida research. Since N concentration was low in ear leaf at Florida and leaf N concentration and whole plant and grain yields continued to increase at the highest N fertilizer rate, fertilizer N should be applied in more than three split applications in order to achieve optimal yield of tropical corn. This should reduce the potential for leaching and help obtain greater N use efficiency.

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LITERATURE CITED

1. **Gallaher, R.N., C.O. Weldon, and J.G. Futral.** 1975. An aluminum block digester for plant and soil analysis. Soil Sci. Soc. Amer. Proc. 39:803-806.

2. **Gallaher, R.N., C.O. Weldon, and F.C. Boswell. 1976.** A semiautomated procedure for total N in plant and soil samples. Soil Sci. Soc. Amer. J. **40:887-889.**

3. **Gallaher, R.N., S.A. Ford, R. McSorley, and J.M. Bennett.** 1991. Corn forage and forage sorghum double cropping yield, economics, crop nutrient removal and quality. Agron. Res. Report AY-91-05, Agronomy Department, Inst. Food and Agr. Sci., Univ. of Florida, Gainesville, FL 32611.

4. **Jones, J.B., Jr. 1974.** Plant analysis handbook for Georgia. University of Georgia Coop. Ext. Serv. College of Agric. Bull. No. 735. Athens, GA.

5. **Lord, P.J.E., and R.N. Gallaher.** 1991. Nitrogen requirements and nutrient content of no-tillage tropical corn and forage sorghum. In: T.C. Keisling (ed.) 1991 Southern Conservation Tillage Conference Proceedings, North Little Rock, Arkansas, June 18-20. Dept. of Agron., East Ark. Soil Test Lab., P.O. Drawer 767, Marianna, AR 72360.

6. **Wright, D.L., I.D. Teare, and R.N. Gallaher.** 1991. Corn silage production in north Florida. P. 15-20. *In* I.D. Teare, *(ed.),* Southern Regional Tropical Corn Symposium. Quincy, Florida, June 27-28, 1991. Potash & Phosphate Institute and Foundation for Agronomic Research, Atlanta, GA.

Overseeding Winter Annuals into Volunteer Summer Annual Sod

Bill Brock, Joey Murphey, Billy Johnson, David Lang, and David Ingram[1]

INTRODUCTION

The need for fall and early winter annual forage is very high in the Southeastern states, especially for dairy farmers and for beef farmers who graze stocker cattle. Ryegrass and cereals are the annuals most used to produce winter grazing. The success in establishment of winter annual pastures is always dependent on soil moisture. September and October are two of the driest months of the year and September is the normal planting time to produce early grazing of winter annuals. The recommended practice for many years to produce fall and early winter annual grazing has been to fallow the pastures 30 to 40 days prior to planting to accumulate moisture and obtain a firm seedbed. This practice allows for storing soil moisture to get the winter annuals up and growing. However, passage of the 1985 and 1990 Farm Bills makes plowing many acres of land that have been planted to winter annuals no longer an acceptable practice.

Research on practices that could be used to produce fall and early winter annuals under conservation practices was expanded in 1988 by the Mississippi Agricultural & Forestry Experiment Station. The Coastal Plain Branch Station, located in central Mississippi, pursued the objective of producing early winter annual grazing with no cultivation in a winter annual and volunteer summer annual continuous rotation. Grazing trials with dairy cows on research pastures that had been in ryegrass for many years and replicated plot trials were utilized. The system that was followed was to utilize summer volunteer annuals (broadleaf signalgrass and crabgrass) that volunteered after the winter annuals for both grazing and ground cover during the summers months, and to no-ti11 plant the winter annual directly into the summer volunteer annual sod in an effort to produce early winter annual grazing.

METHODS AND DISCUSSION

To evaluate the success of establishing winter annuals in a no-till system, a herbicide study was conducted in 1988-89 and 1990-91 and a herbicide/tillage study was conducted in 1990-91 in randomized complete block trials. In the herbicide for annual grass control prior to planting ryegrass no-till study (Table 1) early winter forage was produced in one of the two years of the study. In these tests, the herbicides were applied immediately prior to planting. The first harvest was made on 12-01-88 in the 88/89 study and 2-12-90 in the 89/90 study. The tests were planted during the first week of October in both years. First harvest yields were greater and were more consistent across all treatments in 88/89 than in 89/90. Although the first harvest was much later in 89/90, herbicide treated seedbeds produced significantly more forage than the check.

In the tillage no-till study shown in Table 2, ryegrass was grown under conventional and reduced tillage following volunteer summer annuals. In this study, a seedbed was fallowed lightly (LD) or heavily (DD) in July and August prior to planting on October 9. In the no-till treatment, the summer annual vegetation was either harvested for hay or killed with a herbicide. A third system was harvested for hay and heavily tilled prior to planting. None of the systems in this study produced early winter grazing. Poor stands existed in the no-till treatments due to dry soil conditions at planting.

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Table 1. Herbicides for annual grass suppression before planting ryegrass no-till and yield of volunteer summer annuals following ryegrass.

		Dry Matter Yield of Ryegrass				Broadleaf Signalgrass
		First Harvest		Season Total		
Name	LBai/A*	12/01/88	02/12/90	88/89	89/90	7/19/90
Gramoxone	0.38	861	702	6253	5030	2914
Gramoxone	0.50	1021	678	6454	4771	2727
Roundup	0.50	919	959	7020	5714	2928
Roundup	0.75	1062	1240	6749	5636	2699
Check		1017	316	6928	4646	2899

* LBai/A = lbs of active ingredient per acre

Table 2. Ryegrass grown under conventional and reduced tillage systems following volunteer summer annuals and yield of volunteer summer annuals following ryegrass.

	Dry matter yields - lb/A						
	Ryegrass				Brachiaria/Crabgrass		
	% Stand	% Cover	1st Harvest	Season			
Treatment	11-21-90	11-21-90	01-17-91	Total	7-09-91	8-30-91	Total
LD - J	33	13	842	6071	1715	*	1715
DD - J	70	49	1234	6409	1498	*	1498
LD - A	76	51	655	5977	1799	2024	3823
DD - A	53	33	1415	6361	1428	2132	3560
H - S	22	12	59	4261	1533	2113	3646
H - S+HB[1]	48	28	176	4752	1701	1708	3409
HB - S[1]	30	16	59	3844	1827	1645	3472
H - S - D D	36	20	1521	6605	1652	1992	3644
LSD			415	838	326	409	512
CV %			37.9	10.3	13.5	19.1	10.9

LD - Light disk
DD - Deep disk
H - Hay cut
HB - herbicide
J - Late July
A - Late August
S - Late September

* No harvest due to tillage treatment

[1] Poor stand in no-till treatments due to mechanical problems at planting resulted in lower yield Roundup^{R} herbicide was sprayed on herbicide treatments at the rate of 1 pt/A.

Roundup[R] herbicide was sprayed on herbicide treatments at the rate of 1 pt/A. Results from these replicated plot trials show a wide variation in production of early winter yields. Soil moisture at planting and during the seedling growth stage appears to be a major factor. Ethylene accumulation in the no-till treatments also may be a problem. Lang (1990) reported that a significantly high concentration of ethylene is present in the soil of both perennial and volunteer summer annual sods that were harvested for hay or killed with a herbicide immediately before planting. Concentrations of ethylene are higher in perennial sods than in a summer annual sod and appear to retard growth of ryegrass. All plot trials reported in this paper were planted where the no-till treatment was either harvested for hay or killed with herbicide immediately prior to planting.

A grazing trial at the Brown Loam Branch Experiment Station conducted in 1991 compared grazing days, ADG, gain/hd and gain/acre in six different systems of producing ryegrass for stocker calves (Ingram et al., 1992). In the systems utilizing perennial sods (bermuda) adequate grazing was not available until January 11, 1991. In the prepared seedbed treatment grazing was available on November 23 and in the two volunteer summer annual sod no-till treatments, with and without Gramoxone burndown, grazing was available on November 26. Animal grazing days, ADG, total gain per head, and total gain per acre were simiiar between the prepared seedbed and the volunteer summer annual sod no-till treatment with Gramoxone burndown. In the second year of this study, currently underway, grazing was produced in early November both on the prepared seedbed and the volunteer summer annual sod no-till treatment.

A grazing study with lactating dairy cows was conducted in 1992, that involved spraying volunteer summer annual vegetation 30 days prior to planting cool season annuals. In this study (Table 3), volunteer summer annual grasses in a 20-acre paddock were sprayed with 0.75 lb ai/A of Roundup[R] on August 6, 1991. Oat was planted into this killed sod on September 4, 1991. Cage clippings from 4'X 4' cages were harvested initially and at 30 to 50 day intervals throughout the study.

Table 3. Forage yield from no-till oat planted in a chemically killed summer volunteer annual sod.

Date of Harvest	Dry Matter Yield lb/A
11-07-91	1044
12-11-91	783
01-13-92	485
03-04-92	1074
04-08-92	1008
Total	4394

Herbicide applied 08-06-91
Date planted 09-04-91

Grazing began on this paddock on 11-01-91 and continued through 4-24-92. This paddock has been planted no-till in ryegrass since 1988. Each year grazing has been available within 60 days of planting except for 1990 when drought delayed growth of the ryegrass. In 1990, the paddock was planted on September 15 and grazing began on December 18.

The data from the four trials discussed in this paper varies widely among management practices used in establishing no-till cool season annuals following volunteer summer annuals. The critical factors in successfully establishing no-till cool season forages appear to be soil moisture and timing of herbicide application on the volunteer summer annuals prior to planting cool season annuals. In grazing trials at the Coastal Plain Branch Experiment Station, spraying volunteer summer annuals 30 days prior to planting has been a successful method of insuring an early stand of cool season annuals for the past three seasons in grazing trials using lactating Holstein cows and Holstein steers. Killing these summer annuals 30 days prior to planting allows the accumulation of soil moisture, as does summer fallowing in a prepared seedbed system, with the added bonus of ground cover. As for the toxic effect from high levels of ethylene in the soil, more work is needed to determine how ethylene concentrations change in the soil over time after herbicides are applied. The data from these trials suggest that there is potential to produce early fall and winter forage following volunteer summer annuals, but more research is needed to refine the practice.

REFERENCES

Ingram, **D.M., E.G. Morrison, and R. Hardin.** 1992. Minimum tillage for planting winter pasture. Mississippi Agr. and For. Exp. Station Information Bulletin 218. pp 12

Johnson, B.B., and W.A. Brock. 1991. Herbicides for annual and perennial grass suppression before planting ryegrass. Mississippi Agr. and For. Exp. Station Information Bulletin 202. pp 77-78.

Lang, D.J. 1990. Utilization of crabgrass and broadleaf signalgrass following winter annuals. Proc. Southern Branch of the American Society of Agronomy. p13. abstr.

Farm-scale Validation of Conservation Tillage Systems for Sandy Soils on the Texas High Plains

J. W. Keeling, W. M. Lyle, J. R. Supak and J. R. Abernathy[1]

INTRODUCTION

Cotton is the most important agronomic crop on the Texas Southern High Plains (TSHP) in terms of acreage and crop value. Between 2.6 and 3.3 million acres of cotton are planted annually in the 25-county region. Approximately 50% of this acreage is irrigated from the Ogallala aquifer. Since 1973, higher returns from cotton than from alternative crops has led to conventional-tillage cotton monoculture. Conventional-tillage cotton production in this area includes operations for destroying stalks, deep tillage with moldboard or chisel plow, preplant herbicide incorporation, bedding, planting, and cultivation for weed control. Typically, 12 to 15 tillage operations are performed prior to harvest.

Conservation tillage systems have gained increased interest in the TSHP as a means to increase profitability. Conservation tillage can also contribute toward reducing erosion on highly erodible lands as required by Conservation Compliance provisions of the 1985 Food Security Act (1). Final acceptance and widespread use of conservation tillage cotton production systems ultimately will depend on how their economic performance compares with current conventional tillage cotton production practices in this region. Cropping systems research was initiated at Lubbock, Halfway, and Wellman in 1985 in an effort to increase profitability in cotton production while satisfying Conservation Compliance provisions of the 1985 Food Security Act (2). Results from these test plots have shown significant increases in profitability of cotton production (20-40%) under irrigated and dryland conditions (5). However, a need exists to verify this under large scale field conditions in the sandyland areas south of Lubbock.

Traditional furrow irrigation is being replaced with center-pivot sprinkler irrigation systems incorporating the LEPA (Low Energy Precision Application) design. LEPA distributes water directly to the crop furrows through drop tubes and emitters and conserve water resources by minimizing evaporation, run-off and deep percolation. LEPA irrigation also offers potential for chemigation applications of fertilizers, herbicides, and other crop protection chemicals (4). Studies conducted over a four year period at Halfway indicated higher cotton yields, earlier maturity and increased water use efficiency are obtained with high frequency (3-day) deficit (0.4 ET) irrigation (3). In 1988, 1068 lb/A lint yield was produced with only 2.5 inches of irrigation water compared to 400 lb/A dryland. High-frequency deficit LEPA irrigation can make irrigation feasible in marginal water areas.

The objectives of these studies were to evaluate effects on cotton growth, yield, fiber quality and relative profitability of alternative cotton production systems utilizing cover crops, rotations and conservation tillage under irrigated and dryland conditions and integrate high-frequency deficit LEPA irrigation with conservation tillage systems to optimize rainfall and irrigation water resources.

MATERIALS AND METHODS

In 1990, a cooperative project between the Texas Agricultural Experiment Station, Texas Agricultural Extension Service, and Lamesa

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Table 1. Crop yields, value, production costs, and net returne for irrigated and dryland cropping systems at AG-CARES, Lamesa, Texas, 1991.

cropping system	Irrigated Yield	Irrigated Crop Value	Irrigated Net Returns		Dryland Yield	Dryland Crop Value	Dryland Net Returns	
	-lbs/A-	-$/A-	-$/A-		-lbs/A-	-$/A-	-$/A-	
Continuous Cotton								
Conventional Tillage	674	334	14		392	188	49	
Minimum Tillage	849	424	113		584	280	152	
Terminated Wheat-Cotton	755	376	35		263	134	22	
Conservation Tillage/Rotations								
Sorghum-Cotton	891	444	124	56[1]	275	140		44[1]
Cotton-Sorahuq	5012	200	(-11)		4078	163	82	
Wheat-Cotton	963	484	140	21[1]	448	224	78	18[1]
Cotton-Wheat	14.4 bu	43	(-98)		3	9	-42	
Cotton-Fallow Wheat[2]					521	202	119	
Cotton-Fallow-Wheat					---	---	-32	32[1]
Cotton-Fallow-Wheat					20.8	62	10	

Average return of enterprises in the rotation.
Cotton-Fallow-Wheat rotation is dryland only.

Cotton Growers began with the acquisition of a 160 acre farm in Dawson County near Lamesa, Texas. This site, named the Agricultural Complex for Advanced Research and Extension Systems (AG-CARES) provides the opportunity to evaluate conservation tillage cropping systems in large scale plots (25 acres) under real farm conditions. This site is equipped with a center pivot irrigation system to evaluate both irrigated and dryland systems.

Five cropping systems which have shown increased profitability for cotton production at Lubbock, Halfway and Wellman over the last five years were established at AG-CARES in 1990. Circular rows were established for LEPA irrigation, with dryland areas including 30% of the circle and the comers. These irrigated and dryland systems are being compared to conventional tillage cotton production in terms of cotton yield, fiber quality, and net returns per acre.

The cropping systems being evaluated include:

1) ~~Minimum tillage continuous cotton~~ in which stalks are shredded, the old rows are relisted to incorporate a preplant herbicide and cultivated as needed for weed control,

2) Terminated wheat-cotton in which wheat is planted into cotton stalks following harvest and chemically terminated 2-4 weeks prior to cotton planting and cotton is then planted into the wheat residue,

3) Wheat-cotton conservation till rotation in which wheat is grown for grain, the wheat stubble is left standing and cotton is planted into wheat stubble the following year,

4) Sowhum-cotton conservation till rotation in which cotton is planted into the previous sorghum crop residue,

5) Wheat-cotton-fallow which is similar to the wheat-cotton rotation except that the ground is left fallow between cotton harvest and wheat planting the next fall.

Cotton was planted on April 29, 1991. Irrigated cotton received 125 Ib N and 37 lb P/Acre. Dryland cotton received 15 Ib N and 18 lb P/Acre. Cotton was irrigated on a 3.5 day schedule beginning at the square stage and was based on 0.6X potential evapotranspiration. Total seasonal irrigation was 5.5". Irrigated cotton was harvested October 23 and dryland cotton November 24.

Standard land preparation, tillage practices, herbicides and cultivation were used in the conventional tillage cotton system. In the reduced tillage continuous cotton, deep tillage was eliminated and trifluralin was incorporated with the bedding operation. Winter weeds were controlled in the conservation tillage systems with a 2,4-D. Glyphosate was used to terminate the wheat cover crop as well as control any emerged weeds at planting. Herbicide treatments in the conservation tillage systems included strip-tillage incorporation (13-inch band) and a chemigation application of trifluralin. A layby (July) application of pendimethalin was incorporated by cultivation in the three conservation tillage systems.

RESULTS AND DISCUSSION

The 1991 growing season was characterized by below normal heat unit accumulations during the June through September periods. Insect infestations, including the cotton aphid, were generally light (at least by comparison to some nearby fields). A prolonged period of wet, cool conditions during the latter half of September induced some leaf shedding, slowed boll development, stimulated excessive regrowth and caused some weathering damage to open cotton. The first frost occurred October 30 and was followed by a hard freeze (18°F) November **3.** The freeze damaged or destroyed many green bolls, primarily in the dryland crop, that could have contributed to yield.

Irrigated cotton yields ranged from 674 lbs/A for conventional tillage, continuous cotton to a high of 963 lbs/A with the wheat-cotton rotation (Table 1). The minimum tillage continuous cotton, terminated wheat-cotton and sorghum-cotton rotation systems all produced higher cotton yields than the conventional tillage system. Dryland cotton yields ranged from 275 lbs/A to 584 lbs/A, with highest yields produced in the minimum tillage continuous cotton system. Lower than expected yields resulted with the terminated wheat-cotton and sorghum-cotton dryland system, mainly due to inadequate early season nitrogen applications. In 1992, earlier applications will be made to avoid any nitrogen stress that would affect yields. Three to four years results from the rotations will be necessary to determine yield and profitability over a wide range of weather conditions. We expect cotton yields in the rotations to improve relative to continuous cotton over this period. From this year's results, higher cotton yields are needed in rotations to offset lower returns from sorghum or wheat, unless high yields of these grain crops are produced, such as with dryland sorghum in 1991 (~4,000 lb/A).

LITERATURE CITED

1. Federal Register. 1987. Highly erodible land and wetland conservation; final ruling and notice of finding no significant impact.

2. Keeling, J.W., E. Segarra, and J.R. Abernathy. 1989. Economic evaluation of conservation tillage cropping system for cotton in the Texas Southern High Plains. J. Prod. Agric. 2:269-273.

3. Lyle, W.M. and J.P. Bordovsky. 1991. High frequency LEPA irrigation. Proceedings of South Texas Irrigation Conf., Texas Ag. Ext. Serv., 71-80.

4. Lyle, W.M. and J.P. Bordovsky. 1989. In-canopy chemigation with multifunction LEPA irrigation systems. Trans. of ASAE 32(6):2009-2014.

5. Segarra, E., J.W. Keeling and J.R. Abernathy. 1991. Tillage and cropping systems effects on cotton yield and profitability on the Texas Southern High Plains. J.Prod. Agric. 4:566-571.

Cotton Response to Cover Crops and Tillage in the Brown Loam of Mississippi

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INTRODUCTION

Cotton produces less residue than corn, sorghum, or soybean and has a greater amount of tillage associated with its production. Consequently, it is one of the most erosive row crops grown in the southeastern United States. Murphree and Mutchler (3) calculated a C-value for the Universal Soil Loss Equation of over 1 for the winter and spring tillage period with an over-all yearly average of 0.58.

With the passage of the Food Security Act of 1985, alternative systems such as no-tillage and/or cover crops may have to be implemented for cotton planted on highly erodible land. This study was conducted to study the effects of cover crops and tillage on cotton in the Brown Loam of Mississippi.

MATERIALS AND METHODS

Research was conducted at the Jamie L. Whitten Plant Materials Center near Coffeeville, MS on a Grenada silt loam in 1988-91. A split plot design with four replications was used with cover crops as main plots and tillage systems as split plots. Individual plots were six 101-cm rows 12.2 m in length.

Cover crops were drilled (20 cm rows) at seeding rates of 22, 34, and 134 kg/ha for crimson clover, hairy vetch, and wheat, respectively. Native cover consisted of carolina geranium, cutleaf evening primrose, wild garlic, and annual bluegrass. All plots received a uniform rate of P and K in the fall according to soil test recommendations. Wheat received an additional 28 kg N/ha as ammonium nitrate. Canopy cover of the cover crops was visually rated at three week intervals from February to mid-April. Cover crop DM yield was determined by hand harvesting .3 square meters in each plot prior to termination, air dried, and weighed.

On approximately April 15 each year, cover crops in the conventionally tilled (CT) plots were disked twice or in the no-till (NT) plots chemically killed with glyphosate. Conventionally tilled plots were also chiseled and harrowed before planting. Cotton 'DES 119' was planted at a seeding rate of 23 seeds per row-meter using a no-till planter with a ripple coulter and double disk openers. Planting dates were May 25, 1989, May 7, 1990, and June 3, 1991. Nitrogen (45 kg/ha as ammonium nitrate) was applied to all plots prior to planting. Fluometuron and metolachlor were applied preemergence at 1.7 kg ai/ha each. Four weeks after emergence in 1989 and 1991, cotton received an additional 11, 45, and 45 kg N/ha in crimson clover, native, and wheat plots (2). In 1990, all plots received 45 kg N/ha four weeks after emergence. Seedcotton yield was determined by hand harvesting one middle row in each plot. Ten plants in each plot were measured to calculate plant height at maturity. Plant population was calculated by counting the number of plants per 3 m of row two weeks after emergence in 1989 and after harvest in 1990 and 1991. Whole plants from 0.3 meter of row were harvested on the fifth row of each plot at 4, 8, 12, and 16 weeks after planting (WAP). Plants were separated by parts (stems, leaves, roots, squares, and bolls), dried in a forced draft oven for 72 hours at 35 "C, and weighed.

[1]Jamie L. Whitten Plant Materials Center, Coffeeville, MS, and [2]North Mississippi Branch Experiment Station, Holly Springs, MS.

Records were kept of all operations and inputs to calculate total production expenses for each cover crop-tillage system. Expenses were based upon the three year average of all operations and inputs used in this study.

RESULTS *AND* DISCUSSION

Weather conditions were more favorable for the cover crops in 1988-89 than in the other two years. Record low temperatures occurred in December 1989 and killed many plants. In 1990, temperatures were above normal from early November to mid-December. A sudden drop in temperature in late December killed most of the crimson clover due to lack of acclimation to cold weather. Therefore, data for crimson clover and cotton in 1991 were not analyzed.

Wheat produced more canopy cover than the legumes from emergence to late January (data not presented). Generally, this trend continued until April when hairy vetch produced more cover than crimson clover or wheat (Table 1). In 1991, native cover produced more cover than the planted cover crops on three of the four dates. Competition from these weeds in the planted cover crop plots was higher in NT plots than in the CT plots. Wheat produced significantly higher DM yields during two of the three years (Table 1). Low yields for 1990 reflect the damage resulting from the record cold weather in December 1989.

When cotton was planted in late May or early June, NT cotton produced a higher yield than CT cotton (Table 2). Although delayed by wet weather, NT plots were ready to be planted earlier than CT plots. In 1990 when cotton was planted on May 7, no yield differences occurred between tillage systems. When periods of dry weather occurred during boll development in all years, CT cotton tended to show earlier wilting signs than NT cotton. Cover crop did not affect seedcotton yields. Plant height was influenced by tillage system only in 1989 (Table 2) when plants were significantly shorter in CT plots. Cover crops affected plant height in 1990 when cotton with a legume cover crop was taller. Plant population responded differently to tillage systems (Table 2). Population was higher for CT cotton in 1989 but was lower in 1991. When plant population was reduced, stands were adequate to produce maximum yields.

No-till cotton in 1989 produced more vegetative growth (Table 3) and also produced higher seedcotton yield. Reproductive weights for NT cotton tended to be higher at all sampling dates. In 1990, no consistent trends were found for components' weights between dates. Total plant weights were significantly higher for NT cotton from 4 to 12 WAF in 1989. In 1990, however, heavier plants were produced by CT cotton only at 4 WAP. Cover crops did not affect weights in either year.

Averaged across cover crops, no-till cotton reduced total production expenses by $31.00 per

Table 1. Cover crop canopy and dry matter yield, by dates, 1989-91.

	Canopy cover										DM yield		
	1989				1990		1991						
Cover crop	2/9	3/13	3/28	4/11	3/30	4/13	2/7	2/27	3/21	4/15	1989	1990	1991
	%										kg ha^{-1}		
Crimson clover	80	70	90	100	23	28	--	--	--	--	3013	167	---
Hairy vetch	60	60	90	100	47	85	6	13	41	95	2249	1027	1732
Wheat	93	78	83	94	52	77	25	25	48	52	3699	2195	1652
Native	17	25	58	74	48	59	87	88	90	96	1552	419	1595
LSD(0.05)	14	6	10	10	NS	20	9	10	10	4	1381	608	NS

Table 2. Seedcotton yield, plant height, and plant population as affected by cover crops and tillage, 1989-91.

		Seedcotton yield			Height			Population		
cover crop		1989	1990	1991	1989	1990	1991	1989	1990	1991
		-------kg ha^{-1}-----			--------cm--------			----x 1000 ha^{-1}-----		
Crimson clover		1722	3099	---	117	102	--	148.7	70.9	----
Hairy vetch		1743	3384	2286	117	109	97	151.2	67.2	110.2
Wheat		1920	3076	2344	112	97	94	134.4	75.3	112.1
Native cover		1950	2790	2184	109	91	94	140.8	71.4	93.1
Tillage means										
Conventional		1534	3167	2096	104	99	97	155.1	72.6	83.5
No-till		2134	3007	2447	122	99	94	132.4	69.9	126.7
LSD(0.05)	Cover crop	NS	NS	NS	NS	10	NS	NS	NS	NS
	Tillage	326	NS	368	5	NS	NS	19.2	NS	27.2

Table 3. Dry weight of cotton plant components at 4, 8, 12, and 16 weeks after planting, by tillage systems, 1989-90.

	Dry weight							
Plant	4 weeks		8 weeks		12 weeks		16 weeks	
part	Conv.	No-till	Conv.	No-till	Conv.	No-till	Conv.	No-till
	- - - - - - - - g/plant - - - - - - - -							
				1989				
Stem	.26*	.36	6.63*	9.19	16.18*	22.20	23.40*	31.74
Roots	.16	.15	1.37*	1.75	3.08	3.66	4.60	5.39
Leaves	.54*	.76	7.86*	10.14	15.00*	20.30	13.30	16.89
Squares			.12*	.18	1.28	1.70		
Bolls					.03	.12	23.84	30.14
Total	.96*	1.27	15.98*	21.26	35.37*	47.98	65.14	84.16
				1990				
Stem	.06*	.04	1.78	2.02	15.60	13.56	36.21	38.51
Roots	.06	.04	.70	.74	3.78	3.26	5.46	4.64
Leaves	.30*	.19	4.51	5.20	28.61	27.94	38.50	35.93
Squares			.05	.04	2.63	2.10	2.29	2.32
Bolls							37.70	33.93
Total	.42*	.27	7.04	8.00	50.62	46.86	120.16	116.33

* Component means by date are significantly different at the 0.05 level of probability.

Table 4. Average total production expenses by cover crop-tillage system, 1989-91.

Item	Crimson NT	Crimson CT	H. vetch NT	H. vetch CT	Wheat NT	Wheat CT	Native NT	Native CT
	$/ha							
Defoliant	56.46	56.46	56.46	56.46	56.46	56.46	56.46	56.46
Fertilizer	150.11	150.11	143.50	143.50	169.85	169.85	162.61	162.61
Fungicide	32.41	32.41	32.41	32.41	32.41	32.41	32.41	32.41
Herbicide	141.81	93.70	141.22	93.70	114.81	93.70	121.40	93.10
Insecticide	120.16	120.16	120.16	120.16	120.16	120.16	120.16	120.16
Seed	60.23	60.23	79.45	79.45	52.82	52.82	25.15	25.15
Op. labor	38.12	51.89	38.12	51.89	38.54	52.32	35.07	48.85
Diesel fuel	15.09	22.42	15.09	22.42	15.30	22.63	14.19	20.95
Rep. & Main.	67.38	78.46	67.38	78.46	67.76	74.73	63.69'	74.78
Unalloc. labor	30.50	41.52	30.50	41.52	30.84	41.86	28.06	39.08
Interest	31.82	30.98	30.67	31.64	29.55	32.16	30.29	31.94
Tot. Direct	750.08	738.34	754.95	751.61	728.49	749.09	689.48	706.07
Tot. fixed	138.67	164.14	138.67	164.13	139.45	164.91	130.33	155.78
Tot. Spec.	888.75	902.48	893.62	915.74	867.94	914.00	819.81	861.85

hectare (Table 4). Additional expense of the burndown herbicide in NT cotton was more than offset by the decrease of $13.78 and $7.19 per hectare for labor and diesel fuel, respectively.

Of the planted cover crops, wheat was slightly cheaper than crimson clover. Average cost of seed (dollars per kg) was .20, 1.56, and 1.61 for wheat, crimson clover, and hairy vetch, respectively. Hairy vetch and crimson clover reduced fertilizer cost by producing an expected 45 and 34 lb N/A, respectively, for the cotton (2). Fertilizer expense for wheat was higher due to the application of 28 kg N/ha in the fall. Results from Tennessee suggest that seeding rates of legume cover crops can be reduced by 25% without decreasing DM production or N fixation (1). Therefore, seeding costs of legume and possibly wheat would be reduced.

LITERATURE CITED

1. **Duck, B.N., and D.D. Tyler.** 1990. Seeding rate effects on legume biomass and N accumulation. p. 313. In Agronomy abstracts. ASA, Madison, WI.

2. **Funderburg, E.R.** 1987. Cover crops. Mississippi Coop. Ext. Serv. Information Sheet 1552.

3. **Murphree, C.E., and C.K. Mutchler.** 1980. Cover and management factors for cotton. Trans. ASAE 23:585-588, 595.

Double- and Mono-cropped Corn and Soybean Response to Tillage.

Glenn R. Bathke, Paul M. Porter, Dan Robinson, and Jacob Gibson[1]

INTRODUCTION

Farmers in the Southern United States take advantage of the region's long growing season by double-cropping, with about 7 million acres double-cropped in 1990. The long growing season favors double-cropping of winter and summer crops, which spreads risks and costs and may maximize returns to land and management. Soybean *(Glycine max* L.) has been the only summer crop available to most farmers for double-cropping, and soybean acreage has dropped from 24 million acres in 1982 to 13.5 million in 1990 (USDA-NASS, 1991). Corn *(Zea mays* L.) is also an important crop in the rotation schedule for many farmers, but most of the corn varieties grown are short-season hybrids planted very early in the spring to minimize the effects of drought, heat, or high insect pressures during late summer. Development of new tropical corn hybrids which are more heat tolerant and insect resistant allow the farmer to plant corn later in the season and still have acceptable yields. Cropping systems including tropical corn will give farmers an alternative crop to soybean in double-cropping with wheat *(Triticum aestivum* L.).

Management schemes for the production of double-cropped corn and soybean must account for the limiting soil conditions of this region. In addition to a coarse surface texture and very low water-holding capacity, many of the important agricultural soils in the Southeastern Coastal Plain have a compacted layer in the E horizon, at the base of the Ap horizon. This compacted zone, caused by natural and man-induced factors such as tillage and traffic, restricts plant rooting to very shallow depths. Yields of corn and soybean grown on sandy Coastal Plain soils are frequently reduced due to the presence of hardpans which prevent root acquisition of subsoil moisture and nutrients (Simmons et al., 1989; Smittle et al., 1977). Deep tillage is needed to achieve hardpan breakage. Busscher and Sojka (1987) found that conservation tillage methods can be used to delay recompaction of the E horizon. Conventional double-cropping systems on the Atlantic Coastal Plain utilize subsoiling, but the timing of deep tillage operations and the benefits to subsequent crop growth need to be quantified.

Objectives are to evaluate: 1) the suitability of tropical corn for use in double-cropping systems; 2) the optimal type of tillage (no-till, in-row subsoiling, between-row subsoiling) for corn and soybean mono-crop and double-crop production; 3) the optimal time for deep tillage operations (at planting or at the last cultivation) for corn and soybean mono-crop and double-crop production.

METHODS

This study was conducted at the Edisto Research and Education Center of Clemson University during 1990 and 1991. Full-season corn and soybean and double-cropped tropical corn and soybean were planted using 96 cm row spacing in 12 m by 15 m plots in a randomized complete block arrangement with four replications. Each crop was analyzed separately with tillage as the treatment variable. For the soil properties, row and interrow positions were used as split-plot variables. Tillage treatments were subsoiling in-the-row at planting, subsoiling between-the-row at the last cultivation (about 5 weeks after planting), and no-tillage. In-row subsoiling was performed using a KMC subsoiler with shanks spaced 96 cm apart and

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Table 1. Corn yield response to three tillage systems.

Tillage	Grain bu acre⁻¹	Grain kg ha⁻¹	Stover lb acre⁻¹	Stover kg ha⁻¹
	Double-cropped Tropical Corn - 1990			
No-till	33 B*	2374 B	5804 C	6500 C
Late subsoil	40 AB	2669 AB	7504 B	8405 B
Early subsoil	60 A	4026 A	10871 A	12176 A
	Double-cropped Tropical Corn - 1991			
No-till	16 B	1030 B	1573 A	1762 A
Late subsoil	15 B	964 B	1801 A	2017 A
Early subsoil	28 A	1728 A	2199 A	2463 A
	Mono-cropped Tropical Corn - 1991			
No-till	145 A	9102 A	28150 A	31528 A
Late subsoil	153 A	9605 A	30139 A	33756 A
Early subsoil	156 A	9793 A	30260 A	33891 A

*Means in a column followed by the same letter are not significantly different according to DNMRT, $a = 0.05$.

operated 35 cm deep. Between-row subsoiling was performed using a United Farm Tools subsoiler with the shanks spaced 96 cm and operated 35 cm deep. All plots receiving deep tillage were disked prior to planting. The soil used for the study was a Dothan loamy sand (fine-loamy, siliceous, thermic Plinthic Paleudult; Rogers, 1977). All fertilizers were applied at rates based upon crop and soil test recommendations and broadcast before fall tillage, and in the spring as sidedress application as needed. Insecticides and herbicides were applied as needed according to recommended procedures (Horton, 1991).

In 1990, only double-cropped soybean and tropical corn were used for the test. Pioneer 3165 was used as the full-season corn hybrid and Pioneer 304C as the tropical corn variety. Kirby was used as the full-season and double-crop soybean variety. For double-cropped treatments, wheat was planted in mid-December immediately after disk tillage and harvested in mid-June. The wheat was grown only to plant the summer crop into, so yields were not measured. Full-season corn was planted at a rate of 48500 seed/ha in early April. Full-season soybean was planted at a rate of 110000 seed/ha in mid-May. Double-cropped soybean and tropical corn were planted after wheat harvest at rates equal to the full-season crops. In 1990, corn and soybean were planted with a John Deere 7200 MaxEmerge planter. In 1991, corn and soybean were planted with an Almaco plot planter. Due to adverse weather conditions in 1991, the tropical corn was not planted until July 9, and the late subsoiling tillage treatment was delayed due to wet conditions and resulted in damage to the tropical corn plants. Corn grain and stover were hand harvested by cutting 3 m sections of two center rows in early September. Ears were separated from stalks, weighed, and the grain yield reported at 15.5% moisture. Six randomly selected stalks were weighed, sectioned, and oven dried to adjust the stover yield data to 65% moisture. An Almaco plot combine was used to harvest 15 m sections of *two* center rows of soybean in mid-October, with soybean yield reported at 14% moisture.

Table 2. Soybean yield response to three tillage systems.

	Double Cropped Soybean		Full Season Soybean	
Tillage	bu acre^{-1}	kg ha^{-1}	bu acre^{-1}	kg ha^{-1}
		1990		
No-till	19 A*	1265 A	-	-
Late subsoil	17 A	1151 A	-	-
Early subsoil	20 A	1320 A	-	-
		1991		
No-till	26 A	1565 A	33 A	2005 A
Late subsoil	28 A	1720 A	33 A	1981 A
Early subsoil	30 A	1816 A	34 A	2038 A

*Means in a column followed by the same letter are not significantly different according to DNMRT, $\alpha = 0.05$.

Undisturbed soil cores were taken at the 5 to 12 cm soil depth with Uhland sampler attached to a hydraulic coring device three times during the season: at planting, one week after the late subsoiling operation, and after harvest. The cores were slowly saturated with water and saturated hydraulic conductivity (KSAT) measured using a constant-head permeameter with a hydraulic gradient of 1.8 cm/cm (Klute and Dirksen, 1986). The cores were then oven dried and weighed for bulk density (BD) determination (Blake and Hartge, 1986). Analysis of variance procedures were performed on the data using the Statistical Analysis System (Ray, 1982).

RESULTS AND DISCUSSION

Soil Properties

For the double-cropped tropical corn plots in 1990, KSAT at planting was highest for the early subsoiled treatment at the row position, with the other treatments and depths being similar (Fig. 1). After the late subsoiling treatment. both deep tillage treatments had similar KSAT values in the row, but were significantly different at the interrow position. After harvest all treatments and positions had similar KSAT levels. Bulk density levels had an inverse relationship with KSAT (Fig. 1) Immediately after an early or late subsoil operation, BD at the position nearest the subsoil shank zone was at its lowest value with subsequent densification occurring over time. Averaged over treatments, the row position was less compacted than the interrow position, even with the obvious soil loosening of the interrow area with the late subsoiling operation.

For the double-cropped tropical corn treatments in 1991, KSAT at planting was again highest for the early subsoiled treatment at the row position, with the other treatments and depths being similar (Fig. 1). After both deep tillage operations had been performed, the immediate area where the subsoil shank ran had the highest KSAT values. These areas also tended to have the highest KSAT values at harvest, but they were not significantly different from the other areas. Bulk density values followed a trend similar to that in 1990 (Fig. 1). In the immediate area of the subsoiling operation, BD was at the lowest level for the next two measurement periods. A gradual increase in BD over time occurred, although the no-till treatment did not change appreciably. Density levels did not reach root limiting conditions. The pattern of change in KSAT and BD for the 1990 and 1991 double-cropped

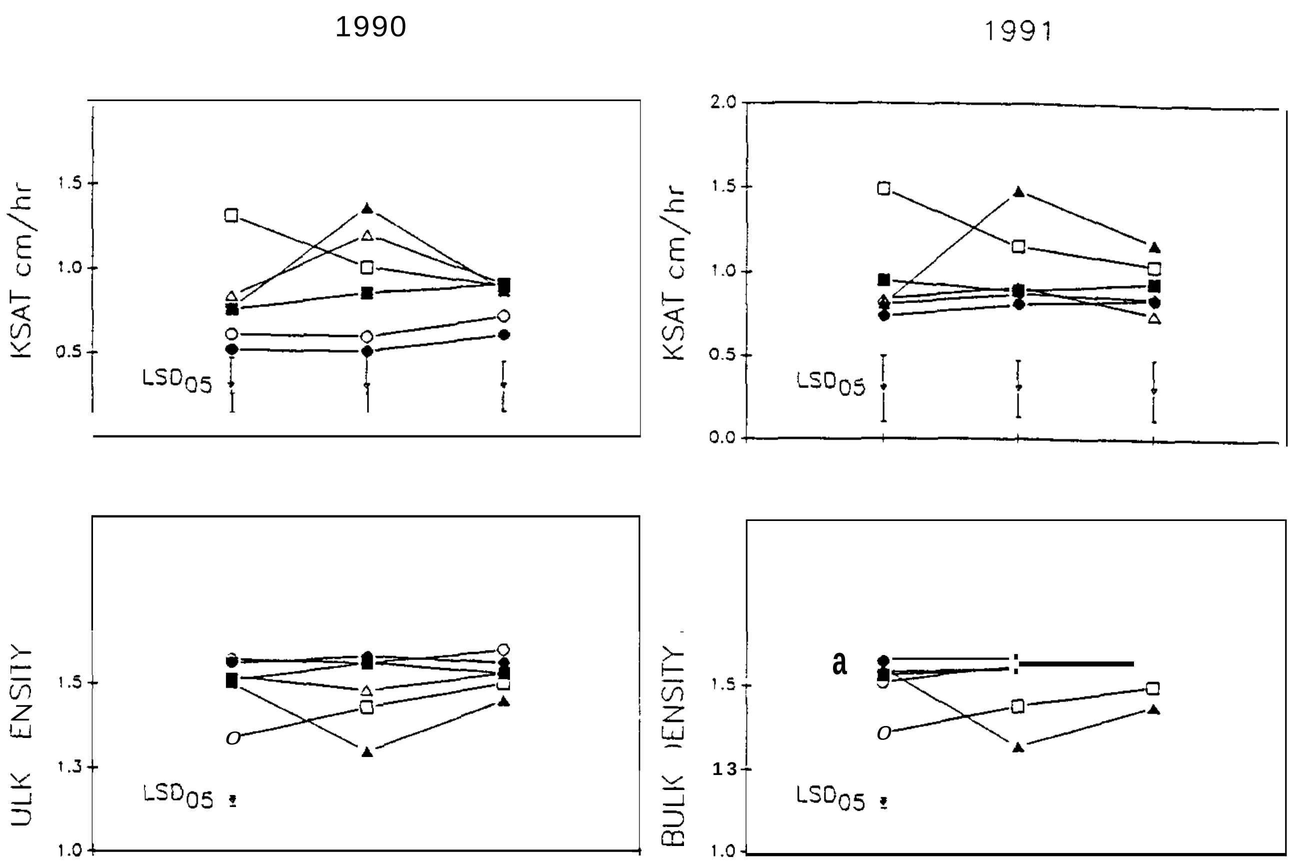

Fig. 1. Soil property response to three tillage systems for double-cropped tropical corn. KSAT = saturated hydraulic conductivity.

soybean treatments (Fig. 2) was similar to that of the tropical corn plots. Conductivities were highest in the zone near the subsoiled slot, which was the early subsoil treatment at the row position and the late subsoil treatment at the interrow position. By harvest, all positions and treatments had similar KSAT levels. Bulk density was lowest just after the deep tillage operation at the respective row and interrow positions (Fig. 2). These BD values were still significantly different from the other four treatment/position combinations at the end of the season. Soil properties for the 1991 full season mono-cropped corn revealed the row position to have significantly higher KSAT at planting than other positions (Fig. 3). Both subsoil treatments were initially high at the row position. A significant decrease in KSAT over time was noted for the interrow position, except for the late subsoil plots. At the row position, BD was highest for the no-till treatments and least for the early subsoil treatment, with the late subsoil treatment intermediate and significantly different (Fig. 3). For the interrow location, no-till treatments also had the highest BD, the late subsoil treatment was least and the early subsoil treatment was intermediate and significantly different.

The full season mono-cropped soybean had significantly different KSAT values only at the first sampling time, with the early subsoil plot at the row position being significantly different from the other treatments (Fig. 3). At the row position, the no-till treatment had the highest BD, the early in-row subsoil plots significantly

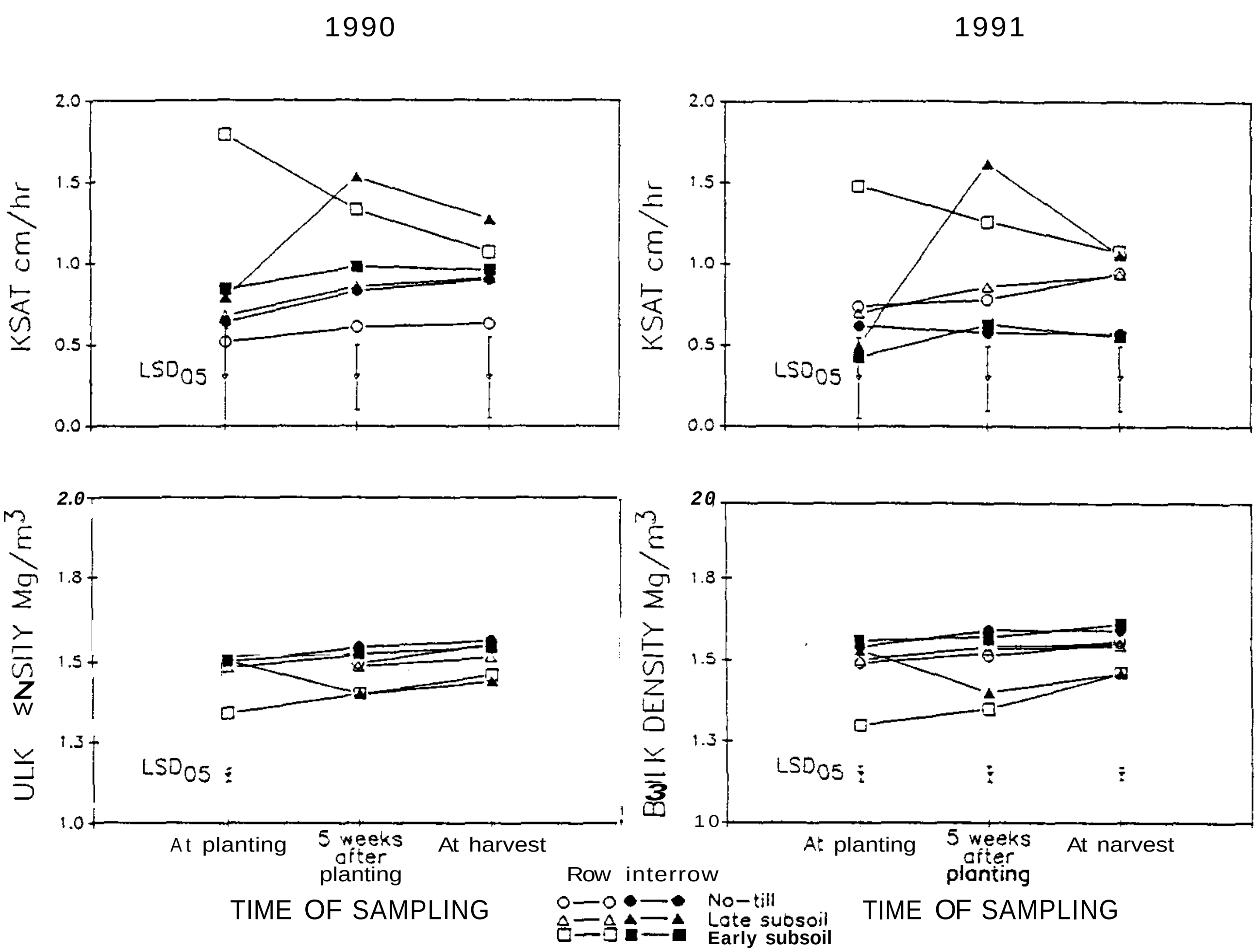

Fig. 2. Soil property response to three tillage systems for double-cropped soybean. KSAT = saturated hydraulic conductivity.

lower, and the late subsoil plots again intermediate. At the interrow position, the late subsoil treatment was significantly different than the early subsoil treatment 5 weeks after planting, but not at the other two sampling dates. Both were always significantly lower than the no-till treatment.

As mentioned, BD typically increased over the growing season due to the natural settling of the soil, with less change noted for the no-till treatment. However, KSAT values for most treatments and positions also tended to increase over time. The exceptions were the early in-row subsoil treatment at the row position and the late between-row subsoil treatment at the interrow position. These were the soil regions where the most tillage disruption occurred, and KSAT decreased with time after the tillage was performed. Root growth throughout this sandy textured soil could account for an increase in macropore flow channels and thus KSAT over time.

Crop yields

Dry weather in 1990 reduced tropical corn yields, with the early subsoiled treatment had the highest grain and stover. yields, no-till the lowest, and the late between-row subsoiled treatment was intermediate (Table 1). A late planting date reduced tropical corn yields in 1991, with the late subsoil treatment being further reduced by mechanical damage from the subsoiling operation. Due to this, the late subsoil treatment was equal to no-till in grain yield and

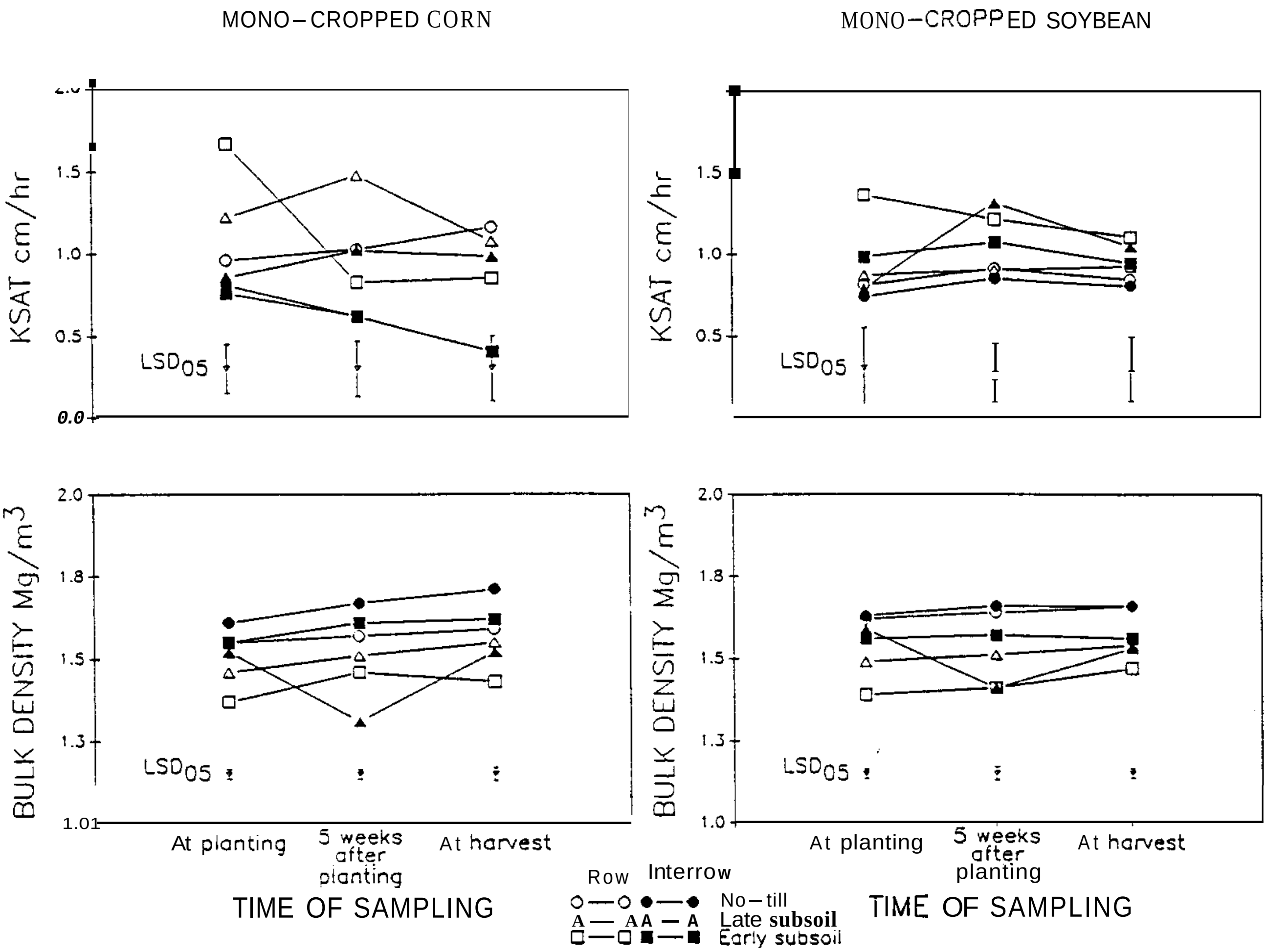

Fig. 3. Soil property response to three tillage systems for full season mono-cropped corn and soybean. KSAT = saturated hydraulic conductivity.

lower than the early subsoil treatment. Stover yields were not significantly different among treatments. With excellent rainfall distribution in 1991, all tillage treatments for full season mono-cropped corn produced similar grain and stover yields (Table 1).

Double-cropped soybean yields in 1990 were similar for all treatments, with very dry weather responsible for the low yields (Table 2). In 1991, though not significantly different, the early subsoil treatment was highest followed by the late subsoil and the no-till treatments. Mono-cropped full season soybean yields were slightly higher than the double cropped soybean, but again the tillage treatments were not significantly different from each other (Table 2). As with the 1991 corn yields, this effect was probably due to the adequate rainfall distribution throughout the growing season.

On this Coastal Plain soil deep tillage will generally benefit crop yields. In normal to wet years the bulk density and conductivity of the soil, as measured in this test, will not be restrictive to root growth and plant development. The restrictive soil density levels will change with changes in soil moisture, and was most obvious in 1990 with the reduced plant growth in the no-till treatment. Even in an adequate soil moisture year (1991) the no-till yields were slightly reduced, with increased soil bulk densities at least partially responsible. Preliminary observation of root growth patterns indicated the least root growth expansion below the hardpan in the no-till areas. Subsoiling between the rows five weeks after planting did damage some root systems, but the majority of roots were directly under or near the plant row. Thus, this treatment did not generally reduce crop yields. In cropping systems utilizing irrigation, the late subsoiling operation may benefit infiltration later in the season when the crop would need supplemental water to avoid drought stress during the silking and tasseling growth stages. Reducing the amount of trips over the field after any deep tillage operation, or limiting traffic to specific paths, such as done in this small-scale test, would also reduce compaction and benefit subsequent water infiltration, root growth and crop yield.

ACKNOWLEDGMENTS

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REFERENCES

1. **Blake, G.R., and K.H. Hartge. 1986.** Bulk density. In A. Klute (ed.) Methods of Soil Analysis. Part 1. 2nd edition. Agronomy 9:363-382.

2. **Busscher, W.J. and R.E. Sojka. 1987.** Enhancement of subsoiling effect on soil strength by conservation tillage. Trans. ASAE 30(4):888-892.

3. **Horton, P.M. *(ed.).*** 1991. Agricultural chemicals handbook. EC 670. Clemson University Cooperative Extension Service, Clemson, SC.

4. **Klute, A., and C. Dirksen.** 1986. Hydraulic conductivity and diffusivity: Laboratory methods. In A. Klute (ed.) Methods of soil analysis. Part 1. Agron. 9:687-734.

5. **Ray, A.A. (ed.). ,1982.** SAS user's guide: Statistics. 1982 Edition. Statistical Analysis Systems Inst. Inc., Cary, NC.

6. **Rogers, V.A. 1977. Soil** survey of Barnwell County, South Carolina. USDA-SCS. U.S. Govt. Printing Office, Washington, DC.

7. **Simmons, F.W., D.K. Cassel, and R.B. Daniels.** 1989. Landscape and soil property effects on corn grain yield response to tillage. Soil Sci. Soc. Am. J. 53:534-539.

8. **Smittle, D.A., E.D. Threadgill, and W.E. Seigler.** 1977. Effect of tillage methods on soil strength, yield, and nutrient uptake of sweet corn. Res. Report 266, Coastal Plain Stn., Tifton, GA.

9. **United States Dept. of Agric. - Natl. Agric. Stat. Serv.** 1991. Summary of crop statistics. U.S. Govt. Printing Office, Washington, DC.

Conservation Tillage Practices for Water-seeded Rice

P.K. Bollich[1]

INTRODUCTION

Rice currently ranks third in total acreage behind soybean and cotton in Louisiana with over 518,000 acres being grown in 1991 (L.S.U. Agricultural Center, 1992). The majority of this acreage is located in southwest and northeast Louisiana. These distinctly different regions have unique cultural management system due to differences in soil type, environment, weather, and tradition. In southwest Louisiana, most water-seeded rice is planted into completely tilled seedbeds. Numerous field operations are required to destroy weedy vegetation and establish a firm and level seedbed. Proper seedbed preparation is considered essential since water management in water-seeded rice is critical to fertilizer efficiency and stand establishment. Wet springs compromise conventional seedbed preparation. Additional field operations are generally required, and planting is delayed. These situations increase production costs, and delays in planting can result in significant yield reductions.

Two alternatives to conventional seedbed preparation are no-till or stale seedbed preparation. These conservation tillage practices have been used in other crops for many years and are increasing in popularity. The advantage in no-till rice establishment is the reduction or elimination of field operations required for conventional seedbed preparation. Stale seedbed systems provide more flexibility in land preparation and allow the producer to take advantage of favorable weather conditions for seedbed preparation weeks or months prior to planting. Conservation tillage is also very effective in reducing soil erosion and conserving soil moisture.

Information on water-seeded rice production in conservation tillage systems is limited. Preliminary studies conducted in Crowley, Louisiana, have shown conservation tillage has potential in rice production (Bollich et al., 1987, 1988, 1989). The objective of this study was to evaluate the performance of water-seeded rice grown in no-till and stale seedbeds as alternatives to planting rice into conventionally prepared seedbeds.

MATERIALS AND METHODS

The experiment was conducted at the Rice Research Station in Crowley, Louisiana, on a Crowley silt loam (fine, montmorillonitic, thermic, Typic Albaqualf)previously cropped to soybeans. Seedbed preparation in the conventional and stale seedbeds consisted of disking, vibrashanking, and conditioning with a roller harrow until a uniform, level, weed-free seedbed was formed. Rice establishment consisted of 1) no-till planting into soybean residue, 2) planting into a stale seedbed tilled in the spring 4 to 6 weeks prior to planting, 3) planting into a stale seedbed tilled 5 to 6 months prior to planting, and 4) planting into a conventionally tilled seedbed. Treatments were arranged in a randomized complete block design with four replications.

Glyphosate (1 Ib ai/acre) was applid to the conservation tillage treatments 7 and 23 days preplant in 1989 and 1990, respectively, to destroy existing vegetation. A no-till grain-fertilizer drill was used to apply preplant fertilizer in a 7-in band to a shallow depth 2 days prior to flooding. Approximately 450 Ib/acre of 20-10-10 fertilizer were applied each year. Pregerminated rice (cv. Lemont) was water seeded by aerial application after floodup.

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The study was drained 3 days after planting to encourage seedling anchorage. A shallow, permanent flood was established 3 to 5 days later. This type of management is typical of water-seeded, pinpoint flood rice culture in Louisiana (L.S.U. Agricultural Center, 1987).

A midseason fertilizer application of urea (45 and 55 lb N/acre in 1989 and 1990, respectively) was applied at the panicle initiation growth stage. In addition, the herbicides propanil, bentazoa, molinate, and bensulfuron-methylwere used for postemergence weed control as required.

Stand density for each planting method was determined at the 4- to 5-leaf growth stage each year. Individual whole plots (3250 ft^2) were combine-harvested and grain yields were adjusted to 12% moisture.

RESULTS AND DISCUSSION

Stand densities for each tillage practice are shown in Table 1. A significant interaction occurred between year and tillage method. Density was significantly influenced by tillage practice in 1989. Densities were lower in the no-till and stale seedbed treatments when compared with conventional seedbed preparation. In 1990, tillage practice had no influence on stand density, and densities were also higher. Difficulty in establishing a rice stand occurred in 1989 and appeared to be due to the elapsed time between glyphosate application and seeding. Flooding followed glyphosate application by 4 days in 1989, and much of the collapse and decay of existing vegetation occurred during rice emergence and stand establishment. Seed to soil contact and seedling anchorage were affected and some

Table 1 Effect of seedbed tillage method on stand density and grain yield of water seeded Lemont rice at Crowley, LA, 1989 and 1990.

	Stand Density			Grain Yield		
Tillage	1989	1990	Avg.	1989	1990	Avg.
	plants ft^{-2}			lb A^{-1}		
Conventional	15	15	15	5549	5851	5700
Stale-spring	12	18	15	5539	6125	5832
Stale-fall	10	19	15	5118	5839	5478
No-till	8	21	14	4539	5754	5146
LSD (0.05)	3	ns	ns	511	ns	315
Source of Variation	df					
Year (Y)	1		*			**
Tillage (T)	3		ns			**
Y x T	3		*			*

*, ** Significant at P = 0.05, P = 0.01 respectively.

seedling loss occurred due to fungal diseases that were more prevalent in the stale and no-till treatments. Inclement weather delayed planting in 1990, and the test area was not flooded until 3 weeks after glyphosate application. The vegetation was completely dessicated and partially collapsed at the time of flooding, and this condition resulted in better seedling anchorage and more rapid stand establishment. The problems associated with stand establishment in this study also occurred in a drill-seeded conservation tillage study conducted during the same time (Bollich, 1991). Stand establishment appears to be more difficult in a water-seeded system, and either excessive vegetation or significant decomposition of vegetation after flooding is a concern.

A significant year x tillage interaction also occurred for grain yield. Yield was significantly reduced in the no-till seedbed in 1989 and was probably related to low stand density. **A** stand of 15 to 20 plants/ft^2 is considered optimum in Louisiana, although successful yields have occurred at lower densities (L.S.U. Agricultural Center, 1987). The nonuniformity of the no-till stand, incomplete canopy closure, and competition from aquatic weeds may have contributed to low yields. Tillage practice had no influence on grain yield in 1990. Yield in 1990 was significantly higher than in 1989.

Conservation tillage practices in water-seeded rice have potential in Louisiana. Stand establishment is critical, however, especially in no-till rice. Additional research is needed to determine the required time interval between application of burndown herbicides and flooding in order to minimize detrimental effects on stand establishment. If burndown of vegetation prior to planting into a conservation tillage seedbed is successful and stand establishment difficulties are minimized, rice culture in a water-seeded, pinpoint flood system is very similar to that in a conventional system.

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LITERATURE CITED

1. **Bollich, P.K.** 1991. Conservation tillage practices for rice southwest Louisiana. pp 11-12. *In:* T.C. Keisling, N.G. Wyatt, and K.L. Kirby (ed). Proc. 1991 South. Till. Conf. June 18-20, 1991. Little Rock, AR. Univ. of Ar. Spec. Rpt. 148.

2. **Bollich, P.K., W.J. Leonards, Jr., S.M. Rawls, and D.M. Walker.** 1987. No-till and stale seedbed rice production for Louisiana. Ann. Res. Rpt., Rice Res. Stn., La. Agri. Exp. Stn., L.S.U. Agri. Ctr. 79:105-108.

3. **Bollich, P.K., W.J. Leonards, Jr., S.M. Rawls, and D.M. Walker.** 1988. No-till and stale seedbed rice production for Louisiana. Ann. Res. Rpt., Rice Res. Sm., La. Agri. Exp. Stn., L.S.U. Agri. Ctr. 80:125-129.

4. **Bollich, P.K., W.J. Leonards, Jr., S.M. Rawls and D.M. Walker.** 1989. No-till and stale seedbed rice production for Louisiana. Ann. Res. Rpt., Rice Res. Stn., La. Agri. Exp. Stn., L.S.U. Agri. Ctr. 81:138-143.

5. **L.S.U.** Agric. **Ctr.** 1987. Riceproduction handbook. La. Coop. Ext. Serv. and La. Agri. Exp. Stn. Pub. 2321. 63 pp.

6. **L.S.U. Agric. Ctr.** 1992. Louisiana summary: Agriculture and natural resources 1991. La. Coop. Ext. Serv. Pub. 2382. 214 pp.

Canopy Development of Wheat in Conventional, Reduced, and No-till Tillage Systems

S. H. Moore, J. L. Kovar, M. P. Braverman, and P. R. Vidrine[1]

INTRODUCTION

Reduced tillage programs have gained popularity primarily in spring-planted crops in Louisiana. Wheat is usually either drilled, or broadcast onto the surface of tilled soil and then lightly cultivated. This study was initiated to determine wheat performance in reduced and no-till tillage systems.

MATERIALS AND METHODS

A cropping systems and tillage experiment was initiated in 1991 on a Norwood silt loam soil at the Dean Lee Research Station in central Louisiana. The test area was fallowed for one year prior to establishing the experiment. The test contained eight cropping systems and three tillage systems in a split plot design with tillage as main plot and cropping system as sub-plot. Initially the test had four replicates, but the fourth replication was dropped due to interference from poor drainage. Two of the cropping systems involved doublecropping with winter wheat. Since this was the first year of the study and there was no effect of other crops, wheat data were pooled in the first year to determine tillage effects.

The three tillage systems were conventional, reduced, and no-till. The conventional system included sub-surface tillage to an approximate 9-inch depth with a chisel, followed by discing and conditioning with a seedbed tool. The reduced system was the same as the conventional system except that there was no sub-surface tillage. There was no cultivation performed in the no-till system. Burndown chemicals were applied, and the entire experimental area was mowed prior to planting.

At harvest, the experimental units were 4.2 m wide (19.05-cm drill rows) and 26 m long. 'Coker 9877' was planted at 112 kg ha^{-1} on 5 November. Above ground plant material for 1 m of row was harvested at 35-day intervals and dried. Leaf area index was determined at the same time. using a LAI-2000 Plant Canopy Analyzer (LI-COR, inc.). Harvest date was 19 May.

General linear models procedures from the Statistical Analysis System (SAS Institute, 1985) were used to analyze leaf area index, dry matter production, yield and test weights. Means from each time period were used to calculate crop growth and net assimilation rates. Trends and observations are not to be interpreted as statistically significant unless stated.

RESULTS

Wheat leaf area development was similar in the three tillage systems (Figure 1). Although sigmoid growth models have not been fitted to the data, there was a trend for the reduced tillage regime to have a slightly higher LAI after the fifth week. Leaf area development in the no-till system was not significantly different from the reduced or conventional systems at any sampling date.

There was a trend for greater dry matter production in the no-till system as the season progressed (Figure 2). It was apparent that dry matter production was as high or higher for

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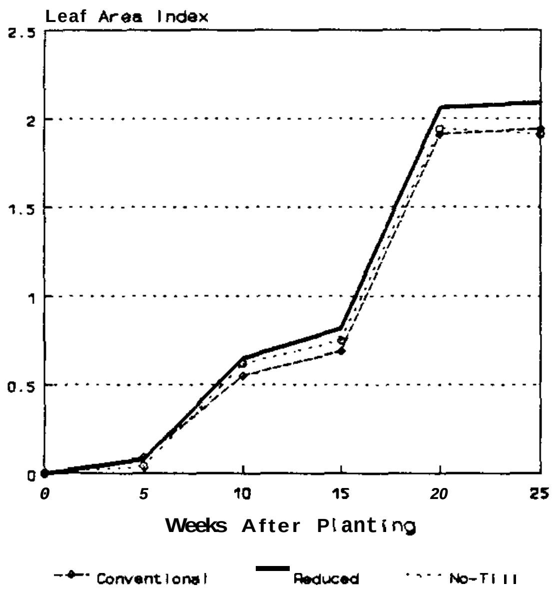

Fig. 1. Effect of tillage on wheat LAI.

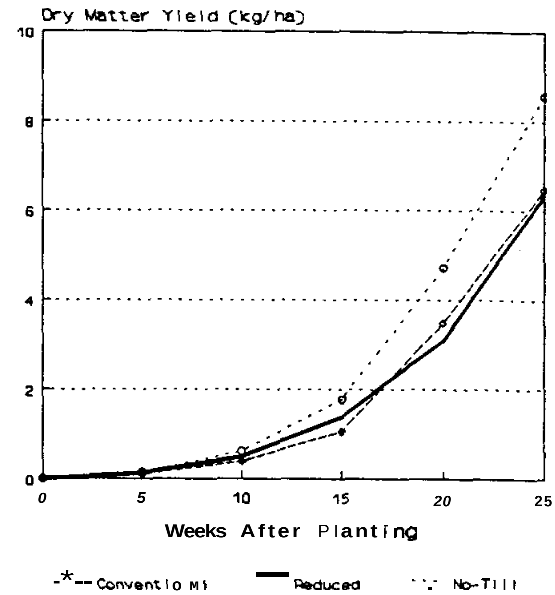

Fig. 2. Effect of tillage on wheat DMY.

wheat in a. no-till system as in conventional or reduced tillage regimes.

Crop growth rates for wheat increased asthe season progressed in all three tillage regimes (Figure 3). There was a trend for higher crop growth rates in the no-till system when compared to the other two systems.

Net assimilation rate measured the amount of dry matter production per unit area (m^2) of leaf surface and was an indicator of photosynthetic efficiency. Highest net assimilation rates were recorded at week 5 for each tillage system (Figure 4). There was a trend for net assimilation rates to be higher in the no-till system.

There were no significant differences in wheat yields among the three tillage systems (Table 1). The test mean was 2948 kg ha^{-1}, which may be slightly lower than average but probably representative of wheat yields on this soil type in the area for 1992.The coefficient of variation (14%) indicated that error in the test was at an acceptable level. There were no significant differences among test weights of wheat harvested in the three tillage systems.

DISCUSSION

Crop growth analysis revealed no negative trends for no-till wheat compared to conventional and reduced systems. Data for 1991-92 still need to be fitted to models and tested for differences; however, it is likely that most differences detected in 1991-92 would be in favor of the no-till system. Although trends in crop growth parameters appeared to be in favor of the no-till system, these were not translated into a significant increase in yield or test weights. Based on one year's data, wheat production in no-till systems approximates that in conventional and reduced systems. More year's data are needed to determine average and long-term effects of tillage on wheat performance.

REFERENCES

SAS Institute. 1985. SAS/STAT: Guide for personal computers. Version 6 ed. SAS Inst. Inc., Cary, NC.

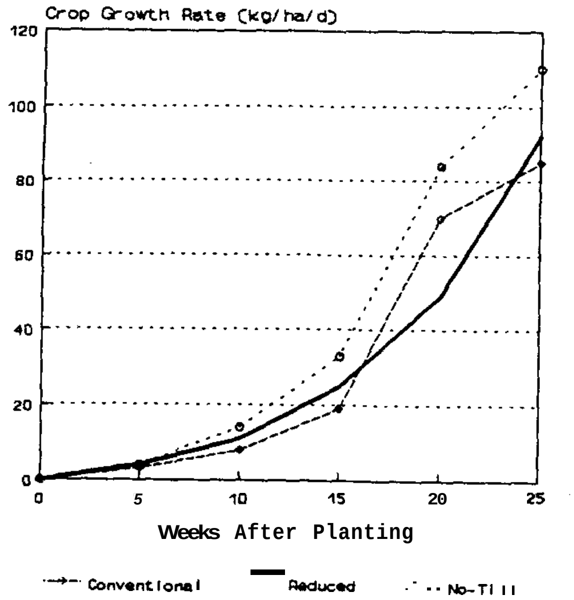

Fig. 3. Effect of tillage on wheat CGR.

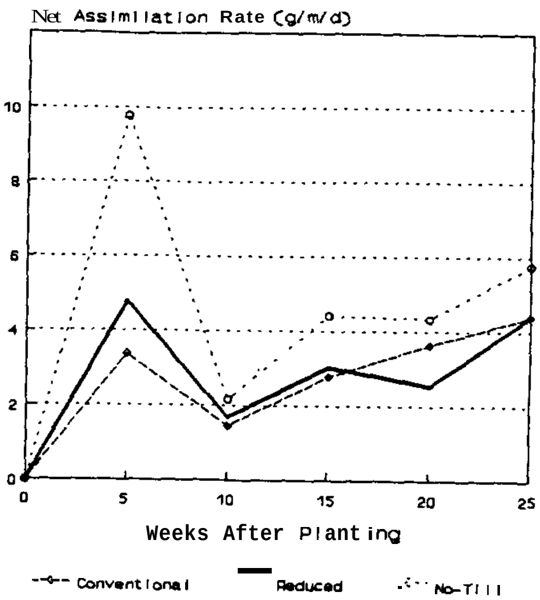

Fig. 4. Effect of tillage on wheat NAR.

Table 1. Effect of tillage systems on yield and test weight of winter wheat on a silt loam soil in central Louisiana, 1991-92.

Tillage System	Yield	Test Weight
	kg ha^{-1}	kg hl^{-1}
Conventional	3045	65.28
Reduced	2947	64.82
No-till	2853	65.38
F Test (p=0.05)	NS	NS
Mean	2948	65.16
% C.V.	14	4.31

Influence of Tillage Methods on Wheat Production Following Different Crops

D.L. Wright and B.T. Kidd[1]

INTRODUCTION

Wheat acreage has fluctuated widely with price outlook at planting time over the past 10 years. New adapted varieties with Hessian fly and disease resistance have made wheat a cheaper and more dependable crop to grow. Wheat in the southeast has often been a crop to fill in between main summer crops such as soybean or corn. However, with new varieties and management techniques, wheat can be a major cash crop. Much of the southern wheat is grown in double cropping systems with soybean or other summer annual crops. Therefore, there is often little time to prepare a good seedbed for the wheat crop if cotton, corn, soybean or even a hay crop are being harvested late in the fall. Reginelli et *al.* (1991) reported that wheat could be grown with reduced tillage in Mississippi. Touchton et al. (1989) reported that summer crops have different tillage requirements when winter crops are compacted by livestock. The objective of this study was to evaluate tillage treatments on wheat when planted behind soybean or perennial grass crops.

METHODS

This research was conducted for three years at the NFREC, Quincy, on a Norfolk loamy fine sand soil (Fine-loamy, siliceous, thermic Typic Kandiudult). Main plots consisted of previous crops: soybean, bermudagrass, and bahiagrass. Split plots were tillage treatments: turning plow, chisel plow, harrow, and no-till. Fertilizer was applied at the rate of 500 lbs/A of 5-10-15 after tillage. Wheat was planted at the rate of 100 lbs/A with a Tye Pasture Pleaser across all tillage treatments between 19 November and 3 December in each of the three years. Nitrogen was applied as a topdress application either the last week of January or the first week of February in each year with a Gandy applicator at the rate of 100 lbs N/A. Penetrometer readings were measured in each of the three years in all plots with a recording penetrometer to determine soil resistance. Wheat was harvested each year with a modified Gleaner E combine and yield, test weight, kernel weight, and moisture determined on each sample. The Duncan's Multiple Range test was used to determine differences among treatments at the 5% level of probability.

RESULTS

Overall grain yields were highest where the land was prepared by using the turning plow (Table 1) in the first year of the study. No-till yields were the lowest planted behind any of the three crops and especially low after bahiagrass. Penetrometer measurements indicated that soil resistance was the highest following bahiagrass than other crops and that no-tillage planting resulted in the highest soil-resistance. However, many farmers prefer to grow summer crops after bahiagrass pastures because of the excellent tilth and low numbers of nematodes and diseases and high yields experienced. Even though there is not very much documented evidence, most researchers who have worked on interseeding crops into bahiagrass have reported a reduction in growth which has been speculated to be allelopathic. Although growth of overseeded crops into bermudagrass may be slower than for prepared seedbeds, it is not usually as slow as in bahiagrass sods (R.L. Stanley, 1992, personal communication). Yields were highest (not statistically different) for no-till wheat in the second year of the study following soybean

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Table 1. Wheat yield as influenced by tillage treatments from three previous crops, year 1.

Tillage Treatment	Previous Crop Soybeans	Bahiagrass	Bermudagrass	Avg. Across crops
turning plow	60.8 a[1]	42.5 a	47.8 a	50.3 a
chisel plow	53.4 a	36.8 a	50.1 a	46.8 a
harrow	48.5 ab	41.4 a	52.0 a	41.3 a
no-till	36.3 b	20.6 b	47.1 a	34.1 b
avg. across tillage trt.	49.8	35.3	49.2	

[1] Means in a column followed by different letters are statistically different at the 5% level of probability according to Duncan's Multiple Range Test.

Table 2. Influence of tillage on soil resistance six weeks after planting wheat into a bahiagrass field, year 1.

Soil depth	Tillage method at planting Bottom plow	Harrow	Chisel plow	No-Till
---in.----	---------------soil resistance (lbs/sq in)------------			
2	4	42	61	192
4	104	133	154	246
6	204	325	238	354
8	250	483	350	479
12	292	483	446	454

(Table 3). Penetrometer data (Table 4) for the year might explain this since no definite tillage pan was noted down to 12 inches during this year while a definite tillage pan was detected in years one and three. Wheat yields were lower with no-till in bahia and bermudagrass. Year three had similar results to year 1 in that no-tillage wheat resulted in lowest yields (Table 5). The three year average (Table 6) showed that no-tillage wheat behind a row crop such as soybean could result in yields 86% as high as using tillage treatment. Where large acreages had to be planted in a timely fashion or risk yield loss with later plantings, no-till could be a favorable alternative. Yields of no-till wheat into bahiagrass were only 61% of the tilled plots averaged over three years. Plantings made into bermudagrass sods more closely resembled those made into soybean stubble and if both sods were available for winter no-till plantings of wheat, bermudagrass would be preferred. Heavier no-till drills could result in better stands. The living mulch (bermuda and bahiagrass), although dormant at planting, gave the wheat some competition for nutrients and moisture during the grain fill period.

SUMMARY

Deep tillage may result in better wheat grain yields in some years. Fields that do not have traffic pans may obtain wheat yields from no-till plantings similar to till plantings. Plantings made after soybean generally did better than plantings made after or into sods. Bermudagrass was a superior sod crop for planting into over bahiagrass. Bahiagrass had a thicker root mass near the surface and perhaps allelopathic effects that reduced wheat yields. Where timeliness is essential, no-tillage plantings may result in near 85% of the yield of tilled plantings following either soybean or bermudagrass.

LITERATURE CITED

1. **Reginelli, D.B., N.W. Buehring, R.L. Ivey, T.E. Foster and J.D. Summers.** 1991. Wheat response to tillage systems and planting dates. 1991 Proceedings Southern Conservation Tillage Conference. Spec. Report 148 pp. 68-71.

2. **Touchton, J.T., D.W. Reeves, and D.P. Delaney.** 1989. Tillage systems for summer crops following winter grazing. 1989 Proceedings Southern Conservation Tillage Conference Special Bulletin 89-1:72-75.

Table 3. Wheat yield as influenced by tillage treatments after three previous crops, year **2.**

Tillage Treatment	Previous Crop: Soybean	Bahiagrass	Bermudagrass	Average All Crops
turning plow	**63.5** a[1]	**61.5 b**	**52.5** a	**59.2**
chisel plow	**65.8** a	**59.0 b**	**54.2** a	**59.7**
harrow	**64.3** a	**75.3 a**	**54.7** a	**64.8**
no-till	**66.9** a	**42.4** c	**47.7** a	**52.3**
avg. over tillage trt.	**65.1**	**59.6**	**59.6**	

[1] Means in a column followed by different letters are statistically different at the **55** level of probability according to Duncan's Multiple Range Test.

Table 4. Three years of tillage influence on soil resistance when planted after soybeans.

Soil depth (in.)	Turnina Plow 1	Turnina Plow 2	Turnina Plow 3	Chisel Plow 1	Chisel Plow 2	Chisel Plow 3	Harrow 1	Harrow 2	Harrow 3	No-till 1	No-till 2	No-till 3
	------	------	------	soil resistance (lbs sq in⁻¹)	------	------	------	------	------	------	------	------
2	**0**	**48**	**31**	**0**	**25**	**0**	**0**	**42**	**19**	**54**	**a**	**~a**
4	**0**	**54**	**81**	**0**	**46**	**69**	**8**	**75**	**56**	**104**	**8**	**163**
6	**21**	**83**	**106**	**75**	**133**	**131**	**171**	**133**	**200**	**242**	**8**	**250**
8	**63**	**79**	**113**	**183**	**221**	**243**	**329**	**270**	**269**	**404**	**63**	**300**
12	**321**	**79**	**112**	**425**	**383**	**381**	**471**	**420**	**300**	**396**	**183**	**475**

Primarv Tillage Method; Year.

Table 5. Wheat yield as influenced by tillage treatments after three previous crops, year 3.

Tillage Treatment	Soybeans	Previous Crop Bahiagrass	Bermudagrass	Average All Crops
turning plow	55.7 b[1]	60.5 a	60.1 a	58.8
chisel plow	70.0 a	62.8 a	62.2 a	65.0
harrow	61.7 ab	54.4 a	64.4 a	60.2
no-till	53.7 b	37.4 b	41.6 b	44.2
Avg. over tillage trt.	60.3	53.8	57.1	

Means in a column followed by different letters are statistically different at the 5% level of probability according to Duncan's Multiple Range Test.

Table 6. Three year average wheat yields as influenced by tillage and previous crop.

Tillage Treatment	Soybeans	Previous Crop Bahiagrass	Bermudagrass	Average All Crops
turning plow	60.0 a[1]	54.8 a	53.5 a	56.1
chisel plow	63.1 a	52.9 a	55.5 a	57.2
harrow	58.2 a	57.0 a	57.0 a	57.4
no-till	52.3 b	33.5 b	45.5 b	43.8
Avg. over tillage trt.	58.4	49.6	52.9	
no-till % of tillage treatment	86%	61%	82%	

[1] Means in a column followed by different letters are statistically different at the 5% level of probability according to Duncan's Multiple Range Test.

Optimal Plant Spacings for Late Season Tropical Corn Production

T.A. Lang and R.N. Gallaher[1]

ABSTRACT

Management of late-season tropical corn *(Zea mays* L.) for silage is of concern to producers in the southeastern US. The objectives of this research were to determine late-season tropical corn yield responses to equidistant plant spacings using regression, calculate theoretical maximum grain and whole plant yields, and compare yields of two control treatments (double row and conventional single row). This late-season, irrigated field study was conducted in 1989 and 1990 on an Arredondo fine sand in north-central Florida. Yield response of an open-pollinated tropical corn synthetic ('FL SYN-1-2') to six equidistant plant-spacing (15, 30, 45, 60, 75, and 90 cm) and two row-spacing treatments (75 cm and alternating 30:60 cm rows) was observed. Quadratic and nonlinear regression equations were fitted to grain and DM yield responses, respectively. Maximum DM yields in 1989 of 879 and in 1990 of 1263 $g m^{-2}$ were predicted. Maximum grain yields in 1989 of 515 and in 1990 of 582 g m^{-2} were predicted at 22 plants m^2. No differences in grain yield between single 75 cm row and alternate 30:60 cm row treatments were observed either year. The alternate 30:60 cm row treatment produced more DM than the single 75 cm row treatment in 1989.

INTRODUCTION

Tropical corn **is** helping to fulfill the demand for high quality silage by the dairy industry in Florida. Proper management of the crop in the late-season environment is critical to produce high silage yields. Gonzalez **(1990)** reported that late-season tropical corn requires higher plant densities for optimum grain and silage yields compared to spring season corn. Grain and whole plant yields were highest at the highest plant population (10 plant m^{-2}). Spring season corn grain yields of a temperate hybrid grown in an equidistant study conducted in Florida (Tetio-Khago and Gardner, 1988) maximized at 10 plants m^{-2}; whole plant yields maximized at 12.5 plants m^{-2}. The objectives of this research were to determine late-season grain and whole plant yield responses to equidistant plant spacings using regression, calculate theoretical maximum grain and whole plant yields, and compare yields of two control treatments (double row and conventional single row).

MATERIALS AND METHODS

This 2 yr field study was conducted on an Arredondo fine sand (sandy, siliceous, thermic, Grossarenic Paleudult) at the Green Acres Agronomy Research Farm in Gainesville, FL. The open-pollinated tropical corn synthetic Syn-1-2 was planted on 5 Aug 1989 and 8 Aug 1990 at six equidistant plant-to-plant spacings (15, 30, 45, 60, 75, and 90 cm) and two check row spacings (75 and alternating 30:60 cm rows). Fertilizer of 168:80:120 (N-P-K kg ha-') was applied at planting, except for N which was applied in three equal split applications (planting, eight-leaf stage, and twelve-leaf stage). The herbicides atrazine (at planting) and paraquat (postdirected) were applied at labeled rates. Carbofuran was banded-in-the-row at planting to control lesser cornstalk borer (Elasmopalpus lignosellus); methomyl was sprayed three times to control fall armyworm (Spodoptera frugiperda). Irrigation of 2.5 to 3.5 cm week-' was provided. Grain and whole plant yields were sampled at black-layer; LAI measurements were taken at mid-silk in 1989 only. Design of the experiment was RCB with

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four replications. Prediction equations were derived from equidistant spacing yield data using SAS regression and non-linear procedures (SAS, 1987); check row treatment means were compared using LSD ($P=0.05$) means separation.

RESULTS *AND* DISCUSSION

Total DM yield responded asymptotically both years to increasing plant density. Separate, yearly nonlinear prediction equations were derived due to a significant year effect (Wiley and Heath, 1970). Maximum TDM yields of 879 and 1263 g m^{-2} were predicted for 1989 and 1990, respectively (Fig. 1). The predicted maximum for 1990 of 1263 g m^{-2} corresponds to a silage yield at 35% DM of 3.5 kg m^{-2} (16 T A^{-1}). The alternate 30:60 cm row treatment yielded more TDM than the single 75 cm row treatment in 1989. No differences in TDM were found between the row treatments in 1990 (Table 1).

Grain yield responded quadratically to plant density; there was a significant year effect (Fig. 2). Maximum grain DM yields in 1989 of 515 and in 1990 of 582 g m^{-2} were predicted at 22 plants m^{-2}. Due to the large interval between the highest two plant densities, predicted grain yields and corresponding plant densities are likely higher than expected. Actual grain yields from a range of densities above and below the predicted optimum plant density are needed to verify the predictions of the quadratic equations. No differences in grain yield between the alternate 30:60 cm row and 75cm row treatments were observed either year Fable 1).

Leaf area index measured at anthesis in 1989 responded quadratically to plant density ($R^2=0.97$); optimum LA1 range of 3.5 to 4.0 was achieved with 15 to 20 plants m^{-2} density (not shown). Alternate 30:60 cm row treatment had higher LA1 than the single 75 cm row treatment (Table 1).

LITERATURE CITED

Gonzalez, N.C. 1989. The effects of cultivar, planting date, sampling date, and plant density on *dry* matter accumulation and N concentration and content in maize (Zea mays L.). M.S. Thesis, University of Florida, Gainesville.

Tetio-Kagho, F. and F.P. Gardner. 1988. Responses of maize to plant population density: II. reproductive development, yield, and yield adjustments. Agron. J. 80:935-940.

Wiley, R.W. and S.B. Heath. 1970. The quantitative relationships between plant population and crop yield. Adv. Agron. 21:281-321.

SAS Institute. 1987. SAS/STAT: Guide for personal computers. Version 6 ed. SAS Inst., Cary, NC.

Table 1. Yield means at harvest and LA1 means at mid-silk of single and double row treatments.

		Grain DM		Total DM	
Treatment	LAI	1889	1990	1989	1990
75 cm rows	2.05	189	211	670	794
30~60cm rows	3.61	180	186	831	801
LSD (0.05)	0.43	ns	ns	158	ns

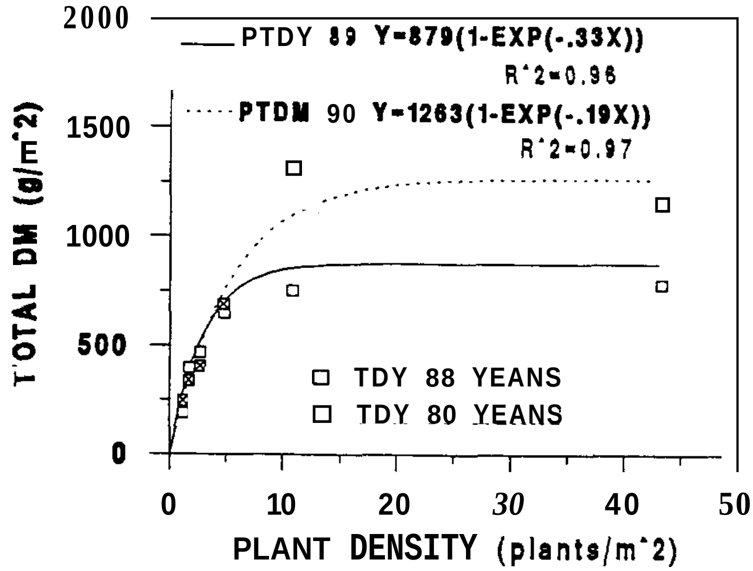

Fig. 1. Total DM yield response to plant density, 1989-90.

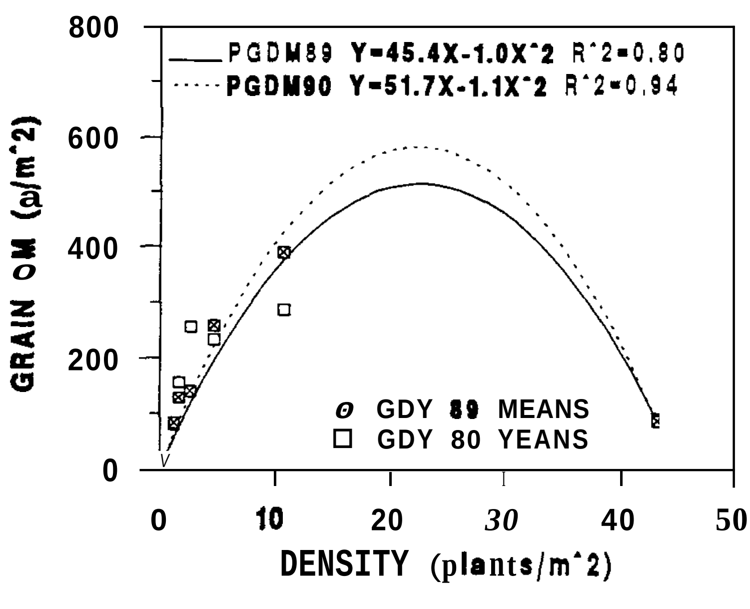

Fig. 2. Grain yield response to plant density, 1989-90.

Using Full-sib Recurrent Selection in a Tropical Open Pollinated Corn Population for Cultivar Use in Sustainable Agricultural Systems

J.R. Espaillat and R.N. Gallaher[1]

ABSTRACT

Synthetic varieties of corn (Zea mays L.) may be better buffered against environmental stresses in sustainable agricultural systems than cultivars with a narrow genetic base. A full-sib (FS) recurrent selection (RS) program was started at the University of Florida using a tropical open pollinated corn population. The goal was to develop a synthetic with a broad genetic base suitable for growing during the fall in north-central Florida under conservation practices. Full-sib crosses were made in the spring of 1987. Then, in August a progeny test was planted in a randomized complete block design with six replications. Collected data included; ear, husk, and grain weight, insect damage (ID), whole plant yield (WY), seed and leaf N percent, and plant height. Analyses included ANOVA, correlations (r), heritabilities, and frequency distribution. There were differences among FS families for most of the traits. Ear weight (EW) was highly positively correlated with yield and plant height traits. Ear weight was negatively correlated with ID and positively correlated with leaf N percent. Tip ID was negatively correlated with husk weight. Heritability varied for all traits. The mean EW of the FS were higher than the parents and 'Pioneer brand X-304C'. Selection for EW improved WY, earworm (Heliothis zea L.) tolerance and N uptake.

INTRODUCTION

Duvick (1981) claimed the diverse gene pool contained in synthetic corn varieties serves as a buffer against environmental stresses allowing their use in conservation agricultural systems. Crosson and Rosenberg (1989) predicted in decades to come, researchers will have to develop many new technologies for expanding food production while preserving land, water, and genetic diversity. Sherrard et al. (1984) proposed correlating physiological traits and growth parameters to predict yield, nutrient assimilation, and pest resistance. Bullard and York (1985) found resistance to earworm to be associated with husk length and thickness. Brewbaker and Kim (1979) associated earworm and fall armyworm (Spodoptera frugiperda L.) resistance with husk number. Cameron and Anderson (1966) found that long husks themselves are of no value in insect resistance unless they are compressed over the tip (small silk-channel diameter). The objectives were to 1) develop a synthetic with a broad genetic base suitable for growing during the fall, 2) determine the correlations among all traits and select the one advantageous to predict yield, 3) determine the heritability of traits contributing to yield and quality, and 4) evaluate the synthetic against commercial hybrids and the parents.

MATERIALS AND METHODS

This corn program had its origin in 1982, when Dr. R.N. Gallaher collected tropical corn from a subsistence farm in the Limon province of eastern Costa Rica and crossed this material with temperate and tropical hybrids in Florida. A total of six mass selection cycles under no-tillage, summer double-crop planting and low input management were accomplished in a 5-yr period. A recurrent selection program was started in 1987 at the Green Acres agronomy farm at Gainesville, Florida. The genetic pool included three population selections

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from Dr. Gallaher's mass selection program; one Levy County, Florida open-pollinated cultivar; and 6 open-pollinated varieties from Central America, Mexico and the Caribbean. This blend of 10 different germplasm was called Population 1 (P_1). A total of 65 full-sib crosses were made in the spring nursery. The full-sib progeny test was planted in early August at the same location in a RCB design with six replications. The parects, the cycle 6 of the mass-selected populations, and the tropical hybrid 'Pioneer brand X-304C', were used as controls. Planting was done using a jab-type planter at a plant population of 65,000 seed ha^{-1}. As in the nursery, standard recommendations were followed to grow the progeny test.

Field data collection corresponded to traits 6, 7, 9, and 10 at the 50% silking stage and traits 16 and 17 at harvest time (Table 1). Post-harvest data collection corresponded to traits 1, 2, 3, 4, 5, 8, 11, 12, 13, 14, 15 and 18 (Table 1). The micro-Kjeldahl N analysis method was used to determine the N concentration in leaves and seeds.

Several statistical parameters were used to analyze the data. These included the analysis of variance (ANOVA) of a RCB design at 5% probability level for all traits, correlation coefficients (r) among all traits, the genetic component of variance (σ_t^2), heritability (h^2) and the expected genetic gain (G_g). Finally, the frequency distribution of the FS families in classes was done for ear weight based on ANOVA, correlations, h^2, and G_g. The top 27% of the full-sib families were selected for initiation of the next cycle.

RESULTS *AND* DISCUSSION

Analyses of variance for a RCB design showed a highly significant difference ($P = 0.01$) among full-sib families in P_1 for 15 of the 18 traits evaluated. Ear weight was positively correlated (+r) with 13 of the traits. Acceptable +r were with whole plant dry matter, grain weight, number harvested ears, stalk weight, and tassel height with +r values of 0. 94, 0.89, 0.63, 0.58 and 0.53, respectively with $P < 0.01$. Tip insect damage was negatively correlated with husk weight, with $r = -0.30$ and $P = 0.01$. Lodging per cent was a function of tassel height and silk height with $r = 0.26$ and 0.21 respectively, at $P = 0.01$.

The best h^2 was given by parent's seed N and the full-sib leaf N with 99 and 98%, respectively (Table 1). Yield traits had h^2 ranging from 54% for husk weight to 29% for grain weight. Ear weight had h^2 of 41%. Both plant height traits showed the same $h^2 = 52\%$. Ear insect damage had h^2 fluctuating from 48% for total insect damage to 32% for body insect damage. The highest G_g was given by the stalk weight (11.4%), followed by ear weight (6.1%). Since they were +positively correlated ($r = 0.58$), any improvement in ear weight should result in a general improvement of the quality of the plant. Because ear weight coefficients σ_t^2 and h^2 were among the highest for yield components ear weight will be used as the main selection criterion (Table 1).

The ear weight of the top 15 full-sib families ranged from 675 to 823 g m^{-2} with a $\bar{x}$ of 710 g m^{-2}. The ear weight mean of the selected families had 92 g m^{-2} (10%) increase over the population mean. The $\bar{x}$ of the two parents, 'Flopup'86' and 'Flopup'87', was 515 and 531 g m^{-2}, respectively. 'Cenia-12' and Pioneer brand X-304C had almost equal ear weight but lower than the top 15 full-sib families selected and averaged 496 and 490 g m^{-2}, respectively.

REFERENCES

1. **Brewbaker, J.L., and S.K. Kim.** 1979. Inheritance of husk numbers and ear insect damage in maize. Crop Sci. 19: 32-36.

2. **Bullard, R.W., and J.O. York. 1985.** Breeding for bird resistance in sorghum and maize. p.193-222. In G.E. Russell (ed.) Progress in Plant Breeding. Butterworths, London.

Table 1. Analysis of variance of full-sib families, heritability and expected gain of traits in Population 1.

Trait	Computed F	Probability Value	Probability Signif.	CV	Unit	σ_t^2	h^2	Gg	G%
				--%--			-%-		-%-
Insect damage traits:									
1- Harvested ears	1.90	0.000	**	18.50	#	3.40	48	1.40	5.40
2- No damage	1.70	0.004	**	66.60	%	11.15	40		
3- Tip damage	1.80	0.001	**	23.90	%	28.40	44		
4- Body damage	1.50	0.024	*	52.00	%	12.20	32		
5- Total damage	1.90	0.000	**	10.90	%	13.30	48	-3.00	-0.03
Nitrogen conc. traits:									
6- Parent's seed	79.50	0.000	**	4.30	dag/kg	0.10	99		
7- FS family leaf	23.20	0.000	**	6.45	dag/kg	0.20	98	0.60	20.90
8- FS family seed	2.40	0.000	**	6.10	dag/kg	0.01	60		
Plant height traits:									
9- Tassel	2.00	0.000	**	6.85	m	0.01	52	0.00	0.00
10- Silk	2.10	0.000	**	13.50	m	0.01	52	0.01	0.80
Yield component traits:									
11- Ear weight	1.70	0.003	**	23.70	g/m2	2,482.10	41	37.90	6.10
12- Grain weight	1.40	0.042	*	27.80	g/m2	419.20	29	13.40	4.70
13- Husk weight	2.20	0.000	**	23.90	g/m2	194.70	54		
14- Cob weight	1.90	0.000	**	33.20	g/m2	672.50	47		
15- Shelling percent	1.80	0.000	**	27.30	%	38.90	46		
16- Stalk dry weight	2.20	0.000	**	28.90	g/m2	1,367.10	53	33.20	11.40
17- Lodging percent	1.50	0.018	*	147.80	%	3.40	34		
18- Whole plant DM	1.70	0.003	**	23.80	g/m2	5,323.80	41	55.90	6.20

(*,**)= different at the 95% and 99% level of significance, respectively. σ_t^2 = Genetic variance component. h^2 = Heritability. Gg = Expected gain in the corresponding unit over the population mean. G% = Expected gain in percent over the population mean.

1966. Husk tightness, earworm egg numbers, and starchiness of kernels in relation to resistance of corn earworm. J. of Econ. Entomol. 59:556-558.

5. **Crosson, P.R. and N.J. Rosenberg.** 1989. Strategies for agriculture. Scientific American. 261(3):128-135.

6. **Duvick, D.N.** 1981. Genetic diversity in corn improvement. p. 48-60. In H.D. Loden and D. Wilkinson (ed.) Proc. 36th Annu. Corn and Sorghum Industry Res. Conf., Chicago. IL, 9-11 Dec. Am. Seed Trade Assoc., Washington, D.C.

Comparison of No-tillage Planted Tropical and Temperate Corn for Yield and Nitrogen Concentration of the Grain Based on Endosperm Type

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ABSTRACT

Much tropical corn (Zea mays L.) available for sustainable farming systems is of the flint endosperm grain type. The objective of this study was to evaluate Florida experimental tropical corn populations for yield and grain N concentration compared to commercially available tropical flint and temperate dent grain types. Four experimental populations of mixed endosperm grain types and selections of either all flint or all semident seeds from these populations were compared to 'Pioneer Brand X304C', a tropical flint hybrid; 'Pioneer Brand 3320', a temperate dent hybrid; and 'Abbe Hill', an open pollinated dent variety from Nebraska. The 15 cultivars were treatments, replicated four times in Tennessee (Ennis cherty loam, Fluventic Dystrochrept) and six times in Florida (Arredondo fine sand, Grossarenic Paleudult) in a randomized complete block design. Grain and forage yields of Florida experimentals ranged from 90 to 161 bu/acre and 17.2 to 22.6 ton/acre, respectively depending on location and were equal or better than the hybrids and better than Abbe Hill. Yields in Florida tended to be greater than in Tennessee and were likely due to higher population, irrigation management and earlier planting dates. Photoperiod response resulted in tropical corn being almost twice as tall in Tennessee compared to Florida.

INTRODUCTION

Tropical corn *(Zea mays* L.) silage is important in the southeastern USA (Wright, et al 1991). Sustainable farming for some producers may well depend upon the adaptation of tropical corn in double cropping systems (Gallaher et al., 1991). Corn grain N concentration can be used as an indicator of N fertility status (Cerrato and Blackmer, 1990) and has been shown to be genetically controlled (Kauffmann and Dudley, 1979). The objective of this study was to evaluate Florida experimental tropical corn populations for yield and grain N concentration versus commercially available tropical flint and temperate dent grain types.

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MATERIALS AND METHODS

One experiment was conducted at the Gallaher Angus Farms, Waynesboro, Tennessee on an Ennis cherty loam (46% sand, 34% silt, 20% clay; fine-loamy siliceous Thermic Fluventic Dystrochrept). Corn was planted on 5 May 1989 to achieve a population of 17,000 plants per acre in two row plots 30 inches wide and 15 feet long. Rows were laid off using a no-tillage planter in a 25 year-old fescue (Festuca arundinacea Schreb.) pasture and planted by hand using a crowbar to punch equally spaced holes in the sod. Seed were dropped in the holes and covered with a mallet. Preemergence herbicides were Gramoxone (paraquat) plus 'X77' surfactant and atrazine. A total of 15 cultivars (Table 1) were tested in a randomized complete block design with four replications. Nitrogen (180 pounds N/acre) was applied by hand in two equal split applications. Based upon soil test and Florida recommendations no additional fertilizer was applied. However, the fescue pasture had been fertilized with 45 Ibs. N, 45 lbs. P_2O_5 and 45 Ibs. K_2O per acre three months prior to planting the corn. The second experiment was conducted

Table 1. Yield, seed characteristics and nitrogen concentration, plant and ear height and plant to ear height ratio of Florida experimental corn populations, a trouical hvbrid, a temperate hybrid and an open pollinated varietv.

Cultivar	Endosperm Planted	Flint Seed	Location Fla.	Location Tenn.	Location Fla.	Location Tenn.	Location Fla.	Location Tenn.
	-Type seed-	-%-	----Seed % N-----		----- Bu/A ----		----Tons/a----	
FLPl	Mixed	77	1.76abc	1.87def	138ab	102ab	22.6a	17.1b
FLP2	Mixed	82	1.74abcd	1.78fg	123b	110ab	17.9c	18.0ab
FLP3	Mixed	72	1.73abcd	1.71gh	161a	121ab	22.2ab	19.5ab
FLP4	Mixed	66	1.62de	1.85ef	119b	136ab	18.6bc	17.7b
FLP1	Flint	81	1.77ab	2.01abc	143ab	142ab	22.1ab	20.3ab
FLPZ	Flint	82	1.58e	2.11a	131ab	127ab	20.4abc	19.9ab
FLP3	Flint	81	1.75abcd	2.04ab	134ab	111ab	19.4abc	17.2b
FLP4	Flint	81	1.69bcde	1.95bcde	133ab	148a	22.1ab	22.2a
FLPl	Semi-Dent	67	1.72abcd	1.97bcd	129b	124ab	21.9ab	18.8ab
FLPZ	Semi-Dent	67	1.75abcd	2.03ab	126b	90bc	20.6abc	16.8b
FLP3	Semi-Dent	63	1.62de	1.88de	123b	108ab	20.5abc	19.2ab
FLP4	Semi-Dent	65	1.74abcd	1.91cde	121b	120ab	17.8c	20.0ab
P.B. X304C	Flint	>95	1.63cde	1.94bcde	150ab	116ab	21.1abc	19.3ab
P.B. 3320	Dent	< 5	1.34f	1.63h	149ab	13d	19.2abc	5.3c
Abbe Hill	Dent	< 5	1.83a	2.03ab	84c	52cd	12.4d	7.5c
C.V. (%)			(4.11)	(2.73)	(17.64)	(29.13)	(13.73)	(15.38)

Cultivar	Endosperm Planted	Plant ht. Fla.	Plant ht. Tenn.	Ear ht. Fla.	Ear ht. Tenn.	Plant to Ear ht Fla.	Plant to Ear ht Tenn.
		------Feet-----		----Feet------		-----Ratio----	
FLPl	Mixed	8.96a	14.45bc	4.77a	7.15bc	1.89d	2.04cd
FLPZ	Mixed	8.77a	14.50bc	4.37abc	7.55abc	2.01cd	1.93cd
FLP3	Mixed	8.99a	15.00bc	4.69ab	7.80abc	1.92d	1.93cd
FLP4	Mixed	8.63a	15.08bc	4.24bc	7.90abc	2.04cd	1.92cd
FLPl	Flint	8.69a	14.53bc	4.49abc	7.40bc	1.95d	1.97cd
FLPZ	Flint	8.92a	14.13c	4.44abc	7.03c	2.0lcd	2.03cd
FLP3	Flint	8.87a	15.60ab	4.36abc	8.33ab	2.05cd	1.88d
FLP4	Flint	8.89a	15.25abc	4.54ab	7.80abc	1.98cd	1.96cd
FLPl	Semi-Dent	8.54a	15.03bc	4.29abc	8.10abc	2.00cd	1.86d
FLPZ	Semi-Dent	9.02a	14.78bc	4.76a	7.65abc	1.90d	1.94cd
FLP3	Semi-Dent	8.84a	16.45a	4.55ab	8.70a	1.96d	1.90d
FLP4	Semi-Dent	8.77a	14.90bc	4.29abc	7.63abc	2.05cd	1.97cd
P.B. X304C	Flint	8.67a	15.13abc	4.04c	7.15bc	2.16c	2.12c
P.B. 3320	Dent	7.70b	10.58d	2.88d	3.90d	2.69b	2.72a
Abbe Hill	Dent	6.50c	9.95d	2.20e	4.354	2.98a	2.30b
C.V. (%)		(5.29)	(6.03)	(8.72)	(9.06)	(6.76)	(6.06)

FLP = Florida populations. P.B. = Pioneer Brand. Values in columns not followed by the same letter are significantly different at the 0.05 level of probability according to Duncan's multiple range test.

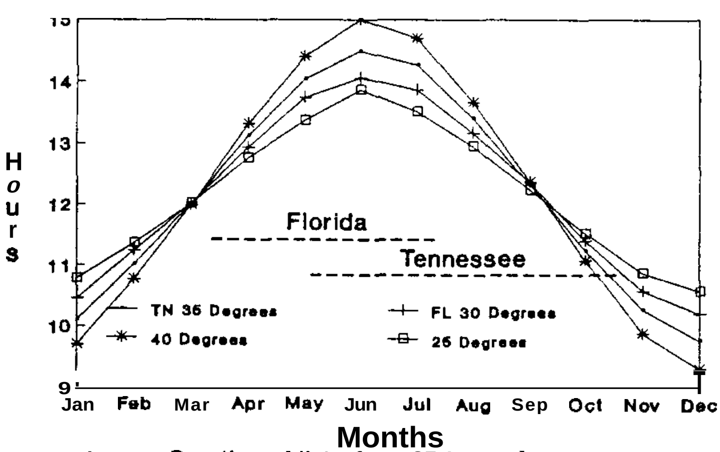

Figure 1 Duration of light from 25 lo 40 degrees lattitude.

at the Green Acres Agronomy Farm near Gainesville, Florida on an Arredondo fine sand (94%sand, 2%silt, 4% clay) (sandy, siliceous, thermic, Grossarenic Paleudult). The 15 cultivars were planted with an in-row subsoil no-tillage planter into corn residue from the previous year on 14 April 1989. The two row plots were 30 inches wide and 16 feet long to achieve 29,000 plants/acre. 'Dual' (metolachlor) plus atrazine was applied to corn at planting. Gramoxone plus X77 surfactant was sprayed preplant. 'Furadan' (#15g, carbofuran) was applied at the rate of 2 pound a.i./acre at planting. Water was applied every four days (1.2 inches) from tasseling through rapid grain fill depending on rainfall. Nitrogen was applied (180 pounds/acre) in three equal splits. At planting 450 pounds 0-10-20/acre and 300 pounds K-Mag/acre were broadcast. Grain and forage yields were determined at black layer. The percent flint seed was estimated at harvest. Grain was analyzed for N concentration after drying at 70^{o} C in a forced air oven, ground *to* pass a 2 mm stainless steel screen in a Wiley mill and stored in air tight sterile plastic bags (Gallaher et al., 1975; Gallaher et al., 1976). Published values for duration of daylight by latitude were plotted (Fig. 1) to aid in data interpretation (List, 1971).

RESULTS AND DISCUSSION

Since simultaneous selection for grain yield and percent protein can result in significant increases in both traits (Kauffmann and Dudley, 1979), it is not surprising that differences in seed yield and protein occurred among cultivars in our study (Table 1). Pioneer Brand 3320, the dent endosperm hybrid, was lowest in percent grain N among all cultivars. Although differences in seed N existed among the other cultivars, they ranged from 20 to 35% higher than Pioneer 3320 in Florida and from 5 to 25% higher in Tennessee. Differences among cultivars in seed N within a location illustrated genetic differences due to endosperm type or within the same endosperm category. Grain N was generally lower for all cultivars in the Florida study compared to the Tennessee study. This was likely due to the less fertile and more leachable fine sand soil in Florida compared to the silt loam in Tennessee and confirms the idea that grain N could possibly be used as an indicator of corn nutrition (Cerrato and Blackmer, 1990).

Grain and forage yield of the mixed, flint or semi-dent endosperm cultivars were affected less by location compared to the two dent or temperate cultivars (Table 1). This may be due to the Florida experimentals and Pioneer Brand X304C responding more to the longer daylight hours in Tennessee, resulting in greater shading of the temperate cultivars. The corn received over one and one-half hours more daylight per day during vegetative growth in Tennessee compared, to Florida (Fig. 1).

These data show that Florida experimentals and the tropical hybrid Pioneer Brand X304C not only have potential as a silage crop in Florida but also as far north as southern middle Tennessee as well. Additional research is required to investigate tropical corn as an alternative for sustaining agricultural systems in the region.

ACKNOWLEDGEMENTS

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LITERATURE CITED

1. **Cerrato, M.E., and A.M. Blackmer. 1990.** Relationships between grain nitrogen concentrations and the nitrogen status of corn. Agron. J. 82:744-749.

2. **Gallaher, R.N., C.O. Weldon, and J.G. Futral.** 1975. An aluminum block digester for plant and soil analysis. Soil Sci. Soc. Amer. Proc. 39:803-806.

3. **Gallaher, R.N., C.O. Weldon, and F.C. Boswell.** 1976. A semiautomated procedure for total N in plant and soil samples. Soil Sci. Soc. Amer. J. 40: 887-889.

4. **Gallaher, R.N., S.A. Ford, R. McSorley, and J.M. Bennett.** 1991. Corn forage and forage sorghum double cropping yield, economics, crop nutrient removal and quality. Agron. Res. Report AY-91-05, Agronomy Department, Inst. Food and Agr. Sci., Univ. of Florida, Gainesville, FL 32611.

5. **Kauffmann, K.D., and J.W. Dudley.** 1979. Selection indices for corn grain yield, percent protein, and kernel weight. Crop Sci. 19:583-588.

6. **List, R.J.** 1951. Smithsonian Meteorological Tables. Duration of Daylight, Table 171. p. 507-508. Smithsonian Miscellaneous Collection. Publication 4014, Vol. 114. Smithsonian Institution, Washington, DC.

7. **Wright, D.L., I.D. Teare, and R.N. Gallaher.** 1991. Corn silage production in north Florida. p. 15-20. In I.D. Teare, (ed.), Southern Regional Tropical Corn Symposium. Quincy, Florida, June 27-28, 1991. Potash & Phosphate Institute and Foundation for Agronomic Research, Atlanta, GA.

Influence of Weed Interactions of Conservation-tillage Systems and Weed Management on Cotton

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INTRODUCTION

Conservation-tillage acreage has increased in the U.S. to improve erosion control. It is estimated that over 90% of U.S. farmland will be under some form of conservation-tillage by the year 2000 (1). However, in the southeastern U.S. there are agronomic and pest management limitations to the adoption of conservation-tillage cotton. In many of the eroded soils of the piedmont, soil compaction can seriously impede cotton growth. Without mechanically disturbing the soil compaction layer, implementation of conservation-tillage cotton will be difficult. Conservation-tillage acreage in the southeast has also been minimal because pest management, including weed control, is difficult.

The objectives of this research were to determine optimal weed management and conservation-tillage system for cotton in the Georgia piedmont.

MATERIALS AND METHODS

Experiment., were established at the Southern Piedmont Research Center near Watkinsville, GA in 1991. The soil was a Cecil sandy loam (Typic Hapludult, clayey, kaolinitic, thermic) with a pH of 5.8 and organic matter of 2.3%. Wheat *(Triticum aestivum* L.) was planted as a cover crop at 100 kg ha^{-1} the fall before cotton establishment. Twenty days before cotton planting, paraquat at 0.6 kg ha^{-1} was applied in 250 L ha^{-1} carrier to kill existing vegetation.

The experimental design was a split-split block with three replications. The whole block consisted of four conservation-tillage systems and a conventional-tillage system for comparisons. Whole blocks were subdivided into sub-plots of three cotton varieties and four herbicide input systems. The three cotton varieties were 'Deltapine 90.' 'Tifcot 56,' and 'DES 119.' The four herbicide input systems were: no-input; norflurazon applied preemergence at 1.1 kg ha^{-1} plus fluometuron applied preemergence at 1.1 kg ha^{-1}; norflurazon and fluometron followed by a split application of MSMA at 1.6 kg ha^{-1} post-directed at cotton 10 cm and 18 cm in height; and a postemergence only treatment of a split-application of MSMA postdirected at cotton 10 cm and 18 cm and sethoxydim applied at 0.2 kg ha^{-1} postemergence over the top. MSMA was applied with 0.25% v/v non-ionic surfactant and sethoxydim was applied with a crop oil at 2 L ha^{-1}. Five tillage regimes were examined. These were a conventional tillage (fall and spring disk harrow) and four conservation tillage regimes that are outlined in Table 2.

Visual evaluations of weed control were made 2 and 6 weeks after planting (WAP). A determination of percent boll open was made 2 weeks before harvest. Seed cotton yields were taken out of the two middle rows of each plot.

Weed control evaluations and other cotton growth measurements were subjected to an analysis of variance and means were separated according to Fisher's Protected LSD at the $p < 0.05$ level.

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Table 1. Weed control in conservation-tillage cotton.

Herbicide	XANST[a,b] 2WAP	XANST[a,b] 6WAP	CASOB 2WAP	CASOB 6WAP	DIGSA 6WAP	AMACH 6WAP	Bolls Open	Seed Cotton Yield
	%							kg ha^{-1}
Control	0	0	0	0	0	0	27	631
Norflurazon (1.1 PRE) + Fluometuron (1.1 PRE)	86	55	89	59	70	66	42	1461
MSMA (1.6 PD) + MSMA (1.6 PD) + Sethoxydim (0.2 POT)	83	79	84	81	69	a4	41	2345
Norflurazon (1.1 PRE) + Fluometuron (1.1 PRE) + MSMA (1.6 PD) + MSMA (1.6 PD)	-	82	-	85	40	83	57	2336
LSD (0.05)[c]	18	7	19	5	11	12	13	882

[a] Visual ratings recorded as weeks after planting.

[b] XANST, CASOB, AMACH, and DIGSA are Bayer codes for common cocklebur, sicklepod, smooth pigweed, and large crabgrass, respectively.

[c] For comparison of any two means within a column.

Table 2. Cotton growth and seed cotton yields over tillage regimes.

Tillage regime			
Fall	Spring	Open Bolls	seed Cotton Yield
		%	kg ha"
Para plow	Coulter Inrow Chisel	32	1492
Para plow	Fluted Coulter	52	1844
Disk harrow	Coulter Inrow Chisel	42	1473
Disk harrow	Fluted Coulter	35	1571
Disk harrow	Disk harrow	41	2086
	LSD (0.05)*	14	NS

* For comparison of any two means within a column.

RESULTS AND DISCUSSION

Visual weed control, percent boll open, and seed cotton yields for the herbicide inputs applied are shown in Table 1. Significant differences in yield and cotton maturity as indicated by percent boll opening were observed. Cotton treated with norflurazon and fluometuron applied preemergence followed by a split application of MSMA and the split application of MSMA with postemergence sethoxydim without a preemergence soil applied herbicide provided the best seed cotton yields. This can be attributed to broadleaf weed provided by treatments containing MSMA (> 80% control of sicklepod, common cocklebur, and smooth pigweed 6 WAP).

There were differences in cotton maturity across tillage regimes. The conventional tillage (disk harrow, fall and spring) and the fall para plow followed by a fluted coulter matured faster than the other tillage treatments. No significant differences in seed cotton yield were found among tillage regimes.

Significant differences in yield were not found among the three cotton varieties examined.

LITERATURE CITED

1. Witt, W. 1980. Weed control in no-tillage. Pages 96-103. *In* (Philips, R. E., G. W. Thomas, and R. L. Blevins, ed.) No-Tillage Research: Research Reports and Reviews. University of Kentucky Agricultural Experiment Station, Lexington.

Influence of No-tillage Practices on Tobacco Thrips Infestations in Cotton.

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ABSTRACT

Infestations by the tobacco thrips *(Frankliniella fusca* Hinds), were reduced in no-tillage as compared with surface tillage for up to 21 days in areas planted with cotton *(Gossypium barbadense* L.), following fallow (1990) and wheat (1991). Thrips populations were also influenced by different cultivars; fewer adults and nymphs were collected on 'Chembred 1135' in either tillage system as compared with 'Coker 320' or 'Delta Pine 90.' Infestations were significantly reduced in all treatments when aldicarb (0.6 kg ai/ha) was applied in the seed furrow at planting time.

INTRODUCTION

Use of no-tillage (NT) practices for the production of cotton is being pursued increasingly in several southern states, and there is concern for potential of increased insect problems associated with reduced tillage. All and Musick (1986) and Stinner and House (1990) reviewed the status of knowledge on insect pest hazard in no-tillage systems, and both indicate that there is a paucity of information on cotton insects. Promotion of "earliness" in cotton with practices that ensure good germination and establishment of vigorous stands has substantial yield benefits Rhone-Poulenc 1989). Reduction in damage by the tobacco thrips in young cotton aids rapid establishment of vigorous stands. Certain cotton cultivars, such as Delta Pine 90, have resistance to tobacco thrips (DuRant, 1989). The current research was conducted during 1991-92 to determine if infestations of tobacco thrips were influenced by NT practice during the initial weeks of cotton growth and to evaluate whether cultivar selection or aldicarb were effective IPM practices.

METHODS

In 1990, the test was conducted in a two ha field near Athens that had been left fallow following harvest of corn the previous year. In 1991 the cotton was planted shortly after harvest of wheat in a two ha field. The fields were arranged in a randomized complete block split-split plot design. Main plots were NT or surface tillage (ST), split plots were cultivars Delta Pine 90 (DP90), Coker 320 (C320), or Chembred 1135 (CB1135) (used in 1990 only) and split-split plots were aldicarb (0.6 kg ai/ha) applied at planting in the seed furrow as compared with no insecticide treatment. Tillage blocks were 20 m long x 48 (1990) or 64 (1991) rows with 3.5 m alleys; cultivar plots were 16 or 32 rows; insecticide and control plots were alternating paired rows within each block. Each treatment was replicated four times.

Thrips populations were sampled 21 days after planting by immersing leaves of 20 plants collected at random from each plot in containers with 80% alcohol. Adults and nymphs were counted and identified using a dissecting microscope. Data were analyzed using computer based ANOVA procedures (SAS, 1985).

RESULTS AND DISCUSSION

In both 1990 and 1991, tobacco thrips were the only species identified from the samples taken 21 days post planting on plants in the first true leaf stage of development. Substantially greater infestations occurred in

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1990 in the corn/fallow area as compared with the wheat area of 1991, but thrips infestations were generally higher statewide in 1990 than 1991. Significantly higher numbers of adults and immatures were sampled from plants in the surface tillage (ST) areas as compared with no-tillage in the 21 day sample both years. Means were 1.47 $\pm$ 0.4 (std. deviation) and 0.6 $\pm$ 0.4 in NT, and 1.75 $\pm$ 0.6 and 1.0 $\pm$ 0.4 in ST in 1990 and 1991, respectively.

There were significant differences in tobacco thrips infestations among the three cultivars in 1990, with CB1135 having significantly fewer insects (x = 1.42 +0.4) as compared with C320 and DP90 (x = 1.64 + 0.5 and 1.76 + 0.5, respectively). In 1991, CB1135 was not used in the test, but C320 had significantly fewer numbers of tobacco thrips (x = 0.65 + 0.4) as compared with DP90 (x = 0.93 + 0.2). There was no cultivar x tillage interaction in either year.

Aldicarb at 0.6 kg ai/ha significantly reduced thrips populations in comparison with the untreated cotton at 21 days in all treatments. The percent control was 42.1 in NT and 32.9 in ST in 1990; whereas, in 1991; 51.7% control of thrips in the NT plots was significantly greater than ST, which had 39.4%. No interaction of cultivar or cultivar x tillage with aldicarb treatment occurred in either year.

In conclusion, the research indicates that infestations of tobacco thrips on seedling cotton (first true leaf stage) are reduced for up to 21 days in NT as compared with ST systems. Damage to the seedling cotton at this stage can result in 10 to 20% or higher reductions in yield with susceptible cultivars. CB1135, a hybrid cotton cultivar, had less infestation by tobacco thrips than C320 or DP90, and damage was significantly reduced to all three cultivars by treatment with aldicarb (0.6 kg ai/ha). Thus, IPM for control of tobacco thrips infestations on seedling cotton may be enhanced using a combination of no-tillage, cultivar selection and aldicarb.

LITERATURE CITATIONS

All, J.N. and G.J. Musick. 1986. Management of vertebrate and invertebrate pests. pp. 347-387. *In:* M. A. Sprague and G. B. Triplett (eds.) No-tillage and surface-tillage agriculture: the tillage revolution. John Wiley and Sons, Inc, New York.

DuRant, J. 1989. Yield response of cotton cultivars to early-season applications of chlordimeform and aldicarb. J. Econ. Entomol. 82:626-632.

Rhone-Poulenc. 1989. Earliness: a planned approach to managing the quality and yield potential of cotton. Rhone-Poulenc Ag. Co. Research Triangle Park, NC.

SAS Institute. 1985. SAS user's guide: statistics, Version 6 ed. SAS Institute, Cary, NC.

Stinner, B.R., and G.J. House. 1990. Arthropods and other invertebrates in conservation-tillage agriculture. Ann. Rev. Entomol. 35:299-318.

Tillage and Crop Rotation Effects on Sustaining Soybean Yields on a Hapludult

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ABSTRACT

Strip-tillage (in-row chiseling), no-tillage, and conventional tillage (moldboard plow) systems have been evaluated for 10 years together with cropping sequences of continuous corn *(Zea mays* L.), continuous soybean (Glvcine max [L.] Merr.), and corn-wheat (Triticum aestivum sp.)-soybean. 'Essex' soybean yields for 1981 to 1984 were highly correlated with soybean cyst nematode (Heterodera *glycine* Ichinohe, SCN) population. Yields were up to 39% higher with strip and no-tillage than with conventional tillage, and yields were up to 28% higher when rotated with corn. In 1985, strip-tillage treatments were split to include a SCN resistant soybean cultivar ('Forrest') and in 1987 all tillage treatments were split to include the SCN-resistant cultivar. Soybean yields in all tillage systems were increased by use of a SCN resistant cultivar; however, when crop rotation was considered, yields of both soybean cultivars were increased up to 30 to 46%. In the double-crop rotation treatment, soybean yields were equal to continuous soybean, but soybean yields were reduced when wheat was a cover crop and not harvested for grain. In 1989, the corn-w-soybean rotation was not planted because for 20 days between May 19 and June 9 no rainfall was recorded but during the next 14 days 11 inches of rainfall was recorded. This prevented planting of double-crop soybean in 1989.

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INTRODUCTION

In the first four years of a conservation tillage study conducted on a Hartsells fine sandy loam (fine-loamy, siliceous, thermic, Typic Hapludults), soil conservation tillage resulted in 16 to 39% higher soybean yields than conventional tillage in 3 of 4 years (Edwards et al., 1988). By the fourth year of the experiment (1983), soybean yields with conventional tillage were reduced to 690 kg ha^{-1} compared to 1660 and 1930 kg ha^{-1} with strip-tillage and no-tillage. Conservation tillage systems in combination with corn-soybean rotation for both full-season or double-cropped soybean gave the most consistent yield increase for the 10 years.

A significant tillage x rotation interaction for soybean yield occurred in 1981, 1982, and 1983 and was probably caused by a buildup of soybean cyst nematode population. These SCN populations increased faster in conventional tillage with continuous soybean than in strip- or no-tillage treatments. The SCN populations in 1984 were highest in all tillage systems with continuous soybean and were lowest with no-till when soybean was rotated with corn. In 1985 and 1986, all strip-tillage soybean plots were split so that Forrest, a SCN race 3 resistant cultivar, could be compared with Essex, a SCN susceptible cultivar. All strip-tillage treatments were split to compare soybean yields in 1985 and 1986 and all tillages were split in the other tillage system with respect to corn-soybean rotation. Thus, the objectives were to determine effects of time on yields and to follow the soybean cyst nematode population as influenced by crop rotation, tillage, and soybean cultivars.

Table 1. Influence of crop rotation on average soybean yields for 'Essex' and 'Forrest' with strip-tillage.

Crop Rotation	Essex 10 yr avg.	Essex 6 yr avg.	Forrest 6 yr avg.
Continuous	1870	1808	2410
Corn-Soybean	2283	2169	2810
C-W-S[a]	2083	1760	2450

[a] Corn-Wheat for grain-Soybean.

Table 2. Influence of conservation tillage systems on average soybean yields for 'Essex' and 'Forrest.'

Tillage	Essex 10 yr avg.	Essex 6 yr avg.	Forrest 6 yr avg.
	kg ha^{-1}		
Conventional	1880	1710	
Strip-tillage	2163	1986	2436
No-tillage	2191	2093	

Table 3. Soybean cyst nematode counts found in 1985 through 1987 at Crossville, Alabama, with different tillage and crop rotation systems.

Tillage system	soybean cyst nematode count (# cm^{-3} soil)						
	1984	1985		1986		1987	
	Essex	Essex	Forrest	Essex	Forrest	Essex	Forrest
				Corn - soybean rotation			
CONV[1]	712	260		161		134	19
STRIP[2]	632	612	36	538	48	362	12
NO-TILL[3]	216	149		399		171	13
				Continuous soybean rotation			
CONV	586	303		126		91	21
STRIP	779	627	133	238	23	510	52
NO-TILL	797	426		310		264	128

[1] Conventional tillage (moldboard plow)
[2] In-row subsoiling
[3] No-tillage

MATERIALS AND METHODS

Strip-tillage treatment consisted of planting soybean over 20 to 22-cm deep chisel slots. No-tillage treatments were planted with a doubledisk opener planter directly into the untilled soil surface. Conventional tillage consisted of turning the wheat cover in spring, disking in herbicides, and planting. Cropping sequences were continuous soybean; continuous corn; corn-soybean; and corn-wheat for grain-soybean. Wheat was planted in the fall on all plots as a winter cover, including those plots not used for grain crop. The wheat was killed on the winter cover plots 10 days before planting corn or soybean. The experiment was located on a Hartsells fine sandy loam soil on the Sand Mountain Substation at Crossville, AL, which is in the Appalachian Plateau area of AL. The experiment was a split-plot design in a randomized complete block with four replications. Whole plots were tillage (32.9 by 15.25 m) and subplots were rotation treatments (5.49 by 15.25 m). Row spacing was 0.92 m for corn and 0.69 m for soybean. Essex soybean has been used since the experiment was started in 1980. In 1985, the soybean treatments were split to include a SCN resistant cultivar Forrest.

Soil samples were collected in March, July, and August for nematode analysis. The March soil was collected before the soybean was planted. The July and August samples were sampled 58 and 59 days after planting full-season and double-cropped soybean. Eighteen cores were taken 12 to 14 cm deep under the rows of each plot for each sampling time. The full-season soybean was planted in late May and double-cropped soybean was planted in late June after wheat was harvested for grain. All plots were uniformly fertilized according to Auburn University soil test recommendations.

RESULTS AND DISCUSSION

When crop rotation is considered, Essex soybean yield was increased each year (1981-90) by having corn in the rotation (Fig. 1). This relationship was observed in years (1982, 1984, 1987, 1988, and 1989) when reduced rainfall caused water stress during critical growth periods. The only year that conventional tillage soybean yield was greater than no-till or strip-tillage was in 1981 (Fig 1). In all other years (1982-90), no-tillage and strip-tillageyields were higher than conventional tillage.

The six-year (1985-90) yields of Essex soybean have continued to decrease with strip-tillage when compared to the ten year average yields (Table 1). However, soybean yields with strip tillage were increased 33% with continuous soybean, 29% with full-season soybean, and 39% with double-crop soybean when the SCN resistant cultivar Forrest was included in the soybean rotation. The highest yields for the six years were obtained when a SCN resistant soybean cultivar was rotated with corn and full-season soybean was grown (Fig. 2).

Essex soybean yields as affected by tillage systems also decreased during the six years (1985-1987) when compared to the ten-year average yields (Table 2). However, yields with no-tillage are being maintained even though the SCN population appears to be building up when compared to conventional or strip-tillage (Table 3). Strip-tillage soybean yields were increased by 23% by using Forrest as compared to yields with Essex.

The number of SCN counts 60 days after planting with conventional tillage appear to be declining in numbers over the last four years, however, yields of Essex soybean continue to be lower indicating that some factor other than cyst nematode population was limiting yields. There also appears to be an increase in the number of SCN with Forrest in the no-tillage systems where continuous soybean was planted as compared to when soybean were rotated with corn (Table 3).

CONCLUSION

The corn-soybean rotation and conservation tillage (no-tillage or strip-tillage) increased yields of Essex and Forrest soybean

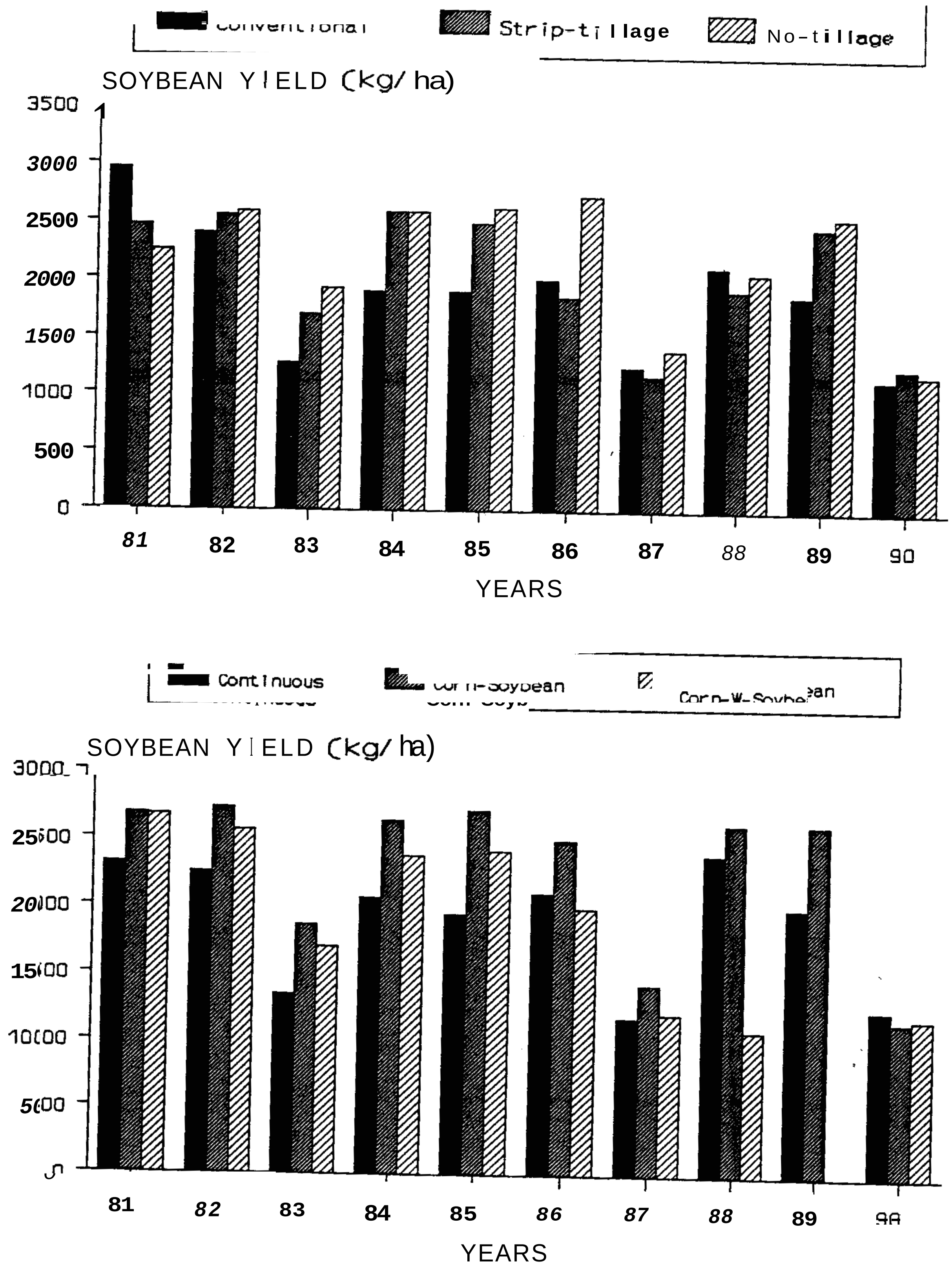

Fig. 1. Influence of tillage and crop rotation on Essex soybean yields.

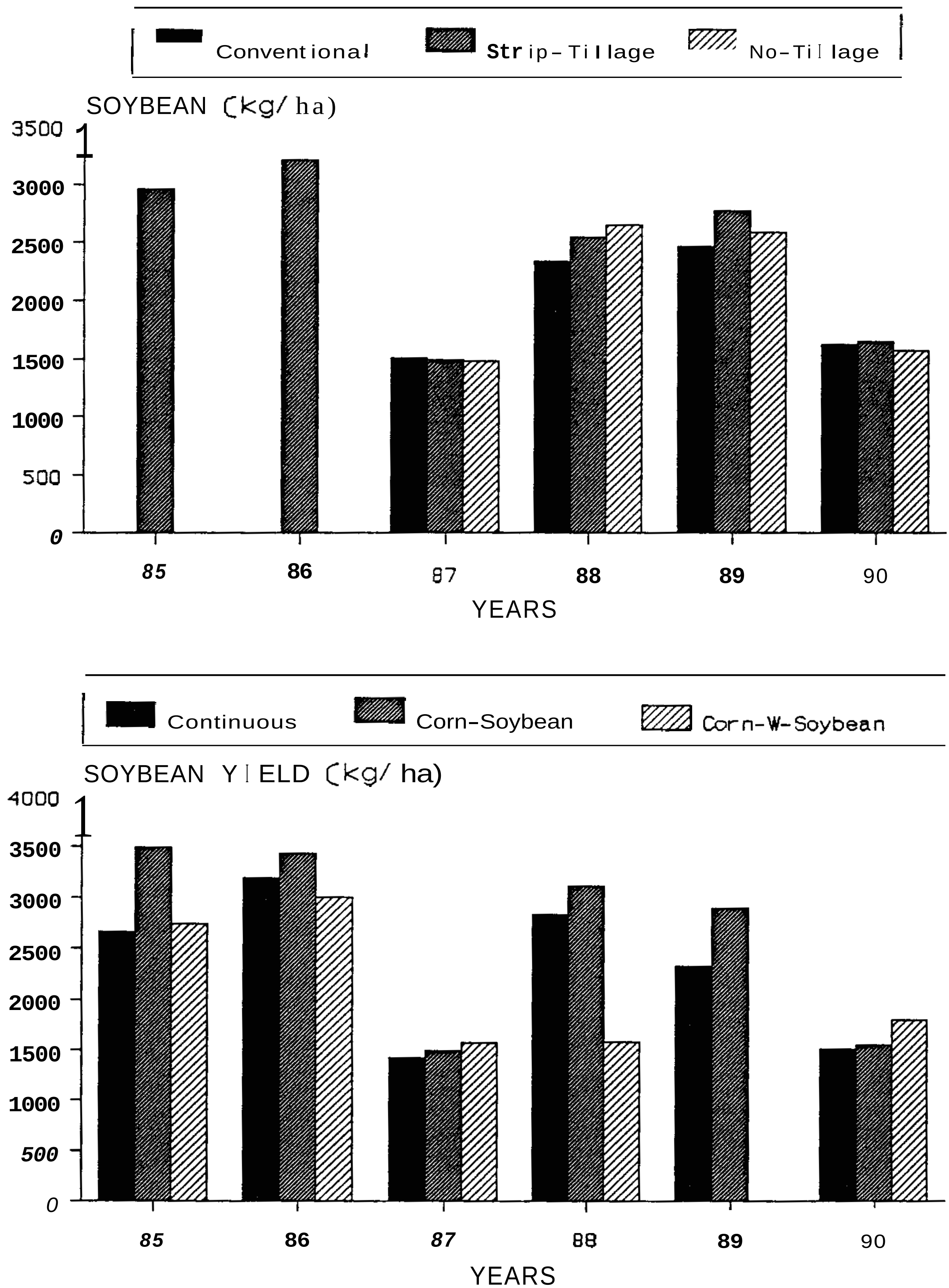

Fig. 2. Influence **of tillage and crop rotation on** Forrest **soybean yields.**

cultivars. With conventional tillage, there was a build-up of cyst nematodes to damaging levels in the first 60 days after planting during the first four years of the experiment. The cyst nematode population reached the same levels in the no-tillage and strip-tillage systems, but the build-up was at a slower rate than with the conventional tillage. By the sixth and seventh years, the conservation tillage had even higher cyst nematodes population when compared to conventional tillage, but soybean yields were not affected. However, the cyst nematode build-up declined with time when Essex was grown with conventional tillage, suggesting that factors other than nematode populations were affecting Essex soybean yields. In general the largest yield difference because of rotation was with the strip-tillage and largest soybean differences due to cultivar were observed in the soybean-wheat for grain-corn rotation.

RELATED LITERATURE

Eason, J. T., J. H. Edwards, and D. L. Thurlow. 1984. Influence of tillage treatments on corn and soybean yields. So. Branch, Am. Soc. Agron. (Abstract).

Edwards, J.H., C.W. Wood, D.L. Thurlow, and M.E. Ruf. 1992. Tillage and crop rotation effects on fertility status of a Hapludult soil. *SSSAJ* 56: (in press).

Edwards, J. H., D. L. Thurlow, and J. T. Eason. 1988. Influence of tillage and crop rotation on yields of corn, soybean, and wheat. Agron. J. 80:76-80.

Edwards, J. H., D. L. Thurlow, and J. T. Eason. 1985. Soybean relative yield as affected by cropping sequences and conservation tillage. Proc. 1985 Southern Region No-till Conference, Griffin, GA. pp.40-44.

Thurlow, D. L., J. H. Edwards, and J. T. Eason. 1988. Effects of tillage, crop rotation, and high nematode population on soybean yields. So. Branch, Am. Soc. Agron. (Abstract). p. 9.

Multiple Cropping as a Sustainable Agriculture Practice

V.L. Jones[1]

MULTIPLE CROPPING: A FORM OF SUSTAINABLE AGRICULTURE

Sustainability is one of the greatest concerns in agriculture. The designation, "Sustainable Agriculture," is a wide umbrella that includes numerous agricultural systems. Cohen et al. (3) identified it as being, "A management system for renewable natural resources that uses such resources to provide food, income and livelihood for current and future generations and that maintains and improves the economic productivity and ecosystem services of these resources." This definition and even the term sustainable suggest the necessity of sustainable agriculture using sound agronomic principles. Soil erosion control, weed management, maximum efficiency of on-farm and purchased inputs, minimal leaching of pollutants through the root zone, maintenance of soil fertility by proper addition of plant nutrients and utilization of appropriate biological principles throughout the farming operation should be included among the sound agronomic principles which may result in sustainability (8, 9, 13).

Multiple cropping, the growing of two or more crops on the same field in one year, fits under the umbrella of sustainable agriculture. Multiple cropping systems result in efficient use of land resources (7). Some of these system provide year-round coverage of crop land, thus reducing erosion and sustaining topsoil. Multiple cropping systems often allow fall seeded crops to emerge and establish good above ground growth before winter and spring weeds can get established. This increases the competitive edge of the cash crop and in some cases reduces the amount of herbicides required for weed control (6, 14). Growing two or more crops in the same field during the same year is usually done either simultaneously (intercropping) or in sequence (double cropping). Studies have shown that multiple cropping has been advantageous in reducing insect pests and disease damage in some areas through diversifying the cropping system by introducing plant species that are nonhosts for certain insects and diseases (5, 10). Perhaps the most attractive aspect of multiple cropping to producers is that these systems can boost yields and increase profits (4).

RELAY INTERCROPPING VERSUS DOUBLE CROPPING

Double cropping is an important component of agriculture throughout much of the South. The most common practice is a sequence that entails harvesting a crop of winter wheat in early summer, planting soybean in the same field, and harvesting the soybean in the fall (1). Success with double cropping varies from year to year. A successful double cropping year usually depends on the amount of available moisture at the time of and following the seeding of each crop in the system. The farther north one moves, the less reliable double cropping becomes. For instance, double cropping soybean following winter wheat may be economical in the South but it is seldom economical in the Midwest. Poor soybean yields in midwestern double cropping systems often result from stand failure or low yields resulting from the short growing season (12).

The growing season in the Midwest and even in some more southern areas such as the upper Southwest is too short to allow soybean planting after the winter wheat harvest. Therefore, to lengthen the soybean growing season, various methods of planting soybean before the wheat harvest have been investigated.

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For example, relay intercropping has been examined as a possible method of reducing the risks of growing two crops a year and in extending the northern limits of a two crop system (2, 11, 12). Relay intercropping refers to a planting system in which a second crop is seeded in the same field with the first crop after the first crop has reached its reproductive stage of growth but prior to being ready for harvest.

Relay intercropping has received limited attention in the United States partly because of modest amounts of equipment tailored for planting, maintaining and harvesting relay intercropped fields. Adequate weed control systems are also limited for relay intercropping. However, besides extending the northern boundary of a two crop per year system, relay intercropping also allows crops to be planted at an optimal date when soil moisture is more readily available.

STUDY METHODS

This experiment began as an off-shoot of a larger double cropping experiment. It was conducted on the Langston University Research Station in central Oklahoma in a fine sandy loam soil. Relay intercropping was compared to double cropping as multiple cropping systems for growing winter wheat and soybean. The experiment was designed as a randomized complete block with four replications. Since wheat is more widely grown in Oklahoma than soybean, winter wheat was considered to be the primary crop in this experiment and soybean the secondary crop. Therefore, instead of relay planting soybean into standing wheat in the spring, winter wheat was relay planted into standing soybean in the fall. Plots were hand planted. Thirty-inch rows were used to reduce injury to standing soybean while relay planting the wheat with a push furrower.

The field was cultivated once a year. In the spring it was moldboard plowed and disked. Roundup was applied prior to cultivation in the spring. Weed control was maintained throughout the growing season by hand eradication. Wheat plots were harvested as above ground biomass, with the exception of one year. In 1987, wheat heads only were harvested. All plots were harvested by hand.

RESULTS AND DISCUSSION

In 1987, winter wheat heads only were analyzed for yield. Relay intercropped winter wheat (RIW) produced 0.91 tons/ac and double cropped winter wheat (DCW) produced 0.72 tons/ac. Relay intercropping yielded 26% better than double cropping. In 1988 and 1989, complete above ground winter wheat plants were harvested and dry matter weights recorded. In 1988, RIW yielded 1.24 tons/ac and DCW yielded 0.63 tons/ac. This was a 97% yield advantage for RIW. Low DCW yields for 1988 may be attributed in part to low moisture availability during the early growth stages of DCW. In 1989, RIW yielded 1.72 tons/ac of dry matter and DCW yielded 1.24 tons/ac. RIW held a 39% yield advantage over DCW for that year.

Soybean components for both the RIW and DCW systems were treated the same way. Seed yields for soybeans grown under the RIW system were 10.3 bu/ac, 15.5 bu/ac and 23 bu/ac, respectively for the years 1987-1989. Soybean yields under the DCW system were 10.7 bu/ac, 15.1 bu/ac and 26 bu/ac, respectively for 1987-1989. These yields were under dryland conditions.

Double cropping has good potential for allowing Oklahoma farmers to get two crops in a single year. Oklahoma's Southwestern growing season is long enough to accommodate select species in a two crop a year system. A double cropping system consisting of winter wheat and soybean is feasible for Oklahoma. However, getting winter wheat seeded after the soybean harvest is completed could result in poor stands and lower yields. The late fall rains could also delay winter wheat seeding to the middle of November or beyond the recommended seeding date. Relay intercropping of winter wheat into standing soybeans would allow the farmer to get into the field earlier and seed wheat at an optimal time for adequate moisture and in time to take advantage of a lengthy growing season. These advantages from relay cropping could result in higher yields.

LITERATURE CITED

1. **Brown, C.M.** 1982. Relay intercropping. Crops and Soils 34(8):7-8.

2. **Chan, L.M., R.R. Johnson, and C.M. Brown.** 1980. Relay intercropping soybeans into winter wheat and spring oats. Agron. J. 72:35-39.

3. **Cohen, J.I., J.B. Alcorn, and C.S. Potter.** 1991. Utilization and conservation of genetic resources: international projects for sustainable agriculture. Econ. Bot. 45(2):190-199.

4. **Cramer, C., and K. Cicero.** 1992. **2** crops €or the price of 1. The New Farm 14(2):14-17.

5. **Hammond, R.B., and D.L. Jeffers.** 1990. Potato leafhopper (Homoptera: Cicadellidae) populations on soybean relay intercropped into winter wheat. Environ. Entomol. 19:1810-1819.

6. **Horwith, B.** 1985. A role for intercropping in modern agriculture. BioScience 35(5):286-291.

7. **Howard, D.D., and G. Lessman.** 1991. Nitrogen fertilization of wheat double-cropped following grain sorghum in a no-tillage system. Agron. J. 83:208-211.

8. **Keeney, D.R.** 1989. Toward a sustainable agriculture: need for clarification of concepts and terminology. Amer. J. of Alt. Agric. 4(3/4):101-105.

9. **Kirschenmann, F.** 1989. Low-input farming in practice: putting a system together and making it work. Amer. J. of Alt. Agric. 4(3/4):106-110.

10. **Martin,** R.C., **J.T. Arnason, J.D.H. Lambert, P. Isabelle, H.D. Voldeng, and D.L. Smith.** 1989. Reduction of European corn borer (Lepidoptera: Pyralidae) damage by intercropping corn with soybean. J. Econ. Entomol. 82:1455-1459.

11. **McBroom, R.L., H.H. Hadley, C.M. Brown, and R.R. Johnson.** 1981. Evaluation of soybean cultivars in monoculture and relay intercropping systems. Crop. Sci. 21:673-676.

12. **Reinbott, T.M., Z.R. Helsel, D.G. Helsel, M.R. Gebhardt, and H.C. Minor.** 1987. Intercropping soybean into standing green wheat. Agron. J. 79:886-891.

13. **Rodale, R.** 1990. Beyond purity. Organic Gardening. 37:27(2).

14. **Weil, R.R., and M.E. McFadden.** 1991. Fertility and weed stress effects on performance of maize/soybean intercrop. Agron. J. 83:717-726.

Field Changes after 10 Years of Continuous No-till Soybeans.

J. R. Johnson, Harold Hurst, and Gene Stevens'

INTRODUCTION

Little is known about the long-term changes continuous no-till production will have on a field in Brown Loamsoils of Mississippi. Producers have questions concerning changes in soil properties, weed species shifts, and consistency of yields. McGregor et al. (1973) found that no-till soybean plots increased surface residue from 2.5 T/A to 4.0 T/A and reduced field soil loss 6.7 T/A annually in some of the early work on Brown Loam soils.

Mutchler et al. (1984) reported average annual soil losses were reduced from 7.9 t/A to 0.6 T/A by continuous no-till soybean during a 9-year study in Brown Loam soils. Accumulated residue after harvest averaged 1.7 T/A for conventional to 3.9 T/A for continuous no-till. During the last 5 years of an 8-year study on Brown Loam soils, McGregor et al. reported no-till soybean yields averaged 44% more than conventionally tilled soybean. Johnson et al. (1985) reported lower yields from no-till over a 3-year period in the same soils but cultivation, however, did improve yields of no-till soybean. Stevens et al. (1987) also reported a significant yield increase from no-till planting followed by cultivation in Brown Loam soils.

The objective of this study was to determine the effects continuous no-till soybean production had on soil properties, weed ecology, and grain yields in Brown Loam soils.

MATERIALS AND METHODS

This study was started in the spring of 1981 at the North Mississippi Branch Experiment Station in Holly Springs, MS on an eroded Grenada silt loam soil with a 2-5%slope. Depth to fragipan varied from 9 to 17 inches across the test area. Five years previous to the study, the site had been used for a soybean variety test area. Weeds were not allowed to produce seed in the study area. The study area soil pH in 1981 was 6.2 and organic matter was 0.82% in the 0-to 6-inch soil depth.

The experimental design was a split-plot with herbicide management system as main plots and cultivation as sub-plot treatment. Main plots consisted of eight rows, 40 inches wide and 30 feet long, and each sub-plot consisted of four rows. Plots were replicated four times. A conventionally tilled plot (disk, chisel, disk, and do-all) was used as a check. Fertilizer was drilled 2 inches to the side of row and 2 inches deep at planting. A standard rate of 300 lb of 0-20-20 was used on all plots since soil test results of drilled fertilizer can be quite variable.

At the onset of the study, the decision was made not to test the efficacy of herbicides. Herbicides were to be changed to superior herbicides when they became available. Not changing herbicides would have allowed definitive statements on herbicide efficacy, but the results might have shown that it is not possible to maintain weed control in no-till soybeans when, in fact, farmers could do so by using new herbicides as they were released. Since evaluating herbicide efficacy was secondary to the broader objective of determining whether weed control can be maintained, herbicides were changed as warranted. The best available herbicide treatments for control of annual grasses and weeds were used for the duration of the study in comparison to a standard program (Lasso*, Dual*, Lexone*). This same decision applied to johnsongrass and burndown herbicides. All herbicides were used according to the labels for best results. The time and manner of application

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Table 1. Preplant, preemergence, and postemergence herbicide programs in main plot treatments.

Trt. No.			PPI or PRE Annual Grasses	PPI or PRE Annual Weeds	Postemergence
1	None	Non-selective	Excellent	Excellent	dir w/contact
2	None	Contact	Excellent	Poor	dir w/residual
3	None	Contact	Excellent	Excellent	O.T.w/str. grass
4.	None	Contact	Excellent	Excellent'	O.T.w/weak grass
5.	None	Contact	Excellent	Excellent'	O.T.w/str. grass
6.	Tilled	None	Excellent	Excellent	O.T.when needed

[1]At low rate (1/2 rate)
[2]At high rate (1 1/4 rate)

were according to MCES recommendations.

Table 1 lists herbicide systems that were applied preplant to foliage (PPF), preplant incorporated (PPI), preemergence (PRE), over-the-top (OT), and postdirected sprayed (dir). Treatments 1-5 were no-till planted and Treatment *6* was a conventionally tilled control. Conventional tilled plots were chiseled and disked 2 weeks before applying PPI herbicides. Incorporation was performed with a finishing harrow immediately before planting.

In the no-till plots preplant burndown herbicides (PPF) were sprayed at planting at the onset of the study. After 5 years into the study, it was decided to apply burndown herbicides 2 weeks prior to planting. Preemergence (PRE) herbicides were sprayed immediately after planting. Postdirected (dir) sprays were applied when soybeans were about 8 inches tall. Cultivation was done 3 to 5 weeks after emergence followed by a second cultivation approximately 2 weeks later.

Plots were visually rated for percent annual weeds and grasses in March and July. Perennial weeds and grasses were mapped in October. Soil samples to a 6-inch depth were taken after removing residue from soil surface. All chemical soil analyses were conducted at the MCES soil testing laboratory. Soybean was harvested from two center rows of each plot. Planting dates for the 10 years ranged from May 9, 1986 to June 25, 1985.

RESULTS AND DISCUSSION

Annual grasses and weeds were not a problem during the soybean growing season in any treatment during the 10-year study. The preemergence herbicides either gave satisfactory control of the weeds or the weed seed were not present in the plots to germinate. Table 2 lists weeds found in test area for 1984, 1987, and 1990 before burndown and preemergence applications. In the no-till plots, henbit became more abundant after 10 years, Virginia pepperweed decreased, while annual bluegrass, little barley, and mousetail ramained the same. Rhizome johnsongrass (perennial), however, became a problem in the postdirected treatments (Treatments 1 and 2) within the first 5 years. Post-directed treatments suppressed the johnsongrass in the early season, but did not prevent growth of johnsongrass later in the season. Johnsongrass, however, was scattered in all treatments after 10 years. Perennial grasses and weeds listed in Table 3 began to show up randomly in the no-till study area. Horsenettle was the only broadleaf perennial that was widespread throughout all no-till plots at the end of the growing season in 1990, since other perennial broadleaf plants found in plots were

Table 2. Distribution of winter weeds 3, 7, and 10 years after initiation of study.

Weed name	Distribution' 3/15/84	4/30/87	3/23/90
Little barley	VA	VA	VA
Annual bluegrass	VA	VA	VA
Mousetail	VA	VA	VA
Horseweed	VA	VS	M
Carolina geranium	VA	M	M
Bittercress	VA	M	M
Henbit	A	VA	VA
Virginia pepperweed	A	S	M
Shepherdspurse	M	VS	VS
Mouseear chickweed	M	M	VA
Wild garlic	M	S	VA
Buttercup	M	S	--
Cutleaf eveningprimrose	S	M	VA
Hop clover	S	M	VS
Narowleaf vetch	S	M–VA	VA
Common chickweed	VS	S	VS
Whitlowort	VS	--	--
Wild lettuce	--	S	VS
Curly dock	--	S	VS
Chervil	--	S	--
Bracted plantain	--	VS	VS
Red sorrel	--	VS	VS
Wild oats	--	VS	--

'Infestation was uniform over the entire no-till area. Visual estimate distributions were described as very abundant (VA), abundant (A), moderate (M), scattered (S), or very scattered (VS).

dormant in October.

Preemergence and over-the-top (OT) herbicides at the rates used did not kill perennial broadleaf plants such as pokeweed, horsenettle, curly dock, and maypop passion flower. For the first 5 years number and magnitude of these plants were not evident until near the end of the growing season, yet the few pokeweed plants present did cause discoloration of the soybean when harvested. Systems, including contact burndown herbicides such as Graxomone® baraquat) that destroyed vegetation within a day or two after spraying, did not produce any better kill than Roundup– (glyphosate), which was slower acting and more effective on weeds such as horseweed. None of the materials used in this study controlled all the vegetation when applied

Table 3. Weeds that were present in the no-till plots either in the spring or fall of 1990.

General weed name	Weeds present and Treatment No. Cult.	No Cult.	Present in All Reps	Present in Tilled Plots
Broomsedge		1	NO	No
Johnsongrass	1,2,3,4,5	1,2,3,4,5	Yes	Yes
Bennudagrass	1,2	1,2	NO	NO
Pokeweeds	1,2,3	1,2,3	NO	NO
Horsenettle	1,2,3,4,5	1,2,3,4,5	Yes	No
Wild Garlic	1,2,3,4,5	1,2,3,4,5	Yes	Yes
Maypop Passion Flower		2,4	No	NO
Broadleaf Plantain	1,2,3,4,5	1,2,3,4,5	Yes	No
Curly Dock	1,2,3,4,5	1,2,3,4,5	Yes	NO
Red Sorrel	1,2,3,4,5	1,2,3,4,5	Yes	NO
Dandelion	1,2,3,4,5	1,2,3,4,5	Yes	NO

Table 4. The effects of tillage for soybean on soil bulk density following 10 years of tillage.

Postemergence cultivation	Tillage treatment Tilled	No-tilled	
------------- within the seed drill -------------			
	------------ gm cm^{-3} ------------		
Yes	1.38	1.38	n.s.
No	1.38	1.39	n.s.
	n.s.	n.s.	
------------- within the traffic row -------------			
	------------ gm cm^{-3} ------------		
Yes	1.47	1.48	n.s.
No	1.49	1.47	n.s.
	n.s.	n.s.	
	n.s.	n.s.	
------------- the non-traffic row -------------			
	------------ gm cm^{-3} ------------		
Yes	1.43	1.45	n.s.
NO	1.43	1.46	n.s.
	n.s.	n.s.	

Table 5. Effects of herbicides and cultivation on soybean yields, 1981-90.

Trt.	Culti-vated	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	10-yr. Avg.
							bu A^{-1}					
1	Yes	28.4	32.1	13.9	24.2	29.9	21.4	18.2	24.6	14.8	12.6	22.0
	No	29.7	36.8	12.6	17.9	26.6	19.3	14.5	16.9	12.9	9.8	19.7
2	Yes	33.0	38.4	14.7	19.4	22.5	25.4	20.3	3.8	18.9	9.3	20.6
	NO	31.4	36.8	13.0	8.9	20.2	26.1	19.7	6.5	19.1	18.1	20.0
3	Yes	35.3	35.7	14.7	18.5	31.6	25.0	14.8	7.4	14.6	16.8	21.4
	NO	30.9	35.1	11.1	11.8	25.5	16.5	5.0	4.8	16.8	11.8	16.9
4	Yes	35.4	38.2	15.9	18.3	34.5	32.0	21.9	19.1	7.7	14.3	23.7
	NO	36.7	37.9	12.1	10.1	29.6	25.1	22.9	18.6	8.9	15.1	20.2
5	Yes	37.3	32.1	17.3	14.5	37.3	30.1	25.1	30.5	16.5	14.4	25.5
	NO	34.9	36.5	14.5	14.9	30.8	26.6	21.6	23.8	14.8	10.6	22.9
6	Yes	33.0	35.5	13.5	26.5	46.8	30.5	24.7	36.1	12.5	17.1	27.6
	NO	33.7	38.5	12.1	24.8	39.5	27.0	20.7	20.0	9.1	13.4	24.0
LSD $_{0.05}$ [1]		ns	ns	ns	4.0	8.7	4.3	4.8	8.9	4.3	4.5	
LSD $_{0.05}$ [2]		ns	ns	ns	2.0	3.4	2.3	2.2	2.3	ns	ns	
CV (%)		20.8	13.9	20.7	21.5	22.0	15.6	23.6	46.9	29.3	42.7	

[1] LSD 0.05 values €or comparing two herbicide means. Statistical analyses of 1984, 1989, and 1990 yields showed a cultivation x herbicide interaction. NS - not significant.

LSD 0.05 values for comparing cultivated and not cultivated means.

alone at rates used, making combinations with other herbicides necessary.

Field organic matter at the 6-inch depth was 0.82% at the beginning of the study. The organic matter content of the plots after 10 years was not consistent within tillage or post-plant cultivation. No significant differences in bulk densities were found between the tilled and no-tilled plots, and the no-tilled values were combined Table 4). It is apparent that soil compaction was no greater in the spring prior to conventional tillage following 10 years of no-tillage on Brown Loam soils than when conventional tillage was used.

Average grain yield of soybean was not significantly different for the first 3 years of the study for either the main plot treatment (herbicide management) or subplots (postemergence cultivation), Table 5. Generally, the yields were closely associated with rains that came during the growing season, especially from July through mid-September. Cultivation produced a significant yield increase 5 of 10 years. The 10-year average favored cultivation in all the main plots.

In summary, bermudagrass was present after 10 years in the treatments where an OT grass herbicide was not used. Scattered johnsongrass plants were found in all plots after 10 years. Horsenettle was abundant in all no-till plots at the end of the soybean growing season. Perennial weeds such as curly dock, dandelion, and wild garlic were dormant during most of the soybean growing season.

REFERENCES

1. **Johnson, J.R., B.L. Arnold, and H.R. Hurst.** 1985. Herbicides for grass control in no-till planted soybeans. MAFES Bulletin 936. Mississippi State University.

2. **McGregor, K.C., J.D. Greer, and G.E. Gurley.** 1973. Erosion control with no-till cropping practices. Paper No, 73-2523. American Society of Agricultural Engineers. St. Joseph, Michigan.

3. **McGregor, K.C., C.K. Mutchler, and R.F. Cullum.** 1991. Soil erosion effects on soybean yield. Paper No. 91-2626. American Society of Agricultural Engineers. Chicago, IL.

4. **Mutchler, C.K., and J.D. Greer.** 1984. Reduced tillage for soybeans. Paper No. 83-2537. Transaction of ASAE.

5. **Stevens, W.E., J.R. Johnson, and H.R. Hurst.** 1987. Weed population changes in no-till soybeans. MAFES Bulletin 954. Mississippi State University.

Establishment of Winter Forages into Summer Annual or Perennial Grass Sods

David Lang, David Ingram, Bill Brock, and Billy Johnson[1]

INTRODUCTION

Over 25 million acres of permanent sods could potentially be overseeded with winter annuals throughout the Southeast. Another 5 to 6 million acres are tilled prior to seeding winter annuals and produce no summer grass. Ideally, forage production year-round would involve summer grass production followed by robust winter annual production. Winter forage production on overseeded permanent sods, however, is half that of winter annual production on prepared seedbeds. Seedbed preparation on highly erodible soils, however, can be a violation of the sodbuster provisions of the 1985 and 1990 farm bills, Establishment of forage crops without tillage offers the opportunity to reduce seedbed preparation costs while conserving soil moisture and reducing soil erosion. Although conservation tillage seedings have increased with many examples of success, there is often a reduction in seedling vigor compared with conventionally plowed and disked seedbeds.

Sod-seeding winter annuals was pioneered in Mississippi over the past four decades (Dudley and Wise, 1953; Coats, 1957; and Thompson et al., 1961). Winter annual forage production in perennial sods is greatly reduced during the fall growth compared to forages sown in well prepared seedbeds. Research interest has recently been renewed at several locations in Mississippi. At Newton and Starkville, ryegrass sown in sod responded well to nitrogen applied from 0 to 150 lb/a. Ryegrass sown into annual sods yielded about 2/3 compared with annual sown in prepared seedbed while annuals sown in sod yielded about half (Lang, 1989). Ethylene evolution from annual sods was about 8 to 10 times higher than from well prepared seedbeds. Increased addition of nitrogen and higher levels of tillage appear to alleviate some of the early fall and suppression of winter annuals. The objective of this research was to compare the response of ryegrass sown in a permanent or annual sod with growth in a prepared seedbed.

METHODS *AND* MATERIALS

Ryegrass was seeded into a bermudagrass sod or a prepared seed bed on September 24, 1991 at Starkville, MS. Nitrogen at 0, 50 and 100 lbs/acre was added at seeding and again in February. Stand cover and height were recorded in December and yields were taken in January, March, and April. At Newton, MS two pastures with annual grasses (crabgrass and broadleaf signalgrass) were disked in SO foot strips with 20 foot strips left undisked. Ryegrass was then seeded into both strips.

The objective of the study at Raymond, MS was to compare reduced or minimum tillage methods for planting ryegrass for stocker calves. The two sod types utilized were coastal bermuda and summer annual grass sod. All treatments consisted of cutting hay prior to applying bumdown chemicals or drilling ryegrass. The following treatments were compared: (1) bermuda sod, paraquat bumdown, plant no-till (2) bermuda sod, disk lightly, plant with grain drill (3) bermuda sod, plant no-till (4) prepared seedbed (5) annual sod, paraquat burndown, plant no-till (6) annual sod, plant no-till. 'Marshall' ryegrass was seeded at 35 lb/a with either **a** 'Marliss' no-till drill or a'John Deere

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8300' series grain drill. Nitrogen was applied at the following rates: 51-0-0 at planting, 34-0-0 mid-February, and 34-0-0 April 1. Each six-acre plot was initially stocked with nine English and Exotic Cross steer calves averaging approximately 450 lb/ha (650 lb/a) when forage growth reached six inches in height.

RESULTS AND DISCUSSION

Ryegrass growth in either perennial or annual sods was much slower in the early fall growth period (Tables 1 and 2). Stands were excellent; however, ground cover was reduced for the sod plantings. Plant height was greatly reduced in sod compared with growth in tilled soil. Application of 100 lbs N per acre only slightly stimulated ryegrass growth when sown in sod.

Yield of ryegrass sown in sod was greatly reduced, particularly in the fall and early spring (Table 2). Nitrogen application stimulated growth of ryegrass to a much larger degree in tilled soil than it did in sod. It took 75-100 lbs N/acre in sod to equal the yield of ryegrass without N in tilled soil. This trend reversed as spring advanced. Yields in April and May favored the sod plantings. Factors other than nitrogen deficiency in sod in the fall may be operative.

Production of ryegrass on annual sods may be facilitated by tilling strips through the field leaving sod strips to reduce erosion. Stands and ground cover were enhanced in the tilled strips as compared with sod strips (Table 3). As with the perennial sods, however, this

Table 1. Ryegrass stands, cover and height when seeded into bermudagrass sod at Starkville, MS.

	Stands		Cover		Height	
Nitrogen	Sod	Till	Sod	Till	Sod	Till
lbs/a	%				cm	
0	94	100	22	100	10.2	27.2
50	95	100	59	100	10.5	25.8
100	94	100	80	100	20.2	26.9
$LSD_{(0.05)}$	6		4		2.5	

Date of Observation: 12-18-91.

Table 2. Growth of ryegrass as affected by nitrogen and seeding into a bermudagraes sod or prepared seedbed at Starkville, MS.

	1/7/92		3/2/92		4/8/92		5/7/92	
Nitrogen	Sod	Till	Sod	Till	Sod	Till	Sod	Till
	lb A^{-1}							
0	111	2967	490	965	439	661	1639	1219
50	302	3923	593	2699	1470	1303	1763	1254
100	734	3695	1229	3010	2489	1838	2087	1240
$LSD_{(0.05)}$	315		458		216		356	

Nitrogen was applied in October and again in January.

early season difference was not evident in the spring.

The average daily gain at Raymond, MS ranged from 2.46 to 2.55 pounds/steer (Table 4). The gain per head was generally greater on annual sod than bermuda sod treatments. The gain per head for bermuda sod ranged from 337 to 349 pounds and for annual sod ranged from 403 to 418 pounds. Total gain per acre was approximately 100 pounds greater for annual sod than bermuda sod. Animal grazing days ranged from 206 days for no-till bermuda sod to 232 days for prepared seedbed ryegrass. The initial

Table 3. Ryegrass seeded into annual sods in 80/20 strips at Newton, MS.

Pasture	Strip	1990 Stand	1990 Cover	1991 Stand	1991 Cover
		%			
89	80	74	42	94	56
89	20	31	18	85	41
$LSD_{(0.05)}$		20	16	6	14
19	80	97	92	97	51
19	20	75	63	86	38
$LSD_{(0.05)}$		8	15	6	17

Observations were in November of each year.

Table 4. Animal performance on ryegrass overseeded into a bermudagrass or annual sod at Raymond, MS.

Sod-Seeding Treatment	Animal Grazing Days	Initial Grazing Date	ADG	Gain/Head	Gain/Acre
			lbs		
Bermuda sod, Paraquat, NT	210	1/11/91	2.47	338	507
Bermuda sod, disk, drill	218	1/11/91	2.46	337	505
Bermuda sod, no-till	206	1/11/91	2.55	349	524
Prepared seedbed	232	11/23/90	2.56	418	626
Annual sod, Paraquat, NT	229	11/26/90	2.49	418	627
Annual sod, no-till	229	11/2690	2.54	403	605

Ryegrass seeded at 35 lb A^{-1} on September 10, 1990.

stocking dates for prepared seedbed and annual sod treatments occurred in late November whereas bermuda sod plots were not stocked until mid-January (Table 4). This difference in animal grazing days per acre was the reason for greater gain per head and *total* gain per acre. The carrying capacity for all treatments increased during the grazing season (Table 5). Where 650 pounds per acre were initially stocked, plots finished at 1250 to 1450 pounds per acre capacity in May. Bermuda sod treatments possessed the same carrying capacity as annual sod treatments but the reduction in grazing days resulted in less total beef produced per acre. Data from 1990-91 suggest that planting ryegrass on summer annual sod resulted in animal performance similar to prepared-seedbed planted ryegrass. Ryegrass planted into bermuda sod also produced satisfactory animal performance but gain per head and total gain per acre were somewhat less due to the reduced animal grazing days. Earlier planting dates on bermuda sod, increased nitrogen fertilization and pasture aeration are possible factors which could help improve early ryegrass performance on permanent sods.

REFERENCES

Coats, R.E. 1957. Sod seeing in the Brown Loam. Miss. Ag. Exp. Station Bull. 554.

Dudley, R.F., and L.N. Wise. 1953. Seeding in permanent pasture for supplementary winter grazing. MAFES Bull. 505.

Lang, DJ. 1989. Comparative effects of tillage on winter annual forage production. In Proceedings 1989 Southern Conservation Tillage Conference. Special bulletin 89-1:62-64. Institute of Food and Agricultural Science, University **of** Florida, Gainsville.

Thompson, W.P., C.M. Johnson, and T.N. Jones. 1961. Sod seeding. Miss. Ag. Exp. Station Info. Sheet 728.

Table 5. Carrying capacity of ryegrass seeded into bermudagrass or annual sods at Raymond, MS.

Date	Prepared Seedbed	Bennudagrass			Annual Sod	
		Paraquat-NT	NT	Disk	Paraquat-NT	NT
	....		hundred pounds/acre		....	
November	6.5	0	0	0	6.5	6.5
January	8.3	6.5	7.0	6.8	8.3	8.4
February	9.2	7.8	8.1	8.0	9.2	9.3
March	10.4	10.0	10.2	10.8	9.8	10.1
Apri1	13.1	12.2	11.8	13.5	11.5	11.6
May	14.2	12.2	12.1	13.8	12.9	12.7

Comparison of Crop Rotation Net Returns under No-till and Conventional Tillage

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INTRODUCTION

Soil conservation through the use of conservation tillage has been a topic of increased importance in recent years. This can be attributed to social pressures on farmers from environmental groups and legislative pressures brought about by recent farm legislation.

With the possible loss of farm program benefits facing farmers with highly erodible land, adoption of conservation tillage has been increasing. The Conservation Technology Information Center (CTIC) in its 1991 executive summary reported conservationtillage was being used on 28.14% of all planted acres in the U.S., up 2.5% from 1989. In particular, no-till soybean and cotton acres have increased dramatically. No-till full season soybean acreage has tripled since 1987 and no-till now accounts for 50.2% of double-crop soybean plantings. No-till cotton acreage has increased from 20,000 acres in 1989 to 101,000 acres in 1991. However, this five fold increase in no-till cotton acres still represents only 0.74% of all U.S. cotton acres.

By comparison, no-till is less prevalent in Arkansas. Of 3.35 million acres of soybeans in 1990 (Arkansas Ag. Statistics Serv. 1991), no-till accounted for only 0.6% of first crop plantings and 10% of double-crop plantings. Likewise, 0.05% of Arkansas cotton plantings were by no-till methods.

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Many factors affect farmers' adoption of conservation tillage. Bultena and Hoiberg (1983) found that farmers adopting conservation tillage had higher gross farm incomes than those not adopting the practices. However, fear of reduced yields and reduced income has often been given as a reason against adoption of conservation tillage. The objective of this study was to compare the economic performance of alternative row-crop systems in eastern Arkansas under conventional and conservation tillage. Economic analysis will provide needed information regarding the profitability of conventional versus conservation systems to assist farmers considering a change to a no-till system.

MATERIALS AND METHODS

Data for this study were taken from a multidisciplinary project conducted at the University of Arkansas Northeast Research and Extension Center (NEREC) at Keiser. The project compared 12 crop rotations grown with conventional and no-till systems over a six year period from 1986 to 1991. Irrigation via overhead sprinkler was applied to 11 of the 12 rotations. The cropping sequence for each of the 12 rotations was as follows:

Rotation 1:	**Soybean**
Rotation 2:	**Wheat-Double Crop (DC) Soybean**
Rotation 3:	**Wheat-DC Grain Sorghum**
Rotation 4:	**Wheat-DC Rice/Wheat-DC Gr. Sorghum/Wheat-DCSoybean**
Rotation 5:	**Grain Sorghum**
Rotation 6:	**Grain Sorghum/Wheat-DC Soybean/Grain Sorghum**
Rotation 7:	**Soybean/Grain Sorghum**
Rotation 8:	**Vetch-Corn/Wheat-DC Soybean/Vetch-Soybean**
Rotation 9:	**Corn/Soybean**

Rotation 10 Cotton/Grain Sorghum/Wheat-DC Soybean

Rotation 11: Cotton
Rotation 12: Soybean (Non-irrigated)

The experimental design of the project was a split-plot with four replications. The main plots were the two tillage systems, conventional and no-till. Each crop in each rotation sequence was planted in every year of the experiment to obtain treatment yields. This was done to remove year*rotation bias and to allow year by year comparisons. Conventional tillage consisted of disking and field cultivation prior to planting, cultivation during the growing season, and diskmg of crop residue in the fall or prior to planting of the next crop in the rotation sequence. No-till main plots were neither tilled nor cultivated. Cotton plots were bedded each spring in both systems to insure a cotton stand. Preplant chemical use was identical between the two tillage systems except for the addition of a burndown herbicide on the no-till plots. Postemergent chemical applications were made on an as-needed basis. Fertilizer and seeding rates and varieties were identical for each tillage system. All field operations performed and material inputs applied were recorded at the project site to allow cost of production estimates to be made.

Enterprise budgets were prepared for each rotation in each year to determine profitability of the rotation. Yields used in developing each budget were the treatment level means averaged across four replications. Price data for 1986-91 estimating representative cost of production and revenue from the sale of crops were taken from Arkansas Cooperative Extension Service (CES) enterprise budgets (various years) and Arkansas Agricultural Statistics Service (various years), respectively. In order to reduce a year*rotation bias and to eliminate the influence of market price

Table 1. Mean yields by crop and tillage system across rotations in the long term rotation study at Keiser, AR for 1986-1991.

	MEAN YIELD							MEAN
	1986	1987	1988	1989	1990	1991	6-YR	GROUP[1]
Soybean (bu/a)								
no till	30.53	50.92	44.99	31.60	44.82	41.43	40.72	A
conventional	24.93	52.57	45.86	35.36	45.92	43.06	41.28	A
Sorghum (bu/a)								
no till	89.38	70.95	61.96	57.86	78.31	58.04	69.42	B
conventional	90.03	85.68	74.89	56.60	87.52	54.54	74.88	A
Corn (bu/a)								
no till	90.28	170.60	135.13	149.71	137.46	48.52	121.95	A
conventional	76.88	165.35	137.93	143.20	135.35	45.59	117.38	A
Cotton (lb lint/a)								
no till	700.87	1125.30	584.28	785.56	NA[2]	NA	799.00	A
conventional	555.44	1101.98	522.48	641.90	NA	NA	705.45	A
Rice (bu/a)								
no till	6.32	33.01	27.90	NA	25.68	20.98	22.78	A
conventional	10.21	44.92	40.87	NA	45.11	10.85	30.39	A
Wheat (bu/a)								
no till	NA	NA	39.55	10.15	NA	NA	25.32	A
conventional	NA	NA	35.57	7.64	NA	NA	21.60	A

[1] Mean separation groupings, Duncan Multiple Range Test (0.05 sig. level)
[2] NA indicates no yields available due to crop failure.

fluctuations, all prices were indexed to 1990 dollars and then averaged to a single value. Costs of field operations and irrigation were estimated using coefficients and equipment values from Arkansas CES budgets. The cost estimation procedure and budget compilation was accomplished by utilizing the Mississippi State Budget Generator (Spurlock and Laughlin, 1987) software package.

All budgets were formulated for a rotated acre. A rotated acre is a concept which allows economic comparison between rotations on a per acre basis regardless of either (a) the number of different crops in the rotation, or (b) the length of time required for the rotation cycle. All cost and return categories in a rotated acre budget are weighted proportionately according to the length of time each crop occupies in the rotation sequence.

YIELD RESULTS

Mean yields for each crop over the life of the study regardless of rotation are shown in Table 1. Statistical analysis showed that only grain sorghum yields were significantly different between tillage systems at the 0.05 level of probablility. Mean grain sorghum yields under conventional tillage (74.88 bu/acre) exceeded no-till yields (69.42 bu/acre) by more than 5 bu/acre. These results indicate that, except for grain sorghum, no-till did not result in a significant yield reduction relative to conventional tillage for the study.

The results in Table 1 do not take differences among rotations into consideration. For soybean, the five lowest-yielding rotations included non-irrigated (rotation 12) and double-crop rotations (rotations 2 and 4). Likewise, grain sorghum yields for double crop rotations (Rotations 3 and 4) were lower than grain sorghum in full season situations. All other crops showed no significant difference among rotations. These results indicate that for the life of this study, rotation yield differences were primarily evident in those rotations involving double cropping and those that were not irrigated.

ECONOMIC RESULTS

Mean gross income, total variable cost (TVC) and total fixed costs (TFC), and ne: returns (NR) for each rotation and for each tillage system are presented in Table 2. The mean gross income for all no-till rotations ($213.08/acre) was not significantly different from the mean gross income for all conventional rotations ($214.86/acre). This confirms the results presented in Table 1 which indicate that no significant difference in tillage systems exists from a yield standpoint.

Costs of production include both variable costs and fixed costs. Variable costs include seed, fertilizer, chemicals, fuel, repair and maintenance costs, custom application charges, hauling charges, labor, and interest on operating capital. Fixed costs include depreciation and interest on investment. Table 2 shows that, on average, TVC for the no-till system were $127.98/acre compared to $114.76/acre for conventional tillage. This $13.22 difference in TVC between tillage systems was significant at the 0.05 level. By contrast, TFC for the two tillage systems exhibited no significant differences when averaged across all rotations with TFC of $68.82/acre and $76.84/acre for no-till and conventional tillage, respectively. The majority of fixed costs in the study were charged to the irrigation system with identical amounts being attributed to each tillage system ($55.13). These results indicate a significant increase in cash costs (TVC) for those farmers changing from a conventional to a no-till system.

Profitability of a system is measured by net returns. Over the 6-year period of the study, NR by tillage system averaged across all rotations were $16.28/acre for the no-till system and $23.26/acre for the conventional system. Statistical analysis of these values reveals no significant difference at the 0.05 level, demonstrating that there is no difference in profitability of no-till and conventional systems.

Table 2 ranks the mean NR for each rotation within tillage system across the six years of the study. Several points are noteworthy regarding these rankings. First, both irrigated and non-irrigated continuous soybean were among the top three rotations for both no-till and conventional tillage. Second, the four lowest ranked rotations for both no-till and conventional tillage contained grain sorghum, or some combination of grain sorghum and double cropping. Third, the highest ranked rotation under no-till (continuous cotton) demonstrated below average performance for conventional systems.

These results support several hypotheses concerning profitability. First, irrigation of soybean results in increases in yield and gross income, but these increases are more than offset by the increased TVC and TFC of irrigation. In this study, full season continuous soybean (rotation 12) does not justify the increased cost of sprinkler irrigation (rotation 1). Second, although grain sorghum resulted in negative net returns when grown continuously (rotation 5), low grain sorghum returns were amplified when double-cropping with wheat under both conventional and no-till (rotations 3 and 4). Soybean works well in a double crop rotation (rotation 2), but grain sorghum yields suffer when following wheat due to late planting. Finally, although no-till continuous cotton (rotation 11) yields were not significantly greater

Table 2. Ranking of net returns within tillage systems for the long term rotation study at Keiser, AR for 1986-1991.

RANK	ROTATION NUMBER	GROSS INCOME	TVC*	TFC	NR
		----------	5 / rotated ac	----------	
NO-TILL					
1	11	279.34	104.86	67.03	107.45
2	12	192.49	84.18	16.91	91.40
3	1	259.37	99.72	72.04	87.61
4	8	259.43	154.12	62.88	42.43
5	2	259.65	133.88	83.51	42.26
6	10	247.83	128.89	78.72	40.23
7	9	254.10	141.06	74.28	38.77
8	7	213.99	115.99	71.87	26.13
9	6	187.86	132.93	57.26	-2.32
10	5	133.79	128.87	71.70	-66.78
11	4	171.72	155.16	86.37	-69.81
12	3	97.35	156.07	83.27	-142.00
NO-TILL AVG.		213.08	127.98	68.82	16.28
CONVENTIONAL					
1	12	214.79	57.40	23.28	134.11
2	1	275.38	75.13	78.41	121.85
3	2	277.58	110.08	91.03	76.48
4	9	255.92	121.98	80.09	53.85
5	8	254.52	143.89	69.94	40.69
6	7	216.34	99.86	78.36	38.12
7	10	238.26	120.21	87.62	30.42
8	11	227.15	119.78	88.13	19.24
9	6	189.01	118.90	64.10	6.00
10	5	148.39	120.01	77.38	-49.00
11	4	182.43	140.87	92.28	-50.72
12	3	98.57	148.98	91.45	-141.86
CONVENTIONAL AVG.		214.86	114.76	76.84	23.26

* TVC = Total Variable Costs 6-yr mean
TFC = Total Fixed Costs 6-yr mean
NR = Net Returns 6-yr mean

than conventional cotton yields, TVC of no-till cotton production was lower than conventional cotton production for this study. For all other rotations, no-till TVC exceeded TVC under conventional tillage.

CONCLUSIONS

This study compared yields and net returns of long term rotations grown with no-till and conventional tillage. The conclusions of the study can be summarized as follows: First, with the exception of grain sorghum, tillage does not have a significant effect on crop yields. Second, from an economic standpoint, although TVC were significantly higher for no-till systems, there is no statistical difference between gross income or net returns under no-till and conventional tillage. These points suggest that the adoption of no-till may be an economically feasible method of decreasing soil erosion. Overall, a farmer with adequate ability to cover cash costs of production should see no significant loss of yields or profitability when changing from a conventional to a no-till system.

REFERENCES

1. Arkansas Agricultural Statistics Service. 1986-1991. Arkansas Agricultural Statistics. Univ. Arkansas Agric. Experiment Station Report.

2. Bultena, G.L., and E.O. Hoiberg. 1983. Factors affecting farmers' adoption of conservation tillage. Journal of Soil and Water Conservation 38(3):281-284.

3. Conservation Technology Information Center. 1991. 1991 National survey of conservation tillage practices executive summary. National Association of Conservation Districts / Conservation Technology Information Center. West Lafayette, Indiana.

4. Cooperative Extension Service. Estimating production costs in Arkansas, 1986-1991. Univ. Arkansas CES, Little Rock, Arkansas.

5. Spurlock, S.R., and D.H. Laughlin. 1987. Mississippi State budget generator users guide, version 2.0. Mississippi Agricultural and Forestry Experiment Station. Agricultural Economics Technical Publication No. 64.

Wheat Straw Management, Variety Selection, and Row Spacing for Double-cropped Soybean Production

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INTRODUCTION

Growers in Arkansas double-crop almost all the wheat acreage with soybeans. The most accepted practice has been to bum the wheat straw, disk and plant. State laws that were passed in 1990 making a grower liable for automobile accidents caused many growers to begin investigating alternatives to burning wheat straw. Federal clear air standards will make burning of wheat straw illegal if enforced.

In recent years there have been unsubstantiated reports that growing wheat on raised beds results in increased yields. Other research has shown that wheat straw residues can be detrimental to soybean production.

Experiments were initiated in fall of 1989 to evaluate different stubble management and tillage practices used in wheat planted on flat or raised seedbeds.

MATERIALS AND METHODS

Experimental sites were selected at two Arkansas locations: Northeast Research and Extension Center (NEREC), Keiser; and the Cotton Branch Experiment Station (CBES), Marianna. Experimental details are given in Tables 1 and 2. Seedbed preparation consisted of bedded (on 38-in. centers) and flat for wheat and five different stubble management treatments (Table 3) for the double-cropped soybean. The experimental design was a split-split-plot. Rainfall and other weather data were recorded at the local experiment station weather station. Soil moisture measurements were taken at stand establishment for soybean. Soybean canopy development data were taken during late R3 or early R4 growth stages on the soybean.

RESULTS AND DISCUSSION

Wheat was planted in the fall on flat and on raised 38-in.-spaced seedbeds at Keiser and Marianna. The wheat at Marianna died in spots as a result of planting too deep, but the remainder as well as that from replanting generated enough straw for the subsequent stubble management test.

Soybean data were collected at NEREC and the CBES in 1990. Data collected earlier on canopy development showed that narrowing the rows to 19 in. resulted in good canopy closure at maturity on most treatments. For example, at NEREC the gap was 2 and 25 in. between canopies for 19- and 38-in.-row spacings,

Table 1. Soil classification of experimental sites.

Site	Year	Soil Series
CBES	1990	Memphis silt loam
	1991	Calloway-Loring complex
NEREC	1990-91	Sharkey silty clay

[1]Formerly, Assistant Professor of Agronomy, located at Keiser, AR. Currently Assistant Professor of Agronomy, located at St. Joseph, LA, [2]Professor of Agronomy located at Marianna, AR; [3]Assistant Professor of Biology and Agricultural Engineering, located at Keiser, AR; [4]formerly Research Associate Professor, located at Hope, AR, currently Associate Director of Research, American Soybean Association, St. Louis, MO; and [5]Professor of Agronomy located at Fayetteville, AR-

Table 2, **Planting and harvest dates, planting rates, and varietal information.**

Location	Year	Variety	Planting Date	Harvest Date
CBES	1990	Asgrow 5403	6/17/90	10/30/90
		Lloyd	6/17/90	11/8/90
	1991	Asgrow 5403		
		Lloyd		
NEREC	1990	Asgrow 5403	6/16/90	10/27/90
		Lloyd	6/16/90	11/4/90
	1991	Asgrow 5403	6/19/91	10/23/91
		Lloyd	6/19/91	11/11/91

respectively. Corresponding gaps were 2 and 18 in. at CBES. The canopy developed essentially the same regardless of the soybean variety or the stubble management treatment. It was obvious from observing the plots that differences in soil resulted in areas of lesser canopy development and growth. This nonuniform development suggests that wen closer row spacing could be advantageous to grain yields, especially in a production field.

Soybtan grain yields showed a strong response to either burning or leaving the straw, row spacing and variety. At NEREC (Tables 4 and 5), grain yields ranged from 14 to 42 and 22 to 41 bu/acre in 1990 and 1991, respectively. The best yield was obtained with burned straw, narrow rows and a group V soybean variety. At CBES (Tables 6 and 7), grain yields ranged from 9 to 27 and 11 to 45 bu/acre in 1990 and 1991, respectively. The best yield was obtained by incorporating the straw and planting narrow rows. The only commonality between the two locations for increasing yield was narrow rows.

The straw load at NEREC in 1990 was very large compared to that at CBES. The day after planting there was a rain in excess of 3 in. at CBES. Disking in the straw allowed these CBES plots to store this water instead of it running off as surface drainage. A similar rainfall pattern occurred in 1991 at the CBES.

These results reflect various contributions arising from straw management, seedbed preparation, varietal selection, and row spicing. These data show that the best selection of cultural practices depends to some extent on the soil type being cultivated. These data were subjected to component analysis in an attempt to assign quantitative values to each cultural component. In this manner, the relative importance of the components can be compared. The results of the component analysis are given

Table 3. Stubble management treatments used for double-cropped soybean at NEREC and CBES[1].

	Seedbed preparation		
Straw turning	Bedded	Flat	Flat-disked
	-- Treatment # --		
Yes	1	3	--
No	2	4	5

[1] NEREC = Northeast Research and Extension Center, Keiser, Arkansas; CEES = Cotton Branch Experiment Station, Marianna, Arkansas.

Table 4. Double-cropped soybean yields following different stubble management treatments in 1990 at Keiser, Arkansas.

Straw management	Row spacing	Bedded		Flat		Flat & Inc.		$\bar{x}$
		Asgrow	Lloyd	Asgrow	Lloyd	Asgrow	Lloyd	
	in.	....		bu/acre-------------------				
Burned	19	42	25	35	35	---	---	34
	38	24	29	27	24	---	---	26
						Burned Mean		30
Left	19	26	24	20	24	22	20	23
	38	15	15	14	18	15	16	16
						Non-Burned Wean		29
						19-in. Row Spacing Mean		29
						38-in. Row Spacing Mean		21
	$\bar{x}$	27	23	24	25	---	---	
		Bedded Mean 25		Flat Mean 25				

Table 5. Double-cropped soybean yields following different stubble management treatments in 1991 at Keiser, Arkansas.

Straw management	Row spacing	Bedded		Flat				$\bar{x}$
		Asgrow	Lloyd	Asgrow	Lloyd	Asgrow	Lloyd	
	in.	....		bu/acre--------------------				
Burned	19	34	30	36	33	---	---	33
	38	33	30	36	26	---	---	31
						Burned Mean		32
Left	19	35	28	41	32	37	30	34
	38	28	23	24	22	32	25	26
						Non-Burned Mean		30
						19-in. Row Spacing Mean		34
						38-in. Row Spacing Mean		29
	$\bar{x}$	33	28	34	28	---	---	
		Bedded Mean 31		Flat Mean 31				

in Table 8. Note the importance of row spacing in 1991 varied with straw management. Also, the effect of wheat stubble removal is different on the two soil types. The importance of preplant tillage may be exhausted because of the large rainfall events at planting.

Table 6. Double-cropped soybean yields following different stubble management treatments in 1990 at Marianna, Arkansas.

Straw management	Row spacing	Bedded Asgrow	Bedded Lloyd	Flat Asgrow	Flat Lloyd	Flat & Inc. Asgrow	Flat & Inc. Lloyd	$\bar{x}$
	in.	bu/acre						
Burned	19	16	22	9	19	---	---	17
	38	14	13	10	14	---	---	13
						Burned Mean		15
Left	19	22	23	15	22	25	27	23
	38	11	11	11	18	15	23	15
						Non-Burned Mean		19
						19-in. Row Spacing Mean		20
						38-in. Row Spacing Mean		14
	$\bar{x}$	16	17	11	18	---	---	
		Bedded Mean 17		Flat Mean 15				

Table 7. Double-cropped soybean yields following different stubble management treatments in 1991 at Marianna, Arkansas.

Straw management	Row spacing	Bedded Asgrow	Bedded Lloyd	Flat Asgrow	Flat Lloyd	Flat & Inc. Asgrow	Flat & Inc. Lloyd	$\bar{x}$
	in.	bu/acre						
Burned	19	30	23	40	21	---	---	29
	38	11	11	24	lo	---	---	14
						Burned Mean		22
Left	19	45	18	26	14	28	29	27
	38	32	24	20	14	24	22	23
						Non-Burned Mean		25
						19-in. Row Spacing Mean		28
						38-in. Row Spacing Mean		19
	$\bar{x}$	30	19	28	15	---	---	
		Bedded Mean 25		Flat Mean 22				

Budget analysis for 1991 indicate that at CBES a two-to-ten fold change in profitability occurs with variety selection. Only about a two-fold change in profitability occurs with straw management and row spacing at NEREC. Variety selection only changed profitability at

Table 8. Yield component analysis for double-cropped soybeans.

Component	CBES Burn	CBES Leave	NEREC Burn	NEREC Leave
	---------- bu A^{-1} ----------			
1990				
Base yield	9	9	15	15
Straw management	0	4	11	0
Preplant tillage	0	7	0	0
Variety selection	4(VI)	4(VI)	0	0
Spacing (19 inch)	6	6	8	8
Projected yield	19	30	34	23
Measured yield	22	27	33	26
1991				
Base yield	14	14	24	24
Straw management	0	8	4	0
Preplant tillage	0	0	0	0
Variety selection	9(V)	9(V)	6(V)	6(V)
Spacing (19 inch)	14	4	2	8
Projected yield	38	36	35	37
Measured yield	35	33	35	38

most two fold. The influence of row spacing and straw management were similar to those obtained at CBES.

CONCLUSIONS

As a result of this study it can be concluded that the effect of leaving wheat straw can be detrimental or beneficial on the subsequent soybean crop. Utilizing narrow rows consistently increased profitability of double cropped beans. Selecting the best variety is the most important factor affecting profitability.

Reduced Tillage for Cotton Production in Arkansas

T.C. Keisling[1], Marilyn McClellan[2] and R.E. Frans[2]

INTRODUCTION

Studies conducted in Arkansas during the 1970s indicated that reduced post-plant tillage resulted in reduced cotton yields on certain soil types but not on others. A summary of another study showed that cover crops tended to improve soil tilth in continuous cotton

Preliminary studies were instigated at Marianna, Arkansas, during the 1990 growing season. The primary objective was to obtain experience in various techniques of planting and machinery operations necessary for no-till cotton production. These studies were continued in 1991.

MATERIALS AND METHODS

An area of Memphis silt loam soil that had been in cotton or fallow was selected to establish plots in 1989.

1990: The conventional-till portion of the test was disked twice and then triple-Ked prior to bedding. On May 25 the beds were dragged off with a triple-K, and DPL-50 cotton was planted in all treatments. Soil fertilizer applications consisted of 0-45-90 applied preplant, 60-0-0 applied June 14 and 24-0-0 applied July 16. Cotoran™ and Dual™ were applied preemerge at recommended rates. Temick™-Terrachlor™ was applied in furrow at planting at the 30-Ib/acre rate. Fusilade™ was applied to the no-till plots for grass control on July 3 at 24 oz/acre. Lay-by was done using Lorox™ at 2 pt/acre. Foliar applications of fertilizer, insecticides, etc. followed recommended procedures. Tilled plots were mechanically cultivated on June 14 and July 3. Plots were hand-hoed on July 15. The harvest consisted of a once-over picking on October 17.

1991: The treatment design was a split split plot with till or no-till main plot, first split was 30 or 38 inch row, and second split was starter fertilizer application or none. The experiment had five replications. Till or no-till strips were established in the fall of 1990 and planted to cover crops. Cover crop vegetation was chemically burned down approximately two weeks prior to target planting date (May 15). Starter fertilizer was applied at 15-15-0,(N-P_2O_5-K_2O) lb/acre. Tilled plots were disk harrowed twice and bedded on 5-30-91, and drug *off* with a do-all in preparation for planting on 6-1-91. All plots were planted with cotton cultivar 'DPL-SO' on 6-1-91. Subsequent insect, weed, and fertilizer practices followed normal recommendations.

Data were collected on plant ontogeny, yield, tissue nutrient concentrations in the petioles and plant characteristics.

RESULTS AND DISCUSSION

Problems were encountered with equipment settings for no-till operations; however, the equipment was finally set so that it operated properly. There was a special problem with the planter. It was noted that the cotton in no-till plots seemed to grow especially slowly while small. In areas in which adverse problems existed with soil acidity or weeds, no-till tended to accentuate the problems in 1990.

University of Arkansas uses the node location of the uppermost white bloom for crop management. When this bloom is first located five nodes from the top, the harvestable crop is already set on the plant. This occurred on August 13, 1990 and July 25, 1991. There was

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Table 1. Yield, stand and mature plant characteristics for the 1990-91 no-till cotton test at Marianna, Arkansas.

Year	------1990------		--------------------1992--------------------			
Tillage Practice	Conv.	No-Till	Conventional		NO-Ti11	
Row Spacing (inches)	38	38	30	38	30	38
Yield or plant characteristics:						
Yield (lb lint/acre)	888 a*	736 b	1117 a	895 b	755 c	611 d*
Stand (Plants/Row-ft)	3.4	3.3	3.4	3.4	3.4	3.4
Nodes below first Sympodia	6	5	6.7	6.9	6.9	6.6
Monopodial with fruit	0	0	1.1	1.3	2.6	1.1
Height (inches)	30	31	24	22	23	21
No. effective sympodia	9	10	16	16	16	16
NO. of sympodia	11	11	16	16	16	16
Total Nodes per plant	1.7	16	23	23	23	23
Ave. internode length (inches)	1.8	1.9	1.0	0.9	1.0	0.9
Total bolls per plant	13	12	10.5	11.2	12.6	10.7
% first position boll	71	68	55	45	62	63
% second position boll	25	28	39	46	29	33
% other position bolls	4	4	2	1	1	1
% auxil.	0	0	0	0	0	0
% bolls position one retained	70	75	35	31	45	41
% bolls in position two retained	32	31	26	31	23	22
Boll size (g/boll)	0.66	0.59	0.81	0.78	0.46	0.55

[1]Numbers in the same row for the same year followed by different letters are significantly different at the 1% level according to LSD.

no differential between no-tilled and conventionally tilled cotton.

Equivalent stands of about 3.4 plants/row-ft were established. Even though there was an apparent height differential between conventional and no-till early in 1990, the plants were the same height at maturity (Table 1). All of the other plant characteristics were similar regardless of tillage (Table 1).

Conventionally tilled cotton yielded 152 lb lint/acre more than no-till cotton in 1990. The source of the reduced yield for the no-till cotton was boll size reduction of 17% (Table 1). Visual observation during the growing season indicated onset of drought symptoms in the no-tilled cotton earlier than in the tilled plots, Soil moisture analysis with a dual source probe failed to confirm a difference in soil moisture usage.

In 1991, starter fertilizer was not found to influence lint yield but tillage and spacing both did (Table 1). Conventional-tillage yielded significantly more lint than no-till at either row spacing. Narrow rows were significantly better than wide rows in either tillage systems. Analysis of plant characteristics and stand data show that the yield increase from narrowing rows within a tillage system was obtained from increasing the number of some size bolls per acre. Yield differences resulting from tillage operations again resulted from a reduction in boll size.

To get some idea of profitability, Coop. Ext. Budgets (1) were completed and are summarized in Table 2. Budgets (Table 2) indicate that in 1991 narrow rows were worth $133.23 per acre if cotton sold for $0.64 per Ib. of lint. The loss in yield for no-till was not overcome by the reduction in tillage costs. Narrow rows in no-till were worth $84.86.

Yield enhancement obtained with narrowing rows from 38 to 30 inches was also shown to be profitable on both conventional and no-till systems. Starter N and P fertilizer had no effect on yield. No-till systems are currently less profitable than conventional systems for cotton production on Arkansas silt loam.

LITERATURE CITED

1. **Herrington, E., Jr., C.A. Stuart, T.E. Windham, and R. E. Coats, Jr.** 1991. Estimating 1991 production costs in Arkansas. Ark. Coop. Ext. Serv. Tech. Bull. No. 127.

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Table 2. Estimated costs and returns for various cotton production systems in 1991.

SPECIFIED OPERATING COSTS				
Tillage Practice:	Conventional		No-till	
Row Spacing (inches)	30	38	30	38
Resource or input:				
Seed	$10.51	$8.30	$10.51	$8.30
Fertilizer	31.40	31.40	31.40	31.40
Lime + Application	10.01	10.01	10.01	10.01
Herbicide	57.38	57.38	87.32	87.32
Fungicide	0	0	0	0
Insecticide	16.20	16.20	16.20	16.20
Defoliant	26.15	26.15	26.15	26.15
Aerial Application	9.54	7.53	9.54	7.53
Machinery:				
Fuel, Oil, Lubricants	25.05	25.05	18.84	18.84
Repairs	44.30	44.30	38.35	38.35
Labor	22.18	22.18	19.53	19.53
Irrigation:				
Fuel, Oil, Lubricants	0	0	0	0
Repairs	0	0	0	0
Irrigation Labor	0	0	0	0
Custom Spread	6.08	6.08	6.08	6.08
Custom Haul	0	0	0	0
Custom Dry or Ginning	0	0	0	0
Miscellaneous	4.00	4.00	4.00	4.00
Crop Insurance Premium	0	0	0	0
Interest on OP. CAP.	12.01	11.85	12.72	12.55
Total Specified Operating costs	$274.20	$270.43	$290.67	$286.26
	Returns per acre			
Base price $0.64/lb lint	$440.68	302.37	192.53	104.78

(continues)

Table 2. Continued.

SPECIFIED OWNERSHIP COSTS

Tillage Practice:	Conventional		No-till	
Row spacing (inches)	30	38	30	38
Resource or input:				
Tractors:				
Depreciation	$ 8.13	$ 8.13	$ 2.17	$ 2.17
Interest	6.71	6.71	2.12	2.12
Equipment:				
Depreciation	7.26	7.26	5.78	5.78
Interest	4.10	4.10	2.91	2.91
Special Equipment:				
Depreciation	32.21	32.21	32.21	32.21
Interest	13.55	13.55	13.55	13.55
Miscellaneous:				
Depreciation	0	0	0	0
Interest	0	0	0	0
Irrigation:				
Depreciation	0	0	0	0
Interest	0	0	0	0
Taxes & Insurance	5.54	5.54	2.89	2.89
Interest	0.61	0.61	0.61	0.61
Overhead Labor	0	0	0	0
Other Overhead	0	0	0	0
Land & Property Tax	0	0	0	0
Management	0	0	0	0
Total Specified Ownership Costs	$78.11	$78.11	$62.24	$62.24
Total Specified Operating and Ownership Costs	$352.31	$348.54	$352.91	$348.42
	Returns per acre			
Base price $0.64/lb lint	362.57	224.26	130.29	42.62'

NOT INCLUDED IN THIS REPORT ARE CHARGES FOR LAND RISK, OVERHEAD LABOR, OTHER OVERHEAD, CROP INSURANCE, REAL ESTATE TAXES, AND MANAGEMENT.

Fertilizer Solution Placement with a Coulter-nozzle Applicator for No-till

J.E. Morrison, Jr. and K.N. Potter[1]

ABSTRACT

Evidence from plant nutrient uptake and surface water quality studies indicate that it is preferable to apply fertilizers in concentrated bands below the soil surface. In conservation-tillage situations, this means that the fertilizers should be applied below the surface residues and the biologically active surface soil. Published fertilizer application research from our laboratory indicated that surface soil and residue disturbances could be minimized by the use of a coulter-nozzle applicator for the application of solution-type fertilizers. The coulter-nozzle design consisted of a solid-stream type hydraulic nozzle mounted behind the trailing edge of a smooth rolling coulter so that the stream of fertilizer solution was directed into the open slot immediately behind the coulter. This design, when integrated with depth control wheels and independent applicator unit flotation, provided an implement for shallow fertilizer application in residue-covered soils.

The coulter-nozzle prototypes used in previously reported studies utilized nozzles which did not produce coherent solid streams of solution, especially at higher pressures and higher flow rates. Performance observations were limited to one rate and one travel speed. Preliminary results suggested that 70-80% of the fertilizer was deposited in the first **0-3** cm of slot depth.

The current studies address parameters which may affect fertilizer placement. These include coulter thickness, travel speed, application pressure, and soil water content at time of application. Appropriate solid-stream nozzles have now been selected for improved applicator performance. Nozzles were aimed to have the stream enter the soil slot 5 cm behind the coulter. Coulter thicknesses were 4.4 and 6.4 mm. Travel speed was 6 and 10 km/hr. Solution delivery pressure was 97 and 276 kPa. The site was an undisturbed wheat stubble field, with surface soil water contents of 30.0% MCdb and 25.3% MCdb. Soil was excavated in 2 cm depth intervals to 8 cm and analyzed for the vertical distribution of extractable N by KCL extraction and automated continuous flow analysis. The results are pending and will be presented at the Conference. Anticipated conclusions are that the system is sensitive to the thickness of the coulter but insensitive to the soil condition and operational parameters. Information from this study will establish the fertilizer placement patterns to be expected when the coulter-nozzle applicator and similar commercial applicators are used in tillage studies and field trials.

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Role of Winter Cover Crops in Reduction of Nitrate Leaching

W.L. Hargrove, J.W. Johnson, J.E. Box, Jr., and P.L. Raymer[1]

INTRODUCTION

The preeminent challenge facing agriculture today is the development of tillage and cropping strategies to protect vital surface and groundwater supplies. Nitrate is of particular concern because relatively low concentrations (10 ppm NO_3-N) render water unfit for human consumption, and because many shallow groundwater supplies exceed recommended NO_3-N drinking standards (US EPA, 1990). The overall objectives of this research are to evaluate several winter annuals for rooting depth and residual N recovery, and measure the influence of a cover crop on the amount of NO_3 leaching during fall, winter and spring months.

MATERIALS *AND* METHODS

Research was initiated in 1990 at the University of Georgia Bledsoe Farm near Griffin and the USDA-ARS Soil and Water Conservation Laboratory at Watkinsville, GA. The first phase of this research included the preliminary evaluation of 16 winter annual selections from 9 species: wheat (3 cultivars), oats (2 cultivars), rye, barley, triticale (2 cultivars), ryegrass, canola (3 cultivars), hairy vetch, crimson clover and forage turnip. Cover crops were planted in the fall, 1990 following corn harvest. Dry matter production, N concentration and total N uptake were measured by collecting above-ground dry matter samples. In the second phase, root growth of selected winter annual species was evaluated using a minirhizotron technique, as described by Box and Johnson (1987). Eight minirhizotrons (transparent polycarbonate tubes) were installed per plot and root counts recorded at 0.1 m intervals to a soil depth of 1.0 m.

[1]University *of* Georgia and USDA-ARS.

The third phase of this project, begun in 1992, consists of an evaluation of the effectiveness of rye winter cover crops in reducing NO_3-N movement through the soil profile by measuring NO_3-N in effluent from drain tile. Drain tile was installed on plots at the Soil and Water Conservation Laboratory at Watkinsville at a depth of 1 m in 1981 (Box, 1986). A rye winter annual cover crop or no winter cover crop was planted following corn on each of six 7.58 m square drained blocks individually surrounded by a 0.3 mm thick plastic sheet extended to a depth of 0.9 m. Plastic drain tiles 0.10 m diameter, with a 0.10 m thick encasement of 0.01 m diameter gravel and spaced 2.52 m apart at a depth of 0.6 m, were placed along the 7.58 m border on the drained block. Drain tile effluent was collected from each block using a tipping bucket in combination with an ISCO pumping sampler. The tipping bucket and pumping sampler provides hydrograph data and stores samples in a refrigerated chamber until N analyses can be performed.

RESULTS AND DISCUSSION

The winter annuals with the greatest amount of early biomass production (9 February, 1990) included 'Wrens Abruzzi' rye, 'Stan 1' and 'Morrison' triticale, and 'Wysor' barley (Table 1). By the 17 May, 1990 sampling date, 'Coker 716' and 'Simpson' oats also had accumulated large amount of biomass, and, along with 'Crystal' rapeseed, appear to show promise for uptake of N from the soil during the winter and spring months. These results indicate that oats warrant further study as an alternative cover crop to prevent nitrate leaching.

Rye, crimson clover, canola and fallow (weeds) were evaluated in Phase 2 for root growth and soil nitrate concentrations in 1991.

Table 1. Winter annual cover crop dry weight, N concentration and N content.

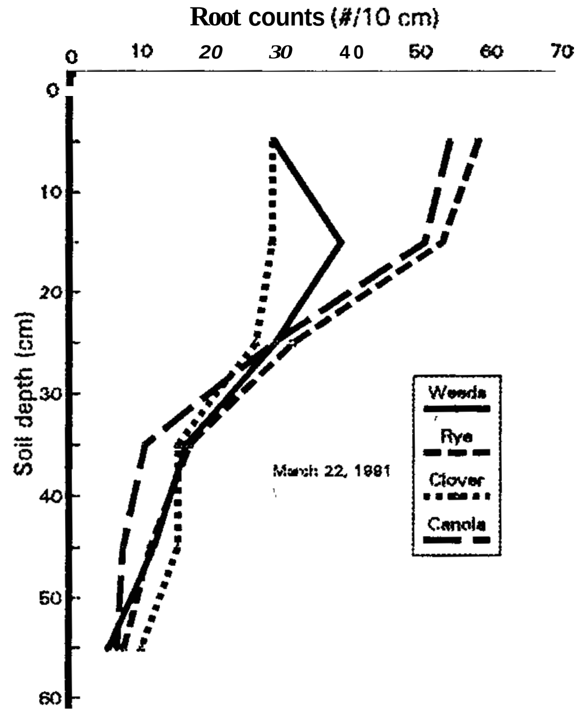
Cover crop	Cultivar	9 February, 1990 Dry wt	N conc.	N content	17 May, 1990 Dry wt	N conc.	N content
		kg ha^{-1}	%	kg ha^{-1}	kg ha^{-1}	%	kg ha^{-1}
Ryegrass	Common	165	3.54	5.2	5109	0.81	40.9
Wheat	Stacy	264	3.50	9.0	6314	0.71	43.8
	C 9766	292	4.15	11.4	5957	0.75	44.4
	GA 100	267	3.78	10.1	4644	0.93	41.5
Triticale	Stan 1	455	3.73	16.9	5587	0.92	50.9
	Morrison	389	3.41	13.1	8520	0.79	66.2
Rye	Wrens Abruzzi	521	3.85	19.7	9273	0.64	58.2
Oat	C 716	258	4.06	10.3	6718	1.05	70.7
	Simpson	245	3.93	8.7	7397	1.15	85.0
Barley	Wysor	344	3.76	12.5	5106	0.79	39.2
H. Vetch	Common	100	4.24	4.3	3362	3.14	109.0
C. clover	Tibbee	31	3.43	1.1	4866	1.30	60.8
Rapeseed	Delta	122	2.53	1.5	1814	2.31	37.3
	Crystal	19	4.43	0.8	3189	1.85	58.0
	Per				424	2.29	8.5
LSD		185	0.87	6.3	1793	0.39	26.7

Results for root counts on February 21 show that rye has greater root growth early in the season, but results from March 22 show no difference between rye and canola (Fig. 1) Both fallow (weeds) and crimson clover had reduced root growth at both sampling dates compared to rye and canola.

Results for root counts were consistent with measured soil nitrate-N concentrations (Fig. 2). Soil nitrate-N concentrations on February 4 show that both rye and canola were very effective in recovering soil nitrate. Concentration of soil nitrate-N for fallow (weeds) treatment was approximately 35 ppm at a depth of about 60 cm, as compared to a 5 ppm nitrate-N concentration as observed in the canola and rye treatments. Crimson clover was intermediate in its effectiveness in recovering soil nitrate, with a nitrate-N concentration of approximately 17 ppm at a depth of 60 cm. On the second sampling date, May 3, the residual nitrate in the fallow and crimson clover treatments moved below the depth of sampling, while soil profile concentrations for the rye and canola treatments remained low (<7 ppm).

Drainage from tiles was first measured in January, 1992 (Fig. 3). Drainage started after approximately 100 mm of rainfall on the fallow treatment, compared to 150 mm of rainfall received prior to drainage on the rye

Figure 1. Root Counts



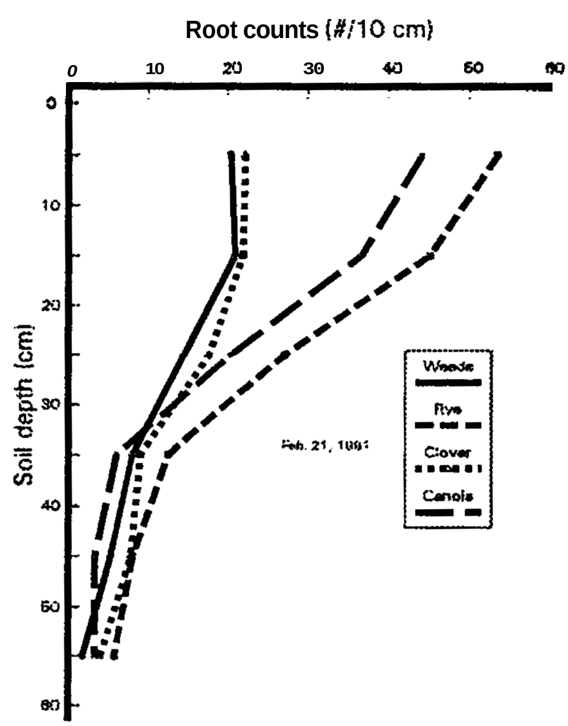
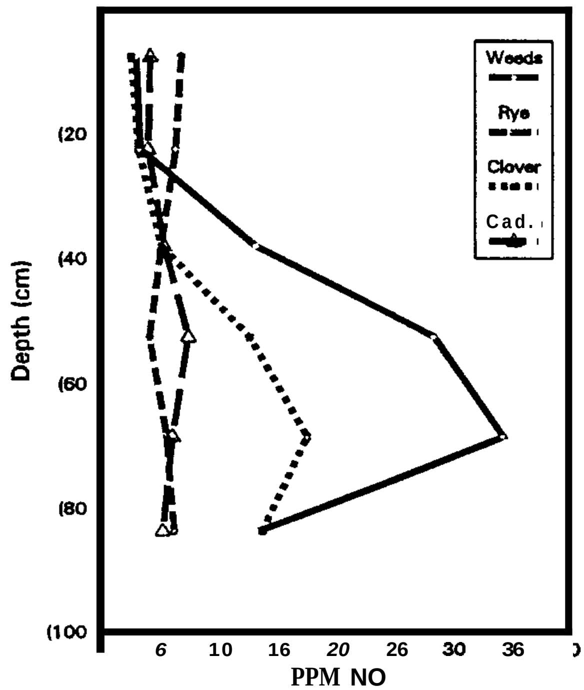


Figure 2. Soil Nitrate Concentration

Soil *Nitrate* Concentrations
February 4,1991



Soil Nitrate Concentrations
May a. 1991

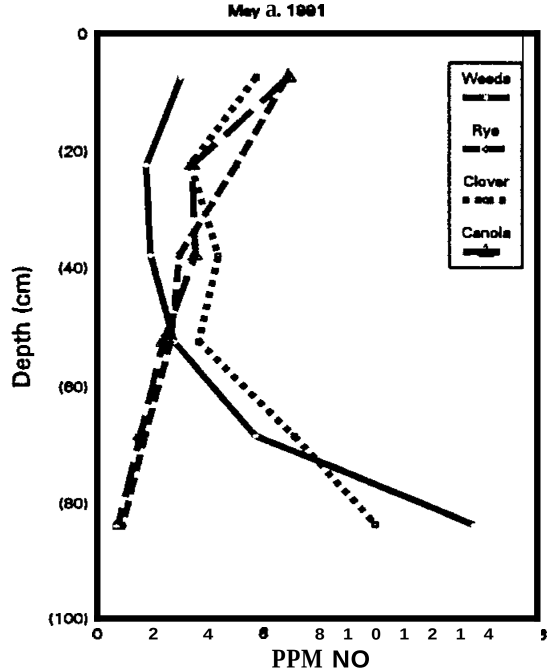
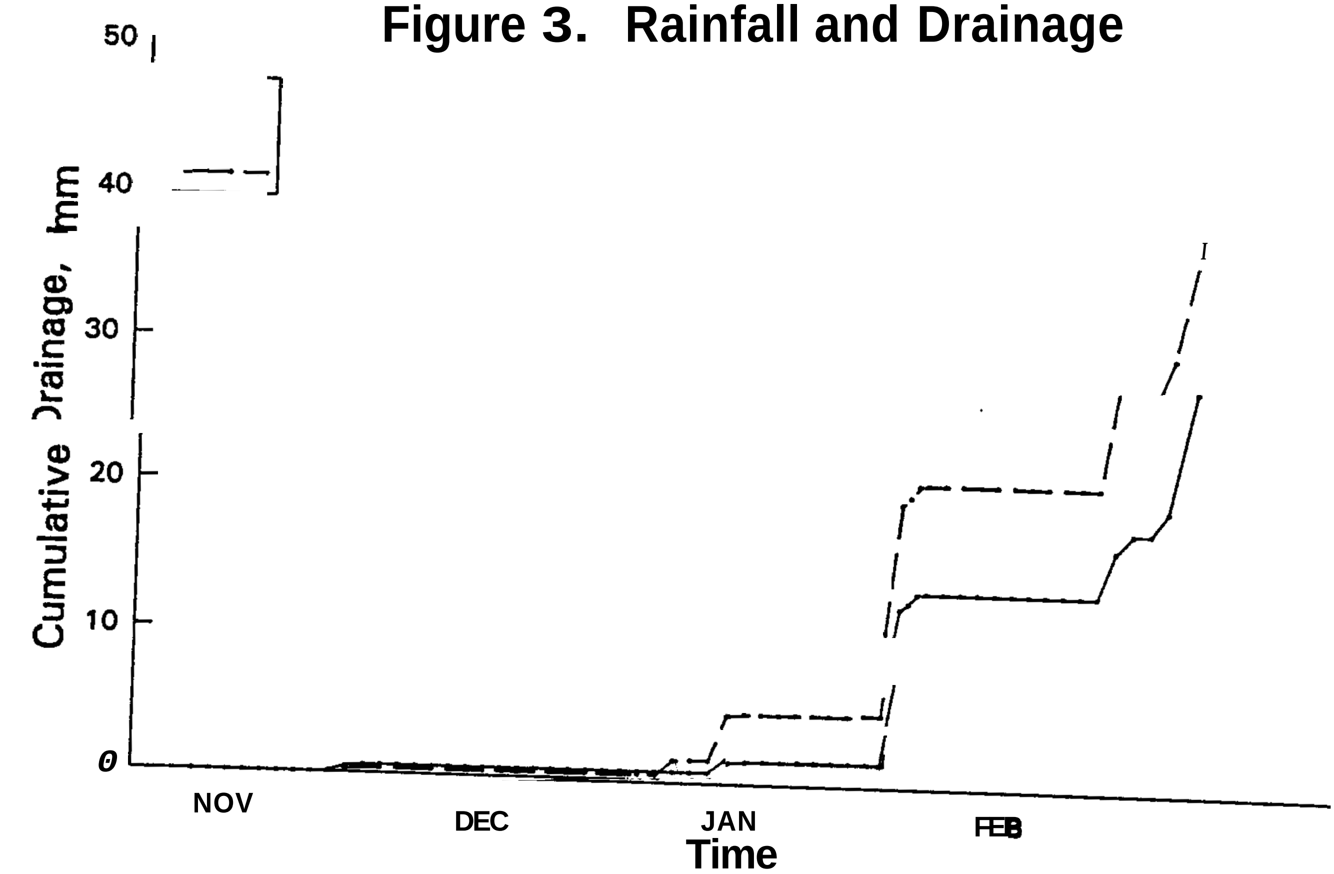
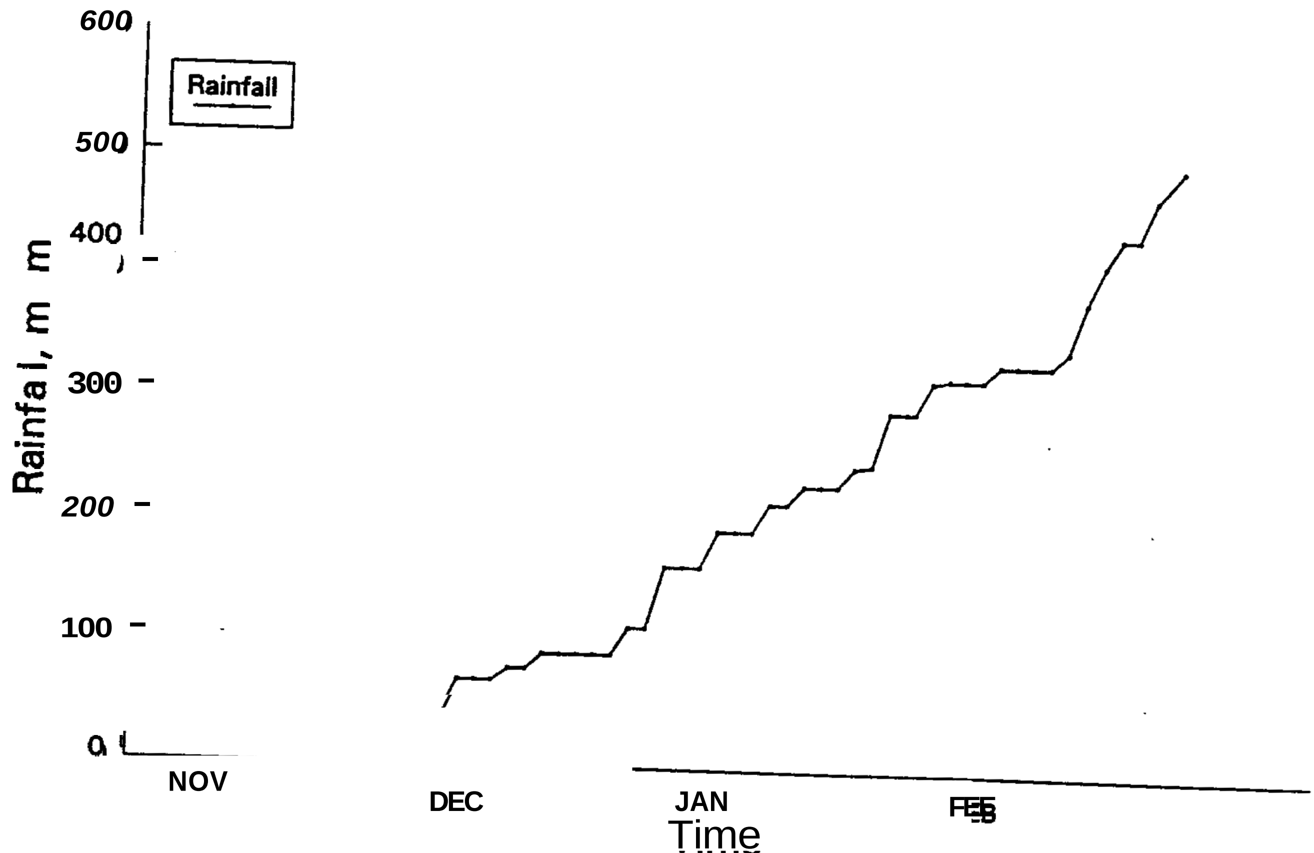


Figure 3. Rainfall and Drainage





treatment. To date, cumulative drainage for the fallow treatment is approximately 40 mm, and only 25 mm for the rye treatment. Nitrate analysis of drainage samples are pending.

CONCLUSIONS

Our preliminary results indicate that rye and canola are very effective in recovering residual nitrate remaining in the soil following corn. Oats and forage turnips also are effective in recovering residual nitrate, and their potential as cover crops to prevent nitrate leaching warrants further study. Non-leguminous cover crops can potentially recover 100 kg N ha^{-1} that would be subject to leaching over the winter months. Results from nitrate analyses of drainage effluent and associated ^{15}N analysis should further elucidate the efficacy of winter cover crops in reducing nitrate leaching.

LITERATURE CITED

Box, J.E., Jr. 1986. Winter wheat grain yield responses to oxygen diffusion rates. Crop Sci. 26:355-361.

Box, J.E., Jr. and J.W. Johnson. 1987. Minirhizotron rooting comparisons of three wheat cultivars. In H.M. Taylor et al. (ed.) Minirhizotron observation tubes: methods and applications for measuring rhizosphere dynamics. Spec. Pub. 50. American Society of Agronomy, Madison, WI.

US Environmental Protection Agency. 1990. National Pesticide Survey: Phase I Report, US Environmental Protection Agency, Washington, DC.

Effect of Intercropping and Residue Management on Soil Water Depletion, Plant Biomass and Grain Production

S. Some W.L. Hargrove, and D.E. Radcliffe[1]

ABSTRACT

Intercropping is an alternative cropping strategy with potential for fostering agricultural sustainability. However, the compatibility **of** many crops for intercropping, especially under different crop residue management systems, has not been established.

During the summer of 1991, we investigated the effect of intercropping and residue management on soil water depletion, plant biomass and grain production. Our results clearly show the yield advantage of crop association. Contrary to some reports, the legume crops yielded significantly more in mixed than in pure stands. The advantage of the intercropping systems was attributed to reduced competition among plants. Velvetbean biomass production was interestingly high, suggesting its integration into cropping systems for soil improvement. However, velvetbean appeared to depress sorghum grain yield when both were grown in mixture.

INTRODUCTION

Numerous factors affect crop performance in mixed stands (3, 4, 9, 11, 12). The complexity of their potential interactions (6. 10), compounded by a scarcity of data, make it difficult to predict the performance of untested intercrop mixtures. Reports on legume/cereal intercropping especially are contradictory (3, 4, 5, 11, 12) and call for additional field work to determine which species to intercrop, when, where, and how. Among the factors influencing crop performance in mixtures, the effect of tillage and crop residue management practices has not been well investigated.

MATERIALS AND METHODS

Grain sorghum [Sorghum bicolor (L.) Moench, cv. 'Pioneer 8230'] was intercropped with velvetbean Mucuna aterrima (Piper and Tracy) Merr.] or groundnut [Arachis hypogaea L., cv. 'Southern Runner'] on a Cecil sandy clay loam at Griffin, Georgia during the summer of 1991. The field experiment was laid out as a split-plot design in randomized complete blocks with three replications. The main-plot treatments were conventional tillage (CT) no-tillage with residue left on surface (NTR) and no-tillage with residue removed immediately after harvest (NTNR), a common practice in West Africa. Sub-plot treatments were pure stands of unfertilized sorghum (S)fertilized sorghum (SF), velvetbean (V), groundnut (G), and mixed stands of sorghum/velvetbean (SV) and sorghum/groundnut (SG). Crops in mixtures were planted in alternating double rows (binary basis). Rows were 34 inches apart and 40 feet long. Plant populations for all crops averaged 200,000 and 100,000 plants/ha in pure and mixed stands respectively.

The soil moisture content was measured at different time intervals at six depths ranging from 6 to 36 inches in the middle of rows by means of a time domain reflectrometer (TDR). Plant biomass was harvested over two randomly located 1-square meter (velvetbean) or 1-meter row (groundnut and sorghum) samples, dried, and weighed. The same sampling procedure was used at harvest for seed yield estimation.

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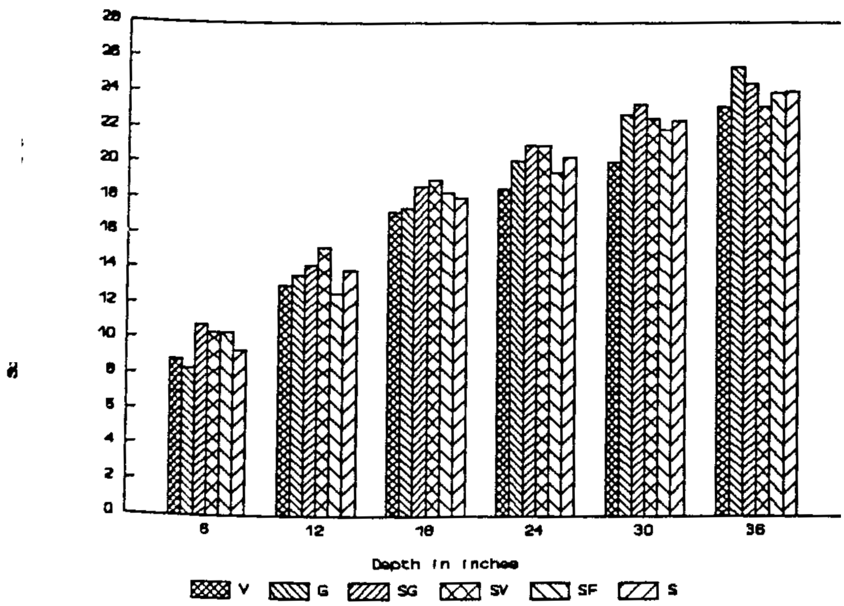

Fig. 1. Effect of intercropping on soil moisture content in the soil profile.

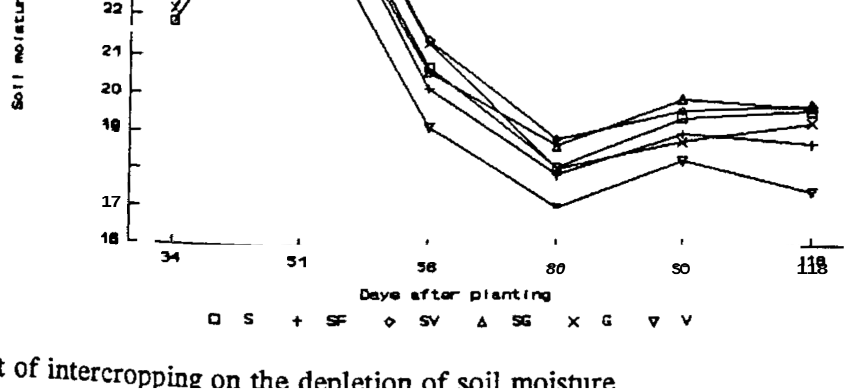

Fig. 2. Effect of intercropping on the depletion of soil moisture

RESULTS AND DISCUSSION

The mean soil moisture content increased with depth with little difference among crop treatments (Fig. 1). However, when summed over depth, soil moisture was more depleted in pure stand velvetbean (Fig. 2), but SV mixture unexpectedly resulted in the highest moisture content for much of the season. The other crop treatments resulted in intermediate soil moisture contents.

Soil moisture content was lower for CT, in contrast to its response under no-tillage (NTNR and NTR; Fig. 3). Loosening of the soil by tillage may have favored more extensive root growth resulting in higher water uptake under CT. The residue mulch with NTR resulted in greater soil moisture conservation, as is often reported (7, 8, 10). In contrast, residue removal with NTNR favored more rapid water loss by evaporation.

Under all the residue management systems, ranking of crop treatments for final biomass yield in decreasing order was V, SV, S, SF, SG, and G (Table 1). Intercropping velvetbean with sorghum significantly reduced overall biomass production. In contrast, SG produced significantly more biomass than a sole crop of groundnut. The high water uptake by velvetbean may justify its rapid growth ater 61 days post planting, i.e., in August, where rainfall was abundant (Fig. 4).

Comparison among residue management systems showed no significant difference in both biomass (Table 1) and grain yield (data not included), suggesting that additional years with these tillage/residue management systems in place are required before these treatments will express significant differences.

A closer analysis (Table 2) shows that intercropping did not significantly affect crop biomass production. However, sorghum grain yield decreased significantly in mixture with velvetbean, but not when intercropped with groundnut. In contrast, both legumes yielded significantly higher in mixed than in pure stands (Table 2).

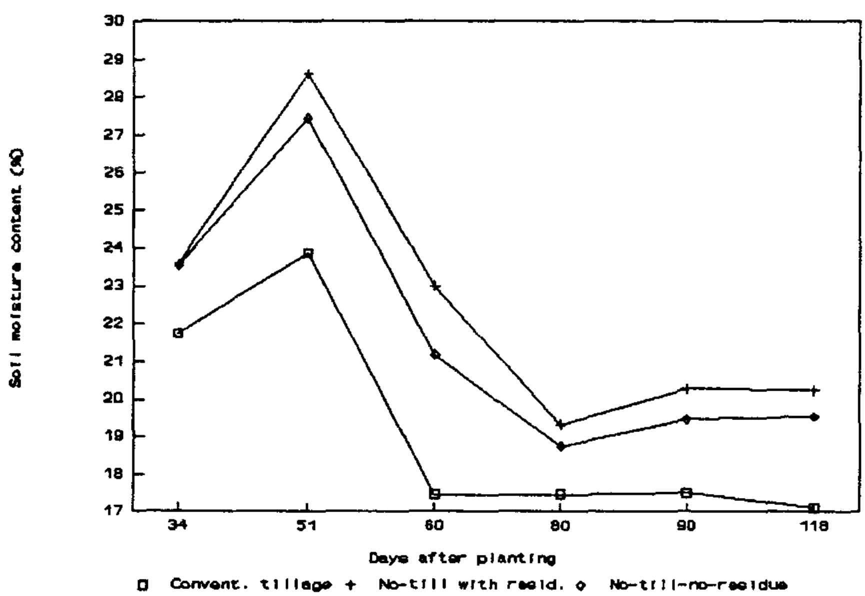

Fig. 3. Effect of residue management practices on soil moisture content.

Several authors have reported reduced yields of legumes when intercropped with cereals, which they attributed to a shading effect (9) or competition for nutrients (4, 11, 12) by the cereal crops. In particular, yield of groundnut has consistently been reported to decrease when intercropped with cereals (1, 2). Our results are not in agreement with these reports. Three explanations appear plausible. First, sorghum variety used averaged only 1.45 m full height, which limited its ability to shade the intercropped legumes. Shading was further reduced by adopting the binary system of planting. Second, high relative humidity in the dense pure stand canopy may have favored disease development, resulting in lower yields for monocropped legumes. This was particularly true for velvetbean; an extensive flower and fruit abortion was observed in the pure stand. Finally, intense intraspecific competition in the pure stand may have resulted in legume yield depression. In general, land equivalent ratios for both biomass and seed yield averaged 2 in each intercropping situation.

CONCLUSION

Our experiment clearly showed the yield advantage of intercropping. Contrary to some reports, the legume crops yielded significantly more in mixed than in pure stands. The advantage of the intercropping systems is attributable to reduced competition among plants. Velvetbean biomass production was interestingly high, suggesting its integration into cropping systems for nutrient replenishment. However, velvetbean may depress sorghum grain yield in mixtures.

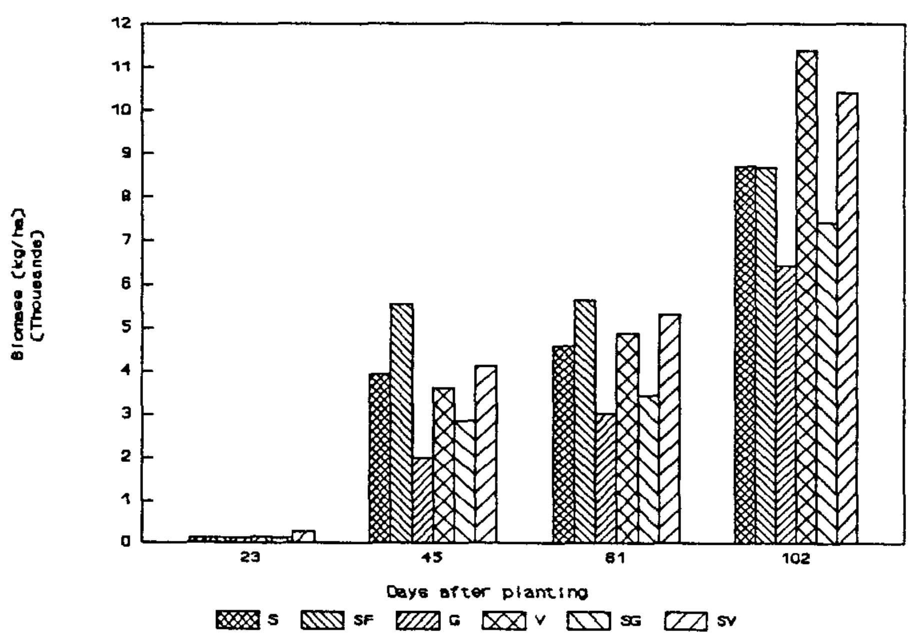

Table 1. combined final biomass yield of crops under different residue management practices. Values for intercrops are combined means.

Crop Treatment	CT	NTR	NTNR	Overall Mean
	....	kg ha^{-1}	---------------------	
V	12020 a*	11443 a	10717 a	11393 a
SV	11622 a	10527 b	9059 b	10403 b
S	8543 b	9015 c	8626 b	8728 c
SF	8747 b	8862 c	8469 b	8693 c
SG	7339 c	7259 d	7664 c	7421 d
G	6058 d	7130 d	6058 d	6416 e
Overall Mean	9055	9039	8432	8842

* Means within a column followed by the same letter are not significantly different ($P = 0.05$).

Table 2. Effect of intercropping and crop residue management on plant final biomass and seed yield.

Sorghum		Groundnut		Velvetbean	
		Means of biomass yields (kg ha^{-1})			
S	8093 a*	G	6415 a	V	11393 a
SF	8728 a	SG	6021 a	SV	12640 a
SG	8821 a				
SV	8165 a				
		Means of grain or pod yields (kg ha^{-1})			
S	4800 b	G	2757 b	V	3150 b
SF	5665 a	SG	3838 a	SV	4772 a
SG	4774 b				
SV	4077 c				

* Means within a crop followed by the same letter are not significgntly different ($P = 0.05$).

CITATIONS

1. Koli, S.E. 1975. Pure cropping and mixed cropping of maize and groundnuts in Ghana. J. Agric. Sci. 8:23-30.

2. IRAT. 1978. Rapport Annuel. 1977. IRAT. Paris.

3. Lai, T.M., and K. Lawton. 1962. Root competition for fertilizer phosphorus as affected by intercropping. Soil Sci. Soc. Amer. Proc. 26:58-62.

4. Mt. Pleasant, J. 1982. Corn polyculture systems in New York. M.S. Thesis. Cornell Univ., Ithaca, NY.

5. Murray, G.A., and J.B. Swensen. 1985. Seed yield in Austrian winter field peas intercropped with winter cereals. Agron. J. 77:913-916.

6. Nyambo, D.B., T. Matimati, A.L. Komba, and R.K. Jana. 1980. Influence of plant combinations and planting configurations on three cereals (maize, sorghum, millet) intercropped with two legumes (soybean, green-gram). In: Keswani, C.L. and B.J. Ndunguru (eds.) Intercropping. Proceedings of the Second Symposium on Intercropping in Semi-Arid Areas, Morogoro, Tanzania.

7. Okigbo, B.N. 1969. Maize experiments on the Nsukka plains: III, effects of different kinds of mulch on the yield of maize in the tropics. L' Agron. Trop. 28:1036-1047.

8. Okigbo, B.N. 1990. Sustainable agricultural systems in tropical Africa. p. 323-352. In: C.A. Edwards, R. Lal, P. Madden, R.H. Miller, and G. House (eds.) Sustainable agricultural systems. Soil and water conservation society, Ankeny. Iowa.

9. Reedy, M.S., and R.W. Willey. 1980. The relative importance of above- and below-ground resource use in determining yield advantages in pearl millet/groundnut intercropping-Summary. p. 70-71. In: L. Keswani and B.J. Ndunguru (eds.) Intercropping. Proceedings of the Second Symposium on Intercropping in Semi-Arid Areas, Morogoro, Tanzania.

10. Russelle, M.P. and W.L. Hargrove. 1989. Cropping systems: Ecology and management. P. 277-317. In: R.F. Follett (ed.) Nitrogen management and ground water protection. Elsevier, New York, NY.

11. Wolfe, E.C., and A. Lazenby. 1973. Grass-white clover relationships during pasture development. I. Effect of superphosphate. Austr. J. Expl. Agric. Anim. Husb. 13:367-574.

12. Wolfe, M.S., P.N. Minchi, and S.E. Slater. 1982. Barley mildew. p. 92-95. In: Annual report of plant breeding institute, 1981. Plant Breeding Institute, Cambridge, United Kingdom.

APPENDIX

**Program for the
12th Annual**

**Milan No-Till
Crop Production
Field Day
and
Planting Equipment
Demonstrations**

**Thursday, July 23, 1992
7:00 a.m. - 3:00 p.m.**

**North Tract of the
Milan Experiment Station
Milan, Tennessee**

**The University of Tennessee Institute of Agriculture
D. M. Gossett, Vice President
Agricultural Experiment Station
D. O. Richardson, Dean
J. F. Bradley, Superintendent**

The University of Tennessee
Milan Experiment Station

WELCOMES YOU

to the 12th Annual Milan No-Till Crop
Production Field Day.

Please turn to the next page for descriptions of the field day activities--including exhibits on display at the West Tennessee Agricultural Museum.

Research-oriented tours of the Milan Experiment Station are described in the center of this booklet, and these descriptions are followed by listings of the organizations displaying commercial products, safety and educational materials, and farming equipment.

Many community events are scheduled to coincide with the field day, and these are described toward the end of this booklet. The final pages include a map to the field day site and descriptions of the amenities available during the activities.

Please let us know if we can assist you. We hope you have an educational and enjoyable visit to the Milan Experiment Station.

John F. Bradley
Station Superintendent

Field Day Activities

Research Tours

Tours will start at 7:00 a.m. CDT, Thursday, July 23rd. Last tours will start no later than 3:00 p.m. Each tour is approximately one hour and fifteen minutes in length, with each stop 15 minutes long.

NOTE: Approximately 6 hours will be required to visit all stops. Those desiring to take several tours should plan to arrive early. Please turn the page for complete descriptions of tours and tour stops.

West Tennessee
Agricultural Museum

The West Tennessee Agricultural Museum will be open throughout the No-Till Field Day events between the hours of 7:00 a.m. and 5:00 p.m. Large displays of antique farm equipment and tools used by early West Tennessee settlers are featured. Replications of a blacksmith shop, early school house, church, country' store, country kitchen, and a diorama of life and living conditions experienced by early settlers of West Tennessee are also available for viewing. The museum is located on the field day site. Admission is free.

Point Sign-up

Recertification of
Restricted - Use Pesticides

Certified pesticide applicators must accumulate at least ten (10) points over a period of five *(5)* years or take a recertification exam in order to become recertified. The Tennessee Pesticide Coordinator and the Head of the Environmental Control Section of the Tennessee Department of Agriculture has assigned **TWO (2)** RECERTIFICATION POINTS to those attending and participating in the **RESEARCH** TOURS at the Milan No-Till Field Day.

Private and commercial pesticide applicators **MUST SIGN** the sign-up sheets located at the Registration Tents around the field day site.

Farm Safety Center
Agricultural Safety and Health Promotion
Tent and Display

The Gibson County Tennessee 4-H Honor Club through a grant received from the Tennessee Agricultural Health Promotion is sponsoring a tent and display area to emphasis Farm Safety. The commercial and educational exhibits will feature:

Tractor Safety
Pesticide Protection
Pesticide Container Rinse Equipment
Pesticide Calibration Equipment
Rotary Cutter and Lawn Mower Safety
Pesticide Container Disposal Methods & Equipment
Well and Water Testing
Power Take Off (PTO) Safety
Grain Bin Safety
Pesticide Spill and Clean-up Materials
Electrical Safety

The Farm Safety Center is located near the food service tents, behind the large commercial and educational exhibit tents.

Tour A

NO-TILL WEED CONTROL -- CORN AND SOYBEANS

Board designated buses at tent area. Buses leave every 15 minutes. The complete tour requires approximately one hour. Tents for shade and bales of straw for seating are provided.

New Herbicides For No-Till Corn
Elmer Ashburn, Professor & Leader, Extension Plant and Soil Science
Bob Montgomery, Extension Leader, Obion County

Round-up Tolerant Soybeans
Blake Brown, Plant and Soil Science
Greg S. Allen, Extension Leader, Lake County

Screening Displav of Various Herbicides on Crops of the Region
G. Neil Rhodes, Jr., Associate Professor, Extension Plant and Soil Science
Tom Mueller, Assistant Professor, Plant and Soil Science

Tour B

No-Till Cotton Production Practices

Board covered trailers across from tent area, near registration tents. Complete tour requires one hour.

Replanting Decision of Cotton
Albert Y. Chambers, Professor, Entomology & Plant Pathology
Melvin Newman, Professor, Extension Entomology & Plant Pathology

Influence of Tillage on Fruiting Patterns of Cotton
P. E. Hoskinson, Professor Emeritus, Plant and Soil Science
Sammy Elgin, Extension Leader, Madison County

Weed Control for No-Till Cotton
Robert M. Hayes, Professor, Plant & Soil Science
Bill Wyatt, Extension Agent, Madison County

Tour C

No-Till Cotton Management

Tour assembles and departs every 15 minutes at tent near bus loading area. Tour is a walking tour, one and one half hour in length. Tents for shade and bales of straw for seating are provided at each stop.

Foliar Feeding Cotton with Potassium In No-Tillage and Conventional Cotton
Donald D. Howard, Professor, Plant and Soil Science

Tips For Successful No-Till Cotton
Paulus Shelby, Associate Professor, Extension Plant and Soil Science
Jamie Jenkins, Extension Leader, Fayette County

Equipment For Successful No-Till Cotton
Ken J. Goddard, Extension Leader, Henry County
Philip A. Coleman, Assistant Extension Agent, Shelby County

Tour D

No-Till Pastures - Summer and Winter Annuals - Hay and Forage Utilization

Tour assembles and departs every 15 minutes at tent near bus loading area. Tour is walking tour, one hour in length. Tents for shade and bales of straw for seating provided at each talk.

Hay Storage and Hay Quality
Bobby L. Bledsoe, Professor, Agricultural Engineering
Robert S. Freeland, Associate Professor, Agricultural Engineering

Summer and Winter Annuals
Joe D. Bums, Professor, Extension Plant and Soil Science
Ricky Joe Carlisle, Associate Superintendent, Ames Plantation

Utilization of Quality Forages & Forage Testing
James B. Neel, Professor & Leader, Extension Animal Science
William Warren Gill, Associate Professor, Extension Animal Science

Tour E

Residue Management and Environmental Quality

Board covered trailers across from tent area, near registration tents. Complete tour requires one hour and 15 minutes.

Soil Cover. Surface Water Quality and Conservation Compliance
Bob Hathcock, Professor, Agriculture/Natural Resources
Brad Denton, District Conservationist, Soil Conservation Service

Soil Cover and Water Quality
Glenn V. Wilson, Assistant Professor, Plant and Soil Science
Grant Thomas, Professor, University of Kentucky, Department of Agronomy

Crop Residue. and Grass Cover Crop Management
Michael D. Mullen, Assistant Professor, Plant & Soil Science
Timothy N. Burcham, Assistant Professor, Extension Agricultural Engineering

Legume Cover Crop Management
Bob N. Duck, Professor, Plant & Soil Science
Don D. Tyler, Professor, Plant & Soil Science

Tour F

Managing Forestry, Wildlife and Fisheries

Assemble in the Forestry, Wildlife, and Fisheries tent near bus loading area. Program includes displays and demonstration of equipment and products for wildlife damage control. Representatives from the Tennessee Wildlife Resources Agency, the Tennessee Division of Forestry, The University of Tennessee Agricultural Extension Service will be available to answer questions.

Crop Damage by Deer and Groundhogs
Jim Byford, Dean of Agriculture, University of Tennessee/Martin

Beaver Management and Control Problem
Allan Houston, Research Assistant Professor, University of Tennessee/Ames

Bird Depredations at Fish and Aquaculture Projects
Thomas K. Hill, Professor, Extension Forestry, Wildlife and Fisheries

No-Till Forestry, Wildlife & Fisheries Continued

Forest Stewardship Program and SIP

Larry Tankersley, Extension Associate, Extension Forestry, Wildlife and Fisheries

Current Timber Prices

George M. Hopper, Associate Professor, Extension Forestry, Wildlife and Fisheries

Displays and Demonstrations

Michael M. King, Assistant Professor, Extension Forestry, Wildlife and Fisheries
Robert D. Smith, Extension Assistant, Extension Forestry, Wildlife and Fisheries

Tennessee Wildlife Resources Agency Display & Information
Tennessee Division of Forestry-Forest Stewardship Display
Electric Fences-Deer Damage Control
Bird Scaring Devices
Traps
Wildlife Repellents
Tree Protectors
Beaver Control Device
No-Till Acorn Planter
No-Till & Conventional Wildlife Food Plot

Tour *G*

Row Spacing and Plant Populations For Crop Production

Attendees participating in this tour should board busses at tent area. Busses depart every 15 minutes and deliver attendees to tour site where a short walking tour convenes. Tents for shade and bales of straw for seating are provided at each stop. Participants may cross field to No-Till Planting and Equipment Demonstrations. Busses return every 15 minutes. Tour is 1 hour in length.

Effect of Row Spacing on the Yield of Soybean Varieties

Wayne T. Flinchum, Professor, Extension Plant and Soil Science
Freddie L. Allen, Professor, Plant and Soil Science

Corn Yields As Affected By Row Spacing and Plant Populations

Dennis R. West, Associate Professor, Plant and Soil Science
Robert C. Williams, Extension Agent, Weakley County
Display of 20" Row Corn Header

Grain Sorghum Yields As Affected By Row Spacing

Charles R. Graves, Professor, Plant and Soil Science
Vernon H. Reich, Associate Professor, Plant and Soil Science

Tour H

No-Till Planting and Equipment Demonstrations

Tours begin at 8:00 a.m. No-Till planters, drills, fertilizer applicators and spraying equipment will be demonstrated. Board buses at tent area; continuous demonstrations will take place until 1:00 p.m., after which, equipment will be on display in the field. Return buses will run every 15 minutes.

William E. Hart, Assistant Professor, Agricultural Engineering

Planter and Drill Demonstrations

Arizona Drip Systems, Inc.
Sundance Puller, 2 row
Sundance Disc, 2 row

Blu-Jet & G & L Distributing
Sub II, 5 row 30"

C.A.P., Inc. - Redball
Spray Hood Applicator equipped with Redball hood and monitors

Fleischer Manufacturing (Buffalo Farm Equip)
Buffalo Cultivator with Scout Guidance System
Buffalo Slot Planter

Great Plains Mfg.
15 ft. no-till drill
Folding no-till drill, 30 ft

Haybuster Mfg.
Haybuster 107 no-till drill

J.I. Case Company
6 row no-till planter
15' grain drill w/coulter cart

John Deere
Narrow-wide no-till planter

The KBH Corp.
Coulter injector applicator-liquid fertilizer, chemical injection for no-till

Lincoln Creek Manufacturing
Cultivator guidance system

Marliss Supply Company
Marliss no-till drill

Martin Row Cleaner
No-till planter w/row cleaner

Melroe Co.
Spray coupe

Northwest Tillers
Strip tiller - 20' unit

Precision Tank & Equipment
Pick up spray unit for row crop

Rawson Coulters
Zone till coulter cart
15' no-till corn planter

S & N Sprayer
Model 35 direct spray wheel unit
Model UF-5 RYO, 12 row

Strohm Brothers
13 ft aerator

Planter/Drill Demonstrations Continued

Sukup Manufacturing
Sukup Model 600 cultivator w/Auto Guide System

The Tye Company
Tye series V no-till drill
Tye paratill

Tri-County Equipment
Kinze 6 row - 15" spacing no-till planter

United Farm Tools
15 ft - 5010-8HD no-till grain drill

Equipment Displays

Ag-Chem Equipment Co., Inc.
3 Wheeler Tru-spread with liquid system

Big Rivers Agri Supply
Shelbourne Reynolds Grain Stripper & DMI Anhydrous applicator

Ciba-Geigy Corp.
Bicep & Dual Farm & Field Paks

Deutz-Allis
Combine & Tractor

Ford New Holland, Inc.
TW Tractor & Hay Equip.

Great Plains Mfg., Inc.
15' 3 pt. No-Till Drill

Haybuster Mfg.
No-Till Drill

J. I. Case Company
4 Row Cotton Picker, Tractor & Planter

J M Innovations, Inc.
ATV Mini-floater sprayer, Smucker Weed Wiper 30'

John Deere Co.
J D 750 No-Till Drill
J D 7300 No-Till Planter

Krone Niemeyer
Hay Equipment

Marliss Supply Co., Inc.
Grain Drills

Melroe Company
Sprayers

Mid-America Sales
Best Grain Drill, Sprayer, and Progressive Farm Tools

Nichols Welding & Manufacturing
Lay-by rig & hydraulic spray boom

Palco Livestock Equip.
Livestock Handling & Holding

Precision Tank Co.
Hi Clearance Pick Up Spray Unit

S & N Sprayer Co., Inc.
Tractor with Lay-By Unit Attached

Tennessee Farmers Cooperative
Sprayers - Spreaders

The KBH Corporation
Cotton Wagon - Module Builder

Tn-County Equipment Co.
Kinze Planter, Great Plains Drill, Hesston Tractor

Equipment Displays Continued

The Tye Company
No-till drill

Tuckasee Irrigation
Irrigation Equipment

United Farm Tools
No-Till Drills

Unverferth Mfg. Co.
CPC 2000 Conservation Deep-Ripper

Vemeer
Round Balers, Rakes, Mower, etc.

Vittetoe Chaff Spreader, Inc.
Combine Chaff Spreader

Western Sales & Service
Fertilizer Spreaders, Fertilizer tenders

Yetter Mfg. Co. Inc.
No-Till Planter

Commercial Displays

Ag-Chem Equipment Co., Inc.
AGCO
Agri-Center International
Amen-Can Pedigreed Seed Co.
American Cyanamid
Arizona Drip Systems, Inc.
Asgrow Seed Company
BASF Corporation
Big Rivers Agri Supply
Blu-Jet & G & L Distributing
Bruce Martin Construction, Inc.
C.A.P., Inc. - Redball
Cargill Hybrid Seeds
Cedar Chemical Corp.
Ciba-Geigy
Data Transmission Network
DeKalb Plant Genetics
Delta and Pine Land Co.
DowElanco
DuPont Chemical Company
Farm Credit Services
Fleischer Manufacturing, Inc., (Buffalo Farm Equipment)
Ford New Holland
Four Star Services, Inc.
Great Plains Mfg. Inc.
Griffin Corporation
Gustafson
Haybuster Mfg.
Helena Chemical Company
ICI Americas
ICI seed
1-40 Communications, Inc.
J C Bradford & Co., Futures
J & K Associates
J I Case Company
J M Innovations Inc.
Jackson Diesel Service
Jacob Hartz Seed Co
John Deere Company
The KBH Corporation
Krone Niemeyer
Lincoln Creek Manufacturing
Marliss Supply Company Inc.
Martin Row Cleaner
Melroe Company
Micro flo
Miles Inc.
Monsanto Agricultural Group
NAPA Auto Parts
Nichols Welding & Manufacturing
Northrup King Co.

Commercial Displays Continued

Northwest Tillers, Inc.
Palco Livestock Equipment
Power Cleaning Equipment of TN
Precision Tank & Equipment Co
Rawson Coulters Inc.
Rhone Poulenc Ag Co.
Rohm & Haas Company
S & N Sprayer Co., Inc.
S & W Supply Inc.
Sandoz Crop Protection Corp.
Spectrum Technologies, Inc.
Stine Seed Co.
Stockade Buildings
Stoneville Pedigreed Seed Company
Spraying Systems Co. "Teejet"
Strohm Brothers Inc.
Sukup Manufacturing Co.
Sure-Grow Cottonseed
TN Ag Supply
Tennessee Farmers Cooperative
Terra International Inc.
Texas Refinery Corp.
The Tye Company
Tri-County Equipment Co
Tri-State Delta Chemicals Inc.
Tuckasee Irrigation
UniRoyal Chemical Company
United Farm Tools Inc.
Valent U.S.A.
Vittetoe Chaff Spreader, Inc.
Western Sales & Service Inc.
Wolf Creek Oil Company
Yetter Manufacturing Company
Zimmerman Hybrids

Educational Displays

Chickasaw-Shiloh R C & D Association
City of Milan Hospital
Conservation Technology Information Center
Easter *Seal* of Tennessee
Farmers Home Administration
Gibson County ASCS Office
Gibson County Farm Bureau Women
Gibson Electric Membership Corporation
Haywood County Agricultural Extension Service **4-H**
Madison County Farm Bureau Women
Milan Department of Public Utilities
Safety Supply America
Tennessee Ag Extension Service Water Quality Committee
Tennessee Agricultural Statistics Service
Tennessee Beef Quality Assurance Committee
Tennessee Certified Varieties, Inc.
Tennessee Department of Agriculture
Tennessee Farm Bureau Federation
Tennessee Forage and Grassland Council
Tennessee Plant Food Educational Association
USDA - Soil Conservation Service
UT Agricultural Experiment Station
UT Agricultural Extension Service - Manage Program
UT College of Agricultural Sciences & Natural Resources
UT College of Veterinary Medicine
UT Computer/Video Safety Training
UT Grain Bin Safety
UT Martin Agronomy Club
UT Radio Control Tractor Hazard Course
UT Tennessee Infield Sprayer-Mounted Rinse System
West Tennessee Women For Cotton
West Tennessee Farmers' Market