Proceedings of the

1991 Southern Conservation Tillage Conference

North Little Rock, Arkansas
June 18-20, 1991

WETLANDS PRESERVATION · CONSERVATION TILLAGE · IMPROVED WATER QUALITY · PROFITABLE PRODUCTION

IMPLEMENTING CONSERVATION AND ENVIRONMENTAL TECHNOLOGY

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Foreword

Conservation tillage, especially no-till, gained greater acceptance during the decades of the 1960s and 1970s. This acceptance coincided with the availability of herbicides that could substitute for mechanical cultivation for weed control. Highly erodible locations were usually the first to implement conservation practices.

Conservation tillage generally reduces erosion, conserves energy costs associated with tillage operations and modifies soil-water relationships. Conservation tillage often requires greater herbicide use to obtain acceptable weed control. Under reduced tillage scenarios, applied lime and fertilizer tend to concentrate in the surface few inches of soil. Greater capture of rainfall and fast transmission of water via large pores to greater depths may pose an increased potential for ground water contamination with pesticides and nitrates. In some cases, continual cropping without mechanical tillage has resulted in increased surface soil compaction.

Conservation tillage issues that evolved during the 1980s included effective herbicide and fertilizer use, proper soil sampling techniques, insect and disease management, crop residue management, soil-water relations, surface and ground water protection and profitability of crop production. Numerous production problems have been addressed by various solutions being tested. As conservation technology improves, its acceptance continues to increase.

The 1991 conference theme, “Implementing Conservation and Environmental Technology,” was chosen for its focus on conservation compliance and the environmental quality the rural as well as non-rural public is beginning to demand. A balance needs to be achieved between profitable agriculture production, wetlands preservation, conservation production technology and improved water quality. The 1991 conservation tillage conference continues to provide a communication link between various agencies and personnel interested in improved natural resource management. We here at the University of Arkansas appreciate the opportunity to host this annual conference and to facilitate the adaptation of conservation and environmental technology.

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Contents

Soybean Production Systems Utilized in the Soybean Research Verification Program in Lonoke County

L.O. Ashlock, G.L. Burke, G. Lorenz and T.E. Windham[1]

INTRODUCTION

During the last decade acreage planted to soybeans in Arkansas has decreased by 38%. Farmers cite the difficulty of producing soybeans profitably as the major reason for this acreage shift. In 1983 soybean workers from the Arkansas Cooperative Extension Service and the Arkansas Agricultural Experiment Station initiated an Arkansas Soybean Promotion Board-funded project entitled the "Soybean Research Verification Programs" (SRVP). One of the objectives of the SRVP was to demonstrate and give needed assurance and validity to farmers that soybeans can be produced more profitably by implementing all research-based recommendations. Another objective was to develop an on-the-farm data base for use in economic analyses. After eight years and 83 full-season irrigated trials, the average yield is 44.3 bu/acre with an average specified operating cost of $104.36/acre. Beginning in 1988 the SRVP included dryland production systems in the program (Lorenz et al., 1989, 1990). Typically, 20-25% or more of the specified operating costs for both irrigated and dryland fields relates to tillage practices. With the advent of both improved planting equipment and herbicides, soybean production systems utilizing reduced tillage can be used with improved opportunity for success. Beginning in 1985 the SRVP included full-season soybean fields that were seeded by grain drills instead of conventional row planters. This paper focuses on the agronomic and economic results of different tillage programs from selected SRVP fields that typified soybean production in Lonoke County, Arkansas.

MATERIALS AND METHODS

Production practices were conducted according to research-generated Extension recommendations. Preplant tillage operations were performed as necessary to prepare an adequate seedbed for planting and varied depending on previous crop residue and field condition. Cultivar selection was made utilizing the Extension computerized variety selection program, "SOYVA." In irrigated fields the water was applied when tensiometers read 50 centibars at the 10- to 12-in. depth for both silt loam and clay soils. Soybeans were harvested with the cooperating farmers' combine, and all yields were adjusted to 13% moisture. Harvest loss measurements were determined for each trial as well. Combine adjustments were made whenever harvest loss exceeded 5%.

RESULTS AND DISCUSSION

The date in Table 1 show selected field operations and agronomic measurements from Lonoke County SRVP trials for four years (Ashlock et al., 1985, 1986; Lorenz et al., 1989, 1990). The data in Table 2 show the yields, specified operating and ownership costs, breakeven prices and net returns above specified operation and ownership costs from different production systems commonly used in Lonoke County on the SRVP trials. Field number 1 had higher specified operating costs since the soybean crop followed a rice crop. The irrigated yield of 46 bu/acre for that field is considered good by producers in that area of the county (compared with typical irrigated yields of approximately 36 bu/acre). A final breakeven price of $6.40 makes it difficult to raise a profitable soybean crop following rice, as reflected in the net loss of $41.57/acre for that field. SRVP field 2 is on the same location as field 1 but was planted the following year (1986). Conventional 30-in. rows were used in 1986. Although yields were slightly lower, the reduction in preplant tillage trips (soybeans following soybeans) and weed control cost (data not shown) resulted in lower total specified operating costs with a net return to management of $26.30/acre greater than the preceding year. This reduction in economic loss was accomplished in spite of a 22-cent lower average soybean price in 1986.

Fields 3 through 6 represent the SRVP dryland trials. These fields include both early-season soybean production (ESSP), in which varieties from

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maturity groups III. and IV. are planted in April or early May, and conventional production, in which varieties from maturity groups V, VI or VII are planted in May or June.

Although the highest net return per acre was by a conventional variety with preplant tillage (field 4), the conventional variety planted on a stale seedbed (field 6) showed considerable promise in terms of net returns per acre. Field 5 was an early-season cultivar and indicated the potential of growing early-season soybeans on a stale seedbed. The data in Table 2 from the ESSP fields (3 and 5) indicate that this production system is comparable to other production systems (fields 1, 2, 4, and 6).

CONCLUSION

The yields obtained and specified operating costs incurred will vary depending on a host of factors, including previous crop, environmental conditions, row width, pest problems, etc., but these data indicate that reduced tillage production systems can be utilized with results equal to or possibly better than those of conventional production.

LITERATURE CITED

1. Ashlock, L.O., J.M. Erstine and J. Clark. 1985. Arkansas Soybean Research Verification Program. Unpub.
2. Ashlock L.O., J.M. Erstine, R. Wells and G.M. Lorenz. 1986. Arkansas Soybean Research Verification Program. Unpub.
3. Lorenz, G.M., L.O. Ashlock and J.D. Clark. 1989. Arkansas Soybean Research Verification Program. AR-15-8-90 (Ark. Ext. Annual Report).
4. Lorenz, G.M., L.O. Ashlock and T.E. Windham. 1990. Arkansas Soybean Research Verification Program. Unpub.

Table 1. A summary of specific operations and agronomic data for selected Soybean Research Verification Program fields in Lonoke County.

	Field number/year					
Operation	1/1985	2/1986	3/1989	4/1989	5/1990	6/ 1990
Field size (acres)	42	42	45	15	17	17
Previous crop	rice	soybeans	soybeans	soybeans	soybeans	soybeans
Spring preplant tillage trips	6	5	6	5	0	0
Fertilizer required	Yes	Yes	no	no	no	no
Lime required	no	no	yes	Yes	no	no
Cultivar	A5474	Forrest	Fayette	Uoyd	A4715	Hartz 6686
Planting Date	5/20	5/16	4/3	5/25	5/9	5/9
Plant population'	–	–	157,653	115,434	137,400	97,076
Row spacing (in.)	13	30	7	24	7	7
Herbicide applied	yes	yes	Yes	Yes	Yes	Yes
Number of cultivations	0	1	0	2	0	0
Harvest date	---	11/16	8/21	10/26	9/17	11/1

[1]Average number of plants per acre

Table 2. A summary of yields and specified costs and returns from selected Soybean Research Verificatlon Program fields in Lonoke County.

	Field number/year					
costs	1/1985	2/1986	3/1989	4/1989	5/1990	6/1990
Yield[1] (bu/acre)	46	44.5	38	38	23	36
Total specified operating cost[2] ($/acre)	141.61	116.41	101.76	71.88	90.54	92.60
Total specified ownership cost' ($/acre)	79.02	64.73	31.66	36.93	21.a5	21.84
Breakeven price[4] ($/bu)	4.80	4.07	3.51	2.86	4.89	3.18
Final breakeven price[5] ($/bu)	6.40	5.34	4.68	3.82	6.52	4.24
Average annual selling price[6] ($/bu)	5.19	4.97	5.85	5.85	6.07	6.07
Net returns[7] ($/acre)	(41.57)	(15.27)	33.30	57.91	(7.68)	49.45

[1]Yields adjusted to 13% moisture.
[2]Includes those expenditures that would require an annual cash outlay.
[3]Includes depreciation, interest, taxes, insurance and miscellaneous costs.
[4]Price required by the farmer to equal total specified operating and ownership costs.
[5]Breakeven price plus a land charge of 25%.
[6]Based on Arkansas Agricultural Statistics Service annual reports.
[7]Net returns to overhead, risk and management above total specified operating and ownership costs plus a land charge of 25% based on the average annual selling price.

Arkansas' Experience with Reduced Rate Herbicide Recommendations

F.L Baldwin, C.B. Guy and L.R. Oliver[1]

HISTORY

In the late 1970s and early 1980s, soybean growers were reporting successes with post-emergence herbicide rates considerably lower than those on the manufacturer's labels. For a short period in the early 1980s popular press articles citing success stories using reduced rates, soybean oil carriers and application by controlled droplet sprayers were even more dramatic. Research conducted to verify these stories began to quickly show that species susceptibility, application timing and environmental conditions had far more effect on herbicide activity than did method of application, spray carrier and other factors. Through research by Banks and Oliver (1984), Hopkins et al. (1985,1986), Oliver (1989) and others, the University of Arkansas quickly built a data base to support reduced rate programs. The first approach in extending this information to the grower was to send the research data to the county agents and let them handle it on an oral basis. The county agents quickly refused to accept the burden of liability in this manner. From there the Extension Director was approached in 1985 with the data, and a request was made to place a set of reduced rate intensive management recomrnendations in a publication (Baldwin et al., 1990b). The potential pressures from industry and liability aspects were discussed. The Director confirmed the mission of the Land Grant system was to conduct and extend research for the grower and, if the scientists had confidence in the data base, the research should be made available.

RECOMMENDATIONS

The first reduced rate recommendations were published in 1985 for 1/4 and 1/2 labeled rates of bentazon, acifluorfen, sethoxydim and fluazifop. Since 1985, reduced rates of lactofen, imazaquin, chlorimuron, fomesafen and quizalofop have been added. In general, the postemergence rates break down as follows: 1 to 6 days after weed emergence (DAE), 1/4 to 1/3 rates; 7 to 12 days DAE, 1/2 rates; and 13 + DAE, labeled rates. Reduced rates of the soil-applied herbicides imazaquin, metribuzin and chlorimuron + metribuzin were added in 1987. Rates of the herbicides range from 1/2 to 2/3 labeled rates for a given soil type. The reduced rate recommendations are published as a separate section with specific instructions and can be obtained by requesting MP-44 from the Arkansas Cooperative Extension Service (Baldwin et al., 1990b). Since 1986, the reduced rate recommendations have also been published in a computer program (Baldwin, 1989). In the Arkansas reduced rate program, it is emphasized that no single reduced rate treatment is a weed control program. Reduced rate treatments are used in conjunction with other reduced rate or, in some cases, labeled rate treatments. The most consistent and economical Arkansas soybean weed control programs use a combination of reduced rate soil-applied treatment followed by a reduced rate of postemergence herbicide, if needed, to control escapes.

RESULTS

This program has been extremely popular with soybean growers in Arkansas as well as in other states. Current survey information indicates reduced rates are used on approximately one half of the Arkansas soybean acreage with an annual cost savings of $7/acre or $8 to 9 million annually. To date, there have been no law suits, and some of the companies who were most critical in 1985 are the most complimentary now. Industry concerns--"the average grower can't pull it off," "it is small plot work that can't be duplicated on large farms," and "the industry reps will get the complaints"--have largely proven to be unfounded. In addition, several new herbicide registrations reflect reduced rates compared to previous labels. From a research and Extension scientist point of view, reduced rate programs are extremely popular with growers, and they are much more challenging than using more herbicides to solve a problem. There are excellent opportunities for funding, and the programs are environmentally sound. The 1990 Missouri rate recom-

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[1]**Baldwin and Guy are with the University of Arkansas Cooperative Extension Service, Little Rock, AR; Oliver is with the Department of Agronomy, University of Arkansas, Fayetteville, AR.**

mendations for soybeans (Sims and DeFelice, 1991) have reduced rates.

FUTURE

Extensive research and demonstration programs are conducted each year to verify the existing recommendations and to expand the program (Baldwin et al., 1990a; Guy, 1990; Oliver et al., 1985). Low Input Sustainable Agriculture (LISA) funds have been a tremendous boost to the program. With LISA funds the reduced rate concept hasbeen taken from broadcast to very narrow band applications using precision cultivators (Baldwin, 1990). Soybean weed control programs with herbicide costs in the $5 to $10 range are easily attained in this program. Through the LISA grant, these concepts have been studied for agronomic and horticultural crops (Boyd, 1990; McCarty et al., 1990). The program is currently being expanded to include cover cropping, ridge tillage and crop rotation *to* allow even further reduction in herbicide inputs.

LITERATURE CITED

1. Baldwin, F.L. 1989. The use of computer programs for weed control in soybeans. Proc. of World Soybean Res. Conf. IV, pp. 1620-1624.
2. Baldwin, F.L. 1990. Weed control with LISA in Arkansas. Proc. So. Weed Sci. Soc 43:376.
3. Baldwin, F.L., J.W. Boyd, T.L. Dillon, T.W. Dillon and LL. VanPelt. 1990a. Weed control demonstrations. Univ. of Ark. Coop. Exten. Serv.
4. Baldwin, F.L., J.W. Boyd and C.B. Guy. 1990b. Recommended chemicals for weed and brush control in Arkansas. Univ. of Ark. Coop. Exten. Serv. MP-44.
5. Banks, V.E., and L.R. Oliver. 1984. Soybean oil and postemergence herbicide. Proc So. Weed Sci. Soc. 37:92.
6. Boyd, J.W. 1990. Cover crops for weed suppression. Proc of the Ark. State Hort. Soc.(in press).
7. Guy, C.B. 1990. Weed control evaluations. Univ. of Ark. Coop. Extn. Serv.
8. Hopkins, J.A., L.R. Oliver and F.L. Baldwin. 1985. Intensive soybean herbicide management programs. Proc. So. Weed Sci Soc. 38:84.
9. Hopkins, J.A., L.R. Oliver and F.L. Baldwin. 1986. Intensive soybean herbicide management programs. Proc So. Weed Sci. Soc. 39:94.
10. McCarty, J.T., R.E. Talbert and J.W. Boyd. 1990. Reduced herbicide rates in vegetable crops. Proc. So. Weed Sci. Soc. 43:173.
11. Oliver, L.R 1989. Factors affecting herbicide rates in soybeans: Strategies for reduced herbicide rates. Proc World Soybean Res. Conf. IV, 1613-1619.
12. Oliver, L.R., RE. Frans and RE. Talbert. 1985. Specific weed control reports. Univ. of Ark. Dept. of Agron., Fayetteville, AR.
13. Sims, B.D., and M.S. DeFelice. 1990. Weed control guide for Missouri field crops. Missouri Coop. Extn. Serv. MP-575

Soil and Plant Growth Response to Interseeding and Double-Cropping Systems

G.R. Bathke, A. Khalilian, P.M. Porter and C.E. Hood[1]

INTRODUCTION

Two of the most promising methods for increasing crop water use efficiency and reducing costs of double-cropping while protecting the environment are relay intercropping and reduced tillage. Interseeding or relay intercropping of soybean into standing wheat has been investigated by a number of researchers (Wendte and Nave, 1979; Chan et al., 1980; Reinbott et al., 1987; Buehring et al., 1990; Hargrove and Ford, 1990; Hood et al., 1990; Khalilian et al., 1990). Where successful interseeded stands of soybean were established, a general conclusion was that wheat and soybean yields were reduced as much as 20% of conventional full-season yield. However, intercropped soybean always equaled or outperformed conventional double-cropped soybean. Using a cropping system with controlled traffic patterns and deep tillage in the fall, Hood et al. (1990) found that interseeded soybean (1987-1990) yielded significantly higher than those double-cropped with a wide-row (97-cm) no-till planter after wheat harvest. They found wheat yields were not affected by interseeding in the Coastal Plain test location. Khalilian et al. (1990) found that deep tillage effects from para-plowing before wheat planting persisted and benefitted the interseeded soybean. Eliminating subsoiling just before soybean planting resulted in a savings of $8 to 10 per acre (Khalilian et al., 1988).

While these studies surveyed the agronomic feasibility of intercropping, few investigated changes in the soil physical environment to explain the crop performance differences. Khaliiian et al. (1990) found distinct differences in soil compaction patterns under interseeded vs. conventional double-cropped systems. Mechanical impedance was highest in the traffic lanes for the interseeded system but was very low in the plant growth zone. Uncontrolled traffic in the double-cropped system caused compaction in areas where plants were growing, resulting in shallower and smaller root systems. Soil moisture utilization was observed to be best with the interseeded plots but was not monitored closely enough to compare treatments.

Many of the important agricultural soils in the Atlantic Coastal Plain have compacted layers primarily in the E horizon but may extend upward into the base of the Ap horizon. Yields of crops grown on sandy Coastal Plains soils are frequently reduced due to the presence of hardpans, which prevent root acquisition of subsoil moisture and nutrients (Smittle et al., 1977). Soil physical properties that have been found to correlate with crop yield response to deep tillage may be associated with the soil water retention characteristics or propensity of the soil for hardpan formation (Simmons et al., 1989). Conservation tillage cropping systems can be used to enhance subsoil water accumulation and delay recompaction of the E horizon. Busscher and Sojka (1987) found that a conventional tillage treatment (which included disking and numerous trips over the field) left many areas of the field with higher soil strength, which inhibited root growth, while a reduced tillage system resulted in a more even distribution of soil penetration resistance across the field.

MATERIAIS AND METHODS

Field experiments with various double-crop rotation systems were established at the Edisto Research and Education Center at Blackville, South Carolina, on a Varina loamy sand (clayey, kaolinitic, thermic Plinthic Paleudult; Rogers, 1977). Test 1, initiated in 1987, used five cropping systems (Table 1) in a randomized complete block design with six replications. Test 2, initiated in the fall of 1990, used a randomized complete block design with four replications to compare "conventional" interseeding (Table 1; treatment 3 fall disking 12 cm deep followed by a four-shank paratill with a 51-cm spacing operating 33 cm deep, wheat planted with the Clemson interseeder, no spring tillage and soybean planted with the Clemson interseeder following the diagram in Fig. 1) and conventional double-cropping (Table 1; treatment 5: fall tillage with a tandem disk operating 12 cm deep and a 30-cm-spaced, eleven-shank chisel plow operating 28 cm deep, wheat planted with a grain drill in 20-cm rows, spring tillage of subsoiling at planting with a 96-cm-

[1]Edisto Res. and Educ. Center, Clemson University

Table 1. Tillage/planting treatment combinations.

Treatment	Tillage before wheat			Wheat planting method		Tillage before soybean	Soybean planting method	
no.	Disk	Ch[1]	Para	Clem	Drill	Para	Clem	KMC/Sub
1	x			x			x[2]	
2	x	x		x			x[2]	
3	x		x	x			x[2]	
4	x		x	x		x	x[3]	
5[4]	x	x			x			x[3]

[1]Ch = chisel plow; Para = paratill; Clem = Clemson interseeder; Drill = conventional grain drill with 20-cm rows; KMC/sub = KMC subsoiler-planter with 96 cm rows.

[2]Mid-May soybean interseeding date.

[3]Soybean planted in June after wheat harvest.

[4]Conventional doublecropping method for wheat and soybean in Coastal Plain soils

spaced KMC subsoiler/planter). Test 2 will also include monocropped soybean as a summer crop.

Coker 9766 wheat was planted at 100 kg seed/ha in late November immediately after tillage. Kirby soybean was interseeded at 67 kg seed/ha between rows of standing wheat in mid-May (Table 1). Wheat from all plots was harvested the first week of June and soybean planted in the remaining treatments (Table 1). Fertilizer was applied based on soil analysis and broadcast before fall tillage and in the spring as topdress application as needed. Post-emergence herbicides were applied as needed. A conventional combine with a 4-m-wide header was used to harvest the crops.

A microcomputer-based, tractor-mounted recording penetrometer was used to assess in-situ mechanical impedance of the soil profile in a transect extending from the wheel traffic lane to the fourth row as indicated by asterisks in Fig. 1. The location of the penetrometer readings are indicated as tire, row 1, and row 2, respectively, in Tables 2, 5, 6 and 7. Soil compaction values were calculated from the measured force required to push a 3.2-cm2 basal area, 30° cone into the soil. Immediately after penetrometer data were recorded, undisturbed soil samples were taken with Uhland sampler attached to the hydraulic coring device. Each soil core was trimmed flush with the ends of the aluminum ring, capped at both ends, placed in a plastic bag and stored at 4 C until analysis. The core was then slowly saturated with water, and saturated soil hydraulic conductivity (KSAT) was measured using a constant-head permeameter with a hydraulic gradient of 1.8 cm/cm (Klute and Dirksen, 1986). The core was oven dried at 105 C and weighed for bulk density (BD) determination.

Plant shoot and root growth parameters were assessed following soybean harvest in 1990 and 45 days after planting wheat. Root samples were taken within one day of penetrometer measurements in 1990 and 1991. Soil cores 7.5 cm in diameter were taken in trafficked and nontraflicked areas in 15-cm increments to a depth of 45 cm with a tractor-mounted hydraulic probe. The cores were washed and sieved on a Gillison hydropneumatic elutriator, and the roots were measured using a modified Delta-T area meter (Harris and Campbell, 1989). Each sample was oven dried to determine root dry weight. Analysis of variance procedures were performed using the Statistical Analysis System (Ray, 1982). The error term used to test significance for each effect was the block (rep) x effect interaction for that effect.

RESULTS AND DISCUSSION

Cone index values before tillage indicated that the field had a hardpan in the E horizon at a depth of 22 to 30 cm in the soil profile. In Test 1, deep tillage significantly reduced penetration resistance compared to disked plots in the 0- to 15-cm and the 30- to 45-cm soil layers for non-traffic rows (Table 2). At the 15- to 30-cm depth of the row locations, KMC subsoiler/planter and paratill treatments significantly reduced penetration resistance of the hardpan layer compared to chiseled and disked plots. There were no significant differences in penetrometer measurements between plots paratilled once in the fall compared to those using a second deep tillage operation (paratill or subsoiler) prior to planting soybean. Cone index values for these plots were less than 1000 kPa in the top 30cm of soil (Table 2). For the row locations the highest soil compaction values were found in the E horizon, although compaction effects were also noted for the 30- to 45-cm layer. Cone index values were high enough to restrict root penetration into the B horizon (Table 3) and reduce crop yield (Table 4). Cone index val-

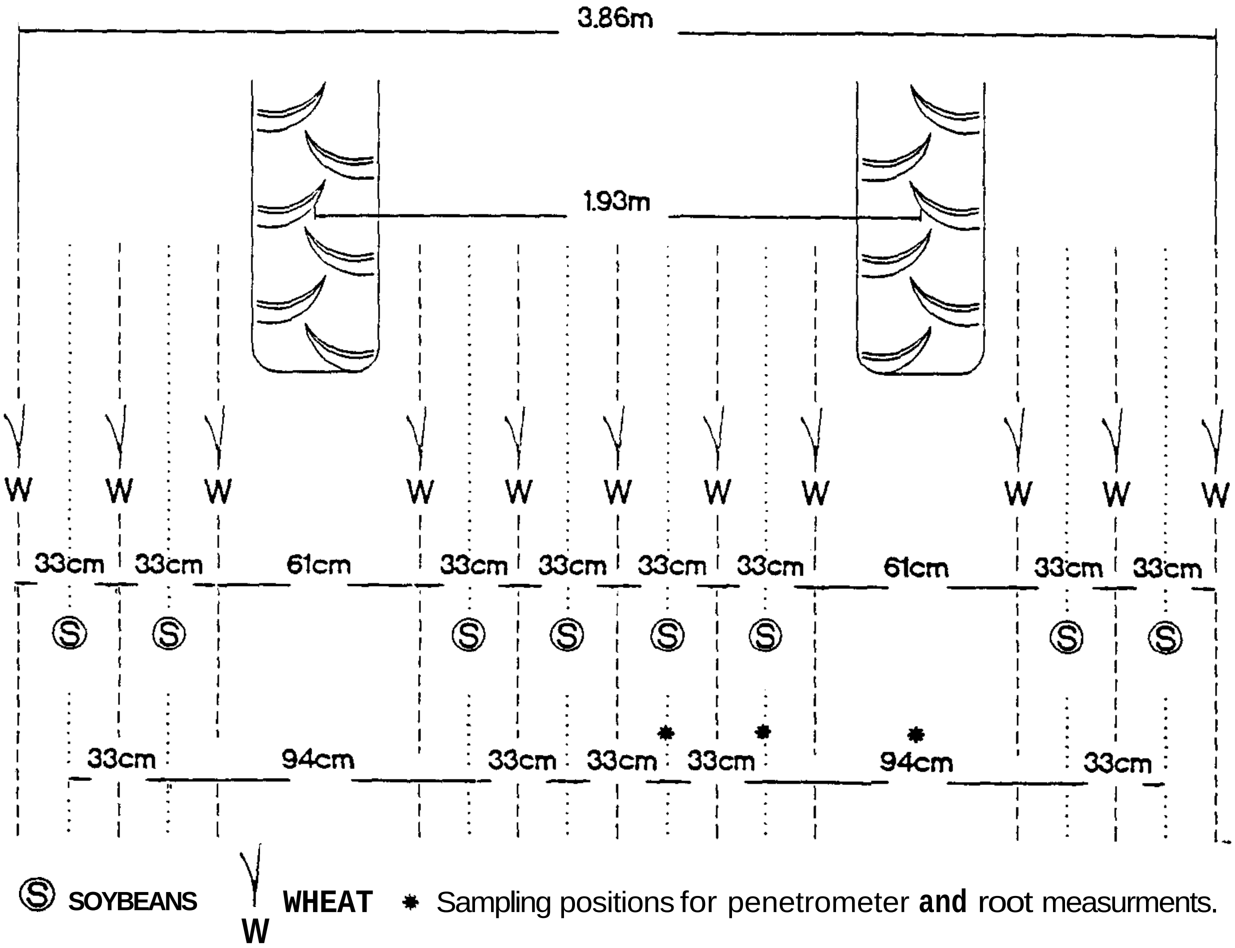

Fig. 1. The intercropping planting pattern for wheat and soybean.

ues above 1000 kPa generally reduce crop yield, and values above 2000 kPa stop root growth (Taylor and Gardner 1963; Carter and Tavernetti 1968).

Traffic significantly increased penetrometer resistance compared to the plant row areas in Test 1 (Table 2). The wheel traffic lanes in all plots were highly compacted with the only significant differences found between the chisel/subsoiler and the disk-only treatment, with the E horizon showing no differences. There were no significant differences in penetrometer readings between wheel traftic lanes and soybean row zones in the disked plots except in the top 15 em of soil (Table 2).

Saturated soil hydraulic conductivity (KSAT) and BD were affected by tillage treatments in Test 1 (Table 5). At the 2.5- to 10-cm depth (A horizon), KSAT differed between row positions for most tillage treatments and between tillage treatments at the row adjacent to the traffic lane. Limited differences were found for KSAT in the E horizon (23- to 30.5-cm depth). Tillage treatments had no effect on BD for the A horizon, but differences were found

Table 2. Penetration resistance at soybean harvest as affected by tillage and traffic eleven month8 after fall tillage, 1990.

Tillage		Cone index (kPa)								
		0-15 cm depth			15-30 cm depth			30-45 cm depth		
Fall	Spring	Row 1[1]	Row2	Tire	Row 1	Row2	Tire	Row 1	Row 2	Tire
Disk	None	877a[2]	884a	1875a	1973a	2058a	2211a	1788a	1696a	2172a
Chisel	None	458ab	391b	1978ab	1142b	1086b	1892a	1594a	1288b	2012ab
Paratill	None	441b	380b	1820ab	841c	730c	1679a	1264b	1261b	2070ab
Paratill	Paratill	456b	428b	1807ab	912c	650c	1820a	1340b	1400b	2008ab
Chisel	Subsoiler	335b	--	1564b	750c	--	2058a	1354b	--	1757b

[1]Tire = wheel traffic lane; Row 1 = row adjacent to traffic lane; Row 2 = row farthest from traffic lane.
[2]values in a column followed with the same letter are not significantly different (Duncan's Multiple Range Test, α = 0.05).

Table 3. Soybean root length and dry welght at soybean harvest as affected by Ullage, 1990.

Tillage		0-15 cm depth		15-30 cm depth		30-45 cm depth	
Fall	Spring	wt	length	wt	length	wt	length
		9	mm	g	mm	g	mm
Disk	None	2.59'	5060	0.07	380	0.07	470
Chisel	None	2.54	5230	0.24	890	0.17	1380
Paratill	None	1.64	4570	0.16	1170	0.11	980
Paratill	Paratill	2.06	3400	0.13	1110	0.12	930
Chisel	Subsoiler	2.80	4500	0.75	2230	0.15	1260
$LSD_{0.05}$		NS[2]	NS	0.39	1010	NS	700
CV (%)		46	36	149	80	73	59

[1]Values are averaged over two row positions for each plot.
[2]NS = nonsignificant.

Table 4. Crop yield response (kg/ha) to tillage systems.

Tillage		Planter		Wheat		Soybean	
Wheat	Soybean	Wheat	Soybean	1989	1990	1989	1990
Disk	None	Clem.'	Clem.[2]	2465b[3]	3112C	1810b	1368b
Chisel	None	Clem.	Clem.[2]	2992a	3346bc	1973ab	1478ab
Paratill	None	Clem.	Clem.[2]	3092a	3718ab	2242a	1704a
Paratill	Para.	Clem.	Clem.[4]	3161a	3908a	1723b	1672a
Chisel	Subsoil	Drill	KMC[4]	3089a	3246bc	1570b	1471ab

[1]Clem. = Clemson interseeder; Drill = conventional grain drill with 20-cm rows; KMC = KMC subsoiler-planter with 96-cm rows.
[2]Mid-May soybean interseeding date.
[3]Values in a column followed with the Same letter are not significantly different (Duncan's Multiple Range Test, $\alpha = 0.05$).
[4]Soybean planted in June after wheat harvest.

Table 5. Response of roll properties to tillage systems as measured after soybean harvest, Nov.1990.

Tillage		2.510 cm depth				23-30.5 cm depth			
Fall	Spring	Tire'	Row 1	Row2	Row $LSD_{.05}$	Tire	Row1	Row 2	Row $LSD_{.05}$
Saturated soil hydraulic conductivity (cm/hr)									
Disk	None	0.53	1.93	1.40	0.80	0.23	0.11	0.24	NS[2]
Chisel	None	0.42	2.17	1.81	0.77	0.11	0.39	0.i9	0.21
Paratill	None	0.33	1.60	1.60	NS	0.42	0.53	1.03	NS
Paratill	Paratill	0.24	1.71	0.76	0.92	0.25	0.52	0.47	NS
Chisel	Subsoiler	0.38	2.80	–	1.30	0.12	0.39	–	NS
Tillage $LSD_{.05}$		NS	1.04	NS		NS	NS	0.64	
Soil bulk density (Mg/m3)									
Disk	None	1.70	1.40	1.41	0.11	1.67	1.75	1.69	NS
Chisel	None	1.74	1.38	1.37	0.12	1.68	1.66	1.71	NS
Paratill	None	1.72	1.45	1.37	0.12	1.69	1.43	1.49	0.25
Paratill	Paratill	1.78	1.44	1.50	0.20	1.68	1.60	1.50	NS
Chisel	Subsoiler	1.75	1.41	–	0.14	1.77	1.66	–	NS
Tillage $LSD_{.05}$		NS	NS	NS		NS	0.28	0.11	

[1]Tire = wheel traffic lane; Row 1 = row adjacent to traffic lane; Row 2 = row farthest from traffic lane.
[2]NS = nonsignificant.

between the traffic lane and the crop rows. In the E horizon, the paratill treatments had lower BD in rows 1 and 2 compared to the other tillage treatments, with the BD of the single paratill operation higher than the BD of the double paratill treatment for row 1, but not for row 2. The traffic lanes in all treatments had the lowest KSAT and highest BD, with no differences found between tillage systems (Table 5). For the row positions, the A horizon had higher KSAT and lower BD than the E horizon almost without exception. In the traffic lanes there were no significant differences in KSAT or BD between soil depths, as the overburden pressure from the equipment was evidently distributed over the coarse-textured A and E horizons.

For Test 1, no significant differences in root length and dry weight were measured in the top 15 cm of soil for soybean root samples after soybean harvest (Table 3). However, at the 15- to 30-cm depth, a difference between deep and shallow tillage treatments was observed in root length and weight. A difference was observed in root weight at the 30- to 45-cm depth. Roots were better able to penetrate the E horizon (15- to 30-cm depth) in plots where deep tillage was performed. Root length increased as soil compaction decreased, with a threshold cone index for reduction in root growth near 1000 kPa for this soil. Khalilian et al. (1988) found a similar correlation between soybean tap root length and soil cone index.

For Test 1, cropping systems incorporating deep tillage (paratill, chisel, subsoiler) produced higher wheat and soybean yields than systems in which disking was the only tillage (Table 4). The paratill treatments tended to produce higher wheat and soybean yield than the other tillage treatments. There was no significant difference in yield between chisel plow plots planted with the Clemson interseeder (33-cm rows) and those planted with a conventional grain drill (20-cm rows) using the same seeding rate. Comparison of interseeded and doubled-cropped plots indicated that interseeding soybean between rows of standing wheat did not reduce wheat yields. Interseeding soybean into standing wheat produced higher soybean yield compared to those planted after wheat harvest for each tillage system (Table 4). Deep tillage before wheat significantly increased soybean yields compared to disked treatments. Due to the controlled traffic patterns provided by the interseeding system, deep tillage before small grain planting carried over and benefitted soybeans. The paratill treatment was the optimum deep tillage operation, and the mid-May planting date was the best time for planting.

For Test 2, which compared "conventional" interseeding vs. double-cropping early in the cropping season, KSAT and BD did not differ between cropping systems, but some differences did exist between trafficked and non-trafficked row positions (Table 6). Rows 1 and 2 had significant differences between soil depths, but the effect of traffic excluded any differences between soil depths in the tire track. The paratill treatment had more consistent differences between row positions than the chisel/disk system. In the A horizon of the traffic lane, the interseeded system had lower KSAT and higher BD, though not significantly different.

With few soil property differences evident, measured root growth parameters did not show any treatment effects at this early stage of plant growth either (Table 7). These values were composites of three 15-cm sampling depth increments (no significant differences between treatments at any depth, data not shown). There were no differences between row 1 and row 2 for root or shoot growth. Shoot weight was significantly different for cropping systems, with the interseeded system having almost twice as much growth (Table 7).

Table 6. Response of soil properties to Ullage systems as measured on 15 January 1991, 45 days after wheat planting.

	Planting	2.5-10 cm depth				2530.5 cm depth			
Tillage	svstem	Tire[1]	Row 1	Row2	Row LSD $_{.05}$	Tire	Row 1	Row2	Row LSD $_{.05}$
Saturated soil hydraulic conductivity (cm/hr)									
Paratill	Interseed	0.05	0.30	0.26	0.23	0.03	0.19	0.10	0.15
Chisel, disk	Grain drill	0.20	0.28	0.37	NS[2]	0.03	0.15	0.04	NS
Tillage LSD $_{.05}$		NS	NS	NS		NS	NS	NS	
Bulk density (mg/m^3)									
Paratill	Interseed	1.84	1.68	1.68	0.11	1.87	1.89	1.83	NS
Chisel, disk	Grain drill	1.79	1.66	1.64	NS	1.84	1.88	1.82	NS
Tillage LSD $_{.05}$		NS	NS	NS		NS	NS	NS	

[1]Tire = wheel traffic lane; Row 1 = row adjacent to traffic lane; Row 2 = row farthest from traffic lane.
[2]NS = nonsignificant.

Table 7. Response of wheat growth to tillage systems as measured on 15 Jan 1991, 45 days after wheat planting.

Tillage	Planting system	Shoot wt		Root wt		Root length	
		Row 1'	Row2	Row 1	Row2	Row 1	Row2
		(g/30 cm row)		(g/0.5 l soil)		(mm/0.5 l soil)	
Paratill	Interseed	28.1	28.4	0.47	0.43	6607	5524
Chisel, disk	Grain drill	13.2	15.7	0.38	0.24	6376	4644
Tillage LSD.05		6.5	5.6	NS[2]	NS	NS	NS

'Row 1 = row adjacent to traffic lane; Row 2 = row farthest from traffic lane.
[2]NS = nonsignificant.

This indicates that one deep tillage operation in the fall to disrupt root-inhibiting hardpans, in conjunction with controlled traffic, could eliminate the need for an additional deep tillage in the spring for soybean in Coastal Plain soils. The controlled traffic approach to managing a field was very evident in the comparison of the interseeded system with the double-cropped system. Soil properties were much more homogeneous between the sample locations (tire, row 1, row 2) in the double-cropped system than in the interseeded system. This homogeneity of soil properties is not advantageous when the needs for vehicle operations and crop growth are considered. Traffic lanes should be managed for vehicle load bearing capacity, which would manifest itself in higher BD and lower KSAT and higher cone index values. Crop growth areas would require just the opposite for optimum root growth and the availability of water and nutrients. Interseeding incorporates the advantages of reduced tillage with the added benefits of better utilization of the long growing season for double-cropping soybean and reduced energy requirements for equipment operation. Based on preliminary results, the use of pesticides may also be reduced by using an interseeded cropping system.

LITERATURE CITED

1. Buehring, N.W., D.B. Reginella and M.A. Blaine. 1990. Long term wheat and soybean response to an intercropping system Proc of 1990 South. Conserv. Till. Conf., July 16-17, 1990, Raleigh, NC.
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. Carter, L.M., and J.R. Tavernetti. 1968. Influence of precision tillage and soil compaction on cotton yields. Trans. ASAE, 11(1):65-67, 73.
4. Chan, L.M., RR Johnson and C.M. Brown. 1980. Relay intercropping soybeans into winter wheat and spring oats. Agron. J. 72:35-39.
5. Hargrove, W.L., and P.B. Ford. 1990. Low input, reduced tillage systems for the Southeast. Am Soc. Agron. South. Branch Abst. 82:9.
6. Harris, G.A., and G.S. Campbell. 1989. Automated quantification of roots using a simple image analyzer. Agron. J. 81:935-938.
7. Hood, C.E., A. Khalilian, J.H. Palmer, T.H. Gamer, T.R Garrett and J.C. Hayes. 1990. Double-cropping interseeding system for wheat, soybeans, and cotton. No. 90-1527. Proc. Intl. ASAE Winter Meeting, Chicago, IL.
8. Khalilian, A., T.H. Garner, R. Dodd, H.L. Musen and A. Hale. 1988. Energy for conservation tillage in Coastal Plain soils. Trans. ASAE 31(5):1333-1337.
9. Khalilian, A., C.E. Hood, J.H. Palmer, T.H. Garner and G.R. Bathke. 1990. Soil compaction and crop response to wheat/soybean interseeding. No. 90-1528, Proc Intl. ASAE Winter Meeting, Chicago, IL.
10. 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.
11. Ray, A.A. (ed.). 1982. SAS user's guide: Statistics. Statistical Analysis Systems Inst. Inc. Cary, N.C.
12. Reinbott, T.M., Z.R. Helsel, D.G. Helsel, M.R. Gebhardt and H.C. Minor. 1987. Intercropping soybeans into standing green wheat. Agron. J. 79:2386-891.
13. Rogers, V.A. 1977. Soil survey of Barnwell County, South Carolina. USDA-SCS. Washington, DC.: U.S. Govt. Printing Office.
14. Simmons, F.W., D.K. Cassel and RB. Daniels. 1989. Landscape and soil property effects on corn grain yield response to tillage. Soil Sci. Soc Am. J. 53:534-539.
15. 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.
16. Taylor, H.M., and H.R. Gardner. 1963. Penetration of cotton seedling taproots as influenced by bulk density, moisture content, and strength of soil. Soil Sci 96(3):153-156.
17. Wendte, K.W., and W.R Nave. 1979. Systems for interseeding and double cropping soybeans. Trans. ASAE 22(4):719-723.

Conservation Tillage Practices for Rice in Southwest Louisiana

Patrick K Bollich[1]

INTRODUCTION

Approximately 540,000 acres of rice were grown in Louisiana in 1990. Virtually all of the state's acreage is planted into conventionally tilled seedbeds, the only recommended method of planting. Rice is produced on clay and silt loam soils, and the field operations required for conventional seedbed preparation on these different soils are very diverse. The number and type of field operations necessary are often related to weather conditions at the time of planting. When wet springs occur, the amount of tillage required for conventional seedbed preparation generally increases, and planting is delayed. The additional tillage operations result in higher production costs, and delays in planting can result in decreased yields.

Conservation tillage practices have been researched and are being adopted in Louisiana for many other crops (Griffin et al., 1984; Griffin and Taylor, 1986; Hutchinson and Shelton, 1990). Advantages to such tillage practices include fuel and equipment savings, less delay in planting and moisture and soil conservation. Information concerning conservation tillage for rice in Louisiana is limited. Preliminary studies conducted in Crowley, Louisiana, have shown potential for utilizing conservation tillage practices in rice production (Bollich et al., 1987,1988, 1989). The objective of this study was to evaluate the performance of rice grown in no-till and stale seedbeds as alternatives to rice planted 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). The test area was previously cropped to soybeans. Tillage operations for seedbed preparation consisted of disking, vibra-shanking and conditioning with a roller harrow until a smooth, level, weed-free seedbed was formed. Rice establishment consisted of 1) no-till planting into previous crop residue, 2) planting into a stale seedbed tilled in the spring four to six weeks prior to planting, 3) planting into a stale seedbed tilled in the fall, about five to six months prior to planting, and 4) planting into a conventionally tilled seedbed. Treatments were arranged in a randomized complete block design with four replications.

A no-till grain-fertilizer drill was used during the study. With the exception of seedbed preparation in the conservation tillage treatments, agronomic management of the drill-seeded study was practiced according to current recommendations (L.S.U. Agricultural Center, 1987). In the conservation tillage treatments, glyphosate (1 lb ai/acre) was applied 3 and 21 days preplant in 1989 and 1990, respectively, to destroy existing vegetation. The test area received 300 lb/acre of 7-21-21 fertilizer, which was preplant incorporated. Rice (cv. Lemont) was drill-seeded at the rate of 110 lb/acre in 7-in. rows on 27 April 1989 and 21 May 1990. Three flush irrigations were required each year to facilitate seedling growth and stand establishment. A fertilizer application of 200 lb/acre of 46-0-0 was applied four to five weeks after planting and prior to the establishment of a shallow, permanent flood. An additional fertilizer application of 46-0-0 was applied during midseason each year (45 and 55 lb/acre in 1989 and 1990, respectively). In addition to the preplant application of glyphosate, the herbicides propanil, bentazon and molinate were 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 prior to permanent flood establishment. Individual whole plots (3250 ft^2) were combined-harvested and grain yields were adjusted to 12% moisture.

RESULTS AND DISCUSSION

Stand densities for each tillage practice are shown in Table 1. Difference in stand density between years was significant. Density was significantly higher in 1990 with an average increase of 28% across tillage methods. Different no-till planting equipment was used each year of the study. Uniformity of seed placement and soil coverage was much

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better in 1990, and the higher stand density could have been due to the equipment. Elapsed time between glyphosate application and planting was also quite different between years and may have influenced stand density. Planting followed glyphosate application by three days in 1989, and much of the collapse and decay of existing vegetation occurred during rice emergence and stand establishment. Planting was delayed after glyphosate application by three weeks in 1990 due to inclement weather. The vegetation was completely dessicated at the time of planting, and this situation was more conducive to rapid stand establishment.

Method of tillage significantly influenced stand density. Stand densities for tillage treatments averaged across years ranged from 17 plants/ft^2 in the fall-prepared seedbed to 21 plants/ft^2 in the spring-prepared seedbed. Compared with conventional tillage, density was significantly lower in the fall-prepared seedbed, but no differences in stand density occurred among the other tillage treatments. A stand of 15 to 20 plants/ft^2 is considered optimum in Louisiana (L.S.U. Agricultural Center, 1987), although successful yields have occurred at stand densities as low as 8 plants/ft^2 and as high as 30 plants/ft^2. No differences in grain yield occurred among method of tillage. Although differences in stand density were associated with tillage practice when measured at the 4- to 5-leaf growth stage, the tillering ability of Lemont resulted in compensatory growth later in the growing season.

Results from this study indicate great potential for conservation tillage practices in rice in Louisiana. Further studies will be required to answer questions relating to the economic potential of these practices, to identify varieties that are suitable in conservation tillage systems and to evaluate the soil conservation and water quality benefits derived from conservation tillage practices.

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LITERATURE CITED

1. 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. Expt., Rice Res. Stn., La. Agric. Exp. Stn., L.S.U. Agric Ctr. 79105-108.
2. 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. Stn., La. Agric. Exp. Stn., L.S.U. Agric. Ctr. 80:125-129.
3. 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. Agric Exp. Stn., L.S.U. Agric. Ctr. 81:138-143.
4. Griffin, J.L., and R.W. Taylor. 1986. Alternative establishment methods for wheat following soybeans. Agron. J. 78:487-490.
5. Griffin, J.L., R.W. Taylor and R.J. Habetz. 1984. Conservation tillage for double-cropped soybeans in southwestern Louisiana. J. Soil Water Conserv. 39:78-80.
6. Hutchinson, RL., and W.L. Shelton. 1990. Alternative tillage systems and cover crops for cotton production on the Macon Ridge. La. Agric. 33(4):6-8.
7. L.S.U. Agric. Ctr. 1987. Rice Production Handbook. La. Coop. Ext. Serv. and La. Agric. Exp. Stn. Pub. 2321. p. 63.

Table 1. Effect of seedbed preparatlon on stand density and grain yield of drill-reeded Lemont rice at Crowley, Louisiana.

Tillage Method	Stand density 1989	Stand density 1990	Stand density Avg.	Grain yield 1989	Grain yield 1990	Grain yield Avg.
	plants/ft^2			lb/acre		
Conventional	16	24	20	5711	5828	5770
Stale - spring	16	25	21	5743	5410	5576
Stale - fall	12	21	17	5909	5714	5812
No-till	15	23	19	5843	5544	5694
LSD (0.05)			3			NS
Source of Variation	df					
Year (Y)	1					NS
Tillage (T)	2		*			NS
YXT	2		NS			NS

* Significant at $P = 0.05$.

Conservation Tillage: A Force Changing Southern Agriculture

John F. Bradley[1]

INTRODUCTION

There are many forces that affect Southern farmers. Several of these are essentially outside farmer control, including weather, water, production costs, habit and government regulations. As few as 20 years ago there were other forces that farmers had little control over. These included soil erosion, pesticide and fertilizer losses, water pollution, weed control, conservation compliance and sometimes profitability. Today these forces must be recognized and evaluated before proper response can be planned and implemented.

The use of conservation tillage is rapidly increasing and is an alternative to several of the factors mentioned above. Indeed, the use of conservation tillage is a force of change in Southern agriculture. In a survey conducted in West Tennessee in 1985, a large percentage of farmers indicated that they were not aware of erosion problems on their own farm but thought that their neighbors had erosion problems (Leuthold, 1987). Popularity of conservation tillage has come to the forefront because it is a cost-effective means of achieving both agricultural production objectives and soil and water conservation goals. Joint efforts from research, extension and the pesticide and equipment industries have rapidly developed practical and applied methods for utilizing conservation tillage.

FORCE OF HABIT

Before bragging about how conservation tillage acreage, which includes no-tillage, minimum tillage and ridge till has increased, let us examine the reasons why the various tillage operations have been performed. Many farmers are reluctant to accept conservation tillage because it contradicts traditional tillage practices to which they are accustomed. Tillage operations have been performed since the first settlers started growing crops for food and sale in America over 200 years ago. Tillage has been repeated several times a season for the following reasons: 1) pest control (including weeds, insects and diseases); 2) seedbed preparation (all good plant and soil science text books recommend starting with a firm, clean seedbed); 3) fertilizer incorporation; 4) herbicide incorporation (although most modern crop herbicides are applied preemergence and postemergence); and 5) that is the way Dad did it.

In many situations, these reasons are now antiquated, and in a very short time they will be obsolete on the majority of cropable acres. Most tillage operations are not justifiable and may be performed for reasons of emotion, security or recreation (expensive recreation). Farmers may justify tillage operations with thinking such as the following:

1) I would love to have a big tractor like.....
2) That black field sure is pretty.
3) All the neighbors are out.
4) I would rather be on the tractor than doing this.
5) It's such a nice day I think I'll make a few rounds.
6) The neighbors will think I'm lazy if I don't.
7) Just one more pass to smooth up the....
8) That should bury those little....
9) If I don't bury the trash it will plug the....
10) Fall fertilizer has to be incorporated.

To justify tillage and cultivation of our crop land, one must question the rationale of each tillage operation and determine the cost and benefit to the crop and environment as well as the budget.

FORCE OF EROSION

In 1977 it was estimated that 2 billion tons of soil were lost to erosion in the United States. In 1981 estimates ran as high as 6.4 billion tons, which is enough to cover Arkansas with a layer of soil 1 in. thick. There are 18 states in which average soil losses are greater than the maximum tolerance of 5 tons/acre/year. These losses range from 5.15 tons in Indiana to 14.12 tons in Tennessee. In Missouri, soil loss averages 11.38 tons/acre/year, which translates to one dump truck load per acre or 640 truck loads/mi^2. Combinations of rainfall, soil series, topography, crop and conventional tillage practices make soil losses in West Tennessee among the highest in the nation. Because of this, researchers have con-

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ducted experiments at the University of Tennessee Milan Experiment Station since 1962 in conservation tillage production techniques with emphasis on no-till. Long-term soil erosion and runoff studies have been conducted continuously since 1980.

Conservation tillage operations leave at least 30% of the soil surface covered with residue prior to planting. No-till is a form of conservation tillage characterized by the elimination of seedbed preparation and the addition of coulters or offset double disc openers to slice through crop residues and create a furrow for seed placement. Conventional tillage consists of using a plow or disk to invert and vigorously stir the soil's surface layer, thus mixing any residue with the soil. Weed control in conventional tillage is accomplished by cultivation(s) and/or herbicide applications, whereas only herbicides are used to control weeds in no-till systems.

No-till has proven to be the most effective method for controlling soil erosion as indicated in Table 1, which illustrates the effects of cropping/tillage systems on soil loss from 0.25-acre plots for selected natural and simulated storms that occurred within the April-July periods of 1980-86. The cropping/tillage systems evaluated over the seven-year period included (1) conventional till, single-crop soybeans; (2) conventional till, double-crop soybeans after wheat; (3) drilled, single-crop soybeans; (4) no-till single-crop soybeans; (5) no-till, double-crop soybeans after wheat (Shelton, 1987).

FORCE OF ECONOMICS

Some producers say it costs more for no-till than for conventional till, while other producers say just the opposite. Who is right? Both--depending upon the costs considered and whether or not there are "problem weeds" in the particular field. However, recent reductions of burndown herbicide prices have reduced the costs of controlling these weeds. Also, variable costs for no-till fields are lower when machinery depreciation and interest on machinery investments are calculated. The reduction of fixed costs may not be fully realized because farmers will likely keep most of their tillage equipment. However, when existing equipment is replaced, it can be replaced with smaller equipment, and thus some cost advantages are realized due to lower investments in machinery.

Table 2 shows the estimated production costs per acre (excluding land costs) for no-tillage and conventional tillage of corn and cotton. Table 3 shows the diesel fuel requirements for various field operations (Hudson, 1987). No-tillage requires 4.8 gal. less fuel per acre compared to the standard cultural practices with conventional tillage.

FORCE OF YIELD

Research and field demonstrations at the Milan Experiment Station and other research centers indicate no significant difference in yields of corn, cotton, soybeans and grain sorghum under no-tillage versus conventional tillage on well- to moderately well-drained soils. Table 4 shows comparisons of cotton yields for conventional till versus no-till planted into wheat or rye over a period of 10 years at the Milan Experiment Station, Milan, Tennessee.

Presently no-till double-crop soybeans is a proven and recommended practice. Table 5 illustrates the average yields of no-till and conventional till soybean in 20 years of research at the Milan Experiment Station (Bradley, 1991).

FORCE OF CONSERVATION TILLAGE

The Conservation Technology Information Center (CTIC) started conducting surveys of conservation tillage acreage 19 years ago. Nationwide, con-

Table 1. Mean rainfall, runoff, cover/management factor and soil loss associated with selected soybean cropplng/tillage systems during April-July study periods. Milan Experiment Station, University of Tennessee.

System	Rainfall	Runoff	C-factor	Soil loss
	in.	% of rain		tons/acre
Conventional-till, single crop[1,3]	2.21	43	0.442	3.34
Conventional-till, double crop[1,3]	2.24	41	0.080	0.75
Drilled, single crop'	2.28	47	0.267	3.33
No-till, single crop[2,3]	2.22	31	0.004	0.05
No-till, double crop[1,4]	2.21	46	0.006	0.04

[1] *17 storms*, 1980-1986
[2] 12 storms, 1980-1983
[3] 40-in. rows
[4] 20-in. rows

Table 2. Estimated costs per acre (excluding land) of conventional and no-tillage corn and cotton (April, 1991).

Item	Corn		Cotton	
	No-till	Conv.	No-till	Conv.
	$			
Variable Costs				
Seed	14.40	12.00	10.20	9.00
Fertilizer & lime	38.60	38.60	37.70	37.70
Herbicides	22.18	13.10	45.00	24.02
Fungicides, insecticides & defoliant			24.48	24.48
Ginning			60.00	60.00
Mach. Reprs.	10.92	16.71	20.37	38.11
Fuel	3.45	6.68	6.08	15.15
Labor	5.60	11.44	14.00	22.04
Int. Op. Cap.	5.37	5.22	12.66	12.78
Total V.C.	100.52	103.75	230.49	243.28
Fixed Costs				
Mach. Int.	9.60	13.20	20.40	24.00
Mach. Depr.	24.44	36.02	52.75	82.26
Total F.C.	34.04	49.22	73.15	106.26
Total Costs	134.56	152.97	303.64	349.54

Table 3. Diesel fuel requirements by field operations at the Milan Experiment Station, University of Tennessee.

Operation	gal./acre
Heavy disking	.79
Chisel plowing	1.80
Light disking	.69
Seedbed finishing (Do-All)	.77
Planting	.44
Cultivating (two times)	.90
Total, conventional till	5.39
Total No-till planting	.59

Table 4. No-till versus conventional tillage mean cotton lint yields in variety trials planted into wheat or rye. Milan Experiment Station, University of Tennessee.

Year	No-till	Conventional till
	lb/acre	
1981	273	382
1982	940	937
1983	508	336
1984	1071	1146
1985	1040	1048
1986	854	853
1987	919	987
1988	767	690
1989	902	949
1990	992	889
10-year ave.	827	822

Table 5. Mean no-till and conventional till soybean yields at Milan Experiment Station, University of Tennessee, 1971-1990

Years	No-till		Conventional	
	Acres[1]	Yield	Acres[2]	Yield
		bu/acre		bu/acre
20	1787	35.1	2784	33.0

[1]All no-till soybean planted wheat stubble after 10 June.

[2]All conventional soybean planted prior to 10 June.

servation tillage is increasing at an average rate of 6% each year. In 1990, conservation tillage was practiced on 42% of all cropland in the United States. This compares to 31% in 1989. In 1972, when the first survey was conducted, 3.4 million acres was no-tilled. Last year 14.2 million acres was no-tilled, representing a 446% increase. Last year United States farmers used minimum tillage on 6.9% of cropland, giving a total of 61.6 million acres that was farmed with ridge tillage and mulch tillage practices.

Leading the way with the most no-till acreage for 1990 was Illinois with 2.1 million acres. They also had the highest total acres of conservation tilled land of any state with 8.2 million acres (CTIC, 1990)., In addition, nine other states no-tilled over 500,000 acres last year. These include Ohio, Missouri, Nebraska, Virginia, Pennsylvania, Michigan, Maryland, North Carolina and Tennessee. Note that only two of these states are participants at the Southern Conservation Tillage Conference. Tennessee conservation tillage acres are shown in Table 6.

Conservation tillage and no-tillage are definitely here to stay. Technology, resources and proven research are available to support conservation tillage. It is up to us as professionals in research, extension, soil conservation, farming, TVA and agricultural industry (seed, chemical and equipment) to enlist this technology on bur farm land with a variety of crops. Thousands of farmers around the South have already proven that conservation tillage can work and that money spent for labor, fuel and machinery *can* be reduced while producing excellent yields and maintaining quality of soil and water, two of our most valuable natural resources.

LITERATURE CITED

1. Bradley, J.F. 1991. Success with no-till cotton. *In* A cotton focus '91, early to mid season. Cooperative Extension Service, University of Tennessee, Knoxville, Tennessee.
2. Conservation Technology Information Center/National Association of Conservation Districts. 1990 national survey report. CTIC, League City, Texas.
3. Hudson, E.H. 1987. Economic considerations of no-tillage farming. Cooperative Extension Service, University of Tennessee, Knoxville, Tennessee. PB923.
4. Leuthold, P.O. 1987. Use of no-till planting by west Tennessee farmers. p. 22. Tennessee Farm and Home Science. 144.
5. Shelton, C.H. 1987. Controlling erosion and sustaining production with no-till systems. Tennessee Farm and Home Science 141:18-23.

Table 6. Tennessee conservation tillage average: > 30% residue or 1000 lb small grain equivalent

Annual crops	Total acres	No-till	Ridge-till	Mulch-till	Cons.-Till[1]
Corn (FS)[2]	652,225	150.277	200	129,538	280,015
Corn (DC)	59,525	20,034	0	16,360	36,394
Small Grain (SpSd)	23,834	4,210	0	4,560	8,770
Small Grain (F1Sd)	636,818	71,420	0	207,312	278,732
Soybean (FS)	891,494	72,146	0	114,351	186,497
Cotton	540,579	11,410	550	4,400	16,360
Grain Sorghum (FS)	63.789	2,993	0	8,682	11,675
Soybean (DC)	445,744	257,335	0	78,179	335,514
Grain Sorghum (DC)	7,520	3,245	0	1,340	4,585
Forage Crops[3]	89,235	19,395	xxx	11,700	31,095
Other Crops[4]	122,446	2,055	0	5,170	7,225
Total Planted Acres	3,533,209	614,520	750	581,592	1,196,862

[1]Cons. till is the sum of no-till, ridge-till and mulch-till
[2]FS = full season; DC = double crop; SpSd = spring seeded; F1Sd = fall seeded.
[3]Forage crops reported in seeding year only.
[4]Other crops include vegetable & truckcrops (e.g. peanuts, tobacco, etc.)

Microirrigation for Reduced Tillage in a Shallow Hardpan Soil

W.J. Busscher, C. R. Camp and E.J. Sadler[1]

ABSTRACT

Deep tillage is expensive and time consuming though necessary for proper root development in southeastern Coastal Plain hardpan soils. Maintaining proper water contents within or above the hardpan might maintain yield without deep tillage. Corn *(Zea mays* L.) was grown using microirrigation for three years without subsoil disruption. In three treatments, tubes were placed on the surface either in every row and between every other row or buried within every row. Mean profile soil cone indices were 1.8 to 3.2 MPa for the top 0.6 m. Cone indices were significantly different for treatment interactions by depth and by position by depth. When soil water content was considered as a covariate, cone index treatment differences disappeared. Yields varied from 9.7 to 13.0 Mg/ha. Because soil water was intensively managed, yield levels were maintained over hardpans without deep tillage for three years.

INTRODUCTION

Deep profile disruption is often necessary to provide a suitable medium for plant root growth in Coastal Plain hardpan soils (Doty et al., 1975). Root-restricting cone indices are commonly found in the E horizon of non-tilled coastal Plain subsoils even at field capacity (Campbell et al., 1974).

About 0.075 m of water per meter of soil is typical retention for sandy Coastal Plain Ultisols. Intensive irrigation is needed to provide enough water for profitable plant yield without deep tillage. Wetting the E horizon can also ameliorate its high cone index (Phene and Beale, 1976).

The objective of this paper was to compare water contents and cone indices of hardpan soils for surface and subsurface microirrigation treatments without deep tillage.

METHODS

This study was conducted between 1984 and 1987 on a Norfolk loamy sand soil (fine loamy, siliceous, thermic, Typic Paleudult) in Florence, SC. Plots were 12 by 6 m. Corn *(Zea mays* cv. O's Gold 5509[2]) was planted in twin rows separated by 0.25 m. Centers of the twin rows were 0.75 m apart.

The experimental design was randomized complete block with four replicates. Three treatments were irrigated with microirrigation tubing (Lake Drip-In). In treatment A, tubes were placed between sets of twin rows in alternate mid-rows at 1.5-m spacings; in treatment S, tubes were placed in the middle of each twin-row pair at 0.75-m spacings. The third treatment, B, had tubes buried at 0.25- to 0.30-m depths below the middle of each twin-row pair at 0.75-m spacings.

Because of the buried tube, it was not feasible to in-row subsoil each year, which is the recommended practice for this soil. All plots had been cross subsoiled at 45° angles to the rows in August 1984 prior to installation of the treatments. In early November 1984, tubes were plowed into treatment B using a steel tube attached to a subsoil shank as a guide. No plots were deep tilled thereafter.

Spring land preparation included disking followed by leveling with a tined field cultivator. Corn was planted at 74,000 plants/ha on 27 March 1985, 31 March 1986 and 14 April 1987. The same wheel tracks were maintained throughout the study. Pesticide and fertilizer were applied as recommended by the South Carolina Cooperative Extension Service (265-24-140, 270-24-46 and 260-29-84 kg/ha of N-P-K for 1985, 1986 and 1987, respectively).

If there was no rain, irrigation of 6 mm was applied daily. This was doubled if tensiometers at the 0.3-m depth indicated 25 kPa or drier. Since treatment A had half the number of tubes, irrigation ran twice as long as for treatments S and B. Irrigation was applied either continuously or in 20-min on-off pulses to improve distribution, as suggested by Busscher and Lin (1981).

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[2]Mention of trademark, proprietary product or vendor does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products or vendors that may also be suitable.

Cone indices were taken for two replicates on 23 July 1986 and 23 July 1987. Measurements were taken with a 13-mm diameter, 30° cone tip penetrometer (Carter, 1967) to a depth of 0.6 m at four positions across the row: at the midpoint within the twin-row, at one of the twin-rows, in the quarter row and in the mid-row.

Cone index data were analyzed using the general linear models procedure (GLM) of SAS (1985) with strip sub-plots for depth and position across the row (Radcliffe et al., 1989). Probability levels up to 10% were considered significant.

In 1986, a drought year, plots received a special irrigation of 25 mm before penetrometer readings were taken. In 1987 penetrometer readings were taken after a regularly scheduled 12-mm irrigation. Gravimetric soil-water contents were taken at 0.15-m depth intervals in the mid-row and in-row (midpoint within a twin-row pair) positions on penetrometer sampling dates. Water content data were also analyzed using GLM.

Cone index data were reanalyzed using only the positions where water content had been measured. Data were also reanalyzed with water content as a covariate, as recommended by Asady et al. (1987).

Tensiometers were installed in two replicates to aid in irrigation scheduling. They were located at 0.3-, 0.6-, 0.9- and 1.2-m depths at positions next to the tube, one fourth of the way to the next tube and between the tubes. Duplicate sets were located at the emitter and midway between emitters of the microirrigation tube. They were read two to three times a week until irrigation ended, at physiological maturity. Tensiometer data were analyzed using GLM with depth, position between microirrigation tubes and location with respect to the emitter as strip subplots.

After the growing season of 1986, fallow plots of four replicates of treatments S and B received 12 mm of irrigation. Gravimetric samples were taken at 0.15-m depth intervals and at 0.075-m intervals perpendicular to the tube to monitor soil-water content. Samples were taken at positions ranging from adjacent to the microirrigation tube to 0.3 m away from it. For Treatment B, a sample was not taken at the tube since that could have punctured it Gravimetric samples were taken just before irrigation and at 1 h, 24 h, 48 h and 144 h after irrigation. These data were analyzed using GLM by treatment, position away from the tube and depth to find differences of water content with time.

RESULTS AND DISCUSSION

Average yield over all types of irrigation was 11.6 Mg/ha (Table 1), indicating that Zea mays could be successfully grown for three years without deep disruption of the soil with intensive water management. Average yields were 11.1 Mg/ha and 12.2 Mg/ha for treatments A and S, respectively. These treatments were not subsoiled annually although they could have been since the microirrigation tubes were removed every fall. Treatment B had an average yield of 11.5 Mg/ha. It could not have been subsoiled without destruction of the buried tube. In 1986 South Carolina experienced a severe drought. During periods of excessive heat, maintaining proper soil water was difficult, and yield was reduced on all treatments. A detailed discussion of the irrigation schedule can be found in Camp et al. (1989).

Deep tillage of all plots was necessary in August 1984 to prevent treatment B from having an advantage since the buried tube was installed with a subsoiler. Higher yields for all treatments in 1985 (Table 1) may have been a result of the 1984 subsoiling.

No cone indices were taken until July 1986 to permit reconsolidation of the disrupted subsoil (Busscher et al. 1986). Analysis of cone index data showed statistically significant treatment interactions for 1986 and 1987 by depth and depth by position. In 1987 there was also a position by treatment difference. Cone indices were higher for treatment A than for treatments S and B in both years, although in 1987 the difference over treatment S was marginal (Table 2). When analyzed by depth, treatments that had significantly higher cone indices also had lower soil water contents (Table 3). This trend was also seen for the means but not as rigorously as for the comparisons by depth.

For all treatments, cone index increased with depth from the surface to the 0.20-m depth, which was within the hardpan (Table 2). Cone indices then decreased until the 0.35-m to 0.50-m depth where they began to increase again. Treatment S had the highest mean soil water content both years, though

Table 1. Corn yield.

Tube placement	Yield 1985	1986	1987
	------------	mg/ha	------------
A	13.0	09.7	10.7
B	12.6	10.8	11.2
S	12.5	11.6	12.4

Table 2. Mean cone indices for each treatment and depth.

	Cone Index (MPa)					
	1986			1987		
	Treatment					
Depth	A	B	S	A	B	S
--m--	MPa					
0.00	0.31a[1]	0.55a	0.46a	0.27a	0.20a	0.16a
0.05	0.86a	1.43a	1.02a	0.65a	0.53b	0.38b
0.10	1.84a	2.06a	1.57a	1.30a	1.17a	1.04a
0.15	3.09a	2.71a	2.45a	3.02a	2.79a	2.62a
0.20	4.02a	3.05a	2.62a	3.48a	3.65a	3.03a
0.25	3.54a	2.768	2.41a	3.02a	3.34a	2.94a
0.30	3.48a	2.30a	1.95a	2.61a	2.70a	2.44a
0.35	2.81a	1.91ab	1.60b	2.52a	2.24a	2.39a
0.40	2.36a	1.58ab	1.23b	2.40a	1.79a	2.74a
0.45	2.63a	1.53b	1.27c	2.87a	1.93b	3.25a
0.50	4.45a	1.43b	1.47b	4.53a	3.37a	4.66a
0.55	5.46a	1.84b	2.09b	5.15a	4.76a	5.46a
0.60	6.18a	2.26a	2.87a	5.84a	5.08a	6.09a
Mean	3.16a	1.95a	1.77a	2.90a	2.58a	2.86a

'Means with the same letter are not significantly different for depth.

Table 3. Mean soil water contents taken at the time of cone index measurement

	Water content					
	1986			1987		
	Treatment					
Depth	A	B	S	A	B	S
--m--	kg/kg					
0.08	0.159	0.157	0.170	0.146	0.182	0.205
0.23	0.131	0.133	0.148	0.127	0.140	0.144
0.38	0.167	0.159	0.193	0.156	0.164	0.178
0.53	0.161	0.174	0.181	0.141	0.164	0.154
Mean	0.154a[1]	0.156a	0.173a	0.142a	0.162b	0.170b

'Means with the same letter are not Significantlydifferent.

it was significantly higher than treatment A only in 1987.

Cone index data were reanalyzed using only positions where water content had been measured. Treatment differences with depth in 1986 and with position by depth in 1987 were still significant. When these data were reanalyzed with water content as a covariate, treatment interactions disappeared. The water content effect on cone index was not significant in 1986; however, including it in the analysis prevented the significance of the treatment interactions.

Low matric water tension was maintained throughout the growing season (Fig. 1 and 2). Tensiometer readings varied with depth, generally decreasing with increasing depth early in the growing season and fluctuating later. Interactions of the treatments with depth and positions across and along the row were significantly different for both years. When the data were analyzed by depth and by position across and along the row, the 0.9-m depth in treatment B usually had the lowest overall matric tension in 1986 (Fig. 1). Treatment B does not have the lowest matric tension at the depth of the tube, presumably because increased root growth increases water losses from the zone.

The largest fluctuations of soil water tension were at the soil surface (Fig. 1 and 2). This was

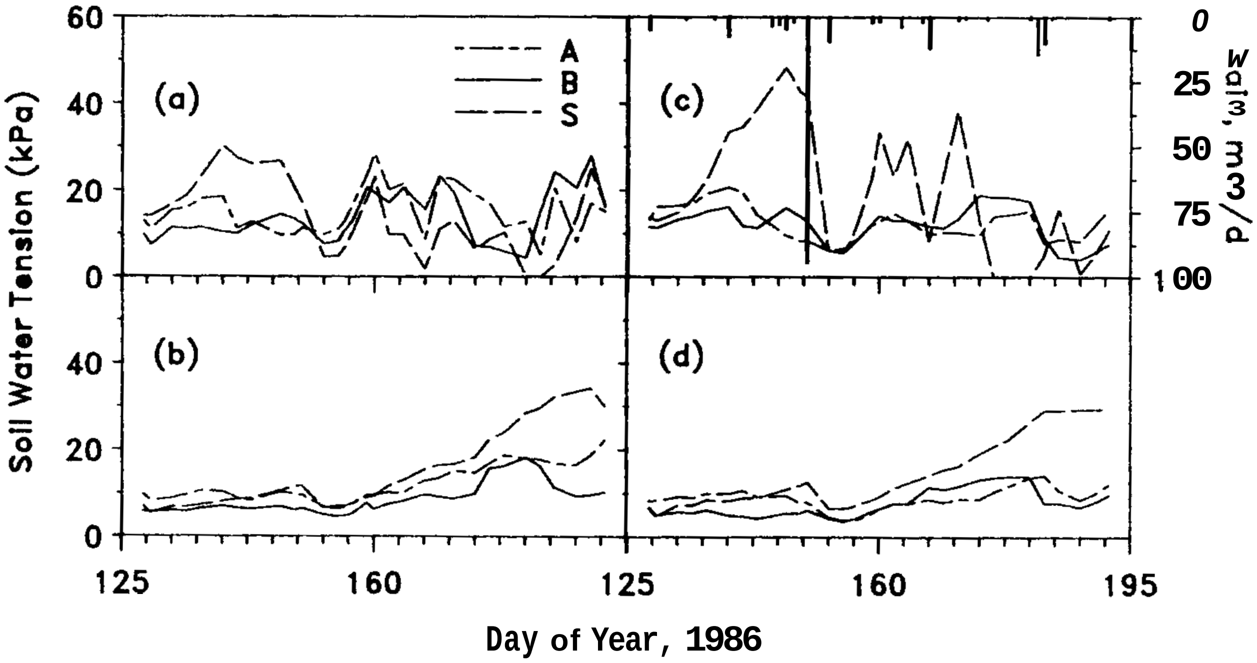

Fig. 1. Soil matric tensions for 0.3-m (a) and 0.9-m (b) depths at the microirrigation tube and for 0.3-m (c) and 0.9-m (d) depths midway between tubes for 1986. The means of readings at the emitter and between emitters were taken before plotting.

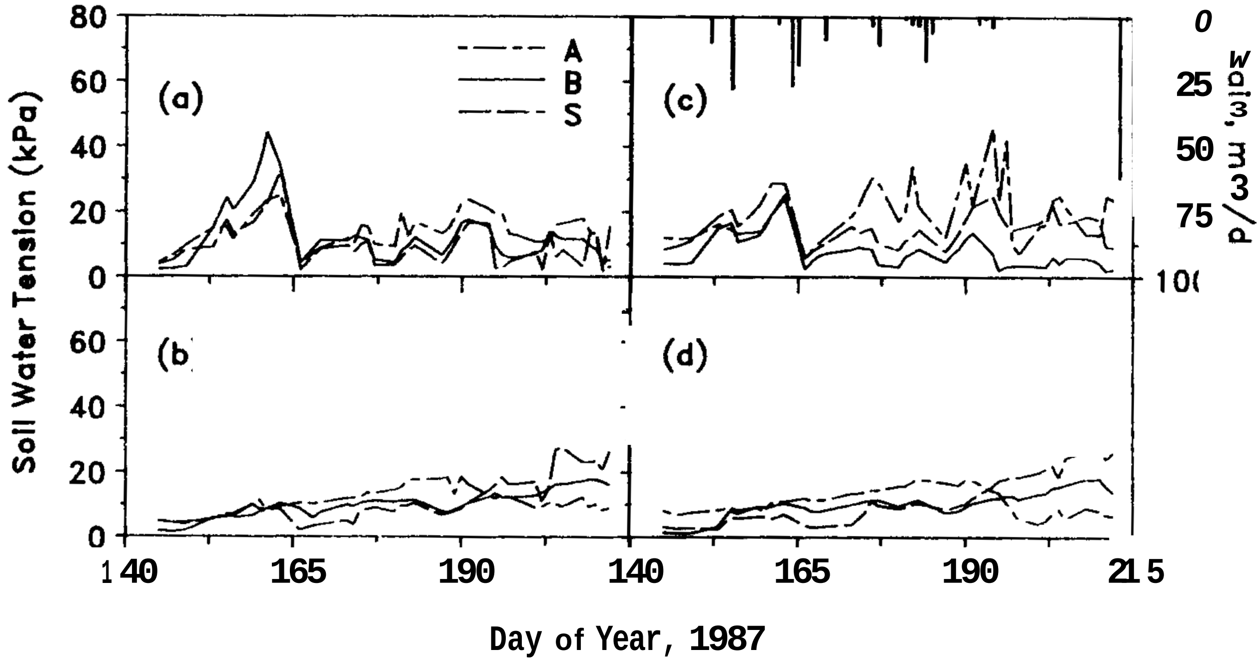

Fig. 2. Soil matric tensions for 0.3-m (a) and 0.9-m (b) depths at the microirrigation tube and for 0.3-m (c) and 0.9-m (d) depths between adjacent tubes for 1987. The means of readings at the emitter and between emitters were taken before plotting.

expected because of root growth and rainfall. Figures 1 and 2 also show a rise of water tension with time at the 0.9-m depth in 1986, a drought year, but not in 1987.

Gravimetric samples taken on bare treatments S and B before and after a 12-mm irrigation in 1986 showed differences in soil wetting patterns, but the water contents for the treatments were not significantly different. However, when data were analyzed by position across the row, treatment wetting patterns did show significant differences (Table 4). During this test, as well as throughout the growing season, water from the tubes of treatment S spread out across the surface before infiltrating. This is seen by the rise in water content at shallow depth 1 hour after initiation of irrigation (Table 4). Occasionally, wet spots were noticed on the surface above the emitters of the buried tubes. However, the wet area was seldom more than 0.1 m in radius. This implies that treatment B would have lower evaporation but may be more susceptible to water losses to deep percolation. Treatment S retained more water in the soil.

LITERATURE CITED

1. Asady, G. H., J. E. Hook and E. D. Threadgill. 1987. Tillage induced modifications of cone index and bulk density in a Coastal Plain sandy soil. Agron. Abst. p. 235.
2. Busscher, W. J., and C. F. Lin. 1981. Simulated flow from discontinuous clogged and unclogged sources. Math. Comput. Simul. 23:384-388.
3. Busscher, W. J., R. E. Sojka and C. W. Doty. 1986. Residual effects of tillage on Coastal Plain soil strength. Soil Sci 141:144-148.
4. Camp, C. R., E. J. Sadler and W. J. Busscher. 1989. Subsurface and alternate middle micro irrigation in the southeastern Coastal Plain. Trans ASAE 32(2):451-456.
5. Campbell, R B., D. C. Reicosky and C. W. Doty. 1974. Physical properties and tillage of Paleudults in the southeastern Coastal Plains. J. Soil Water Conserv. 29(5):220-224.
6. Carter, L. M. 1967. Portable penetrometer measures soil strength profiles. Agric. Eng. 48:348-349.
7. Doty, C. W., R. B. Campbell and D. C. Reicosky. 1975. Crop response to chiseling and irrigation in soils with a compact A2 horizon. Trans. ASAE 18(4):668-672.
8. Phene, C. J., and O. W. Beale. 1976. High-frequency irrigation for water nutrient management in humid regions. Soil Sci. Soc Am. J. 40:430-436.
9. Radcliffe, D. E., G. Manor, R L. Clark, L. T. West, G. W. Langdale and R. R. Bruce. 1989. Effect of traffic and in-row chiseling on mechanical impedance. Soil Sci. Soc.Am. J. 53:1197-1201.
10. SAS Institute, Inc. 1985. SAS Users Guide: Statistics. SAS Institute, Cary, NC.

Table 4. Soil water **contents** for **five positions** across **the** rows *of* bare plots **before and after** Irrigation.

	Position									
	0		0.076		0.152		0.228		0.304	
Time	S	B	S	B	S	B	S	B	S	B
---h---	kg/kg									
0	0.1%'	--	0.1%	0.13c	0.14b	0.13a	0.14ab	0.13a	0.13b	0.13a
1	0.18a	--	0.17a	0.15a	0.1%	0.14a	0.15a	0.1%	0.14ab	0.14a
24	0.15b	--	0.16ab	0.15ab	0.14b	0.14a	0.14b	0.14a	0.14ab	0.14a
48	0.14bc	--	0.14bc	0.14abc	0.14ab	0.14a	0.15ab	0.14a	0.14ab	0.14a
144	0.14bc	-	0.14c	0.13bc	0.14ab	0.13a	0.15b	0.14a	0.15a	0.14a

'Times with the same letter are not significantly different.

Conservation Tillage and Water Quality

T.C.Daniel[1]

INTRODUCTION

Conservation tillage (CT) systems have become increasingly popular because they offer the grower an opportunity to save time and fuel without a reduction in yield. The systems are also popular with resource managers because of their potential to protect and preserve the quality of surface and ground water. Because of this, CT is being looked to as an ideal best management practice (BMP); however, to achieve water quality production as well as production benefits, different management is required. For example, no-till may dramatically reduce erosion rates but increase phosphorus (P) concentration in the runoff.

Before individual CT systems can be evaluated, an identification of various accepted CT systems is in order. There are probably as many different CT systems as growers, and while terminology varies widely, the generally accepted systems include chisel plow (CH), till-plant (TP) and no-till (NT) with the standard of comparison being the conventional (CN) system.

SURFACE WATER

Runoff and Erosion

Contaminants are transported dissolved in the runoff water or adsorbed to the sediment. The effect that CT systems have on these two important transport mechanisms determines their ultimate impact on water quality. Studies have shown that CT systems are highly effective in reducing soil loss relative to the CN system. The effectiveness of NT in reducing sediment concentrations and soil loss, relative to other CT systems, has been mostly ascribed to increased residue cover (Laflenand Colvin, 1981). However, the success of the NT system in reducing runoff volumes has been variable. The majority of studies (such as McGregor and Greer, 1982) have shown reduced runoff with NT; however, a limited number report little or no reduction (Mueller et al., 1984). The CH and TP systems may also substantially reduce soil loss compared to CN tillage (Johnson and Moldenhauer, 1979). Relative to CN tillage, CH and TP svstems have reduced both sediment concentrations and runoff volumes. Several studies have reported that soil loss reductions for the CH system were similar to those for NT (Griffith et al., 1977). Laflen et al. (1978) found the CH and TP systems to be less effective than NT but more effective than CN tillage in reducing soil loss.

Most scientists agree that relative to CN tillage, all the CT systems do a good job in reducing soil loss. While less firm in their conviction, most scientists also agree that CT systems generally reduce runoff. The inconsistency among studies as to the effect of CT on runoff data relates primarily to NT.

Phosphorus Loss

Phosphorus availability most often limits biological productivity in surface waters (Schindler, 1977). Consequently, increased input of available P in fresh water lakes and streams will often result in concomitantly increased growth of aquatic weeds and algae. Thus, reducing the amount of available P in runoff is a logical means of reducing the impact of agriculture on accelerated rates of eutrophication.

Maintenance of crop residues may limit fertilizer placement options and thus affect nutrient concentrations and losses (Baker and Laflen, 1983). Total P losses have generally been found to decrease due to soil loss reductions with CT systems (Mueller et al., 1984). However, studies have also indicated that concentrations and losses of dissolved P can substantially increase when CT is used (McDowell and McGregor, 1980; Johnson et al., 1979). Investigators generally attribute such increases to unincorporated fertilizer P and to a release of P from crop residues (Timmons et al., 1973; Wendt and Corey, 1980). In a study by Mueller et al. (1984) in which fertilizer was banded, concentrations and losses of dissolved P from CT treatments were similar to those from conventionally tilled plots, and concentrations and losses of algae-available P were reduced by CT. These researchers also demonstrated a dramatic increase in P loss relative to CN when manure was applied to NT and most of the runoff P occurred in the dissolved form. Andraski et al. (1985) later confirmed the ability of CT systems to reduce dissolved P load over CN tillage provided the fertilizer is banded (incorporated).

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Total P loss is decreased with CT systems due to reduced soil loss. The effect of CT on dissolved P loss depends on whether or not the fertilizer or manure is soil incorporated. Generally, when the material is incorporated, the P loss is reduced; when the material is not incorporated, significant increases in P loss can occur. The controversy appears to focus on NT because the materials are not incorporated into the soil. However, with some modification such problems can be circumvented. For example, manure application on NT is not a recommended practice from either a production or a water quality stand-point. The application of manure to an already high residue system only increases the probability of production problems and virtually ensures water quality degradation. A light incorporation of the manure reduces the potential for weed, temperature and planting problems and dramatically lowers P loss.

Pesticide Loss

Conservation tillage systems may have a detrimental effect on surface water quality due to increased runoff losses of pesticides. Reasons for this concern stem largely from the increased use of and reliance on chemicals for weed and insect control with CT systems.

Atrazine and alachlor are two widely used herbicides. Several researchers have monitored runoff losses of these compounds from agricultural land under a variety of conditions (Hall et al., 1983).

Ritter et al. (1974) reported that atrazine runoff from a TP watershed over a two-year period was only 24% of that from CN. No-till watersheds in Ohio showed reductions in atrazine runoff losses as compared to CN watersheds, while average loss for all watersheds was < 2% of the active ingredient applied (Triplett et al., 1978). Baker et al. (1982) compared six tillage systems on three Iowa soils and found reduced alachlor losses due to decreased runoff and erosion with CT systems. However, this reduction was diminished by higher herbicide concentrations in runoff water and sediment from these systems. Baker and Johnson (1979) compared CN, TP and CH systems with respect to both atrazine and alachlor runoff losses on six small watersheds. Again, decreased runoff and erosion with CT systems relative to CN tillage resulted in decreased herbicide losses, while concentrations of the compounds in sediment and/or runoff water were sometimes higher for CT systems.

In Pennsylvania, CN tillage combined with light incorporation of atrazine and strip cropping provided herbicide runoff control equivalent to CT (Hall et al., 1983). Baker and Laflen (1983) reported lower atrazine and alachlor losses when these compounds were incorporated rather than surface-applied. Runoff losses of atrazine and alachlor were 1.6 and 1.7%, respectively, when incorporated and 18.3 and 22.1%, respectively, when the compounds were surface-applied. Sauer and Daniel (1987) demonstrated that CT systems, especially NT and TP, could result in higher loss of some pesticides depending on time and intensity of rainfall. Intense rainfall soon after application resulted in higher atrazine loss with NT and TP relative to CN. Lowest pesticide loss occurred with the CH system regardless of conditions. In all cases, most (80%) of the atrazine loss was dissolved in the runoff, not attached to the sediment. For those compounds attached to the sediment, such as chlorpyrifos, CT systems resulted in dramatic reduction in loss when compared to CN.

Soil incorporation of pesticides reduces loss in the runoff; however, the most popular application method even for the CN is pre-emerge without incorporation. For compounds transported by the sediment, such as chlorpyrifos, CT dramatically reduces the loss because of the reduced sediment load. Reducing the loss of compounds transported in the runoff water, such as atrazine, can be accomplished only through a reduction in total runoff volume, and the BMP strategy should reflect this approach. Should reduction in runoff not be sufficient to reduce total pesticide loss with high residue systems such as NT, use of the CH system should be considered. This system has two distinct advantages: it appears to consistently reduce runoff volumes, and incorporation of the pesticides can be an inherent step in normal land preparation.

GROUND WATER

Contamination of groundwater by agricultural chemicals has become a national concern. This attention is appropriate because approximately 95% of all rural households depend on ground water for their drinking water supply. Concurrently, concern has been raised regarding the impact of CT on ground water quality. The effect of CT on ground water quality is not clear; in some situations research has demonstrated increased potential for contamination, while in others quite the opposite has been shown to occur. Generally, the contaminants of concern are nitrates and pesticides because P has been shown to be relatively resistant to leaching.

Nitrate Loss

Thomas et al. (1981) noted that., under Kentucky conditions, considerably more nitrogen (N) leached below 90 cm in a NT sod system than in a CN treatment.. These workers indicated that the leached N came largely from surface-applied ammonium nitrate and that there was a potential for greater leaching of N in CT systems than in CN systems. Their results are consistent with greater infiltration into a soil already at a higher moisture content and containing more continuous pores (Goss et al., 1978). Until recently, essentially all work showed that CT resulted in greater infiltration and it became accepted that greater leaching also occurred. However, recent work has shown that this assumption is not always correct. Kanwar et al. (1985), working on a loam soil in Iowa, observed much less leaching of N in NT as compared to CN. The following interpretation is offered to explain the discrepancy. In each case the majority of the drainage water is transported by large pores in the NT. In the Kentucky situation, this allowed the water containing the surface-applied fertilizer N to move deeper and faster into the soil, thus deeper N movement was observed. In the Iowa example, the nitrate was present in the soil profile where less interaction occurred with the water that moved in the large pores. Thus, less nitrate leaching was observed.

Pesticide Loss

Various researchers (such as Dick et al., 1986) have documented increased penetration of water and surface-applied chemicals under CT systems when compared to CN. Helling et al. (1988) and Isensee et al. (1988) reported that small amounts of surface-applied herbicides could be transported to depths greater than 1 m in NT fields. These authors also found preferential water flow to be an important method of transport on the soil studied, particularly when significant rainfall events occurred shortly after pesticide application.

Chlorpyrifos and carbofuran are the most commonly used insecticides on field corn. Chlorpyrifos has a strong affinity for soil colloids and has been found to resist leaching (Pike and Getzin, 1981). Carbofuran, on the other hand, is less adsorbed to the soil and thus is more mobile in the unsaturated zone (Felsot and Wilson, 1980). Several researchers have found carbofuran to be susceptible to leaching. Read and Gaul (1983) found carbofuran to leach past a depth of 45 cm in a sandy soil in 130 days with 43.5 cm of rainfall. In addition, carbofuran has been extensively detected in groundwater as a result of normal field use (Holden 1986). Fermanich and Daniel (1991) showed that twice as much carbofuran leached through the root zone of CN systems as through the root zone of NT systems, and it was postulated that greater decomposition and attenuation of carbofuran occurred under NT.

Research information is just becoming available on the effect of CT on ground water quality; however, preliminary results do indicate that management practices are important. For example, surface application of chemicals in a NT system appears to increase the probability of rapid transport through the soil profile. Should this prove to be the case, alternative CT systems such as CH may prove satisfactory because the tillage operation destroys the continuous pores responsible for the bulk of the transport.

SOUTHERN REGION AND ARKANSAS

The potential for increased use of CT in the southern region and in Arkansas is high. The variety of crops and the potential for double cropping provide numerous opportunities for integration of the CT concept. As growers and researchers in this region know, management changes are required to maintain present production levels. Maintaining water quality goals under these systems will also require adjustment and planning. Integration of proper timing and placement of fertilizer and manure with CT systems can ensure maintenance of water quality. However, the potential for increased pesticide loss under CT systems in the southern region is a problem. Runoff loss of herbicides is of particular concern because of the year-long weed pressure and the intensity of the storms that coincide with application. Innovative approaches require development and testing. For example, perhaps a winter cover crop that provides N credits can be incorporated into a CT system that leaves sufficient residue to reduce runoff during the critical period. Double cropping also offers some interesting opportunities to reduce pesticide input while maintaining residue cover.

LITERATURE CITED

1. Andraski, B.J., D.H. Mueller and T.C. Daniel 1985. Phosphorus loss in runoff as affected by tillage. Soil Sci Soc. Am. J 49:1523-1527.
2. Baker, J.L., and H.P. Johnson. 1979. The effect of tillage systems on pesticides in runoff from small watersheds. Trans. ASAE 22:554-559.
3. Baker, J.L., and J.M. Laflen. 1983. Water quality consequences of conservation tillage. J. Soil Water Conserv. 36:136-193.

4. Baker, J.L., J.M. Laflen and R.O. Hartwig. 1982. Effects of corn residue and herbicide placement on herbicide runoff losses. Trans. ASAE 21:886-892.

5. Dick, W.A., W.E. Edwards and F. Highiri. 1986. Water movement through soil to which no-tillage cropping practices have been continuously applied. pp. 243-252. *In* T.J. Logan et al. (ed.). Effects of conservation tillage on groundwater quality-nitrates and pesticides. Chelsea, MI: Lewis Publ.

6. Felsot, A., and J. Wilson. 1980. Adsorption of carbofuran and movement on soil thin layers. Bull. Environ. Contam. Toxicol. 24778482.

7. Fermanich, K.J. and T.C. Daniel. 1991. Pesticide mobility and persistence in microlysimeter soil columns from a tilled and notilled plot. J. Environ. Qual. 20195-202

8. Goss, M.J., K.A. Hawse and W. Harris. 1978. Effects of cultivation on soil water retention and water use by cereals in clay soils. J. Soil Sci. 29:475-488.

9. Griffith, D.R., J.V. Manneringand W.C. Moldenhauer. 1977. Conservation tillage in the Eastern Corn Belt. J. Soil Water Conserv. 32:20-28.

10. Hall, J.K, N.L. Hartwig and L.D. Hoffman. 1983. Application mode and alternate cropping effects on atrazine losses from a hillside. J. Environ. Qual. 12:336-340.

11. Helling, C.S., W. Zhuang, T.J. Gish, C.B. Coffman, A.R. Isensee, P.C. Kearney, D.R. Hoagland and M.D. Woodward. 1988. Persistence and leaching of atrazine, alachlor, and cyanazine under no-tillage practices. Chemosphere 17:175-187.

12. Holden, P.W. 1986. Pesticides and groundwater quality: Issues and problems in four states. Natl. Academy Press, Natl. Res. Counc., Board on Agric., Washington, D.C.

13. Isensee, A.R., C.S. Helling, T.C. Gish, P.C. Kearney, C.B. Hoffman and W. Zhuang. 1988. Groundwater residues of atrazine, alachlor, and cyanazine under no-tillage practices. Chemosphere 17:165-174.

14. Johnson, H.P., J.L. Baker, W.D. Shrader and J.M. Laflen 1979. Tillage system effects on sediment and nutrients in runoff from small watersheds. Trans. ASAE 22:1110-1114.

15. Johnson, C.B., and W.C. Moldenhauer. 1979. Effect of chisel versus moldboard plowing on soil erosion by water. Soil Soc.Am. J. 43:177-179.

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

17. Laflen, J.M., J.L. Baker, RO. Hartwig, W.F. Buchele and H.P. Johnson. 1978. Soil and water loss from conservation tillage systems. Trans. ASAE 21:881-885.

18. Laflen, J.M., and T.S. Colvin. 1981. Effect of crop residue on soil loss from continuous row cropping. Trans. ASAE 24:605-609.

19. McDowell, L.L., and KC. McGregor. 1980. Nitrogen and phosphorus losses in runoff from no-till soybeans. Trans. ASAE 23:643-648.

20. McGregor, KC., and J.D. Greer. 1982. Erosion control with no-till and reduced till corn for silage and grain. Trans. ASAE 25:154-159.

21. Mueller, D.H., RC. Wendt and T.C. Daniel. 1984. Soil and water losses as affected by tillage and manure application. Soil Sci. Soc. Am. J. 48:2396-900.

22. Pike, K.S., and L.W. Getzin. 1981. Persistence and movement of chlorpyrifos in sprinkler-irrigated soil. J. Econ. Entomol. 74:386-388.

23. Read, D.C., and S.O. Gaul. 1983. Movement and residual toxicity of carbofuran in acid mineral soil. Agric. Ecosys. Environ. 1551-61.

24. Ritter, W.F., H.P. Johnson, W.G. Lovely and M. Molnau. 1974. Atrazine, propachlor, and diazinon residues on small agricultural watersheds. Environ. Sci. Tech. 83842.

25. Sauer, T.J., and T.C. Daniel. 1987. Effect of tillage system on runoff losses of surface-applied pesticides. Soil Sci. Soc.Am. J. 51:410-415.

26. Schindler, D.W. 1977. Evolution of phosphorus limitation in lakes. Science 195260-262.

27. Timmons, D.R., R.E. Burwell and RF. Holt. 1973. Nitrogen and phosphorus losses in surface runoff from agricultural land as influenced by placement of broadcast fertilizer. Water Resour. Res. 9:658-667.

28. Thomas, G.W., K.L. Wells and L. Murdock. 1981. Fertilization and Liming. pp. 43-54. *In:* RE. Phillips et al. (eds.). No tillage research: Research reports and reviews. Lexington, KY: Univ. KY.

29. Triplett, G.B., B.J. Conner and W.M. Edwards. 1978. Transport of atrazine and simazine in runoff from conventional and no-tillage corn. J. Environ. Qual. 7:77-84.

30. Wendt, R.C., and RB. Corey. 1980. Phosphorus variations in surface runoff from agricultural lands as a function of land use. J. Environ. Qual. 9:130-136.

A Comparative Study of the Influence of Two Tillage Systems on Soybean Production, Soil Properties and Nutrient Uptake

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ABSTRACT

Due to savings in fuel, labor and machinery, conservation tillage is generally more economical even with equal, or slightly reduced, yields relative to conventional tillage (CN). Because of its increased potential for double-cropping, for reduced soil erosion and for reduced environmental pollution and due to its various other advantages, conservation tillage is attractive to growers and is becoming increasingly popular. Tennessee State University has been involved in a study of no-till (NT) soybeans for the last several years. This study is being conducted on a Byler silt loam soil, which is moderately well-drained with about 5% land slope. Perennial weeds have not generally been a problem on this site.

In seven years of side-by-side comparison of NT and CN, soybean yields in NT were equal to those in CN. No significant bulk density difference in the two tillage systems was found after five years under our conditions on a medium-textured silt loam soil. However, research elsewhere in Tennessee has shown that silt loam soils are less likely to compact than sandy or heavy clay soils. Organic matter levels were also higher in NT.

Even though we did not use any nitrogen fertilizer, we found that NT surface soil had a tendency to be acidic at the end of five years. However, this condition was easily ameliorated by surface application of lime to the soil.

Some growers are skeptical of surface stratification of fertilizer elements with continued surface application of fertilizers in no-till. This research has shown that generally such surface accumulations of nutrients do not occur. Available phosphorus, potassium, calcium and magnesium content of soil was practically equal in the two tillage systems after five years of continuous experimentation. Similarly, with the exception of seed nitrogen, plant nutrient-uptake remained uninfluenced by tillage. Seed nitrogen tended to be higher in NT than in CN.

In conclusion, in five to eight years of experimentation with soybeans, NT has been equal or superior to CN in regard to yield, soil properties and nutrients. Potential savings in fuel, labor and soil should more than make up for the added possible seed, herbicide and lime costs in NT. However, these results may be different under other soil and growing conditions, especially if heavy soils, poorly drained soils or perennial weeds are a problem.

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INTRODUCTION

Because of savings in fuel, labor and machinery, conservation tillage is generally more economical with equal, or even slightly reduced, crop yields in conservation tillage. Due to its potential for double-cropping, for reduced soil erosion and for reduced environmental pollution and due to its other advantages, conservation tillage is generally attractive to farmers and is becoming increasingly popular.

OBJECTIVES

This research, initiated in 1981, sought to study the influence of two tillage systems, conventional (CN) and no-till (NT), (1) on the performance and yield of soybean *(Glycine max* (L.) Merrill) (var. Forrest), (2) on soil pH and soil organic matter (OM) and (3) on the dynamics of soil-nutrients and plant-uptake of these nutrients.

METHODS

This research was conducted for eight years on a Byler silt loam soil (Typic Fragiudalf). An old sod-field, uncultivated for at least 15 years, was utilized for the study. The two tillage systems, CN and NT, were main plots in a split-plot statistical design. The splits were comprised of three herbicides in the first four years. Five potassium (K) rates (0. 45, 90, 135 and 180 kg %O/ha) were superimposed on the main tillage plots during the last four years of the study. Conventional tillage consisted of plow/disc and plant; the NT consisted of either glyphosate or paraquat application and planting with a no-till planter. Main plots measured 29 x 4.6 m with 4.6 x 4.6 m. sub-plots. Soybean yields were determined, except in

1989. Soil pH, OM and soil N, P, K, Ca and Mg were monitored, and seed and leaf nutrient-uptake by soybeans was measured at four- to five-year intervals. However, this paper reports, in addition to the soybean yields, the soil properties/plant nutrient uptake after the initial five years.

RESULTS

Growth/Yield

Seven-year data indicated that soybean general plot population and growth (vigor, height) in NT compared favorably with those of CN (data not shown). Grain yields in NT were equal to or better than those in CN (Table 1.

Table 1. Soybean **yields (kg/ha)** as Influenced by tillage.

Year	Tillage CT'	NT
1981	2138	2075
1982	2263	2201
1983	1446	1572
1984	2263	2452'
1985	---	---
1986	2452	2578
1987	1760	1949
1988	3049	3074
Average	2225	2194

* Statistically different at P = 0.05
[1]CT = conventional tillage; NT = no-till

Soil pH, Organic Matter and Soil Nutrients

Soil pH tended to be lower in NT than in CN (Table 2) as expected after five years of no-tillage. Soil organic matter levels were generally higher in NT than in CN. Available P, K, Ca and Mg content of the soil was not significantly different after five years of continuous experimentation.

Plant Nutrient Uptake

With the exception of seed N, plant nutrient uptake remained uninfluenced by tillage (Table **3).** Seed N tended to be higher in NT than in CN.

CONCLUSION

In five to eight years of experimentation with soybeans, NT has been equal or superior to CN in regard to yield, soil properties, soil nutrients and plant nutrient-uptake. Potential savings in fuel and labor costs should more than make up for the added possible seed, herbicide and lime costs in NT.

In the case of NT, the potential for reduced soil erosion and reduced pollution, with lower overall operating/capital costs, should make this method of cultivation an excellent choice under most soil/climatic conditions.

Table 2. Effect of tillage on **pH,** organic matter and roil nutrients.

Soil property/ Nutrient	Tillage	Soil depth (cm) 02.5	2.55	5-10	1015	15-30	Ave
pH	CT'	6.31	6.26A[2]	6.03A	6.08	6.34	6.16A
	NT	6.38	6.06B	5.888	6.10	6.32	6.058
	Ave.	6.34P[3]	6.06Q	5.91Q	6.09R	6.33P	
Organic matter (%)	CT	1.98A	1.92A	1.65	1.51	0.85	1.57A
	NT	2.728	1.868	1.70	1.49	0.88	1.81B
	Ave.	2.36P	1.89Q	1.68R	1.50s	0.87T	
P (ppm)	CT	111.2	128.4	135.2	139.2	72.4	119.6
	NT	124.8	140	146	151.2	80	130
	Ave.	118P	134.4Q	140.8QR	145.2R	76.4S	
K (ppm)	CT	74.4	48.8	36.4	32.8	25.2	44
	NT	70.4	53.6	37.2	30	25.6	43.2
	Ave.	72.4P	51.2Q	36.8RS	31.2ST	25.2T	
Ca (ppm)	CT	1508	1600	1576	1644	1416	1552
	NT	1760	1320	1448	1624	1392	1520
	Ave.	1640P	1456QR	1512PQR	1636P	1404R	
Mg (ppm)	CT	100	54	47.2	51.2	50.8	60.4
	NT	92	56.8	*50*	46.4	46	57.6
	Ave.	96P	55.4Q	48.8R	48.8R	48.4R	

[1]CT = conventional tillage: NT = no-till
[2]**A,B = Statistically** significant (*P* = .05) differences within each depth by **F** test.
[3]**P,Q,R,S,T = Statistically** significant (f = .05) differences between depths by Duncan Multiple Range Test.

Table 3. Effect of tillage on plant nutrient uptake.

Nutrient	Tillage		K rate (kg K_2O/ha)				
	CT[1]	NT	0	45	90	135	180
Leaf N	4.4	4.6	4.5	4.4	4.3	4.6	4.4
Leaf P	0.28	0.29	0.28AB[2]	0.29A	0.29AB	0.29AB	0.276
Leaf K	1.2	1.4	1.1A	1.2A	1.2A	1.46	1.5C
Leaf Ca	1.19	1.13	1.21	1.13	1.16	1.15	1.13
Leaf Mg	0.39	0.39	0.44A	0.396	0.36C	0.38BC	0.37BC
Seed N	6.3P[3]	6.5Q	6.3	6.5	6.5	6.3	6.3
Seed P	0.60	0.61	0.61	0.60	0.61	0.61	0.60
Seed K	1.8	1.9	1.78A	1.84AB	1.90BC	1.94BC	2.0C
Seed Ca	0.23	0.24	0.22A	0.23AB	0.256	0.23AB	0.24AB
Seed Mg	0.20	0.20	0.20	0.20A	0.20A	0.20A	0.216

[1]CT = conventional tillage; NT = no-till

[2]A,B,C = Statistically significant (P = .05) differences betwenn K rates by Duncan Multiple Range Test.

[3]P,Q = Statistically significant (P = .05) differences between two tillages by F test.

Field Demonstration of Effects of Various Crop Residues on No-Till Farming

Larry D. Farris[1]

INTRODUCTION

No-till farming is a practice that has been used in Arkansas, on a limited basis, since the early 1960s. For the most part, no-tilling in Arkansas has been confined to planting double-cropped soybeans in wheat stubble. This double cropping no-till practice has been perfected to the extent that most farmers who chose to try it have acceptable success. However, little work has been done in Arkansas on using the no-till method on other major cash crops.

For that reason a field demonstration of no-till grain sorghum, soybeans, field corn and cotton was initiated in 1990. The Soil Conservation Service, in cooperation with ICI Americas, agreed to establish the project to demonstrate the effect various types of crop residues have on no-till stand establishment and weed control.

PLOT LOCATION AND SOILS INFORMATION

The demonstration plots are located on the Bussey Ray farm in eastern Lonoke County, Arkansas, approximately 15 miles east of the greater Little Rock area. The four crops to be grown in the demonstration are normally grown in this area. The soils on the plot are Keo silt loam 0-1% and Hebert silt loam 0-1%. Both of these soils are moderately well-drained, deep soils. The cropping history of the land has been cotton and soybeans as well as small grain cover crops.

PLOT DESIGN AND ARRANGEMENT

The demonstration plots were established in the spring of 1990. In order to set up the plots and be able to use the farmer's equipment, the land was conventionally tilled and bedded on 38-in. rows. Each of the four crops--cotton, corn, grain sorghum and soybeans--was planted in plots 36 rows wide. Herbicides were applied as needed to control weeds, and the crops were allowed to grow to maturity. The crops were then either harvested or destroyed and the residue left undisturbed on the soil surface.

In the spring of 1991 all plots will be planted no-till. Each of the four large plots will be divided into four sub-plots. Each of the four plots (residues) will have each of the crops planted on them. For example, the cotton plot will have corn, grain sorghum, soybeans and cotton planted no-till into the existing cotton residue. The corn and grain sorghum will be planted on or about 15 April with the soybeans and cotton planted on or about 1 May.

OBSERVATIONS OF PLOT RESPONSES

Each of the plots will be monitored to see what effect the type of residue has on stand establishment, seedling vigor and weed control. Shortly after seedling emergence, plant populations will be taken and a comparison made of the number of plants in 100 ft of row of each of the crops in each of the residues.

As the growing season progresses, observations will be made to note any differences between treatments in vegetative growth and reproductive responses. At the end of the growing season, yield estimates will be made on each of the crops in each of the residue treatments.

Throughout the growing season, data will be collected on both weed species and populations in each of the plots. Comparisons will be made to see how the type of residue affects the ability to control weeds with the no-till herbicide programs selected. These observations will be compared to last year's weed population information when the plots were conventionally tilled.

SUMMARY

If the objectives of this project are met, we will be able to demonstrate the effect that residue has on no-till stand establishment, seedling vigor and weed control in corn, grain sorghum, soybeans and cotton in Arkansas. On-farm demonstrations of no-till systems such as these will provide information that can be used to effectively develop criteria for no-till farming in this area. It is hoped that this type of demonstration work can be continued and possibly expanded in Arkansas.

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Preliminary Weed Control Evaluations in Conservation Tillage Cotton in Arkansas: Problems and Plans

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INTRODUCTION

One of the major concerns of conservation tillage systems is weed control (Brown and Whitwell, 1985; McWhorter and Jordan, 1985 Webber et al., 1987; Witt, 1984). Traditionally, weed control in cotton includes preventive measures prior to weed establishment, the goal being to control all weeds regardless of the means required. Typically, a dinitroaniline herbicide is applied prior to planting and is incorporated into the soil. A single herbicide (or mixture) is then applied after planting (preemergence) and is followed by directed postemergence herbicides and cultivation as needed throughout the season. In a conservation tillage system, in which the crop is planted directly into crop stubble or a cover crop such as wheat, rye or legume or in which only minimum seedbed preparation is performed, a preplant-incorporated herbicide cannot be applied. Often this results in an increase in annual grass infestations, one of the disadvantages of reduced tillage systems (Brown and Whitwell, 1985; Kapusta, 1979; McWhorter and Jordan, 1985).

Cover crops are sometimes used with conservation tillage. They reduce erosion, usually increase soil moisture retention and add organic matter to the soil. Such crops must be destroyed prior to planting the primary crop, and they differ in their susceptibility to herbicide desiccation. Brown and Whitwell (1985) found that vetch was harder to manage in these systems than crimson clover or rye. Cotton stand and yield were reduced and maturity was delayed in plots in which vetch was not desiccated.

One of the questions about conservation tillage that arises is whether herbicide usage will be increased with such systems. Cultural control of weeds, which is the primary objective of tillage, will be reduced and probably replaced by chemical, preventive or biological control (Burnside, 1980). Although it is generally agreed that more herbicides will be needed as tillage is reduced, at least initially, some researchers feel that herbicide use will decline over time as the weed seed population near the soil surface is depleted (Burnside, 1980; Burnside et al., 1980). Reducing tillage may also necessitate higher herbicide rates because plant residues on the soil surface interfere with herbicide activity (Jones et al., 1968; Webber et al., 1987). Although herbicide usage in long-term conservation tillage production needs continuous evaluation, most researchers and farmers agree that an intensive, carefully managed herbicide program is needed to establish cotton in a conservation tillage system (Brown and Whitwell, 1985; McWhorter and Jordan, 1985).

Cotton is grown in several areas in Arkansas, but production is most prevalent on silty or sandy loam soils, although acreages of cotton on clay soils are increasing. Because the land does not need extensive preparation in the spring, conservation tillage practices may offer a tool for increasing cotton acreage in clay soils.

Research in several Southern states has provided a knowledge base for the development of conservation tillage weed control systems in the South. However, local and regional studies are needed to refine control measures based on sound weed ecology data for specific soils and weed problems. The objective of preliminary weed control research in Arkansas is to determine the feasibility of controlling weeds and maintaining cotton yield in conservation tillage systems.

DISCUSSION

The focus of this part of the paper will be on the problems encountered with experiments conducted in 1989 and 1990. The following section will briefly discuss experiments in progress and plans for future work.

Cover Crop Area, Clarkedale, Arkansas

Weed control experiments were conducted in 1989 and 1990 in an area planted to winter cover crops (rye, vetch and rye + vetch) and cotton each

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year since 1973. The soil is a Dubbs-Dundee complex. Each cover crop was treated with paraquat (Gramoxone Extra™) or paraquat plus oxyfluorfen (Goal™). Tillage practices prior to planting cotton consisted of conventional tillage, no tillage or minimum tillage (disk once prior to planting). Standard preemergence and post-directed herbicides were applied for season-long weed control.

Results from the experiments were inconclusive, but early observations indicate some of the problems that can be encountered in employing these systems. No effect of treatment on cover crops could be detected, although two applications of paraquat were needed both years to control vegetation. There were differences in cotton yield among treatments, but the differences were not consistent between years, In 1989, yields from no-till plots were equal to those from conventionally tilled plots. That year, 1989, the soil was moist at planting, so a conventional planter was satisfactory for placing seeds in the soil. In 1990, however, yield from no-till plots was significantly lower than that from conventional tillage. At planting in 1990, the soil was dry and hard on the surface, and a conventional planter was not able to break the surface and cover the cotton seeds adequately. These plots had to be re-planted. It is suspected that a no-till planter would have made a significant difference in cotton stand. In plots that had been disked one time in the week before planting, soil-to-seed contact was sufficient to obtain an adequate cotton stand that yielded almost as much as conventionally tilled plots.

The primary conclusion that could be drawn from the experiments was that obtaining a cotton stand in a no-till situation can be a problem if the planting equipment is not appropriate. However, if a cotton stand can be established, as it was in 1989, yields in no-till cotton can equal those of conventional production.

Conservation Tillage in a Johnsongrass Area, Clarkedale, Arkansas

An experiment was conducted in 1990 at Clarkedale on a Sharkey silty clay soil in an area with a heavy weed infestation that included seedling and rhizome johnsongrass, smartweed and morningglory species. The area had been planted to soybeans in 1989, but no herbicides had been applied. After soybeans were harvested in the fall, beds were rehipped. Approximately one month before cotton planting in 1990, preplant burndown treatments of glyphosate (Roundup?, paraquat and glufosinate (Ignite™) were applied to designated plots. Tops of the beds were leveled for cotton planting, and a preemergence herbicide was applied. Burndown herbicides were applied with the preemergence herbicides on plots that did not receive preplant treatments. A standard postemergence program, including quizalofop (Assure) for johnsongrass control, was followed.

As with the cover crop experiment, results were inconclusive: in this experiment; conclusions could not be drawn because cotton yield data were not obtained. Leveling the beds provided a planting surface adequate for planting with a conventional planter, and the resulting cotton stand was good. Two problems that prevented good cotton growth were soon evident, however. The first was lack of rainfall. Although the area received rainfall in the 12 weeks after cotton emergence, the amount each time was less than 1 to 2 cm. Because the experiment could not be irrigated, cotton growth was poor.

The second problem was one of weed control. It was observed that most weeds in plots that had a preplant treatment were controlled 80 to 100% at planting. In other plots, however, a heavy infestation of smartweed (Polygonurn spp.) was present. Although all preemergence treatments specified a burndown herbicide in the tank mixture, the smartweed was too large by that time (late May) to be adequately controlled. Additionally, with the slow growth of cotton, a height differential for proper application of post-directed herbicides was not obtained. Although the applications were finally made, they were not effective, and most plots had sufficient weeds present to be competitive with the cotton. The johnsongrass, however, was controlled with quizalofop.

It should be noted that a similar experiment was established in an area with a low weed population, also on a Sharkey clay. Every treatment in this experiment, however, had a preplant burndown added, which was applied approximately four weeks prior to planting. With the low initial weed pressure and irrigation to aid cotton growth after emergence, a height differential between cotton and the summer annual weeds was obtained, and control in most plots was good. (Because irrigation was limited, cotton yields were low and too inconsistent to accurately reflect differential treatment effects.)

One remedy for the problems in a heavily infested area, such as the johnsongrass area, is increased flexibility of the weed control program. Treatments in this experiment contained no options that would have allowed better control of smartweed. Conservation tillage production requires careful management and, apparently, a degree of flexibility that was not available in this experiment. As Steve Crawford stated in an interview (Laws, 1990), "If you plant into a mess, things are just going to get worse. We don't have the technology in cotton to buy our way out of a jam like we do in soybeans." All plots should probably have been treated with a preplant burndown treatment, and most should have received another burndown application around the time of planting.

FUTURE RESEARCH

Experiments will be conducted at three Arkansas locations in 1991: Clarkedale (cover crop and johnsongrass areas), Marianna (two experiments on silt loam soil) and Fayetteville (an experiment to evaluate burndown of weeds, vetch and wheat followed by a season-long control program). In all these experiments, options for burndown of vegetation through the time of planting are a part of most treatments. One experiment will compare the effects of initiating preplant treatments (burndown plus residual) at approximately 10 to 12 weeks before planting, 4 to 6 weeks before planting and 0 to 7 days before planting.

Preliminary research in Arkansas will continue to focus on screening of burndown and residual herbicides at several rates and timings. The objective of the work essentially will be to define and verify sound weed control practices for conservation tillage practices in Arkansas. This must, of course, include various tillage practices, equipment, cover cropping systems and economic analysis. As the preliminary economic and weed control evaluations continue, other research will evaluate the effects of various conservation tillage systems on weed population dynamics.

LITERATURE CITED

1. Brown, S.M., and T. Whitwell. 1985. Weed control programs for minimum-tillage cotton. Weed Sci. 33:843-847.
2. Burnside, O.C. 1980. Changing weed problems with conservation tillage. Proc Am. Soc Agric Eng. (Crop production with conservation in the 80's). pp. 167-173.
3. Burnside, O.C., G.A. Wicks and D.R. Carlson. 1980. Control of weeds in an oat *(Avena sativa)* - soybeans (Glycine max) ecofarming rotation. Weed Sci. 28:146-150.
4. Jones, H.N., J.E. Moody, G.M. Shear, W.W. Moschler and J.H. Lillard. 1968. The no-tillage system for corn *(Zea mays)*. Agron. J. 60:17-20.
5. Kapusta, G. 1979. Seedbed tillage and herbicide influence on soybean (Glycine max) weed control and yield. Weed Sci. 27:520-526.
6. Laws, F. 1990. Fallow beds aid timely cotton planting. Delta Farm Press, Scp. 21, p. 4.
7. McWhorter, C.G., and T.H. Jordan. 1985. Limited tillage in cotton production. Chpt. 6. *In* A.F. Wiese (ed.). Weed control in limited-tillage systems. Monograph Series No. 2 of Weed Sci Soc Am.
8. Webber, C.L., H.D. Kerr and M.R. Gebhardt. 1987. Interrelations of tillage and weed control for soybean (Glycine mar) production. Weed Sci 35:830-836.
9. Witt, W.W. 1984. Response of weeds and herbicides under no-tillage conditions. Chpt. 7. *In* R.E. and S.H. Phillips (eds.). No-tillage agriculture. New York Van Nostrand Reinhold.

A Comparison of Predicted and Actual Nitrate Nitrogen Profiles as a Result of Application of Poultry Litter to a Pasture

B. A. Ibrahim and H. D. Scott[1]

ABSTRACT

The disposal of poultry litter on pasture lands can result in beneficial or detrimental effects. To better understand the mechanics of these effects, this work was aimed at assessing the fate of NO_3-N from the application of poultry litter to a tall fescue pasture. The computer simulation model, POULT, was developed and compared to results obtained in the field. A significant plant response was found to the application of 8.96 Mg/ha of poultry litter. Plant uptake of N followed a similar pattern as dry matter production. The computer program reasonably predicted NO_3-N in the profile shortly after application but failed to do so at 24 days after application. Generally, the greatest discrepancy between the predicted and actual NO_3-N was in the upper portion of the soil profile where most of the root growth and development and N uptake occurs.

INTRODUCTION

Poultry litter has been used successfully by many growers in northwestern Arkansas as a fertilizer for pastures. It has been used as the only source of plant nutrients, as a supplemental source for nutrients and as a mulch for the soil (Hileman, 1967). Extensive studies have been conducted to quantify the chemical composition and fertilizer value of poultry litter (Perkins et al, 1964; Hadas et al., 1983; Sims, 1986; Gale and Gilmour, 1986). However, land disposal of poultry litter recycles nutrients back into the food production system, and some concern has been expressed about the possible contamination of domestic water supplies from continuous and/or heavy application of the litter on pastures.

Low rates of poultry litter application usually do not produce high forage yields, as shown by Huneycutt et al. (1988), and thus farmers resort to high rates of application. Siegal et al. (1975), in a greenhouse experiment, found that the application of poultry manure at an air-dry rate of 5% by weight resulted in reduced yields of forage due to the toxicity of uric acid that is contained in the litter. They concluded that NO_3-N in excess of forage requirement leached below the root zone or runoff and, therefore, might move to both surface and subsurface water sources.

The mobility of nitrates to drinking water sources has become a focus of several research studies in light of the growing emphases on environmental quality and pollution control. Recent reports of contamination of domestic water supplies from the application of poultry manure were cited by Liebhardt et al. (1979), who showed that the NO_3-N level of groundwater was raised considerably above 10 ppm as a result of excessive applications of poultry litter. Ritter and Chirnside (1984) reported higher nitrate levels in wells within 305 m of poultry houses compared to those beyond this distance.

The objective of this study was to compare predictions using the computer model POULT as described by Ibrahim and Scott (1990) with the measured field nitrate profiles after the application of poultry litter to pastures.

MATERIALS AND METHODS

Tall fescue *(Festuca arundinacea* Schreb.) was planted on 17 March 1989 at the Main Experiment Station farm, Fayetteville, Arkansas. The soil was a Captina silt loam classified as a fine-silty, mixed, mesic, Typic Fragiudult. The 0.243-ha field was limed at a rate of 2.24 Mg/ha using pelletized lime at planting. Ammonium nitrate at a rate of 0.112 Mg/ha was broadcast preplant to aid in the establishment of the grass. On 19 February 1990 0.336 Mg/ha of 13-13-13 fertilizer was broadcast. The field was irrigated several times during the summer of 1989 to reduce drought stress.

The field layout of the poultry litter application experiment was established on 27 April 1990 (Fig. 1). Eight plots in a completely randomized design with four replications and two treatments were bordered with a metal hedge-edger. The treatments were 8.96 Mg/ha of poultry litter broadcast by hand on 22 May 1990 and a control. The individual plot

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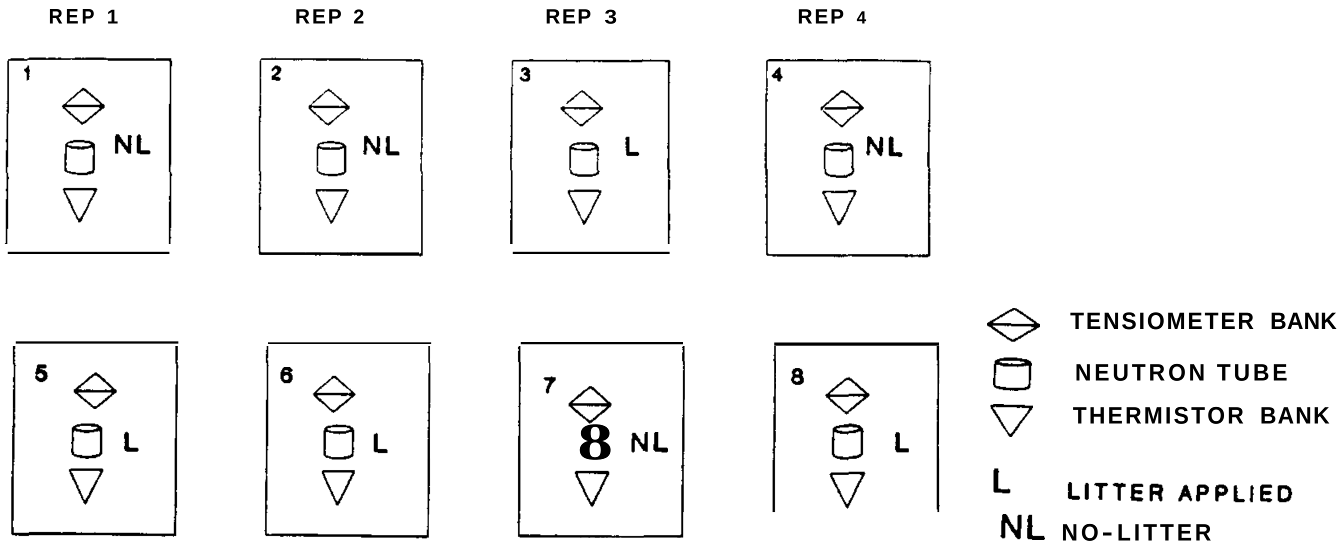

Fig. 1. Poultry litter experiment field layout

size was 4 x 6 m. Each of these plots contained a tensiometer bank and a thermistor bank by 16 May 1990. The tensiometers were installed at 15-cm increments to a depth of 90 cm. The thermistors were installed at the 5-, 10- and 30-cm depths. On 17 May 1990 the tall fescue in the plots was mowed to a height of 10 cm, and plant samples were taken for determinations of initial N content. Gravimetric samples for the determination of the initial soil water content distribution in the profile were taken just before application of the poultry litter on 22 May 1990 and at harvest. Soil samples were also taken on this date for the initial NO_3-N content determinations.

Soil water pressure readings using the tensiometers were taken three days per week starting on 22 May 1990. The thermistors were read at the same time as the tensiometers in order to determine soil temperature directly and soil water content through the use of a calibration curve that was determined using the same soil as that of the experimental site. The readings of the tensiometers and the thermistors were usually taken at 14:00 CDT. The tall fescue was harvested whenever the height of the new growth was about 20 cm. A randomly selected area of each plot was harvested, and the fresh weights and dry weights were taken to determine dry matter production. A subsample of the grass was ground for the determination of N content. Soil samples were also taken on harvest day for the determination of the NO_3-N concentrations in the profile at depth increments of 15 cm to a depth of 90 cm. The samples were frozen right after collection until analysis. NO_3-N was determined by the steam distillation method as described by Keeney and Nelson (1982).

RESULTS AND DISCUSSION

Poultry litter application to tall fescue resulted in a flush of above-ground growth (Fig. 2). Significantly higher dry matter yields were found in the treated plots as compared to the control (Fig. 2A). Much of the response in dry matter production due to poultry litter addition occurred during the first three months after application. The fescue in the control plots showed an increase in dry matter production but at a much slower rate than the treated fescue, as shown in Fig. 2B.

Plant N concentrations during the growing season are shown in Fig. 3. The N concentration of treated fescue was significantly higher than that of the control. The plant concentration of N was less than 4% throughout the experiment, which was in agreement with the poultry litter N content. Nitrogen uptake by the tall fescue was significantly higher for the treated plants than for the control, as shown in Fig. 4A. This reflected the abundance of N in the treated plots, especially during the first three months after application of the litter. The cumulative plant N uptake as shown in Fig. 4B maintained a higher rate of increase in plant uptake for the treated tall fescue as compared to the control. This was similar to the response of the tall fescue dry matter yield to the application of the poultry litter.

The computer program, POULT, which was used for the prediction of the soil NO_3-N profiles after the application of poultry litter, presently does not

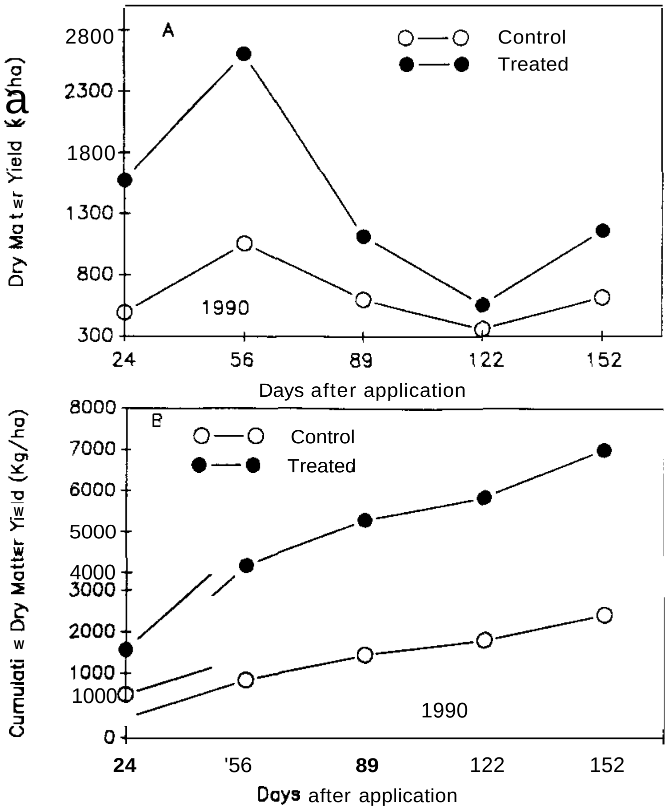

Fig. 2. Tall fescue dry matter yield (A) and cumulative dry matter (B) yield during the season.

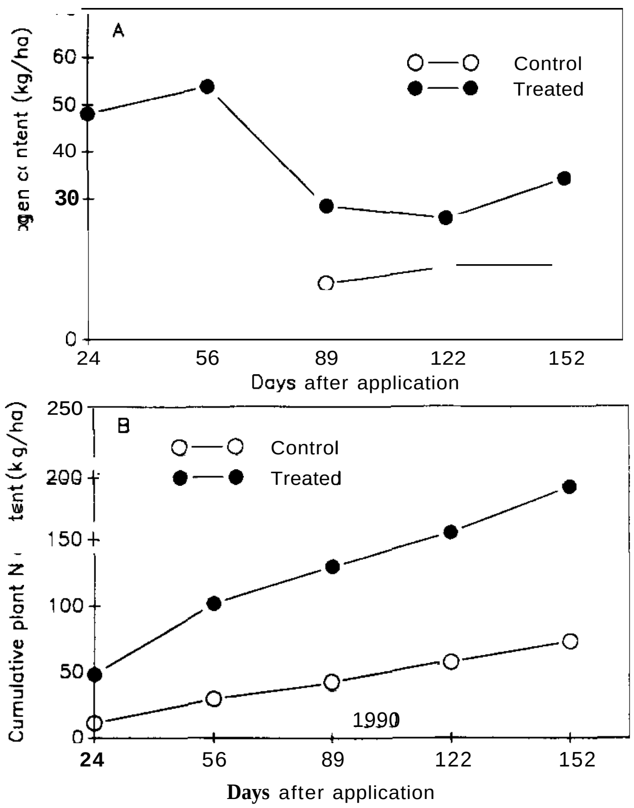

Fig. 4. Tall fescue nitrogen content (A) and cumulative nitrogen content (B) during the season.

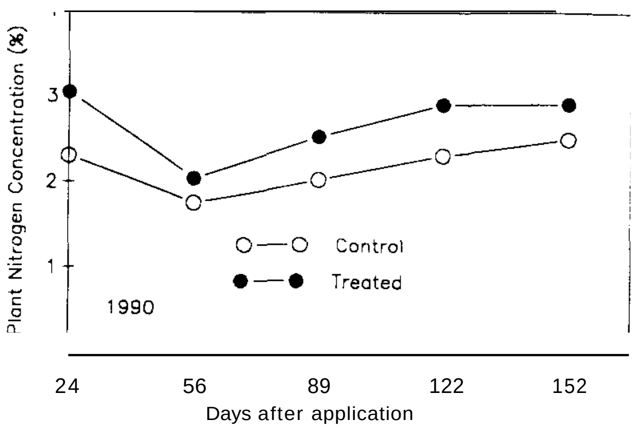

Fig. 3. Tail fescue nitrogen concentration (%) during the season.

consider the volatilization loss of the applied N from the poultry litter. The measured and predicted soil NO_3-N concentration profile one day after the litter was applied is shown in Fig. 5. There was a general agreement between the predicted and measured NO_3-N profiles except in the top 30 cm. This could be due to the fact that the soil samples taken on the first day after application contained some litter. Fig. 5B shows the same profile of NO_3-N concentration after 24 days. The model under-predicted the NO_3-N profile in the upper portion of the profile and over-predicted the NO_3-N in the lower portion of the profile. This may be because this was the time when the tall fescue was experiencing the highest rate of dry matter production and plant N uptake.

As the season progressed, the computer model was able to generally give better predictions of the NO_3-N profiles in the lower portion of the soil profile. The pattern of under-prediction of the NO_3-N in the upper portions continued (Fig. 6A and B). This suggests that the computer model was over-predicting the NO_3-N plant uptake throughout the growing season. Work is underway to reconcile the computer model predictions with the field results.

LITERATURE CITED

1. Ibrahim, B.A., and H.D. Scott, 1990. Fate of nitrogen from the disposal of poultry litter: A simulation approach. Ark. Water Resource Res. Ctr. Publ. No. 148.

2. Gale, P.M., and J.T. Gilmour. 1986. Carbon and nitrogen mineralization kinetics for poultry litter. J. Environ. Qual. 15:423-326.

3. Hadas, A, B. Bar-Yosef, S. Davidov and M. Sofer. 1983. Effect of pelleting, temperature, and soil type

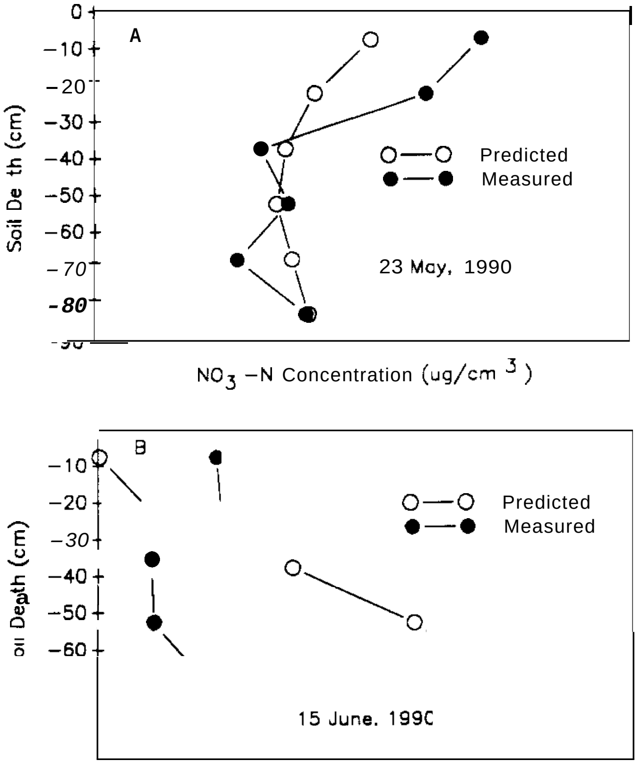

Fig. 5. Nitrate nitrogen concentration profile (A) one day and (B) 24 days after application of poultry litter.

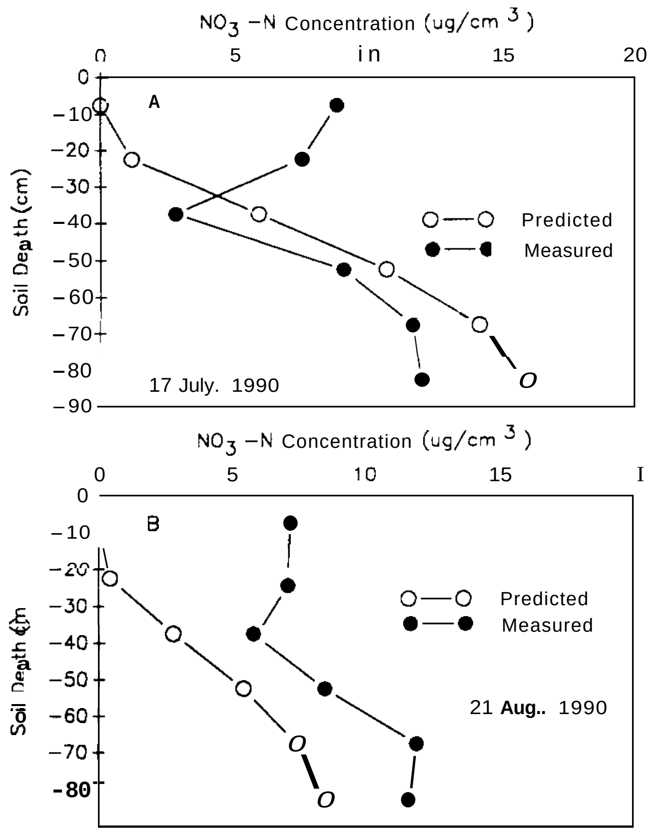

Fig. 6. Nitrate nitrogen concentration profile (A) 56 days and (B) 89 days after application of poultry litter.

on mineral nitrogen release from poultry and dairy manures. Soil Sci Soc. Am. J. 47:1129-1133.

4. Hileman, L.H. 1967. The fertilizer value of broiler. Ark. Agric. Exp. Stn. Rep. Ser. 158.

5. Huneycutt, H.J., C.P. West and J.M. Phillips. 1988. Responses of bermudagrass, tall fescue and tall fescue-clover to broiler litter and commercial fertilizer. Ark. Agric. Exp. Stn. Bull. 913.

6. Keeney, D.R, and D.W. Nelson. 1982. Nitrogen-inorganic forms. *In* A.L. Page et al. (eds.). Methods of soil analysis. Part 2. 2nd ed. Agron. 9643-693.

7. Liebhardt, W.C., C. Golt and J. Tubin. 1979. Nitrate and ammonium concentrations of ground water resulting from poultry manure applications. J. Environ. Qual. 8:211-215.

8. Perkins, H.F., M.B. Parker and M.L. Walker. 1964. Chicken manure - its production, composition, and use as a fertilizer. Georgia Agric. Exp. Stn. Bull. N. S. 123.

9. Ritter, W.F., and A.E.M. Chirnside. 1984. Impact of land use on ground water quality in southern Delaware. Ground water 22:39.

10. Siegal, RS., A.A.R.Hafez, J. Azevado and P.R. Stout. 1975. Management procedures for effective fertilization with poultry manure. Compost Sci 16:5-9.

11. Sims, J.T. 1986. Nitrogen transformations in a poultry manure amended soil: Temperature and moisture effects. J. Environ. Qual. 15:59-63.

No-Till Cotton in Arkansas

T.C. Keisling[1]

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 (Keisling et al., 1991). A summary of another study showed that winter cover crops tended to improve soil tilth in continuous cotton (Keisling et al., 1990).

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.

MATERIALS AND METHODS

An area of Memphis silt loam soil that had been in cotton or fallow the year before was selected to establish plots. The conventional till portion of the test was disked twice then triple-Ked prior to bedding. On 25 May 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 14 June and 24-0-0 applied 16 July. Cotoran™ and Dual™ were applied preemerge at recommended rates. Temick™-Terrachlor™ was applied in furrow at planting at the 30-lb/acre rate. Fusilade™ was applied to the no-till plots for grass control on 3 July at 24 oz/acre. Lay-by was done using Lorox™ at 2 pt/acre. Foliar applications of fertilizer, insecticides, etc. are shown in Table 1. Tilled plots were mechanically cultivated on 14 June and 3 July. Plots were hand-hoed on 15 July. The harvest consisted of a once over picking on 17 October. 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.

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 13 August. There was 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, the plants were the same height at maturity (Table 2). All of the other plant characteristics were similar regardless of tillage (Table 2).

Conventionally tilled cotton yielded better than no-till cotton at 152 more lb of lint/acre. The source

Table 1. Dates, rates and materials foliar-applied to No-Till Cotton test

Date	Rate	Material
	(lb/acre)	
June 29	7.0	21% Urea Solution
	0.1	Boron
	0.03	Baythroid™
July 6	7.0	21% Urea Solution
	0.1	Boron
	0.25	Karate™
July 16	7.0	21% Urea Solution
	0.1	Boron
	0.25	Karate™
July 20	10.0	21% Urea Solution
	0.1	Boron
	0.25	Karate™
July 27	10.0	21% Urea Solution
	0.1	Boron
	0.25	Karate™
August 3	10.0	21% Urea Solution
	0.1	Boron
	0.25	Karate™
August 16	0.1	Boron
	0.25	Karate™
August 23	9.0	21% Urea Solution
	0.1	Boron
	0.25	Karate™
August 31	9.0	21% Urea Solution
	0.1	Boron
	0.25	Karate™
September 6	0.1	Boron
	0.25	Karate™
September 13	0.1	Boron
	0.25	Karate™
September 25	2.0	Prep Def.

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of the reduced yield for the no-till cotton was a boll size reduction of 17% (Table 2). Visual observation during the growing season indicated a visual 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.

Tissue analysis showed more erratic N content of the petioles the first three weeks of bloom in the conventionally tilled plots than in the no-till plots (Fig. 1). Phosphorus was consistently lower the first three weeks of bloom in the no-till plots. Both K and S contents in the petioles showed little difference due to tillage methods. Tissue analysis was used for a guide of the nutrition in this test, and nutrients were applied to foliage to insure that lack of plant nutrients was not the cause of reduced yields.

Future plans are to investigate conservation tillage in conjunction with

1. Legume cover crops to fix N and reduce inputs;
2. Starter fertilizer (in cooperation with researchers in Tennessee who have shown substantial yield increases to N placed 2 x 2).
3. Narrowrows;
4. Limited in-the-row tillage.

LITERATURE CITED

1. Keisling, T.C., R.F. Ford and H.D. Scott. 1991. Tillage system for cotton on Mississippi River delta and loessial plains soils. Soil and Tillage Research (submitted).
2. Keisling, T.C., H.D. Scott, B.A. Waddle, W. William and R.E. Frans. 1990. Effects of winter cover crops

Table 2. Yield, stand and mature plant characteristics for the 1990 No-Till Cotton test at Marlanna, Arkansas.

Yield or growth characteristics	Conventional tillage	No-till
Yield (lb/acre)	888 a*	736 b
Stand (plants/row-ft.)	3.4	3.3
Nodes below first sympodia	6	5
Monopodia with fruit	0	0
Plant height (in)	30	31
No. effective Sympodia	9	10
No. of Sympodia	11	11
Total nodes per plant	1.7	16
Ave. internode length (in)	1.8	1.9
Total bolls per plant	13	12
% First position bolls	71	68
% Second position bolls	25	28
% Other position bolls	4	4
% Second axil bolls	0	0
% Bolls position 1 retained	70	75
% Bolls position 2 retained	32	31
Boll size (g/boll)	8.6	7.1

'Numbers in the same row followed by different letters are significantly different at the 1% level according to LSD.

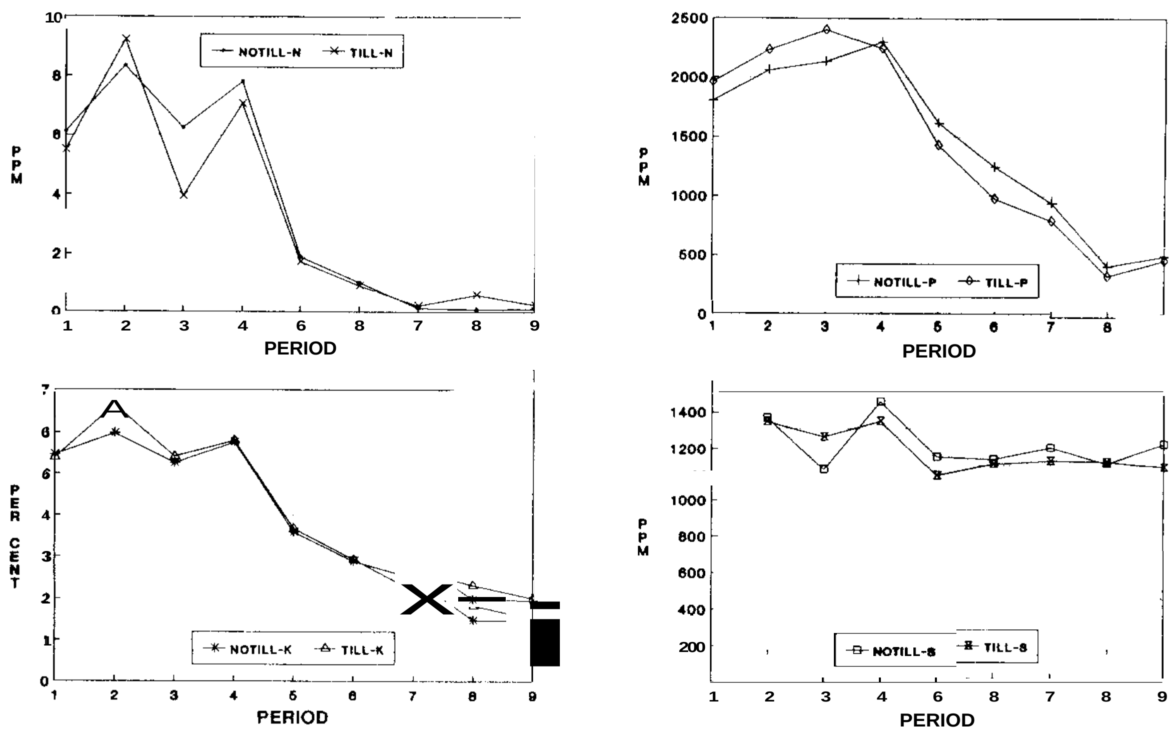

Fig. 1. Petiole analysis for nitrate-N, P, K and sulfur.

Herbicide Carryover May Limit Winter Cover Cropping Potential in Arkansas

J.A. Kendig, R.E. Talbert, D.L. Jordan and R.E. Frans[1]

INTRODUCTION

Herbicides are used extensively to control weeds in warm-season row crop production in Arkansas. Some herbicides in certain situations may persist through the summer and injure fall-seeded cover crops and winter annual weeds. Recent concerns about soil conservation have led to legislation requiring that cover crops be considered for use on erodible land. Cover crops may also benefit warm-season crops by improving soil organic matter and tilth and by providing nitrogen.

MATERIALS AND METHODS

Field studies were established on three soils at two Arkansas locations in 1976 with the following objectives: 1) to compare various levels of long-term, continuous herbicide use on herbicide carryover and injury to fall-seeded cover crops and 2) to assess soil and climatic factors influencing herbicide carryover. This report summarizes data collected by B.R. Corbin (Corbin, 1988), T.S. Green (Green, 1978) and C.B. Rogers (Rogers, 1983) and data collected by the authors since 1988.

Studies were conducted with soybeans and cotton. Herbicide treatments were modified in 1986 to include new persistent herbicides that were receiving extensive use. The current treatments for cotton are 1) no herbicide check, 2) a "minimal herbicide program" consisting of norflurazon, applied preplant incorporated (ppi), followed by (fb) methazole + MSMA directed at the V-2 and V-4 stage of cotton and 3) an "intensive herbicide program" consisting of trifluralin, ppi, fb fluometuron, preemergence (pre), fb fluometuron + MSMA directed at the V-2 and V-4 stage of cotton, fb linuron directed at cotton layby. Soybean treatments were a factorial arrangement of three ppi treatments and four pre/postemergence (poe) treatments. The ppi treatments were no herbicide, clomazone and trifluralin. The pre/poe treatments were 1) no pre- or postemergence herbicides, 2) imazaquin pre, fb imazaquin poe at the V-2 stage of soybeans, 3) chlorimuron + metribuzin (Canopy™), pre, fb chlorimuron at the V-2 stage of soybeans and 4) metribuzin + imazaquin, pre. Cotton and soybean herbicides were applied at label-recommended rates, adjusted for soil texture and organic matter when appropriate. The experiments were conduced on three soils: a Dundee silt loam (11% sand (S), 74% silt (Si), 15% clay (C) and 1.3% organic matter (OM)) located at Clarkedale, Arkansas; a Loring silt loam (2% S, 80% Si, 18% C and 1.6% OM) at Marianna, Arkansas; and a Sharkey silty clay (4% S, 48% Si, 47% C and 2.3% OM) located at Clarkedale, Arkansas.

After cotton and soybean harvest, a portion of each plot was disked and planted with winter cover crops. Wheat and vetch have been evaluated since 1976. Clover and rye were evaluated from 1976 to 1978 and in the 1990-91 growing season. Austrian winter peas were also evaluated in the 1990-91 growing season.

Soil samples were collected in selected years and analyzed for the quantities of herbicide residues that had accumulated.

RESULTS AND DISCUSSION

Interactions occurred among years, soils and herbicide treatments although some consistent trends were observed.

Soil Effects

Carryover injury was highest on the Sharkey silty clay while the Loring silt loam and the Dundee silt loam, on average, behaved similarly. On Sharkey silty clay, norflurazon in the "minimal cotton program" resulted in complete kill of wheat, vetch and winter annual weeds. The fluometuron in the "intensive cotton program" and clomazone, ppi treatments from soybeans usually resulted in moderate to severe injury of wheat, vetch and winter annuals on the Sharkey. In the spring of 1991, both fluometuron and norflurazon completely killed wheat, vetch and winter annuals. On the Dundee and Loring silt loams, carryover injury to wheat,

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vetch and winter annuals was usually less than 30% and often not observed.

Herbicide Effects

The herbicides norflurazon and clomazone cause the most carryover problems. Norflurazon causes significant injury on all three soils. Clomazone usually causes significant injury although in certain years injury may be slight on the silt loam soils. Fluometuron also carries over on the Sharkey clay and causes significant stand reductions of cover crops. Some injury is observed from carryover of the soybean pre/poe treatments of imazaquin, chlorimuron and metribuzin. However, this injury interacts greatly with years and soils. The injury is greatest on the small-seeded, winter annual weeds. Larger-seeded cover crops usually tolerate residues of the pre- and postemergence soybean herbicides.

Cover Crop Tolerance

Work in 1976 to 1978 determined that the susceptibility ranking of cover crops was crimson clover (most susceptible) > hairy vetch > wheat > rye (least susceptible). In the 1990-91 season, Austrian winter peas appeared somewhat tolerant to herbicide residues. Foliar symptoms were evident in certain plots; however, plants were surviving. Because of poor seedbed conditions, Austrian peas were not established on the Sharkey soil, where carryover was greatest.

Residue Levels

Soil samples taken from the Sharkey clay in the spring, before herbicides were applied, typically contained residual concentrations equivalent to the normally recommended use rate of fluometuron and norflurazon. These residue levels would be expected to be very detrimental to cover crops and winter annual weeds.

CONCLUSIONS

When norflurazon, clomazone or fluometuron is used on clay-textured soils, severe cover crop injury is likely. When norflurazon, clomazone or fluometuron is used on silt-textured soils, wver crops may or may not be injured, depending upon specific soil properties and weather trends. Imazaquin and chlorimuron can, in certain instances, injure cover crops and reduce the cover from winter annual weeds, although cover crops usually tolerate the injury. Repeated use of the same herbicides in monoculture cotton and soybeans worsens carryover problems. Where persistent herbicides are used, cover crops should be used cautiously, and growers should recognize that there is a risk of injury. High-value cover crops should not be planted into high-risk situations.

LITERATURE CITED

1. Corbin, B.R 1988. Dissipation of herbicide residues from continuous cotton *(Gossypium hirsutum),* and alleviation of injury with seed treatments. Dissertation, University of Arkansas. p. 71.
2. Green, T.S. 1978. The effects of herbicides used in monocultural production of cotton and soybeans on four fall-seeded crops. Thesis, University of Arkansas. p. 36.
3. Rogers, C.B. 1983. Fluometuron carryover and damage to subsequent crops. Dissertation, University of Arkansas, p. 60.

Nitrogen Requirements and Nutrient Content of No-Tillage Tropical Corn and Forage Sorghum

P.J.E. Lord and R.N. Gallaher[1]

ABSTRACT

Tropical corn *(Zea mays* L) and forage sorghum *(Sorghum bicolor* L. Moench) can provide Florida farmers with alternatives in multiple cropping. The objectives of this study were to determine 1) inorganic N requirements for 'Pioneer brand X304C' corn and 'DeKalb FS25E' forage sorghum under no-tillage management, 2) leaf N-yield relationships and 3) content of nutrients. Crops were whole plots, and N rates (0, 6.7, 13.4 and 20.1 g N/m^2) were split plots with five replications. In-row subsoil no-tillage planting into rye *(Secale cereale* L) straw gave 79,000 corn seed/ha and 247,000 sorghum seed/ha Dry matter yield estimates were from middles of plots. MicroKjeldahl and dry ashing procedures were used for N and minerals, respectively. Dry matter per m^2 times concentration gave nutrient content per m^2. Dry matter increased from N fertilizer more in sorghum than in corn. Both crops removed similar amounts of N by the whole plant. They responded in N content to the highest N rate of 20.1 g N/m^2 with an average removal of 6.95 g N/m^2. This represents about 35% recovery of N in relation to the N applied. Suspected leaching from heavy rainfall resulted in deficiency levels of N and K in leaves of both crops.

INTRODUCTION

The number of dairy cattle in Florida is on the increase. As more dairies move into Florida, particularly into north Florida, there will be a demand for a high-quality feed. Tropical corn *(Zea mays* L.) and forage sorghum *(Sorghum bicolor* L. Moench) can provide Florida farmers with an opportunity to produce this type of feed.

Blevins et al. (1980) reported N fertilizer to be the greatest single energy input into corn production. As more N fertilizer is used, the contamination of ground water in Florida's sandy soils becomes an environmental concern. Loss of fertilizer from leaching can also be an economic concern,

Lang et al. (1989) reported a significantly higher ear leaf N concentration in corn when N was applied. They determined no differences in leaf N concentrations at three N rates (34, 67 and 134 kg N/ha). Grain and whole plant yields of 'Pioneer X304C' tropical corn responded to N rates when K-Mag™ was added.

A drop in yields of sorghum has been reported (Hipp and Gerard, 1971) when the leaf N concentration drops below 20 g/kg. Leaf N concentration accounted for about 63% of the variation in grain yields.

The objective of this experiment was to study the response of no-tillage tropical corn and forage sorghum to different N rates as measured by whole plant yield, leaf N concentration and plant nutrient content.

MATERIALS AND METHODS

The experiment was conducted at the Green Acres Agronomy Farm near Gainesville, Florida, in 1990. The soil is an Arredondo loamy sand to sand (Grossarenic Paleudult) (Soil Survey Staff, 1984). The site has a history of 14 years constant no-tillage rye *(Secale cereale* L.) succeeded by soybeans *(Glycine max* L. Merr.). 'Wrens abruzzi' rye was planted in the winter of 1989 and harvested 10 May 1990. Pioneer X304C tropical corn and 'DeKalb FS25E forage sorghum were planted on 20 May 1990. A Brown-Harden™ in-row subsoil no-tillage planter was used for each crop. Corn was planted at 79,000 seed/ha and forage sorghum at 247,000 seed/ha in 0.75-m-wide rows. The experimental design was a randomized complete block with the two crops as whole plots and inorganic N rates (ammonium nitrate) of 0, 6.7, 13.4 and 20.1 g N/m^2 as split plots.

Atrazine:(2-chloro-4-ethylamino-6-isopropyl-amino-1,3,5-triazine) + crop oil was sprayed over the top when forage sorghum was about 5 cm tall. Dual (Metolachlor:2-chloroo-N-(2-ethyl-6-rnethylphenyl)-N-(2-methoxy-l-methylethyl) acetamide) + Atrazine was applied to corn at planting. Gramoxone: (Paraquat:l.l'-Dimethyl-4,4'-bipyridinium ion + X77 surfactant was sprayed preplant on all crops. Furadan (#15g) (Carbofuran:2,3-Dihydro-2,2-dim-

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ethyl-7-benzopuranyl methylcarbamate) was applied at the rate of 2.2 kg ai/ha to all crops at planting. Lannate (Methomyl: S-Methyl-N-((methylcarba-moy1)oxy)thioacetimidate) was sprayed over the top of the crops one time to control insects.

Fertilizer was applied at 450 kg/ha of 0-10-20 plus 340 kg/ha of K·Mag™ at planting. N rates were split, with 1/2 applied at planting and 1/2 when plants were 0.4 m tall.

Both crops were irrigated as needed using a over-head sprinkler system. water was applied every four days (2.54 cm) depending on rainfall.

Corn ear leaf samples were taken at early tas-seling and silking. Forage sorghum leaves were taken from the third leaf from the flag at early bloom. Forage yields were taken at about 35% dry matter. Leaf and whole plants were analyzed for N using the micro-Kjeldahl technique (Gallaher et al., 1975; Gallaher et al., 1976). Minerals were dry ashed, and solutions were analyzed for P by colorimetry, for K by flame emission spectrophotometry and for Ca, Mg, Cu, Fe, Mn and Zn by atomic absorption spec-trophotometry.

RESULTS AND DISCUSSION

Both crops were expected to show a dry matter yield increase as N rates were increased. Dry mat-ter yield and nutrient content for both crops are shown in Table 1. Dry matter yield increased from N fertilizer more for sorghum than for corn.

Table 1. Dry matter yield and nutrient content for corn and forage sorghum.

	Drv Matter			Nitroaen			Phosphorus		
Treatment	Corn	Sorghum	Mean	Corn	Sorahum	Mean	Corn	Sorahum	Mean
g N/m²	Kg/m²			g/m²			g/m²		
0	0.35b[1]	0.71c**	0.53	2.67	3.1 1	2.89c	1.14	1.59	1.36b
6.7	0.64a	1.44b**	1.04	4.61	6.06	5.34b	1.50	2.31	1.91a
13.4	0.85a	1.50b**	1.18	6.10	6.26	6.18ab	1.49	2.20	1.84a
20.1	0.87a	1.92a**	1.40	5.94	7.97	6.95a	1.43	2.36	1.90a
MEAN	0.68	1.39		4.83	5.85NS		1.39	2.12**	

	Potassium			Calcium			Maanesium		
Treatment	Corn	Sorghum	Mean	Corn	Sorghum	Mean	Corn	Sorghum	Mean
g N/m²	g/m²			g/m²			g/m²		
0	2.42	6.50	4.46b	0.93b	1.60c**	1.27	0.76b	1.30c**	1.03
6.7	4.17	10.58	7.38a	1.53a	3.18b**	2.36	1.22a	2.33b**	1.78
13.4	4.88	9.82	7.35a	1.67a	3.39b**	2.53	1.31a	2.53b**	1.92
20.1	4.49	11.80	8.15a	1.96a	4.52a**	3.24	1.328	3.26a**	2.29
MEAN	3.99	9.68**		1.52	3.17		1.15	2.35	

	Copper			Manganese			Iron		
Treatment	Corn	Sorghum	Mean	Corn	Sorghum	Mean	Corn	Sorghum	Mean
Q N/m²	mg/m²			mg/m²			mg/m²		
0	0.76	1.46	1.11a	9.48 b	23.60c**	16.54	48.6	40.0	44.3b
6.7	1.18	1.53	1.36a	16.11ab	50.72b**	33.42	180.1	69.8	125.0a
13.4	1.42	0.78	1.10a	18.70ab	55.60b**	37.15	109.7	56.7	83.2ab
20.1	0.88	2.44	1.65a	22.34a	73.73a**	48.04	180.3	82.2	131.2a
MEAN	1.06	1.55NS		16.66	50.92		130.0	62.2**	

Zinc			
Treatment	Corn	Sorghum	Mean
Q N/m²	mg/m²		
0	20.79	17.05	19.32b
6.7	35.02	29.62	32.32a
13.4	32.67	39.79	36.23a
20.1	36.67	39.16	37.92a
MEAN	31.29	31.61 NS	

'Values in columns among N rates not followed by the same letter are significantly different at the 0.05 level of probability according to L.S.D. test. Values in rows between crops are significantly diiferent at the 0.01 level of P with a ** or 0.05 level of *P* with a * or are non-significant with NS.

A significant increase in corn dry matter was observed at the first increment of N. Sorghum showed similar results except that a significant increase was observed at the 20.1-g N/m^2 level over the 6.7- and 13.4-g N/m^2 rates. This increase may indicate sorghum's ability to extract N from the soil at a greater depth than corn. Both crops removed similar amounts of N by the whole plant, responding to the highest N rate of 20.1 g N/m^2. In general, forage sorghum removed more P, K, Ca, Mg and Mn than did corn. Both crops removed similar quantities of Cu and Zn, but corn removed more Fe than did forage sorghum.

Heavy rains and suspected leaching of N resulted in deficient N (14 to 16 g/kg) in diagnostic leaves of both crops, as shown in Table 2. However, sorghum leaves had a significantly higher N concentration at all N levels. Corn had a significant increase in N leaf concentration at the 13.4- and 20.1-g N/m^2 levels. Both corn and sorghum leaves were below the sufficiency range for N according to Jones (1974) and Lockman (1972). They reported the sufficiency ranges to be at 27.5 - 32 g N/kg for corn and 29.0 - 34.0 g/N kg for sorghum. As N rates were increased, the P, Cu, Fe and Zn concentration decreased in the leaves of corn and sorghum. Ca, Mg and Mn leaf concentration increased as N rates increased. The K was below the sufficiency range, 17.5 - 22.5 g/kg for corn (Jones, 1974) and 14 - 17 g/kg for sorghum (Lockman, 1972), in all cases indicating loss of K from leaching.

SUMMARY

The low response of no-tillage corn and forage sorghum to N fertilizer was thought to be due to heavy rainfall and leaching soon after sidedress N was applied. Both N and K deficiency levels were detected from diagnostic leaf analysis. This provided support that these elements had likely leached out of the root zone. In sandy soils, N and K fertilizer should be applied to no-tillage corn and forage sorghum in several small applications to prevent leaching losses due to heavy rainfall.

Table 2, Leaf concentratlons of corn and forage rorghum at four nitrogen rates.

	Nitrogen			Phosphorus			Potassium		
Treatment	Corn	Sorahum	Mean	Corn	Sorahum	Mean	Corn	Sorghum	Mean
g N/m^2	g/kg			g/kg			g/kg		
0	12.78b[1]	11.30b**	12.04	4.26a	2.96a*	3.61	17.30	16.88	17.09a
6.7	12.68b	14.64a**	13.66	3.45b	2.63ab*	3.04	16.50	14.76	15.63b
13.4	16.20a	15.30a**	15.75	3.12b	2.73ab*	2.93	16.54	14.58	15.56b
20.1	16.60a	15.80a**	16.20	3.31b	2.50b*	2.91	15.48	13.08	14.28c
MEAN	14.57	14.26		3.54	2.71		16.46	14.83**	
	Calcium			Maanesium			Manganese		
Treatment	Corn	Sorahum	Mean	Corn	Sorghum	Mean	Corn	Sorghum	Mean
g N/m^2	g/kg			g/kg			mg/kg		
0	3.04c	2.14c*	2.59	1.72c	1.85ab*	1.78	33.00	26.20	30.60a
6.7	3.79b	2.55bc*	3.17	2.19b	1.68b*	1.93	30.60	28.20	29.40a
13.4	4.91a	2.83ab*	3.87	2.35ab	1.89ab*	2.12	29.80	31.20	30.50a
20.1	5.22a	3.24a*	4.23	2.55a	2.11a*	2.33	38.20	34.00	36.10a
MEAN	4.24	2.69		2.20	1.88		32.90	30.40NS	
	Copper			Iron			Zinc		
Treatment	Corn	Sorahum	Mean	Corn	Sorahum	Mean	Corn	Sorahum	Mean
g N/m^2	mg/kg			mg/kg			mg/kg		
0	6.00	5.40	5.70a	72.00	52.00	62.00a	40.60a	21.20a*	30.90
6.7	5.20	3.20	4.20b	58.00	52.00	55.00a	31.00b	21.00a*	26.00
13.4	4.20	4.40	4.30b	72.00	44.00	58.00a	29.00b	21.40a*	25.20
20.1	3.80	2.40	3.10c	60.00	42.00	51.00a	31.00b	20.80a*	25.90
MEAN	4.80	3.85*		65.50	47.50**		32.90	21.10	

[1]Values in columns among N rates not followed by the same letter are significantly different at the 0.05 level of probability according to L.S.D. test. Values in rows between crops are significantly different at the 0.01 level of *P* with a ** or 0.05 level of *P* with a * or are non-significant with NS.

LITERATURE CITED

1. Blevins, RL., W.W. Frye and M.J. Bitzer. 1980. Conservation of energy in no-tillage systems by management of nitrogen. pp. 14-20. *In* Proceedings of The Third Annual No-tillage Systems Conference. RN. Gallaher (ed.). Gainesville, FL: University of Florida.
2. Gallaher, RN., C.O. Weldon and F.C. Boswell. 1976. A semiautomated procedure for total N in plant and soil samples. Soil Sci Soc Amer. J. 40887-889.
3. 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.
4. Hipp, B.W., and C.G. Gerard. 1971. Influence of previous crop and nitrogen mineralization on crop response to applied nitrogen. Agron. J. 63:583-586.
5. Jones, J.B., Jr. 1974. Plant analysis handbook for Georgia. Univ. of Georgia Coop. Ext. Serv. College of Agric Bull. No. 735. Athens, GA.
6. Lang, T.A., D.L. Overman and R.N. Gallaher. 1989. Yield and ear leaf nitrogen status in no-tillage second crop temperate and tropical corn. pp. 3638. *In* 1989 Southern Conservation Tillage Conference. LD. Teare (ed.). North Fl. Res. Educ. Center, Quincy, FL.
7. Lockman, Raymond B. 1972. Mineral composition of grain sorghum plant samples. Part III. Suggested nutrient sufficiency limits at various stages of growth. Soil Sci & Plant Anal. 3(4):295-303.
8. Soil Survey Staff. 1984. Official series description of the Arredondo series. Washington D.C.: US. Gov. Printing Office.

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Effects of Cover Crops and Irrigation on Cotton

Richard L. Maples, William H. Baker and J. Joe Varvil[1]

INTRODUCTION

Soil scientists generally agree that incorporating cover crops into the soil prior to planting inter-tilled crops such as cotton is a desirable practice. However, there is a scarcity of evidence to determine whether the benefits derived from the practice outweigh the disadvantages. The primary objectives of this study were

1. To measure the effects of winter and summer cover crops on the following cotton crop;
2. To measure the effects of cover crops on soil organic matter and related soil-test properties;
3. To measure the effects of irrigation on cotton grown with and without cover crops.

PROCEDURES

This study is located on the University of Arkansas Cotton Branch Experiment Station, Marianna, Arkansas, on Loring silt loam. The plots were established in 1985, and cotton was grown on all plots, using normal production practices, to measure soil uniformity. The 1985 cotton yields showed no appreciable differences due to soil variation. Therefore, the following rotations were initiated that fall.

1. Vetch/cotton/vetch
2. Wheat/cotton/wheat
3. Vetch/sudan/vetch/cotton
4. Vetch/sudan/vetch/cotton plus 52-52-52 extra fertilizer applied for Sudan.
5. Cotton.

Each main plot consists of eight 38-in. rows 800 ft long. Each main treatment is replicated four times in a randomized complete block design. Cotton was grown in the plots of treatments 1, 2 and 5 in 1986 without irrigation. Beginning in 1987, each plot in which cotton was grown was split to compare furrow irrigation and non-irrigation. Supplemental nitrogen (N) is applied to individual plots during fruiting and maturation as need is indicated by petiole analyses to nullify any bias resulting from N fixed by the vetch cover crop.

Measurements include:

1. Routine soil tests of samples collected in 6-in. increments 0-36 in. deep;
2. Nine weekly petiole analyses for NO_3-N, P, K and SO_4-S during fruiting and maturation each year;
3. Cotton lint yields.

Only the yields are presented in this report.

RESULTS

All cover crops were incorporated into the soil as green manure. The effects of N fixation by vetch was evidenced by increased nitrate concentrations in the soil of those plots in which vetch was turned under. It was, therefore, necessary to apply higher rates of N to the non-legume plots in order to equalize available N across rotations. Nitrogen was maintained in the sufficiency range in all plots.

Lint yields are listed in Table 1. There was no yield response to any cover/green manure crop treatment in 1986, 1987 or 1988. In 1989 the vetch-sudan-vetch plus high fertility treatment increased yields compared to cotton alone or cotton following vetch or wheat. Lint yields following vetch-Sudan-vetch were greater than yields following wheat. At this point in the study, there appeared to be a trend for the summer cover crop (sudan) to be more effective than the winter crops (wheat and vetch).

In 1990, the vetch-cotton-vetch rotation and cotton alone produced higher yields than the wheat-cotton-wheat rotation. Adverse weather conditions in May 1990 resulted in below-average yields.

Irrigation increased cotton yield each of the three years in which it was applied.

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Table 1. Cotton lint yields following cover crops, with and without furrow Irrigation, Cotton Branch Station, Marianna, **Arkansas, 1986** through 1990.

		1986		1987		1988		1989		1990	
Rotation[1]	Irrigation[2]	Yield	Mean	Yield	Mean	Yield	Mean	Yield	Mean	Yield	Mean
		lb lint/acre[3]									
VCV	yes	—		948		1035		1002		885	
VCV	no	—	675	690	819	745	890	730	866	743	814
WCW	yes	—		925		1013		973		680	
WCW	no	—	649	666	796	812	913	714	843	649	665
VSVC	yes	—		914		—		1027		—	
VSVC	no	—	—	639	777	—		767	897	—	
VSVC(+h.f.)	yes	—		972		—		1057		—	
VSVC(+h.f.)	no	—	—	733	853	—		812	935	—	
C	yes	—		953		1053		1013		850	
C	no	—	629	676	815	800	927	724	869	807	829
LSD(.05)		—	NS	NS	NS	NS	NS	NS	43	NS	52
Irrigated			—	—	942	—	1034	—	1014	—	805
Non-irrigated			—	—	681	—	786	—	749	—	733
LSD(.05)			—	—	25	—	34	—	36	—	56

[1]C = cotton, S = sudan, V = vetch, W = wheat, h.f. = high fertilizer.
[2]There was no irrigation in 1986.
[3]There were no significant interactions of rotation x irrigation effects.

Management of the Wheat Crop and Wheat Stubble in Double-Cropping Soybean

H.J. Mascagni, Jr, T.C. Keisling, E.D. Vories and M.LMay[1]

INTRODUCTION

Growers in Arkansas double-crop almost all the wheat acreage with soybeans. The most accepted practice has been to burn the wheat straw, disk and plant. State laws were passed in 1990 making a grower liable for automobile accidents caused by burning wheat straw. Conservation compliance has caused many growers to begin investigating alternatives to burning wheat straw.

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 three Arkansas locations: Northeast Research and Extension Center (NEREC), Keiser; Southwest Research and Extension Center (SWREC), Hope; and the Cotton Branch Experiment Station, Marianna. Experimental details are given in Tables 1 and 2. Seed bed preparation consisted of bedded (on 38-in. centers) and flat for wheat and five different stubble management treatments (Table 3) for the double-cropped soybeans. 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 the soybeans. Soybean canopy development data were taken during late R3 or early R4 growth stages on the soybeans.

RESULTS AND DISCUSSION

Wheat was planted in the fall on flat and on raised 38-in. spaced seedbeds at Keiser, Marianna and Hope. 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. Wheat grain yields were lost at Hope due to the continual spring rains. Wheat grain yield at Keiser was 44.5 and 46.0 bu/acre on 38-in. raised beds and on conventional flat plantings, respectively.

Soybean data were collected at NEREC and the Cotton Branch Station. Data were lost at SWREC due to deer grazing the plots of double-cropped soybeans. 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 Keiser the gap was 2 and 25 in. between canopies for 19- and 38-in. row spacings, respectively. Corresponding gaps were 2 and 18 in. at Marianna. 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 even closer row spacing could be advantageous to grain yields, especially in a production field.

Soybean grain yields showed a strong response to either burning or leaving the straw, row spacing and variety. At Keiser (Table 4), grain yields ranged from 14 to 42 bu/acre. The best yield was obtained with burned straw, narrow rows and a Group V soybean variety. At Marianna (Table 5), grain yields ranged from 9 to 27 bu/acre. The best yield was obtained by incorporating the straw, narrow rows and using a Group VI soybean variety. The only commonality between the two locations for increasing yield was narrow rows.

The straw load at Keiser was very large compared to that at Marianna. The day after planting there was a rain in excess of 3 in. at Marianna. Disking in the straw allowed these Marianna plots to store this water instead of it running off as surface drainage.

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Table 1. Soil test values for wheat experiments.

Location	pH	OM	P	K	Ca	Na	Mg	Fe	Mn	Cu	Zn	S	EC
	Analysis												
		-%-	lb/acre										mmhos
Marianna	5.5	1.0	117	215	1276	151	122	282	214	5	4	26	47
Keiser	6.1	2.9	55	912	8521	271	1923	484	238	2	8	38	67
Hope	7.0	1.2	54	187	2250	148	—	103	142	3	2	24	61

Table 2. Soil classification, planting and harvest dates, planting rates and varietal Information for each experiment

Location	Soil series	Variety	Planting Date	Planting Rate	Harvest date
Marianna	Memphis silt loam	Wheat			
		Caldwell	11/1/89	110 lb/acre	Not Applicable
		Soybeans			
		Asgrow 5403	6/17/90	8 to 10 viable seed/ft	10/30/90
		Uoyd	6/17/90	8 to 10 viable seed/ft	11/8/90
Keiser	Sharkey silty clay	Wheat			
		Caldwell	11/1/89	110 lb/acre	6/14/90
		Soybeans			
		Asgrow 5403	6/16/90	8 to 10 viable seed/ft	10/27/90
		Uoyd	6/16/90	8 to 10 viable seed/ft	11/4/90
Hope	Bowie fine sandy loam	Wheat			
		McNair 1003	11/6/89	110 lb/acre	Not Applicable
		Soybeans			
		Asgrow 5403	6/21/90	8 to 10 viable seed/ft	Not Applicable

Table 3. Stubble management treatments used for double cropped soybeans at NEREC, SWREC and Cotton Branch Station.[1]

Straw burning	Seedbed preparation: Bedded	Flat	Flat-Disked
	Treatment #		
Yes	1	3	---
No	2	4	5

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

The difference in varietal response at the two locations could have been due to the varietal tolerance to wheat straw or to differences in maturity occurring when water, sunlight and temperature are conducive to pod fill.

CONCLUSIONS

Conclusions based on one year's data are always questionable for crop production. This year's results show that wheat yields do not respond to planting on 38-in.-wide beds on clay soil. Soybean responses or components of yield increases reflect straw management (burning or leaving), seedbed preparation, row width and soybean variety. Through proper selection of straw management, row spacing, seedbed preparation and variety for the soil and climatic environment, yields can be increased dramatically (Table 6). Note that Table 6 is an interpretative attempt to give realistic values to factors found to increase yield in 1990.

Table 4. Double-cropped soybean vlelds followlna different stubble management treatments at **Kelser,** Arkansas.

Straw	Row	Bedded		Flat		flat & Inc.		
management	spacing	Asgrow	Uoyd	Asgrow	Uoyd	Asgrow	Uoyd	x̄
	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	10	15	16	16
						Non-Burned Mean		20
						19-in. Row Spacing Mean		29
						S i n . Row Spacing Mean		21
	x	27	23	24	25	---	---	
		Bedded Mean		flat Mean				
		25		25				

Table 5. Double cropped soybean **ylelds** followlng different stubble management treatments at Marianna, Arkansas.

Straw	Row	Bedded		Flat		Flat & Inc.		
management	spacing	Asgrow	Uoyd	Asgrow	Uoyd	Asgrow	Uoyd	x̄
	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
	x̄	16	17	11	18	--	--	
		Bedded Mean		Flat Mean				
		17		15				

Table 6. Yield **component analysls** for **double-cropped soybeans** at **Kelser** and Marlanna. Arkansas.

Estimated base yield lowest	Keiser	Marianna
	bu/acre	
Lowest yielding treatment combination	15	9
Positive yield component added by		
Burning Straw	+11	0
Leaving Straw	0	4
Incorporating Straw	0	7
Planting Asgrow 5403	0	0
Planting Uoyd	0	4
Using **19-in.** Rows Instead of S i n . Rows	0	6
Estimated best yield	34	30
Measured best treatment combination	34	27

Population Densities of Plant-Parasitic Nematodes Following Winter Cover Crops

R. McSorley, R.N. Gallaher and D. W. Dickson[1]

ABSTRACT

Densities of plant-parasitic nematodes were compared following winter cover crops of rye (*Secale cereale* L.) and vetch (*Vicia villosa* Roth.) over two seasons in north Florida. Numbers of *Belonolaimus longicaudatus* Rau, *Paratrichodorus minor* (Colbran) Siddiqi and *Pratylenchus brachyurus* (Godfrey) Filipjev and Schuurmans Stekhoven did not differ ($P \leq 0.05$) with cover crop, but numbers of *Criconemella sphaerocephala* (Taylor) Luc and Raski and *Xiphinema* spp. were greater following rye than following vetch in one of the two seasons. Densities of *Meloidogyne incognita* (Kofoid and White) Chitwood declined greatly following each cover crop but were lower ($P \leq 0.05$ on rye than on vetch in one season. This and previous studies suggest that a winter cover crop of rye may be advantageous in lowering *M. incognita* population densities, provided that B. *longicaudatus* is not present in the site.

INTRODUCTION

Recently research has increased on the use of winter cover crops for conservation tillage systems (Myers and Wagger, 1989). Cover crops may aid in reducing erosion and weed populations (Hoyt and Hargrove, 1986), and leguminous crops may provide a supplemental source of nitrogen (Hargrove, 1986). However, multiple cropping may increase population densities of soilborne pests such as plant-parasitic nematodes, resulting in potential production problems (Good et al., 1965; Johnson 1982; McSorley and Parrado, 1983; Rhoades, 1983). Rye (*Secale cereale* L.) and hairy vetch (*Vicia villosa* Roth.) are frequently grown as cover crops in the southeastern states, and the nematodes associated with them have been investigated recently (Dickson and Gallaher, 1989; McSorley and Dickson, 1989a; Post et al., 1984). Low populations of root-knot nematodes (*Meloidogyne incognita* [Kofoid and White] Chitwood) were maintained in a vetch-corn (*Zea* mays L.) system (Dickson and Gallaher, 1989). Our objective was to compare the effects of rye and vetch winter cover crops on nematode population densities.

MATERIALS AND METHODS

Plots of rye and hairy vetch were established at the University of Florida Agronomy Farm near Gainesville, Florida, on an Arredondo fine sand (96% sand, 2% silt, 2% clay; pH 6.0, 1.2% organic matter). Plots were planted in early November 1986 following conventional tillage of a corn (*Zea mays* L.) crop. Eight plots (3 m x 3 m square) were planted with rye and eight with vetch. Vetch seed inoculated with *Rhizobium leguminosarum* (Frank) was drilled in rows 15 cm apart at a rate of 68 kg/ha. 'Wrens Abruzzi' rye was planted at 50 kg/ha. Vetch and rye plots were maintained until early April when they were mowed and disked in preparation for planting 'Davis' soybean (*Glycine max* (L.) Merr.). No fertilizers or pesticides were used on the vetch and rye cover crops. The cover crop plantings were repeated during the winter of 1987-88.

Soil samples for assessing initial nematode densities in each season were collected from all plots on 7 November 1986 and 12 November 1987. Samples were also collected near the end of each cover crop, on 1 April 1987 and 28 March 1988. Individual soil samples consisted of 12 cores, 2.5 cm in diameter and 20 cm deep, collected in a stratified random pattern. Three replicate samples were collected from each 3 x 3-m plot on each sampling date. Nematodes were extracted from a 100-cm^3 subsample from each sample using a modified sieving and centrifugation technique (Jenkins, 1964). The counts from the three replicate samples per plot were averaged to obtain an estimate of mean nematode population density per 100 cm^3 of soil for that plot. Nematode densities in rye and vetch plots were compared using a t-test on log-transformed data.

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RESULTS AND DISCUSSION

The plant-parasitic nematodes *Belonolairnus longicaudatus* Rau, *Meloidogyne incognita, Criconemella sphaerocephala* (Taylor) Luc and Raski, *Pratylenchus brachyurus* (Godfrey) Filipjev and Schuurmans Stekhoven, *Paratrichodorus minor* (Colbran) Siddiqi and *Xiphinemu* spp. were found in both rye and vetch plots (Table 1). No significant ($P \leq 0.05$) differences in nematode densities between rye and vetch were observed in any of the initial (November) samples for any nematode species. Spring densities of *C. sphaerocephala* were greater ($P \leq 0.05$) in rye than in vetch plots in 1987 but not in 1988. Densities of *M. incognita* declined from November to March/April during each season in both cover crops, and densities were lower ($P \leq 0.05$) following rye than following vetch in 1988. *Xiphinemu* spp. densities were greater ($P \leq 0.05$) on rye than on vetch in the March 1988 sampling.

Among the plant-parasitic nematodes found in this study, those with the most potential for damaging subsequent corn or soybean crops are *B. longicaudatus, M. incognita* and *P. brachyurus* (McSorley and Dickson, 1989b,c). Densities of *P. bmchyurus* seemed to be affected very little by type of cover crop (Table 1). Differences in *B. longicaudatus* final densities on rye and vetch were not significant ($P \leq 0.05$), but rates of population increase of this nematode are greater on rye than on vetch (McSorley and Dickson, 1989a). In this study (Table 1) densities of *B. longicaudatus* increased tenfold on rye but only four-fold on vetch during 1986-1987. In 1987-1988, densities declined on vetch but more than doubled on rye. Therefore, caution should be exercised in using rye as a winter cover crop where *B. longicaudatus* is present.

Densities of *M. incognita* declined on both cover crops over each winter of this study. However the higher levels remaining on vetch are of concern, since this nematode can be damaging to many crops at low population levels. In another study (Dickson and Gallaher, 1989), numbers of *M. incognita* remained high in a vetch-corn rotation compared to a vetch-rye rotation. However, efforts to reduce *M. incognita* using a winter cover crop of Wrens Abruzzi rye have been very successful. Population densities of *M. incognita* declined greatly under rye in both field (McSorley and Dickson, 1989a) and microplot (Opperman et al., 1988) studies. Densities of *M. incognita* remained very low ($\leq$ 4/250 cm^3 soil) following four years of no-tillage management of a rye-soybean system, regardless of whether no-tillage or conventional tillage was practiced in the fifth year (Post et al., 1984). Thus winter rye may be an effective management tool in lowering *M. incognita* populations and may be advantageous for this purpose, provided that *B. longicaudatus* is not also present in the same location.

LITERATURE CITED

1. **Dickson, D.W., and R.N. Gallaher. 1989. Population densities of plant-parasitic nematodes in multiple-cropping and tillage systems. p. 16-19. *In* I.D. Teare (ed). Proc 1989 Southern Cons. Till. Conf., Tallahassee, FL.**
2. **Good, J.M., N.A. Minton and C.A. Jaworski. 1965. Relative susceptibility of selected cover crops and Coastal Bermudagrass to plant nematodes. Phytopathology 55:1026-1030.**
3. **Hargrove, W.L. 1986. Winter legumes as a nitrogen source for no-till grain sorghum. Agron. J. 78:70-74.**

Table 1. Nematode population densities in soil from plots of either rye or vetch cover crops over *two* winter seasons.

			Nematodes per 100 cm^3 soil					
Years	Month sampled	Cover crop	*Belonolaimus longicaudatus*	*Criconemella sphaerocephala*	*Meloidogyne incognita*	*Paratrichodorus minor*	*Pratylenchus brachyurus*	*Xiphinema* spp.
1986	November	Rye	0.7	42.9	13.1	1.0	80.5	0
		Vetch	1.3	33.9	19.0	2.7	61.6	0
1987	April	Rye	7.1	79.7'	0.1	0	22.6	0
		Vetch	5.4	34.7	0.5	0	30.3	0
1987	November	Rye	3.2	49.1	3.5	0.3	64.4	0.1
		Vetch	5.0	38.3	16.3	0.2	95.0	0.2
1988	March	Rye	7.0	22.2	0.1[1]	0.2	18.4	2.3*
		Vetch	2.5	28.5	1.7	0.3	18.8	0.1

'Significant differences between cover crops on the same sampling date, according to a t-test. Data are means of 8 replications.

4. Hoyt, G.D., and W.L. Hargrove. 1986. Legume cover crops for improving crop and soil management in the southern United States. HortScience 21:397-402.

5. Jenkins, W.R 1964. A rapid centrifugal-flotation technique for separating nematodes from soil. Plant Dis. Reptr. 48692.

6. Johnson, A.W. 1982. Managing nematode populations in crop production. p. 193-203. *In* R D. Riggs (ed.). Nematology in the southern region of the United States. Southern Coop. Ser. Bull. 276. Ark. Agric Exp. Sta, Fayetteville.

7. McSorley, R., and D.W. Dickson. 1989a Nematode population density increase on cover crops of rye and vetch. Nematropica 1939-51.

8. McSorley, R., and D.W. Dickson. 1989b. Effects and dynamics of a nematode community on maize. J. Nematol. 21:462-471.

9. McSorley, R., and D.W. Dickson. 1989c. Effects and dynamics of a nematode community on soybean. J. Nematol. 21:490-499.

10. McSorley, R., and J.L. Parrado. 1983. Influence of summer management strategies on nematode populations in a subtropical agroecosystem Nematropica 13:l-8.

11. Myers, J.L., and M.G. Wagger. 1989. Reseeding potential of crimson clover in no-till corn. p. 56-58. *In* I.D. Teare (ed). Proc 1989 So. Cons. Till. *Conf.*, Tallahassee, FL.

12. Opperman, C.H., J.R. Rich and R.A. Dunn. 1988. Reproduction of three root-knot nematodes on winter small grain crops. Plant Disease 72:869-871.

13. Post, T.J., RN. Gallaher and D.W. Dickson. 1984. Nematode populations in a sye/soybean succession after four years of no tillage management. Res. Rep. AY-84-6. Agron. Dept., Univ. FL, Gainesville.

14. Rhoades, H.L. 1983. Effects of cover crops and fallowing on populations of ***Belonolaimus longicaudatus*** and *Meloidogyne incognita* and subsequent crop yields. Nematropica 13:9-16.

Effect of Various Agronomic Practices on Arthropod Ground Predators in a Soybean-Wheat Double-cropping System

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INTRODUCTION

Double-cropping of wheat *(Triticum aestivum* spp.) and soybeans *(Glycine max* L.) in Louisiana has increased significantly in recent years. Double-cropping enables producers to derive additional income from more intensive land use. As cropping systems change, the effects of these changes on pest and beneficial arthropod populations must be examined. Arthropod ground predators that may be significantly affected by changes in agronomic practices and cropping systems represent an important component of the soybean agroecosystem. Buschman et al. (1984) examined the effects of planting date, row spacing and maturity group on several foliar-inhabiting soybean arthropod populations. Predator populations were found to be only mildly influenced by the three cultural practices. Ferguson at al. (1984a) examined foliar-inhabiting predators in four soybean cropping systems (full season, conventionally plowed; drill planted; no-till, double-cropped soybeans after barley; and no-till, double-cropped soybeans after wheat) and concluded that at least three factors (planting date, row spacing and the presence of previous crop stubble) may contribute to the enhancement of the natural predator complex found in the narrow-row and no-till cropping systems. Ferguson et al. (1984b) also examined both foliar-inhabiting and ground-dwelling spiders in four soybean cropping systems and found that ground-dwelling spiders were more numerous in barley-soybean and wheat-soybean double-cropping systems than in drilled or conventionally planted soybeans not double-cropped. McPherson et al. (1982) examined the seasonal incidence of a number of foliar-inhabiting predator species in conventionally seeded, drill-seeded and double-cropped soybeans and concluded that cropping system significantly influenced the abundance of predatory species. In Louisiana, Troxclair and Boethel (1984) examined insect populations for two years by sweepnet in conventionally tilled and no-till soybeans in both narrow and wide row spacings. The only species to exhibit a consistent population response at all locations was the banded cucumber beetle, *Diabrotica balteata* (LeConte).

The following study was conducted to determine the response of arthropod ground predators to soybeans grown under several management systems with an emphasis on conservation tillage and double-cropping with wheat.

MATERIALS AND METHODS

The study was conducted on a Moreland silty clay soil on the Red River Research Station, Bossier City, Louisiana, during 1984 and 1985. Experimental design was a randomized complete block with a split-split-plot arrangement of treatments and four replications. Main plots and subplots were management practices for the handling of wheat straw residue. Main plots were burned and not burned with subplots being disked and not disked. Sub-subplots were tillage practices and were as follows: 1) 10-in. no-till beans following wheat, 2) 20-in. no-till beans following wheat, 3) 40-in. no-till beans following wheat, 4) 40-in. tilled beans following wheat and 5) 40-in. tilled beans with plots winter fallowed. Sub-subplots were 15.23 m by 8.12 m.

In 1984, 'Centennial' soybeans were planted on 6 June after the harvesting of 'Coker 916' wheat. Burning and disking of wheat straw stubble was conducted the day prior to bean planting. Pitfall traps consisted of an outer 16-oz plastic cup, which was buried so that the lip was level with the soil surface and remained in the ground during the entire trapping period, and an inner 4-02 plastic cup, which was placed inside the buried outer cup only during specific two-day periods. Approximately 2-3 oz of ethylene glycol was placed in the inner cup as a preservative. Pitfall traps were operated (inner cup with ethylene glycol in place) only two days each week during July and August. Two-day pitfall trap

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collections were removed in 1984 on 3, 10, 18, 24 and 31 July and 9, 15, 22 and 28 August. Plots were harvested on 8 November and planted to Coker 916 wheat.

In 1985 'Tracy-M soybeans were planted on 5 June after burning and disking of wheat stubble. Two-day pitfall collections were removed on 16 and 30 July and on 6, 13, 20 and 28 August. Soybeans were harvested on 12 November. No insecticides were used in the test plots during the course of this study.

This study reports the pitfall trap data for carabids (ground beetles), formicids (ants, primarily fire ants) and spiders only. Data were analyzed using the GLM procedure, Duncan's multiple range test and Student's t-test (SAS Institute, 1982). Statistical differences are shown only for total trap catches (Fig. 6) and not for individual sampling dates (Figs. 1-5).

RESULTS AND DISCUSSION

Carabids

In both 1984 and 1985, pitfall traps in the burned plots generally captured more carabids than traps in the non-burned plots (Fig. 1). In 1984, the peak two-day trap catch in the burned plots occurred on the first sampling date (3 July), while in the non-burned plots the peak trap catch occurred on 31 July. Total seasonal carabid captures were higher in the burned plots than in the non-burned plots although only in 1985 was the total significantly higher for the burned plots (Fig. 6). Disking had no significant effect on total carabid numbers captured in 1984 or 1985 (Fig. 6).

In 1984 on each sampling date, more carabids were captured in pitfall traps in the 40-in. no-till plots than in either the 10-in. or 20-in. no-till plots (Fig. 2). Total carabids captured was significantly higher in the 40-in. no-till plots than in the 10-in. and 20-in. no-till plots in 1984 (Fig. 6). Although the trend was similar for 1985, no significant differences occurred among row spacings in total numbers of carabids captured. No significant differences in carabid numbers occurred among tillage practices (40-in. no-till, following wheat; 40-in. tilled, following wheat; 40-in. tilled, winter fallowed) in 1984 or 1985.

Formicids

Although the burned plots had numerically more formicids captured on each sampling date in both 1984 and 1985 (Fig. 3), the total number of formicids captured was not significantly affected either year by burning (Fig. 6). In 1985, approximately 10-fold more formicids were captured in pitfall traps than in 1984. Disking reduced formicid numbers on most individual dates in 1984 and 1985 (Fig. 4). Total number of formicids captured was lower in the disked plots in both 1984 and 1985, although the difference was statistically different only in 1984 (Fig. 6). Row spacing and tillage practice (tilled versus no-till and tilled following wheat versus tilled following winter fallowed) did not significantly affect formicid numbers (Fig. 6).

Spiders

Burning of wheat stubble reduced the number of spiders captured on most dates in both 1984 and 1985 (Fig. 5). The number of spiders captured in

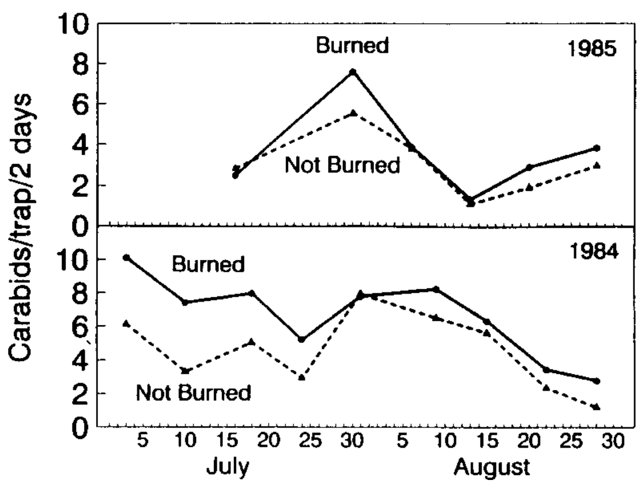
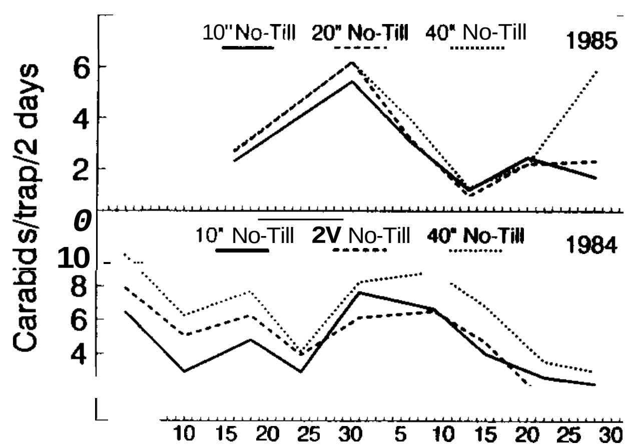


Fig. 1. Effects of burning wheat straw residue on carabid numbers in soybeans in 1984 and 1985.



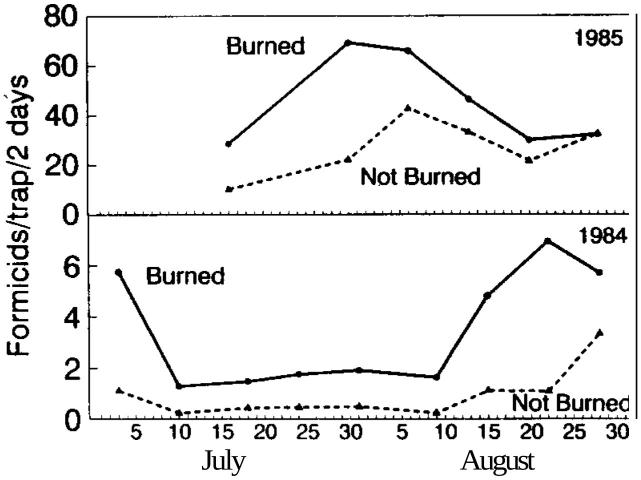


Fig. 3. Effects of burning wheat straw residue on formicid numbers in soybeans in 1984 and 1985.

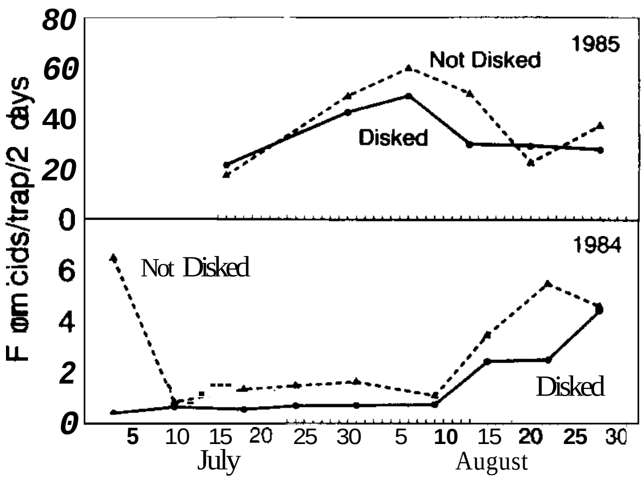


Fig. 4. Effect. of preplant disking of wheat straw residue on formicid numbers in soybeans in 1904 and 1985.

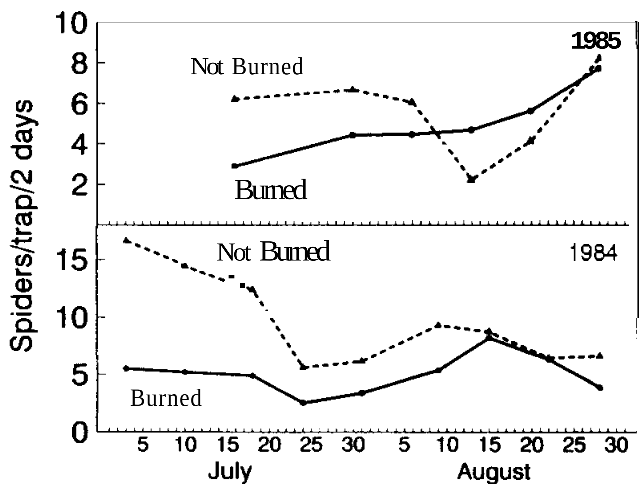


Fig. 5. Effects of burning wheat straw residue on spider numbers In soybeans in 1904 and 1985.

the burned plots, however, increased in mid-August of 1985, and by mid-August more spiders were captured in the burned plots than in the non-burned plots. As a result, only in 1984 was the total number of spiders captured during the season significantly lower in the burned plots compared to the non-burned plots (Fig. 6). Disking, row spacing and tillage practice did not significantly affect total spider numbers captured in either 1984 or 1985 (Fig. 6).

Data on ground-dwelling spiders in the study differ from those obtained by Ferguson et al. (1984b), who found ground that spiders were more numerous in both barley-soybean and wheat-soybean double-cropped systems than in a conventional system. This study did not demonstrate an increase in ground-dwelling spider numbers in double-cropped systems versus a conventional system.

This study also failed to indicate an increase in ground arthropod predators in a no-tillage system compared with a conventional tillage system. This contrasts with the results of House and Alzugaray (1989) in North Carolina demonstrating that arthropod predators were more numerous in no-till corn than in conventional tillage corn. However, they sampled below-ground macroarthropods by the use of a soil corer in contrast to our use of pitfall traps.

CONCLUSION

In conclusion, carabid and formicid numbers were greater both years in the burned plots compared with the non-burned plots. This increase was statistically significant only for the carabids in 1985. The total number of spiders captured in pitfall traps was lower both years in the burned plots compared with the non-burned plots, however, the difference was statistically significant only in 1984.

Pre-plant disking of wheat stubble resulted in significantly fewer total formicids captured in 1984 but had no significant effect in 1985. The number of carabids and spiders captured both years was unaffected by disking.

Row spacing did not significantly affect the number of formicids or spiders captured during 1984 and 1985 but did significantly affect the number of carabids captured during 1984. In 1984, significantly more carabids were captured in the 40-in. rows than in the 10-in. or 20-in. rows. Carabid, formicid and spider numbers were not significantly affected by tillage practices (no-tilled versus tilled and tilled following wheat versus tilled following winter fallowed).

Results from this study indicate that ground predators are significantly affected by changes in

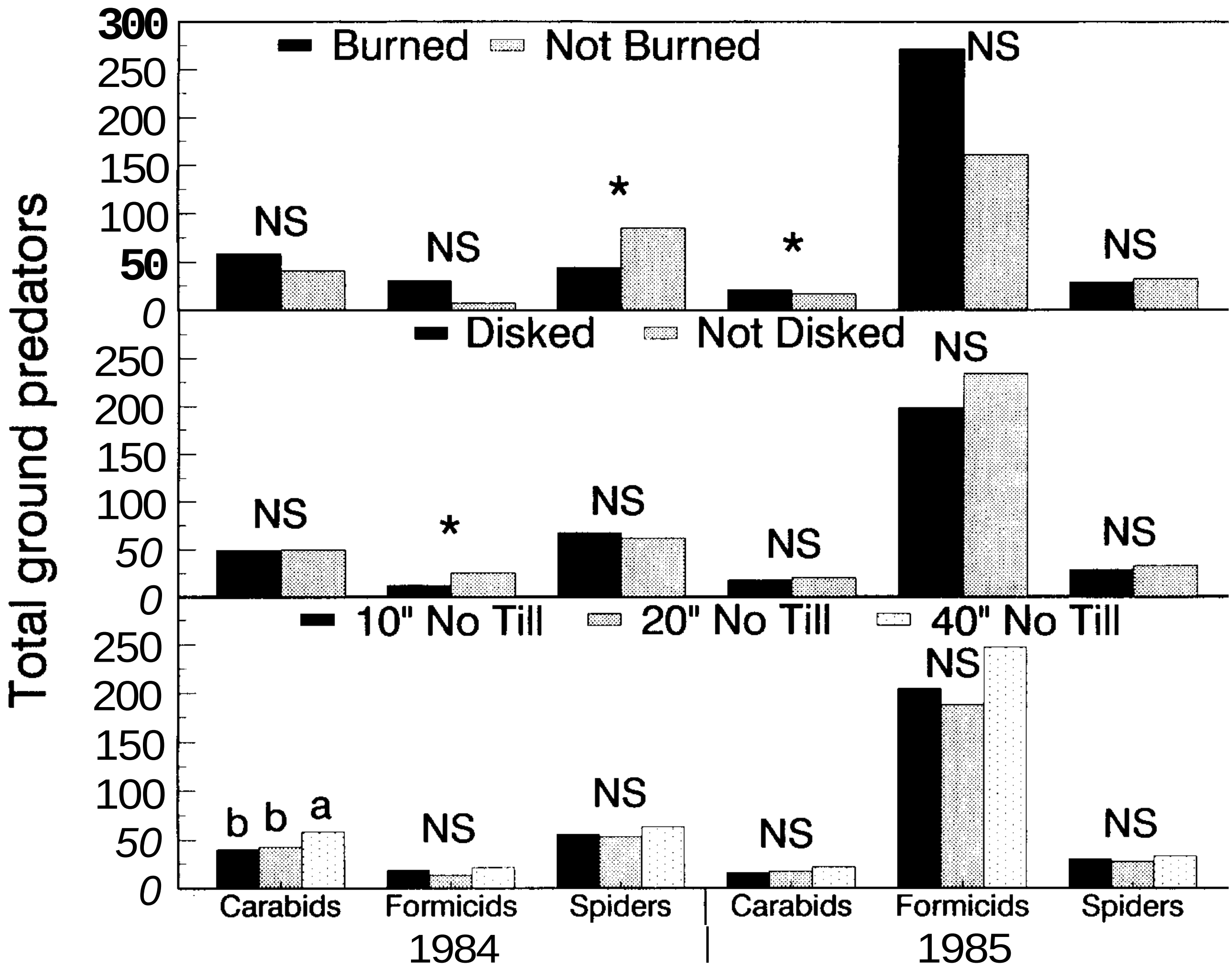


Fig. 6. Effect. of burning, disking, and row spacing on total carabid, formicid, and spider number during 1984 and 1985.

agronomic practices. The study also indicates, however, that each ground predator group responds differently to each agronomic practice.

LITERATURE CITED

1. Buschman, L.L., H.N. Pitre and H.F. Hodges. 1984. Soybean cultural practices: Effects on populations of geocorids, nabids, and other soybean arthropods. Environ. Entomol. 13:305-317.
2. Ferguson, H.J., RM. McPherson and W.A. Allen. 1984. Effect of four soybean cropping systems on the abundance of foliage-inhabiting insect predators. Environ. Entomol. 13:1105-1112.
3. Ferguson, H.J., RM. McPherson and W.A. Allen. 1984b. Ground- and foliage-dwelling spiders in four soybean cropping systems. Environ. EntomoL 13:975-980.
4. House, G.J., and M.D.R. Alzugaray. 1989. Influence of cover cropping and no-tillage practices on community composition of soil arthropods in a North Carolina agroecosystem. Environ. Entomol. 18:302307.
5. McPherson, RM., J.C. Smith and W.A. Allen. 1982. Incidence of arthropod predators in different soybean cropping systems. Environ. Entomol. 11:685-689.
6. SAS Institute. 1982. SAS user's guide: statistics, 1982. ed. SAS Institute, Cary, N.C.
7. Troxclair, N.N., and D.J. Boethel. 1984. Influence of tillage practices and row spacing on soybean insect populations in Louisiana. J. Econ. Entomol. 77:1571-1579.

Response of Lowland Rice to Inorganic and Organic Amendments on Soils Disturbed by Grading in Eastern Arkansas

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ABSTRACT

In eastern Arkansas, yields of rice growing on subsoil materials exposed as a result of land grading are low and often cannot be improved through the application of inorganic N-P-K fertilizers. In this two-year field study, experimental plots located on eight recently graded fields were amended with inorganic (P, K, S, Zn and gypsum) and organic (uncomposted broiler litter, composted broiler litter and rice scalping) materials, alone and in various combinations, and planted to rice. Composted and uncomposted broiler litter, applied at rates ranging from 280 to 4480 kg/ha, were most effective in increasing rice yields relative to the fertilized but otherwise unamended control. Rice scalping at rates up to 6720 kg/ha had no effect on rice yields. With the exception of gypsum application to sodic soil, applications of a single inorganic amendment were ineffectual compared with applications of litter, although significant rice yield increases were occasionally obtained when two or more inorganic amendments were applied together.

INTRODUCTION

Land grading is popular among rice farmers because it simplifies levee construction and facilitates efficient use of water (Nir, 1983). However, the subsoil that is exposed during the leveling operation is frequently infertile and difficult to manage (Miller, 1990). As a result, yields of rice and soybean growing on deeply cut areas of leveled fields are often quite low. In many cases soil tests are unable to identify the element or elements that are limiting yields.

This study reports the yield response of rice grown on graded soils to additions of inorganic (zinc, potassium, phosphorus, sulfur or gypsum) or organic (composted and uncomposted chicken litter or rice scalping) amendments, alone and in various combinations. Zinc was chosen as a treatment because of the well-known tendency for rice to suffer from zinc deficiency in eastern Arkansas (Wells et al., 1973) and because zinc deficiency in graded soils has been documented (Grunes et al., 1961). Because graded soils are typically low in organic matter (Olson, 1977; Jessop et al., 1985), and because both phosphorus (Broadbent, 1986) and sulfur (Stevenson, 1986) deficiencies are frequently associated with low organic matter contents, P and S treatments were included. Gypsum was used as a treatment on those soils believed to be sodic because it has been shown to be effective in the reclamation of such soils (Loveday, 1984). Organic waste treatments were included because additions of organic residues have been shown to be effective in restoring productivity to both disturbed (Carlson et al., 1961; Mbagwu, 1985) and salt-affected (Lipman and Gericke, 1919; Gupta and Abrol, 1990) soils.

MATERIALS AND METHODS

The fields in which the tests were conducted were located in Jackson County, Arkansas. Site designations and selected site characteristics are listed in Table 1. Chicken litter compost (CLC), chicken litter (CL), composted rice scalping (CRS), gypsum (GYP) and phosphorus were applied preplant at all locations and were incorporated to a depth of ap-

Table 1. Experimental site characteristics.

Site	Graded	Soil Mapping Unit	Comments
Connor #1 (C1)	1985	Calhoun silt loam	High Ca, low Na
Connor #2 (C2)	1987	Dexter Silt loam	Low P, pH 7
Connor #3 (C3)	1987	Foley-Calhoun complex	Moderate sodicity
Lewis (L)	1988	Foley-Calhoun complex	Severe sodicity
Huey A (HA)	1989	Bosket sandy loam	Loamy sand, pH 6
Huey B (HE)	1989	Oundee silt loam	Silty clay loam, pH 5.5
Lewellyn (LEW)	1989	Dundee/Bosket	Highly variable

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proximately 4 in. The zinc was applied after seedling emergence as a chelate at all sites. Total N, P and K contents (%, dry weight basis) of the organic amendments were 4.24, 1.06 and 1.30 for the CL and 3.30, 2.09 and 2.40 for the CLC, respectively. The N content of the CRS was 0.64%. Application rates for the various amendments and treatment combinations are shown in Tables 2 and 3 for the 1989 tests and in Table 4 for the 1990 tests. At each site, a completely randomized block design with four replications was used, giving a total of 64 plots per site at all sites except at Lewellyn (LEW), where only 10 treatments (40 plots) were installed due to space limitations. Plot size was 1.8 x 4.6 m.

All plots were in farmers' fields and were fertilized with N by the farmer according to the N requirements of the cultivar being grown. In general, N fertilization consisted of a preflood topdress application of urea with one or two subsequent aerial applications of urea during the growing season (134 - 157 kg total N/ha). In 1989 'Tebonnet' was planted at Huey A (HA) and Huey B (HB) on 20 April and at Lewis (L) on 26 April, while 'Newbonnet' was planted at Connor 1 (C1) on 20 April and at Connor 2 (C2) on 26 April. In 1990, Tebonnet was planted at LEW on 10 May while a mixture of two genotypes was planted at Connor 3 (C3) on 15 May (hybrid seed was being produced on this farm). A 3.7 x 0.8 m area of each plot was harvested on 15 September (HA and HB), 18 September (L and C1) or 20 September (C2) 1989 or on 22 September 1990 (LEW and C3). Grain yields, corrected for moisture, are shown in Tables 2 through 4.

RESULTS AND DISCUSSION

At the HA site mean yields ranged from 1093 (P) to 5537 (CLC +Zn+P) kg/ha. There was a great deal of variability among replicates at this site, possibly due to herbicide runoff from an adjacent road embankment. As a result, the yields of only two treatments, CLC+S and CLC+Zn+P, were significantly greater than that of the control. At the HB site mean yields ranged from 2812 (S) to 6903 (CLC+Zn+S+P) kg/ha. The yields of nine treatments significantly exceeded that of the control; of these, eight were treatments involving CLC. At the L site mean yields ranged from 2014 (control) to 6515 (CLC+GYP+Zn) kg/ha. The yields of 12 treatments (all except Zn and P) were significantly greater than that of the control. The seven highest-yielding

Table 2. Rice response to chicken litter compost, Zn, S and P when grown on a precision-leveled Bosket fine sandy loam soil., J.D. Huey farm, Jackson Co., Arkansas, 1989.

Treatment				Grain Yield	
C.L.C.[1]	Zn[2]	S[3]	P[4]	Site A[5]	Site B[6]
kg/ha				kg/ha	
0	0	0	0	2641	3614
0	1.12	0	0	4114	3811
0	0	22.4	0	1901	2813
0	0	0	22.4	1093	3548
2240	0	0	0	3596	5852
0	1.12	22.4	0	3151	4453
0	1.12	0	22.4	3695	5230
2240	1.12	0	0	3833	6433
0	0	22.4	22.4	3033	5274
2240	0	22.4	0	5269	6718
2240	0	0	22.4	3153	6255
0	1.12	22.4	22.4	1838	5716
2240	0	22.4	22.4	2843	6552
2240	1.12	22.4	0	4468	6381
2240	1.12	0	22.4	5537	6743
2240	1.12	22.4	22.4	2682	6902
$LSD_{.05}$				2151	1816

[1]C.L.C. = chicken liner compost
[2]Zn as Zn EDTA.
[3]S as $CaSO_4$.
[4]P as TSP.
[5]Sand base.
[6]Clay base.

Table 3. Response of rice to chicken litter compost, Zn, P and gypsum when grown on graded soils suspected of having a nitric B horizon. Jackson Co., Arkansas, 1989.

Treatment				Grain Meld		
Zn[1]	Gypsum[2]	CLC[3]	P[4]	Lewis[5]	C1[6]	C2[7]
kg/ha				kg/ha		
0	0	0	0	2014	5320	4463
1.12	0	0	0	2614	5414	4638
0	4480	0	0	4218	4997	4171
0	0	2240	0	5768	6475	7145
0	0	0	22.4	2629	6230	6092
1.12	4480	0	0	3308	4436	5622
1.12	0	2240	0	6288	7170	7705
1.12	0	0	22.4	3720	6622	7268
0	4480	2240	0	5676	6359	7595
0	4480	0	22.4	4784	6092	7194
0	0	2240	22.4	5077	6792	8243
1.12	4480	2240	0	6515	5643	8110
0	4480	2240	22.4	6431	5977	7903
1.12	4480	0	22.4	3993	5716	7262
1.12	0	2240	22.4	6014	6870	7116
1.12	4480	2240	22.4	5833	6690	8034
$LSD_{.05}$				1313	994	1209

[1]Zn as Zn EDTA
'Gypsum as $CaSO_4$.
[3]CLC = chicken litter compost.
[4]P as TSP.

[5]Tommy Lewis' farm.
[6]Connor - Holden - Grubbs.
[7]Connor - Holden - Ark. Rt. 18.

Table 4. Rice response to chicken litter, chicken litter compost, composted rice scalping and inorganic fertilizers on recently graded soils, Jackson County, Arkansas, 1990.

Treatment				Grain Yield	
CL[1]	CLC[2]	CRS[3]	P,K,Zn,S[4]	C3	LEW
kg/ha					
0	0	0	0,0,0,0	2531	4791
0	280	0	0,0,0,0	4240	NT[5]
0	560	0	0,0,0,0	3755	NT
0	1120	0	0,0,0,0	3862	4445
0	2240	0	0,0,0,0	4409	6189
0	4480	0	0,0,0,0	4115	6381
280	0	0	0,0,0,0	3884	NT
560	0	0	0,0,0,0	3727	NT
1120	0	0	0,0,0,0	4450	5887
2240	0	0	0,0,0,0	4426	6713
4480	0	0	0,0,0,0	4719	5770
0	0	2240	0,0,0,0	3349	5025
0	0	4480	0,0,0,0	NT	4705
0	0	6720	0,0,0,0	3082	4879
0	0	0	0,67,0,0	2345	NT
0	0	0	22.4,67,1.12,22.4	4015	NT
$LSD_{.05}$				993	1053

'CL = chicken litter.
[2]CLC = chicken litter compost.
[3]CRS = composted rice scalping.
[4]P as TSP, K as KCl, Zn as Zn EDTA, and S as elemental S.
'Treatment not performed at this location.

treatments, which did not differ significantly among themselves, were treatments involving CLC. The yield of the gypsum-only treatment was significantly greater than the yields of the zinc only, phosphorus only and control treatments. It is also interesting to note that the yield of the GYP+P treatment was not significantly different from the GYP+P +CLC+Zn treatment.

At the C1 site, mean yields ranged from 4435 (GYP+Zn) to 7170 (CLC+Zn) kg/ha Six of the seven treatments with yields significantly greater than the control received CLC; the one that did not was the Zn+P treatment. The yields of two treatments involving CLC (CLC+Zn+GYP and CLC+P+GYP) were no greater than that of the control. At the C2 site mean yields ranged from 4171 (GYP) to 8243 (CLC+P) kg/ha. The only treatments whose yields were not significantly greater than that of the control were Zn, GYP and GYP+Zn. The top six yielding treatments all involved CLC, but overall there were no significant differences in yields among the top eleven yielding treatments. A significant response to P applied alone was observed at the C2 site. At C1, response to this treatment was also significant but at a lower probability level (.10). Beyrouty et al. (1991) have reported significant rice yield responses to P fertiliztion on ungraded but otherwise similar soils.

The 1990 yield data presented in Table 3 indicate that both CLC and CL increased rice yields relative to the check plots, but one does not appear to be more effective than the other. By contrast, the CRS did not improve yields. From this it may be inferred that rice will not respond to all organic amendments in the same manner, and that litter, either fresh or composted, is likely to be superior to other organic amendments. At the C3 site, fertilization with K only was not effective, but fertilization with a mixture of P, K, Zn and S was as effective as any of the organic amendments.

There were no statistically Significant differences in yields among the CL and CLC treatments at the C3 site, regardless of application rate (Table 3). All CL and CLC treatments, however, were significantly greater than the checks. This indicates that at this particular site application of 280 kg/ha of either CL or CLC was just as effective in increasing yields as was application of 4480 kg/ha. However, grain yields at this site were limited by the use of two non-adapted rice lines to produce hybrid rice seed. Thus, the response to higher rates of CL or CLC may have been masked. Different results were obtained at LEW, where application of 1120 kg/ha of CLC did not significantly increase yields while 2240 and 4480 kg/ha did. On the other hand, application of 1120 or 2240 kg/ha of CL significantly increased yields while 4480 kg/ha did not. Thus, the optimum rate of application may be quite low in some cases, and the optimum rates of CL and CLC may not always be the same.

SUMMARY AND CONCLUSIONS

At all of the test sites there was a clear and consistent positive response to the CLC. In addition to producing greater grain yields, rice grown on CLC- or CL-amended plots was taller and matured earlier than rice grown on other plots. This was particularly noticeable at the L and LEW sites, where the surface soil was sodic. In addition, there appeared to be a positive response to gypsum at the sodic L site. Visual observations made throughout the growing season indicated that this gypsum response occurred primarily during the last half of the season. The lack of a response to gypsum at the C1 and C2 sites may have been due to the fact that the gypsum had insufficient time to leach into the profile during the course of the experiment. The fact that application of zinc alone did not significantly improve yields at any of the sites suggests that zinc fertilization by itself may be of limited value in restoring productivity to graded soils.

Fresh and composted chicken litter appear to be of equal effectiveness in improving rice yields on graded soils, but CRS did not improve yields. This indicates that organic amendments are not all equivalent in their ability to restore productivity to graded soils. The optimum application rate of CL and CLC appears to vary with site conditions, making generalizations difficult. Because of the relatively low N contents of the CL and CLC, and because mineralization of organic N is a slow process, it is unlikely that response of rice to CL or CLC is due to increased N availability.

LITERATURE CITED

1. **Beyrouty, C.A., D.M. Miller, RJ. Norman, B.R Wells, RS. Helms, H.M. Chaney and N.A. Slaton. 1991. Rice response to phosphorus fertilization on soils testing low in phosphorus. *In* W.E. Sabbe (ed.). Arkansas soil fertility studies. Ark.** *Agric.* **Exp. Sta Research Series 411.**

2. **Broadbent, F.E. 1986. Effects of organic matter on nitrogen and phosphorous supply to plants. *In* Y. Chen and Y. Avnimelech (eds.). The role of organic matter in modern agriculture. Dordrecht, Netherlands: Martinus Nijhoff.**

3. **Carlson, C.W., D.L. Grunes, J. Alessi and G.A. Reichmann. 1961. Corn growth on Gardena subsoil**

as affected by application of fertilizer and manure. Soil Sci Soc Amer. Proc 25:44-47.

4. Grunes, D.L, L.C. Boawn, C.W. Carlson and F.G. Viets, Jr. 1961. Land leveling: It may cause zinc deficiency. N. Dak. Farm Res. 21:4-7.

5. Gupta, RK, and I.P. Abrol. 1990. Salt affected soils: Their reclamation and management for crop production. Adv. Soil Sci 11:223-288.

6. Jessop, R.S., D.A. Macleod, P.J. Hulme and D.C. McKenzie. 1985. The effects of land forming on crop production on a red-brown earth. Aus. J. Soil Res. 23:85-93.

7. Lipman, C.B., and W.F. Gericke. 1919. The inhibition by stable manure of injurious effects of alkali salts in soils. Soil Sci 7105-120.

8. Loveday, J. 1984. Amendments for reclaiming sodic soils. *In* I. Shainberg and J. Shalhevet (eds.). Soil salinity under irrigation. New York Springer-Verlag.

9. Mbagwu, J.S.C. 1985. Subsoil productivity of an Ultisol in Nigeria as affected by organic wastes and inorganic fertilizer amendments. Soil Sci 64:36441.

10. Miller, D.M. 1990. Variability of soil chemical properties and rice growth following land leveling. Ark. Farm Res. 39(1):4.

11. NU, D. 1983. Land grading. In H.J. Finkel (ed.). CRC Handbook of Irrigation Technology. Vol. 2. Boca Raton, Florida: CRC Press.

12. Olson, T.C. 1977. Restoring the productivity of glacial till soil after topsoil removal. J. Soil Water Conserv. 32:130-132.

13. Stevenson, F.J. 1986. Cycles of soil: C, N, P, S, and micronutrient. New York: Wiley & Sons.

14. Wells, B.R., L. Thompson, G.A. Place and P.A. Shockley. 1973. Effect of zinc on chlorosis and yield of rice grown on alkaline soil. Ark. Agric Expt. Stn., Univ. of AR, Fayetteville, AR. Rpt. Ser. 208.

Performance of Steers as Influenced by Overseeding Annual Grasses and Clover into Tall Fescue

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INTRODUCTION

Tall fescue *(Festuca arundinacea* Schreb.) is grown on approximately 809,400 ha in Arkansas. Its popularity as a forage is due to wide adaptation, ease of establishment, long productive season and tolerance to grazing, drought, poor drainage, pests and a wide range in soil pH (Burns and Chamblee, 1979). Many Arkansas livestock producers grow tall fescue in conjunction with a broiler litter operation and use the litter as an inexpensive fertilizer. Even though tall fescue is a popular forage grass among livestock producers in the southeastern United States, poor animal performance associated with the fungal endophyte *(Acremonium coenophialum* Morgan-Jones and Gams) is widespread (Stuedemann and Hoveland, 1988). Development of low-endophyte, tall fescue cultivars in recent years has improved steer performance at several locations in the southeastern United States (Read and Camp, 1986; Pedersen et al., 1986; Stuedemann et al., 1986; and Hoveland et al., 1983).

The objectives of this study were to evaluate the practice of diluting high- and low-endophyte tall fescue by overseeding with wheat *(Triticum aestivum* L.), annual ryegrass *(Lolium multflorum* Lam.) and white clover *(Trifolium repens* L.), while realizing that fall and early winter grazing will be sacrificed due to no-till overseeding. The criteria for evaluation were steer average daily gain (ADG), steer gain per hectare (SG/ha) and changes in pasture species composition over three 28-day grazing periods in the spring of the year.

METHODS

The study was conducted at the Southwest Research and Extension Center near Hope, Arkansas, on a Sawyer loam soil (fine-silty, siliceous, thermic Aquic Paleudults) (Hoelscher and Laurent, 1979). Three of the six 1.62-ha pastures had been established and maintained for many years as high-endophyte (HE) 80% 'Kentucky 31' tall fescue. Three other pastures containing low-endophyte (LE) (less than 5%) Kentucky 31 tall fescue were established in the fall of 1984 and spring of 1985. The LE pastures were not grazed for approximately one year after establishment to allow adequate root development. The pastures were overseeded with a Tye no-till drill on 25-cm spacing in the fall of 1985 and 1986. Pasture treatments were as follows: (1) LE tall fescue, (2) LE tall fescue overseeded with wheat and white clover, (3) LE tall fescue overseeded with wheat and annual ryegrass, (4) HE tall fescue, (5) HE tall fescue overseeded with wheat and white clover and (6) HE tall fescue overseeded with wheat and annual ryegrass.

'McNair 1003' wheat and 'Regal' ladino white clover were used in treatments two and five at seeding rates of 55 kg and 1.4 kg pure live seed (PLS)/ha, respectively. McNair 1003 wheat and 'Gulf annual ryegrass were used in treatments three and six at seeding rates of 27 kg and 9 kg of PLS/ha respectively. All pastures were fertilized with 56 kg/ha nitrogen as ammonium nitrate in mid-September of 1985 and 1986 and early March and mid-April of 1986 and 1987. Steers grazed the pastures for approximately 35 days in the fall of 1985 and 1986. All pastures were grazed for three consecutive 28-day periods in the spring of 1986 and 1987. No significant steer gain was obtained in either the fall of 1985 or 1986 on any pasture treatments; thus, no fall data will be presented.

Crossbred steers from other grazing experiments were weaned in the late summer of 1985 and 1986. Steers were dewormed with fenbendazole at weaning and grazed bermudagrass *[Cynodon dactylon* (L.) Pers.] pasture until fall, at which time they were wintered on bermudagrass hay. Grazing was initiated on 11 March 1986 and 25 February 1987, at which time all steers were dewormed with fenbendazole and weighed. Steers were weighed at the end of each of the three 28-day periods (Periods 1, 2 and

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3 in succession). Pastures were stocked at 4.9 steers/ha throughout the trial periods, resulting in 1646 and 1371 kg of liveweight/ha in 1986 and 1987, respectively. All pastures were grazed continuously both years.

Pastures were periodically evaluated for species composition by randomly tossing a quadrat 20 times in each pasture on 19 March, 21 April and 6 June in 1986 and on 3 March and 13 May in 1987. Two investigators visually estimated the percentage composition in each quadrat on a ground area basis, and means were calculated for each pasture.

Data from the three-factor, factorial design experiment were analyzed by analysis of variance. Average daily gain was evaluated for year, pasture type and grazing effects, and SG/ha was evaluated for year and pasture type effects. Steers were used as replications within a given grazing period each year.

RESULTS AND DISCUSSION

Interactions among year, pasture type and period effects were observed for steer performance measurements; therefore, main-effect means are not given (Table 1). Average daily gain was greater in Period **1** in both years when overseeding was conducted in LE and HE tall fescue pastures as compared with fescue grown alone. Average daily gain for HE tall fescue tended to be enhanced by overseeding wheat-clover and wheat-ryegrass only in Period **1** of both years because selective grazing of wheat and ryegrass components in early spring nearly depleted the overseeded species by Periods 2 and 3 (Table 2). White clover contents were negligible in most cases. Average daily gain was less for Period 3 in 1986 than for Periods 1 and 2 in all pastures containing HE fescue (Table 1). Although forage availability was sufficient, tall fescue in these pastures became mature because of low consumption rates. Overseeding wheat-clover and wheat-ryegrass into LE fescue in 1986 roughly doubled ADG in Period 1 to 1.44 and 1.24 kg/head/day, respectively, compared with fescue alone. Average daily gain was generally acceptable (0.68 to 0.91 kg/head/day) for Periods 2 and 3 for the LE pastures, with and without overseeding. Steer gain per ha in 1986 tended to be higher with LE tall fescue overseeded with wheat-clover and wheat-ryegrass than with LE fescue alone. Overseeding HE fescue, however, did not significantly boost SG/ha in 1986.

Responses of steer performance to overseeding and grazing period in 1987 were similar **to** those in 1986 except that a low ADG (0.31 kg/head/day) was observed for LE tall fescue in Period 1 (Table **1).**

Table 1. Steer performance *as* influenced by year, pasture *type* and grazing period on tall fescue pastures.

Year	Pasture type[1]	Average daily gain Per. 1[2]	Per. 2	Per. 3	Steer gain per ha
		------kg/head/day		—	kg/ha
1986	LE	0.67	0.97	0.69	321
	LE + W + C	1.44	0.94	0.92	455
	LE + W + R	1.24	0.63	0.96	395
	HE	0.49	0.59	0.32	199
	HE + W + C	0.59	0.64	0.32	205
	HE + W + R	0.77	0.57	0.30	226
1987	LE	0.31	0.85	0.95	291
	L E t W t C	1.39	1.34	0.79	485
	L E t W t R	1.50	1.31	0.83	502
	HE	1.07	1.11	0.57	372
	H E t W t C	1.10	1.15	0.41	367
	HE + W + R	1.47	1.28	0.49	448
LSD (0.01)			0.38		157

[1]LE = low-endophyte tall fescue, W = wheat, C = white clover, R = ryegrass, HE = high-endophyte tall fescue.
[2]Each of the three consecutive grazing periods consisted of 28 days. Grazing was initiated on 11 March and 25 February in 1986 and 1987, respectively. Per. = period.

Table 2. Forage **composition changes** during the grazing **season** In 1986 and 1907.

Pasture tvpe[1]	Forage species'	1986 3/19	4/21	6/6	1987 3/3	5/13
LE	F	82	79	68	41	74
	B	16	19	28	59	26
	C	2	2	4	0	0
LE + W + C	F	28	44	30	51	71
	W	55	10	0	27	1
	B	14	39	54	14	19
	C	3	7	16	8	9
LE + W + R	F	28	35	42	19	18
	W	39	13	0	33	3
	R	28	15	0	25	18
	B	3	35	51	15	42
	C	2	2	7	8	19
HE	F	87	90	85	86	92
	B	11	9	13	11	3
	C	2	1	2	3	5
H E t W t C	F	77	97	88	70	88
	W	12	2	0	21	1
	B	10	1	9	7	8
	C	1	0	3	2	3
HE + W + R	F	67	92	91	39	69
	W	17	1	0	28	1
	R	11	2	0	22	16
	B	5	4	7	5	8
	C	0	1	2	6	6

[1]LE = low-endophyte tall fescue, W = wheat, C = white clover, R = ryegrass, HE = high-endophyte tall fescue.
[2]F = fescue, B = bermudagrass, C = white clover, W = wheat, R = ryegrass.

This pasture treatment contained only 41% tall fescue during Period 1 with bermudagrass comprising the remaining 59% ground cover (Table 2). All other pastures during Periods 1 and 2 produced ADGs that exceeded 1.06 kg/head/day. Although ADGs for pasture treatments containing LE fescue were again in an acceptable range (0.77 to 0.95 kg/head/day) in Period 3, ADGs for HE fescue treatments were lower in Period 3 than in Periods 1 and 2. The HE pastures was composed predominantly of mature tall fescue during Period 3 (Table 2), which, again, was apparently consumed at a low rate.

LITERATURE CITED

1. Burns, J.C., and D.C. Chamblee. 1979. Adaptation. In R.C. Buckner and L.P. Bush (eds.). Tall fescue. Agronomy 29:930.
2. Hoelscher, J.E., and G.D. Laurent. 1979. Soil survey of Hempstead County, Arkansas. United States Department of Agriculture, Soil Conservation Service, in cooperation with the Arkansas Agricultural Experiment Station.
3. Hoveland, C.S., S.P. Schmidt, C.C. King and E.M. Clark. 1983. Summer syndrome on tall fescue. Proceedings of the Tall Fescue Toxicosis Workshop, Atlanta, Georgia.
4. Pedersen, J.F., J.A. McGuire, S.P. Schmidt, C.C. King Jr., C.S. Hoveland and L.A. Smith. 1986. Steer performance as affected by tall fescue cultivar and level of Acremonium coenophialum. N. Z. J. Exp. Agric 14:307-312.
5. Read, J.C., and B.J. Camp. 1986. The effect of the fungal endophyte Acremonium coenophialum in tall fescue on animal performance, toxicity, and stand maintenance. Agron. J. 78:848-850.
6. Stuedemann, J.A., and C.S. Hoveland. 1988. Fescue endophyte: History and impact on animal agriculture. J. Prod. Agric 1:39-44.
7. Stuedemann, J.A., S.R. Wilkinson, D.P. Belesky, C.S. Hoveland, O.J. Devine, F.N. Thompson, H.C. McCampbell, W.E. Townsend and H. Ciordia 1986. Effect and level of fungus and nitrogen fertilization rate of KY31 tall fescue on steer performance. J. Anim. Sci 63 (Supplement 1):290-291.

Wet Detention Basins for Managing Citrus Drainage Waters in South Florida

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INTRODUCTION

Historically, most of Florida's citrus production has been in the upland regions of the central part of the state. Following a series of devastating freezes in the 1980s, there was a major shift in the geographical distribution of citrus acreage (Behr, 1989). Growers seeking to reduce the risk of freeze damage have been locating new groves in south Florida.

There is a concern that the scale of these developments may significantly affect the hydrology and ecosystems of the region, which includes the environmentally sensitive Everglades National Park and the Big Cypress National Preserve. Much of the current and proposed citrus development is occurring in areas occupied by several rare or endangered species. The region has also experienced rapid growth in the coastal urban population. Therefore, concern exists over the availability and quality of water resources to meet these diverse needs.

Because of a seasonally high water table, drainage is required for most of the land to be agriculturally productive. Much of the area currently being developed for citrus was cattle rangeland in native or improved pasture. The drainage requirements significantly differ for rangeland use and citrus groves. Native grasses can tolerate periods of wet and flooded conditions. Therefore, pasture and rangeland areas are typically drained by shallow ditches placed on wide intervals. Citrus is sensitive to excess water, thus requiring grove developments to have more elaborate and responsive drainage systems.

There is concern that the expansion of citrus groves in south Florida may have the following impacts: (1) the drainage impacts on existing wetlands may destroy the habitat for a number of species that are currently endangered and may result in other species becoming endangered; (2) the required pumpage capacities for responsive drainage systems may produce large distortions from the pre-development surface water hydrology of the surrounding area; (3) fertilizers and pesticides used in citrus production may be transported with the drainage water and could possibly contaminate nearby water bodies; and (4) through reduced surface storage, groundwater recharge rates may be affected.

The South Florida Water Management District (SFWMD) has the governmental responsibility and authority to regulate storm water. Given these concerns, the SFWMD has set certain guidelines for the construction of wet detention basins for the impoundment of agricultural drainage water before it can be discharged off-site.

Wet detention areas are defined as water storage areas with a bottom elevation at least 1 ft (30 cm) below the elevation of a controlled discharge structure. Wet detention basins for drainage water from citrus groves are designed to have four primary functions: 1) to maintain off-site discharge peak flows at or below pre-development levels; 2) to provide detention time for sediment removal and enhancement of the quality of the discharged water; 3) to preserve wetland habitats; and (4) to provide groundwater recharge areas.

CITRUS DRAINAGE MANAGEMENT STRATEGY

Conceptual Approach

The conceptual approach to grove design, development and management is to feasibly maintain existing hydrologic conditions with respect to the quantity and quality of off-site water discharge. In addition, the development should not adversely affect overland flow or result in the destruction of viable wetlands (Rodgers, 1982).

Since most developments will have relatively low areas (swamps, marshes and bogs) that can be converted to grove only with extensive land forming, the desired approach is to include those areas into the wet detention basin. Since it is considered more viable to have a few larger wet areas than many small unconnected ones, certain modifications are allowed. Small wet areas, which still exist after designating the wet detention basin, can be replaced by a "tradeoff" with land adjacent to the wet detention basin (Rodgers, 1982).

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Floodplain encroachment must be avoided and should be considered from the aspecta of storage reduction and flow interference. A flow channel cross-section must be maintained to adequately *carry* a three-day, 25-year storm. The post-development hydrography for that same storm event should conform to the pre-development hydrography. To maintain the desired water quality, it is required that the wet detention basin be designed to hold the first **1** in. of runoff in the detention basin and to release it over a five-day period.

Grove Layout and Drainage System

After the proposed site for the grove is surveyed and an elevation grid established on 100-ft interval wet and low areas are identified for possible inclusion in the wet detention area. Natural overland flow paths are located, and a plan is developed to channel this flow through the grove while avoiding floodplain encroachment. Location and size of the wet detention basin is then determined. Effort is made to include and connect existing wet areas. Exterior levees are located and sized to allow passage of off-site flow while protecting the actual grove area. Interior lateral and collector ditches are located, sized and installed to provide drainage. Typically, lateral ditches 5 ft deep are placed at 1300-ft intervals.

Lift pumps are installed in the main collector ditch adjacent to the wet detention basin. Pump stations are typically sized to remove 4 in. of drainage water from the grove area within a 24-hour period. This pumping capacity along with soil storage is intended to provide protection to the citrus trees from a 10-year 24-hour rainfall event.

One of the first steps in actual grove development is landforming. Landforming is performed after consideration of the natural drainage, and the actual grading design attempts to minimize depths of cuts and fills. After grading, tree beds are formed. Bed height (distance from top of bed to bottom of furrow) is usually about 30 in. This bed provides drainage for two tree rows typically planted on 24-ft. centers. Tree spacings usually range from 10 to 22 ft. Finally, 8-in. drainage pipes are installed to convey drainage water from the furrows to the lateral ditches.

Irrigation is required to maintain the trees through the 8-month dry season typical in south Florida Micro-irrigation is the accepted practice with micro-sprinklers and micro-sprayers being most common. This irrigation method has a significant influence on drainage. First, only a portion of the surface area (usually less than 50%) is wetted; therefore, significant soil storage capacity is available for rainfall. In addition, fertigation (fertilizer application through the micro-irrigation system) is commonly practiced with micro-irrigation systems. Since nutrients are delivered on demand through the irrigation system, there is less opportunity for their leaching during rainfall, and the concentration of nutrients in discharge water is expected to be much lower.

Wet Detention Basin Design Procedure

Accepted engineering procedures are followed in the design of the wet detention basins. Runoff volume from the grove area is estimated by the SCS runoff equation (Eq **1**) (**USDA-SCS**, 1972):

$$Q = (P - 0.02S)^2/(P + 0.8S) \qquad \text{Eq [1]}$$

where,

Q = runoff volume,
P = 24-hour rainfall depth,
S = watershed storage parameter depth.

Methods for determining the value of the storage parameter, S, are given by Capece et al. (1987).

The design storm rainfall is based on a 25-year, three-day event. The area of the wet detention area is determined from estimated runoff volume and the maximum design storage water depth for the impoundment area (usually equal to or less than 5 ft). To improve the quality of water discharged off-site, water is held in the detention basin to allow physical and biochemical processes to occur. Only 0.5 in. of the storm runoff is allowed to be discharged off-site in the first 24 hrs after the storm event. This is accomplishedby a control structure designed to restrict the discharge flow fate.

Peak discharge through a control structure is limited to the pre-development peak runoff rate that would have occurred from the design storm. Peak pre-development runoff rates are computed from a graphical technique published by the SFWMD (1979). Graphs are presented that were developed from a computer model constructed by Higgins (1976). The model employs the Manning equation combined with an assumed retention depth to estimate peak discharge. The control structure is set at an elevation of 1 ft above the bottom of the wet detention basin to maintain a flooded condition in a significant portion of the basin during the rainy season.

The emergency overflow structure is sized to discharge the entire pumping inflow capacity and rainfall from a 100-year, three-day storm on the detention basin, and the overflow is directed ***on-site.*** Therefore, flood waters from extreme events are controlled and held on the grove site. Finally, the design storm is routed through the wet detention area to insure proper functioning of each component.

Water Quality Enhancement and Wetlands Preservation

Initial studies have indicated significant enhancement in the quality of drainage water leaving the detention basins (Stone et al., 1988; Black, 1990). These studies have indicated a 95 and 64% reduction in the nitrogen and phosphorus, respectively, after the drainage water has passed through the detention basins. There is concern that the long-term effect could be the concentration of nutrients and pesticides in the detention areas, which attract wildlife. Studies have been initiated to evaluate the long-term impact to wildlife (Arnold, 1990).

Work has also been initiated to develop strategies for managing the detention basins to preserve the wetlands and to enhance wildlife habitat. One strategy that is being examined is the manipulation of the control discharge elevation. For example, water levels could be reduced to concentrate food resources for wading birds during critical periods in the reproductive cycle. Another approach that is being investigated is the drawdown of water level and controlled burning to eliminate undesirable flora. Numerous other management techniques will be examined.

SUMMARY

Wet detention basins are water storage areas with bottom elevations at least 1 ft below the elevation of the control discharge structure. The primary functions of these detention basins are as follows: 1) to maintain off-site discharge peak flows at or below pre-development rates, 2) to improve the quality of drainage water, 3) to provide and preserve wetlands habitat and 4) to provide groundwater recharge. Intensive studies are in progress to determine how effectively these detention basins are performing in meeting the above functional objectives.

LITERATURE CITED

1. Arnold, C. 1990. Personal communication, project leader - wildlife study. Southwest Res. and Ed. Ctr., Univ. of FL, Immokalee, FL.
2. Behr, R.M. 1989. Report presented by Florida Department of Citrus, to the Gulf Coast Growers Association, LaBelle, FL.
3. Black, D. 1990. Personal communication. Water Quality Engineers, South Florida Water Management District. West Palm Beach, FL.
4. Capece, J.C., K.L. Campbell, L.B. Baldwin and K.D. Konyha. 1987. Estimating runoff volumes from flat, high-water table watersheds. Trans. of the Am. Soc. of Agric. Eng., 30(5):1397-1402, St. Joseph, MI.
5. Higgins, R.W. 1976. The development of a general watershed-highway mathematical model. Unpublished master's thesis, Univ. of S. FL, Tampa.
6. Rodgers, D. 1982. Surface water management permitting for new agricultural construction. pp. C-VIII, 2-4, *In* SFWMD (South Florida Water Management District) permit information manual. West Palm Beach, FL.
7. SFWMD (South Florida Water Management District). 1979. Memorandum report on peak runoff estimates for undeveloped lands. S. FL Water Mgmt. Dist. W. Palm Beach, FL.
8. Stone, K.C., K.L. Campbell, J.C. Capece and L.B. Baldwin. 1988. Southern Region Project S-211 of USDA-CSRS. Contribution of IFAS, Univ. of FL.
9. USDA-SCS. 1972. Soil conservation service national engineering handbook. Sec 4, Hyd. U. S. Dept. of Agric., Washington, D.C.

Wheat Response to Tillage Systems and Planting Dates

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INTRODUCTION

Wheat *(Triticum aestivum* L.) is grown on approximately 400,000 acres in Missisippi. Two types of conventional tillage, chisel + disking or disking alone, are the most common seedbed preparation methods used. Increased tillage of the seedbed increases the erosion potential.

Research efforts during the past decade have been directed toward economizing the conservation-tillage system with specific soils and crops. Different tillage requirements among crops and soils are related to the compadability of the soil and sensitivity of the crop to compacted soils (Touchton et al., 1989).

Most soils in the South have a tillage pan that restrids root growth. In dry spring, this tillage pan may have a substantial influence on wheat yields. No-tillage and paraplow are two possible reduced-tillage systems for growing wheat in north Mississippi that can have a positive role in reducing soil erosion (Langdale et al., 1979; McDowell and McGregor, 1980; McGregor et al., 1985), increasing soil water storage capacity (Jeffers et al., 1973), lowering inputs of fossil fuels (CAST, 1977) and reducing labor and land preparation costs (Jeffers et al., 1973). The paraplow is similar in appearance to a moldboard plow but differs in that the plow-shank lifts the soil vertically and causes minimum surface disturbance. The objective of this study was to evaluate wheat growth and yield response to different production systems (tillage-row spacing combinations) and planting dates.

MATERIALS AND METHODS

The study was conducted from 1985 through 1990 on the same site on an Atwood silt loam (Fine-silty, mixed, thermic Typic Paleudalfs) with a 3% slope at the Mississippi Agriculture and Forestry Experiment Station (MAFES) Pontotoc Branch, Pontotoc, Mississippi. A randomized complete block design with treatments arranged as a split plot was utilized. Wheat planting dates (Table 1) were whole plots, and production systems (tillage-row spacing combinations) were sub-plots within planting dates (Table 2). Treatments were replicated four times, and individual plots were 10 x 35 ft. Seven tillage-row spacing combinations were planted on each of the three planting dates, about 15 October, 1 November and 15 November.

Plot management in preparation for fall wheat planting involved mowing, applying fertilizer and applying selected tillage treatments (Table 2). In late August of each year the entire experimental site was mowed to a height of 5 to 6 in. with a rotary mower. In mid-September of each year, 450 lb/acre of 0-20-20 (N-P_2O_5-K_2O) granular fertilizer was surface broadcast on the study area before tillage treatments were initiated. Tillage treatment dates were 13 Sep. 1985, 15 July 1986, 15 Sep. 1987, 23 Sep. 1988 and 19 Sep. 1990. Before planting wheat in early October, granular urea fertilizer was surface broadcast at a rate of **50** lb N/acre.

Three wheat plantings (Table 1) were made each year on about 15 October, 1 November and 15 November. The chisel + disk and paraplow plots were all smoothed with a row conditioner (implement with a rolling cutter bar and drag harrow) prior to planting each year. All 8-in. wheat row spacings were planted with a Marliss® no-till drill. The 4-in. row spacing was planted with a conventional 4-in. Marliss® drill. All row spacings were planted with **30** seed/ft^2 except with the chisel + disk broadcast treatment. This treatment was seeded on the soil surface at **60** seed/ft^2 (2x rate) with the no-till drill and incorporated with a disk. Wheat cultivars and planting dates for all years are listed in Table **1.** An additional **80** lb N/acre of granular urea was surface broadcast on all wheat treatments in mid-February of each year.

Herbicides were used for winter weed control. Glyphosate at **1.5** lb ai/acre was applied as a burndown application on all no-tillage and paraplow

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Table 1. Wheat cultivars and dantina dates in 1985-89.

Year	Plantina date			Brand/cultivar
1985	Oct 18	Nov 6	Nov 20	Florida302
1986	Oct 17	Novl	Nov 17	Pioneer Brand 2551
1987	Oct 25	Nov 3	Nov 16	Florida302
1988	Oct 14	Nov 7	Nov 18	Florida302
1989	Oct 17	Nov 2	Nov 20	Pioneer Brand 2555

Table 2. Wheat production systems for 1985-89.

Tillage	Primary tillage depth (inches)	Wheat row spacing (inches)
Chisel t Disk t Doall	6-8	Broadcast
Chisel t Disk	6-8	4
Chisel t Disk	6-8	8
No-tillage	---	8
Paraplow	7	8
Paraplow	14	8

treatments about 5 October of each year. Diclofop at 1lb ai/acre was applied postemergence in the fall to all treatments for annual ryegrass control. One application of thiameturon + triton CS7 spreader-sticker at 0.025 lb ai/acre + 0.25% v/v was made in mid-February to mid-March to all treatments for winter annual broadleaf weed control. After wheat harvest in June, one application of 2,4-D amine + surfactant at 0.5 lb ai/acre + 0.25% v/v was applied in early July and August for summer annual broadleaf weed control.

Wheat population data were obtained during the wheat growing season, and plant height and spike data were obtained at maturity. Stand counts were made in mid-March at Feekes' 4 (Zodak et al., 1974) growth stage. Stand counts were determined by randomly selecting one 8-in. linear sample per row of six randomly selected rows within a 10-ft-wide plot. Plants were removed from each plot, hand separated and counted. Wheat plant height was determined by randomly selecting a site in each of six randomly selected rows. The first three consecutive plants at each site were measured from the soil surface to the top of the spikes. Wheat spikes per unit area were determined by randomly selecting an 8-in. linear sample in each of six randomly selected rows and counting the number of spikes per sample. The total number of spikes per six samples was averaged for each plot and converted to spikes/ft^2.

Wheat plots were harvested with a plot combine, harvesting a 6 x 35-ft area on 16 June 1986, 28 May 1987, 10 June 1988, 20 June 1989 and 6 June 1990. Wheat yields were adjusted to 13% seed moisture. Data were subjected to analyses of variance, and means were separated across years using least significant differences (LSD) at the 5% statistical probability level.

RESULTS AND DISCUSSION

The influence of wheat planting dates on yield averaged over production systems in 1986-90 is shown in Table 3. In all years production systems and planting dates had a significant effect on grain yield. However, there was no production system x planting date interaction. The yield of wheat planted 1 November was higher than that from the 15 October planting four of five years. Wheat yields for these two planting dates were equal in 1987. Wheat yield from the 1 November planting was higher than that from the 15 November planting three of five years with no differences between the dates in 1988 and 1990. The wheat yield for the 15 November planting was higher than that from the 15 October planting in 1986, 1989 and 1990 but lower than that from the 15 October planting in 1987 with no differences in 1988. These results indicate that about 1 November is the optimum planting date to maximize wheat yields in north Mississippi.

Averaged over planting dates, wheat yield response during the five-year study differed among production systems (Table 4). Both paraplow treatments with 8-in. rows produced yields equal to those from chisel + disk with 4-in. rows four of five years. The paraplow tillage depth had no effect on yield all five years. The paraplow treatments produced yields equal to no-tillage three of five years and greater than no-tillage two of five years. No-tillage 8-in. rows produced yields equal to chisel + disk with 8-in. rows in 1986, 1987 and 1989. However, in 1988 and 1990, chisel + disk 8-in. rows produced yields of 64 and 55 bu/acre, 7 and 13 bu/acre higher than no-tillage. Yields from chisel + disk 8-in. rows were equal to those of chisel + disk broadcast seeding four of five years while the chisel + disk 4-in. rows produced yields greater than chisel + disk 8-in. rows in three of five years with no differences in the other two years.

Production systems had no effect on plant height at maturity, but planting date did influence plant height. In 1986, the 15 October planting produced wheat plants that were shorter in height than those produced by the 1 November and 15 November planting dates. In 1987 and 1990, wheat planted on 15 October and 1 November planting dates was taller

Table 3. Effect of wheat planting date on yield averaged over production systems In 1986-90.

	Yield					
Planting date'	1986	1987	1988	1989	1990	LSD 0.05
	bu/acre					
Oct 15	34	51	61	40	44	3
Nov 1	44	52	66	57	60	3
Nov 15	41	44	64	57	50	3
			LSD 0.05			
Date within year	2	2	4	3	4	

'Planting dates were target dates. Actual planting dates are listed in Table 1 for each year.

Table 4. Wheat yield response to production systems averaged over planting dates In 1986-90.

Production systems		Yield					
Tillage	Row spacing	1986	1987	1988	1989	1990	LSD 0.05
	(in)	bu/acre					
Chisel + Disk	B'cast	37	44	64	48	49	5
Chisel + Disk	4	42	53	68	56	56	5
Chisel + Disk	a	38	45	64	50	55	4
No-tillage	a	38	48	57	50	42	4
Paraplow 7 in.	a	41	51	65	54	50	5
Paraplow 14 in.	8	41	51	63	51	55	4
				LSD 0.05			
Systems within vear	3	3	5	4	5		

than wheat planted on the 15 November planting date. Planting date had no effect on plant height in 1988. However in 1989, wheat planted on the 15 November planting date was taller than wheat planted on 15 October and 1 November.

Plant population and number of spikes/ft² were not affected by planting dates. The chisel + disk 4-in. row spacing all years had more plants/ft² and spikes/ft² than other systems across planting dates and years. The chisel + disk 8-in. rows and both paraplow systems had higher plant populations than chisel + disk broadcast and no-tillage. However, chisel + disk broadcast had a higher number of spikes/ft² when compared to no-tillage paraplow and chisel + disk 8-in. rows. There were no differences among chisel + disk 8-in. rows, no-tillage and both paraplow systems.

SUMMARY

The 1 November planting date produced grain yields higher than the 15 October planting four of five years and higher than the 15 November three of five years. Paraplow treatments produced wheat grain yields equal to chisel + disk 4-in. rows four of five years. The paraplow tillage depth of 7-in. was adequate in this study on this soil type to maximize wheat yields. The paraplow treatments produced yields equal to no-tillage three of five years and greater than no-tillage two of five years. Wheat grain yields for Chisel + disk 8-in. rows produced yield equal to the chisel + disk *2X* seeding rate and higher than no-tillage two of five years.

Results of this study indicate that the reduced tillage paraplow system not only has the advantage of reducing soil erosion potential but also can produce wheat grain yields equivalent to conventional chisel + disk.

LITERATURE CITED

1. **Council for Agricultural Science and Technology (CAST). 1977. Energy use in agriculture: Now and in the future. Rep. No. 68. CAST, Ames, IA.**
2. **Jeffers, D. L., G. B. Triplett and J. E. Beyerlein. 1973. Management is the key to success doublecropped soybeans. Ohio Rep. on** Res. **and Dev. 58:67-69.**

3. Langdale, G. W., A. P. Barnett, R.A. Leonard and W. G. Flemings. 1979. Reduction of soil erosion by the no-till systems in the Southern Piedmont. Trans. MAE 22:82-92.

4. McDowell, L. L., and K. C. McGregor. 1980. Nitrogen and phosphorus losses in runoff from no-till soybeans. Trans. ASAE 23:643-648.

5. McGregor, K. C., J. D. Greer and G. E. Gurley. 1985. Erosion control with no-till croppingpractices. Trans. ASAE 18918-920.

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

7. Zodak, J. C., T. T. Change and C. F. Konzak 1974. A decimal code for the growth stages of cereals. Weed Res. 14:415-421.

Vegetable Production with Conservation Tillage, Cover Crops and Raised Beds

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INTRODUCTION

In southeastern Oklahoma, soils often have a sandy topsoil and a clay or clay loam subsoil. A typical soil at the Wes Watkins Agricultural Research and Extension Center (WWAREC) at Lane, Oklahoma, is a Bernow fine-loamy, siliceous, thermic Glossic Paleudalf. With this soil, the A horizon is a fine sandy loam, approximately 30 to 35 cm deep, with a percolation rate of 5.1 to 15.2 cm/hr. The B horizon is a sandy clay loam, 1.25 to 1.65 m deep, with a percolation rate of 1.5to 5.1 cm/hr.

Rainfall at WWAREC averages over 100 cm/ year. Distribution is erratic, and rainfall in excess of 17 cm was received in a five-day period during both 1989 and 1990. During winter and spring months, the water table is often within 60 cm of the soil surface. With this combination of rainfall and soil conditions, the soil can become saturated during periods of heavy rainfall, and the surface may at times be under water. In order to combat this problem of excessive moisture, vegetable producers are encouraged to grow all crops on raised beds. Bed size and shape vary, but a typical bed is 0.9 m wide and 0.2 m tall. For early spring crops, the soil in the spring is often too wet to allow the use of heavy machinery to till the soil and form the raised beds. An ideal situation would be to form raised beds in the fall and then plant the vegetable crop into the beds in the following spring. However, the sandy loam topsoil is subject to erosion from both wind and water during the winter months. In order to preserve the height and shape of the raised beds, cover crops are being sown on the beds in the fall. The covers are allowed to over-winter from October to March, and then vegetables are planted into the beds without additional tillage in the spring.

Cover crops are an integral part of conservation tillage systems that have been proven effective at reducing soil erosion (Papendick and Elliott, 1984). Most of the work with conservation tillage has been done with agronomic crops, but some work has also been done with vegetables. There are contrasting results concerning the effects of conservation tillage methods and cover crops on the yield of vegetable crops. Knave1 and Herron (1981) showed that spring cabbage yields in Kentucky were reduced using no-tillage methods when compared to conventional tillage. In contrast, yields of fall cabbage were increased with the no-tillage method in Virginia (Morse et al., 1982). Morse and Seward (1986) in Virginia considered rye to be an effective mulch crop for no-tillage production of fall cabbage. In Oklahoma a screening test to determine the ability of various cover crops to provide a quick, dense soil cover was conducted (Nelson et al., 1991). From this initial study, rye (Secale ***cereale)*** and hairy vetch (Vicia villosa) were chosen for further experimentation.

Conservation tillage and cover crops may affect insect populations in resultant vegetable crops, but the results are inconclusive. Phillips et al. (1980) showed that crops grown with conservation tillage may require higher inputs of pesticides, but Lockeretz et al. (1984) showed that crop residues can also increase beneficial biological control agents that may reduce insect pests. Reduced tillage methods have been shown to lower certain insect pest populations on certain vegetable crops (Zehnder and Linduska, 1987). There is little information concerning interactions among cover crops, nitrogen (N), crop yields and insects.

MATERIALS AND METHODS

Studies were conducted at Lane, Oklahoma, in 1988, 1989 and 1990 with broccoli, cabbage, sweet corn and tomatoes to determine the effects of soil covers and N fertilization on crop yield, insect populations and insect damage by the primary pests of each crop. Numerous experiments were conducted with both rye and hairy vetch, with the covers being sown during both the fall and spring. At all times, the soil was tilled prior to seeding, and raised beds were formed. The beds were approximately 6.1 m long and 0.9 m wide on 1.8-m centers and were approximately 0.2 m high at the time of formation. Covers were planted on top of and between the beds. At all times, a bare soil treatment was included in the experimental design to serve as a comparison with the cover crop treatments.

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In April 1988 raised beds were either seeded with rye or hairy vetch or left as bare ground. Cover crops were allowed to grow during the summer. In the fall, prior to planting the vegetable crops, glyphosate was applied to all plots. A narrow band approximately 30 cm wide was tilled in the center of each row and planted with broccoli. Each soil cover treatment received each of four N rates (44, 90, 134 or 179 kg/ha). A repeat experiment was initiated in the spring of 1989, when rye and hairy vetch were planted. Broccoli was again planted into the cover crops in the fall of 1989.

In October 1988 additional plots were either seeded with rye or hairy vetch or left as bare ground. In the spring of 1989, these soil cover treatments received each of four N rates (44, 90, 134or 179 kg/ha). Glyphosate was applied to all plots prior to planting the cash crop. There was no tillage. Cabbage, sweet corn and tomatoes were planted into the covers during the spring of 1989.

In October 1989 plots similar to those of the previous year were either seeded with rye or left as bare ground. In the spring of 1990, N was applied at 34, 101, 168, 235 or 302 kg/ha. There was no tillage. The rye was not killed with an herbicide but was instead allowed to seed and die naturally. Cabbage, sweet corn and tomatoes were planted into the covers during the spring of 1990.

Each crop was surveyed weekly or twice weekly for the presence of insect pests. In addition, the quantity and quality of the harvested commodity (fruit, heads or ears) were evaluated at the end of the season. Since a primary use of cover crops is to protect the soil from erosion, the height of the raised beds was measured shortly after the beds were formed, and subsequent measurements were taken periodically throughout the duration of the experiment, with the final bed height measurement being taken when the cash crop was harvested.

RESULTS

In general, the height of raised beds in the bare soil plots was not maintained as well as the height of the beds in plots covered with rye and vetch. Plots covered with rye were generally the tallest beds at the end of the experiment while the height of the plots covered with vetch was between the heights of the bare soil and rye-covered plots. This information supports the supposition that cover crops will reduce the severity of soil erosion.

In most experiments, the highest yields of cash crops occurred with bare soil plots, and the lowest yields occurred with the rye-covered plots. With each crop, there was a positive yield response to increasing rates of N fertilizer. The response was linear with tomatoes and sweet corn. With cabbage, the response was linear in 1989 and quadratic in 1990, with the highest yield occurring at the 168-kg/ha N rate.

In general, there was less difference in yield between the bare soil and the rye-covered plots at the higher rates of N than at the lower rates of N. The results varied somewhat from one experiment to another, but the general trend indicated that crops grown in rye-covered plots and fertilized at low levels of N will have a lower yield than will any other treatments. Crops grown in rye-covered plots and fertilized at high levels of N will usually yield less than plots fertilized with the same level of N but grown in bare soil. However, the difference between the yields from the bare soil and those from the rye-covered plots at the high rates of N will not be as great as the difference in yields between the bare soil and rye-covered plots at the low rates of N.

Hairy vetch was included in the first studies but not in later studies. Hairy vetch planted in the fall at WWAREC germinated well, and some growth occurred during late fall and early winter. However, growth was minimal in relation to rye. Neither cover crop grew well during the early and mid-winter months, but rye resumed growth and grew well in late February and early March. In contrast, hairy vetch did not grow substantially until April. The average frost-free date at WWAREC is April 15, with cabbage normally being planted prior to this date and corn and tomatoes planted shortly after this date. When hairy vetch is killed prior to this date, little biomass has been produced.

Not only is there little biomass produced prior to the average frost-free date, but hairy vetch is difficult to kill with glyphosate. Although growth suppression was obtained from the herbicide, regrowth normally occurred within three weeks of the herbicide application, and vigorous growth occurred shortly thereafter. By the middle of the growing season, vetch was often a significant weed species. Vetch planted in the spring grew minimally during the summer and, even after being sprayed with glyphosate, grew vigorously and competed with the broccoli during the fall. Because of these problems, hairy vetch was not included in the later studies.

Broccoli

Both crops of broccoli were grown in the fall. The yield of broccoli in 1988 was lower in the vetch-covered plots than in either the bare soil or rye-covered plots (Table 1). In 1989 the lowest yield was in the ryecovered plots. In both years, the highest yield was in the bare soil plots. Insect damage to the broccoli was minimal, and no significant differences were seen among cover crop treatments.

Cabbage

In 1989 the yield from the rye-covered plots was lower than the yield from either the bare soil plots or the vetch-covered plots. In 1990 the yield from the rye-covered plots was lower than the yield from the bare soil plots. In 1989 cabbage loopers *(Trichoplusia ni)*, thrips (>90% *Frankliniella fusca)* and turnip aphids *(Hyadaphis erysimi)* were the major pests observed on cabbage. Populations of cabbage loopers, thrips and aphids were significantly lower on cabbage grown in rye-covered plots than in bare soil or vetch-covered plots. In 1990 few aphids were observed, and thrips populations were substantially lower than observed in 1989. As a result of lower populations, no significant effects of soil cover on thrips or aphid populations were observed. Diamondback moths *(Plutella xylostella)* were present as pests in 1990 but did not occur in large numbers and appear not to be affected by ground cover. However, fewer cabbage looper eggs and larvae were observed on rye-covered plots than on bare soil plots. Generally, it appears that cabbage grown in rye tends to have fewer insect pest numbers and reduced amounts of damage.

Populations of cabbage looper and aphids were positively related to increasing N levels in 1989. In 1990 a strong relationship between N levels and damage caused by cabbage looper was observed. The percentage of marketable heads declined with increasing N rates as a direct result of increased amounts of damage by lepidopterous larvae.

Sweet Corn

In 1989 the marketable yield was lowest in the rye-covered plots. In 1990 the same trend was noted, although the differences were not statistically significant. Most insect damage was caused by the corn earworm *(Heliothis zea)*. Although populations of corn earworm and the resulting damage to ears were high in 1989 and 1990, significant effects of ground covers were not observed. It appears that oviposition by earworm moths is not affected by ground covers.

Table 2. Tomato damage by stink bug and fruitworm for two years as affected by soil covers.

	Stink Bug		Fruitworm	
Soil Covers	1989[1]	1990[2]	1989[2]	1990[2]
Bare Soil	3.3b[3]	15.4b	9.5ab	19.4a
Rye	3.8a	33.6a	6.4b	10.9b
Vetch	3.4b	...	10.1a	...

[1] 1-5 rating: 1=no damage, 5=severe damage
[2] Percentage of culls caused by stink bug or fruitworm
[3] Means separation by Duncan MRT (P = 0.05). Means followed by the same letter within the same year and crop are not significantly different.

Tomatoes

Marketable yield of tomatoes was lower in the rye-covered plots than in the bare soil plots in 1990 (Table 1). In 1989 the same trend was noted, although the differences were not statistically significant. Two insect groups caused the majority of pest damage in our studies: stink bugs (green stink bug *[Acrosternum hilare]* and brown stink bug *[Euschistus servus]);* and tomato fruitworm *[Helicoverpa zeal*. Damage by stink bugs was extremely heavy in 1989. In 1990 there was less stinkbug damage but more fruitworm damage. The effects of ground cover were consistent in both years. Tomato fruitworm damage was lower on tomatoes grown in rye plots, and damage by stink bugs was greater in rye-covered tomato plots compared with bare ground tomato plots (Table 2).

DISCUSSION

All of the experiments described above were conducted for one growing season in a particular field. One explanation for the reduced yield of the crops

Table 1: Yield of broccoli, cabbage, sweet corn and tomatoes In metric tons per hectare as affected by soil covers during two years.

	Broccoli		Cabbage		Corn		Tomato	
Soil Covers	1988	1989	1989	1990	1989	1990	1989	1990
Bare Soil	8.6a[1]	8.1a	24.9a	15.4a	12.5a	8.6a	37.1a	46.5a
Rye	7.8a	6.9b	20.1b	8.8b	9.1b	6.2a	35.3a	33.1b
Vetch	6.3b	7.9a	23.9a	...	13.08	...	38.2a	...

[1] Means separation by Duncan MRT (P = 0.05). Means followed by the same letter within the same year and crop are not significantly different.

grown in rye was that a N deficiency was caused by N immobilization by the rye. If this was the case, then the N content of the soil should be increasing with time. If the same cropping system is used for several seasons, the immobilized N in the soil should eventually reach an equilibrium with the plant-available N in the soil. At this time, there should not be a further reduction in yield with cash crops grown in the rye-covered plots.

Weed control is a major concern when cash crops are planted into cover crop residues. Mechanical cultivation techniques such as plowing and hoeing do not work well because the machinery used in such operations has been developed for bare soil conditions. Cover crop residues on the soil surface interfere with the tillage operation and prevent the development of a finely tilled soil surface. In addition, the concept of mechanical cultivation is contrary to the objectives of cover crop-conservation tillage techniques, since the cultivated soil is now subject to erosion.

Herbicides have been used extensively in many crops for weed control. However, most herbicides were developed for a clean cultivation production system and may not perform adequately when the soil contains cover crop residues. The effectiveness of these herbicides may be greatly reduced if they come in contact with soil organic matter or cover crop residues. Weed control was less effective with no-till than with conventional till when snap beans were grown in Tennessee (Mullins et al., 1988). In addition, there is now an emphasis on the development of farming systems that minimize the use of all pesticides, including herbicides. Because of these restrictions, it is imperative that an alternative method of weed control be developed.

Plant allelopathy is a factor that needs to be further explored relative to weed control in cover crop systems. Rye is known to be allelopathic (Chou and Patrick, 1976), but allelopathy as a method of weed control has never been fully explored (Altieri and Doll, 1978; Minotti and Sweet, 1981; Rice, 1974). Patrick and Toussoun (1965) found that certain cereal residues were allelopathic to plant germination and seedling growth. They stated that the phytotoxic effect was greatest from 10 to 25 days after residue incorporation, with little or no activity after 60 days. Barnes and Putnam (1986) found in a greenhouse simulation that rye residues reduced emergence of lettuce and millet. Worsham (1984) stated that rye used in a no-till situation could reduce weeds grown during the next season, but the effect on growth of the cash crop was inconclusive.

Allelopathy could also explain why cash crops grown in rye-covered plots yielded less than the same crops in bare soil. It is probable that a combination of reasons, including N immobilization, allelopathy and competition from weeds, lowered the crop yields. Farming systems are needed that will maximize farmer profit while minimizing damage to the environment. An ideal system would eliminate soil erosion, allow the growth of the cash crop, and suppress weed growth. At present, no such system has been designed. Work is now underway at WWAREC to examine the allelopathic effects of rye as an herbicide or as a weed suppressant.

SUMMARY

The results from two years of data with four crops indicate that marketable yields from crops grown in rye-covered plots will usually be lower than yields from bare soil plots. Increased applications of N may partially offset, but not totally eliminate, this decrease in yield. Hairy vetch grows more slowly than does rye and is more difficult to kill with glyphosate than is rye. Although N fixation by vetch is advantageous, rye has been a better cover crop relative to soil cover and lessened soil erosion than has hairy vetch.

The response of insects to cover crops varies with the insect in question. The greatest change in pest populations as a result of altering ground covers was observed on cabbage, especially with cabbage looper. On tomatoes, rye covers decrease tomato fruitworm damage but result in greater damage by stink bugs. Corn earworm on sweet corn does not appear to be significantly affected by ground covers. In general there were fewer insects and less insect damage in rye-covered plots. Nitrogen fertilization appears to have its greatest effect on cabbage looper and aphid populations on cabbage. Pest populations and damage on sweet corn and tomatoes appear not to be significantly affected by changes in N fertilization.

LITERATURE CITED

1. Altieri, M.A., and J.D. Doll. 1979. The potential of allelopathy as a tool for weed management in crop fields. PANS 24(4):495-502.

2. Barnes, J.P., and A.R. Putnam. 1986. Evidence for allelopathy by residues and aqueous extracts of rye (*Secale cereale*). Weed Science. 34:384390.

3. Chou, Chang-Hung, and Z.A. Patrick. 1976. Identification and phytotoxic activity of compounds produced during decomposition of corn and rye residues in soil. J. Chem. Ecol. 2:369-387.

4. Knavel, D.E., and J.W. Herron. 1981. Influence of tillage system, plant spacing, and N on head weight, yield, and nutrient concentration of spring cabbage. J. Am. Soc. Hort. Sci 106:540-545.

5. Lockeretz, William, Georgia Shearer, Daniel H. Kohl and Robert W. Klepper. 1984. Comparison of organic and conventional farming in the Corn Belt. p. 37-48. *In* Organic farming: Current technology and its role in a sustainable agriculture. Madison WI: ASA, CSSA, SSSA.

6. Minotti, P.L., and RD. Sweet. 1981. Role of crop competition in limiting losses from weeds. p. 351-367. *In* D. Pimentel (ed). CRC Handbook of pest management in agriculture. Vol 2. Boca Raton, Florida: CRC Press, Inc

7. Morse, Ronald D., and David L. Seward 1986. No-tillage production of broccoli and cabbage. Applied Agricultural Research 1(2):96-99.

8. Morse, RD., C.M. Tessore, W.E. Chappell and C.R. O'Dell. 1982. Use of no-tillage for summer vegetable production. The Vegetable Growers News 37(1):1.

9. Mullins, Charles A., R Allen Straw and David L. Coffey. 1988. Production of snap beans as affected by soil tillage method and row spacing. J. Amer. Soc. Hort., Sci 113(5):667-669.

10. Nelson, W.A., B.A. Kahn and B.W. Roberts. 1991. Screening cover crops for use in conservation tillage systems for vegetables following spring plowing. HortScience (in press).

11. Papendick, RI., and L.F. Elliott. 1984. Tillage and cropping systems for erosion control and efficient nutrient utilization. p. 69-81. *In* Organic farming: Current technology and its role in a sustainable agriculture. Madison WI: ASA, CSSA, SSSA.

12. Patrick, Z.A., and T.A. Toussoun. 1965. Plant residues and organic amendments in relation to biological control p. 440-459. *In* K E Baker and W.C. Synder (eds.). Ecology of soil-borne pathogens. Berkeley, Calif: Univ. of California

13. Phillips, RE., RL. Blevins, G.W. Thomas, W.W. Frye and S.H. Phillips. 1980. No-tillage agriculture. Science. 208 1108-1113.

14. Rice, E.L. 1974. Allelopathy. New York Academic Press, Inc

15. Worsham, AD. 1984. Crop residues kill weeds: Allelopathy at work with wheat and rye. Crops and Soils Magazine. Nov. 1984. p. 18-20.

16. Zehnder, G.W., and J.J. Linduska 1987. Influence of conservation tillage practices on populations of Colorado potato beetle (Coleoptera: Chrysomelidae) in rotated and non-rotated tomato fields. Environ. Entomol. 16:135-139.

Opportunities for Wheat-Soybean Relay Planting in Arkansas

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INTRODUCTION

A major contributor to the reduction of soybean grain yields in Arkansas is the hot, dry weather experienced in July and August. Normal soybean planting (15 May to 30 June) results in flowering and pod filling during July and August. One attempt to avoid this impact of the hot, dry weather has been the introduction of Group IV soybean planted prior to 25 April. This management approach allows flowering and the majority of the pod-tilling period to occur before 1 August.

Another soybean operation in late June occurs where planting of soybean follows wheat harvest (i.e. doublecrop). This popular practice places seedling growth and flowering in the July-August period but does force the pod filling segment into a cooler and usually wetter September. If the plants survive the July-August period in good condition, doublecrop soybean will yield well under subsequent normal weather patterns.

A third option would be relay planting of soybean into standing green wheat. For this option to be accepted by growers, two objectives need to be met 1) the feasibility of Group IV soybean to be incorporated into relay planting and 2) the agronomic advantage of relay planting (i.e. Group N soybean and lower wheat yields) over the normal doublecrop system in which Group V soybean is utilized.

BACKGROUND

Removal of a wheat row increased the grain yield from the adjacent two rows--especially so when removed at an early growth stage (Darwinkle, 1984). Removal at the early growth stages (Zadooks GS 21) allowed for a 82% yield compensation by adjacent rows, whereas removal at the GS 51 resulted in only a 29% yield compensation. Chan et al. (1980) identified the late boot stage for soybean planting to minimize wheat grain losses. Reinbatt et al. (1987) reported that establishment of soybean into wheat progressively reduced wheat yields as growth stages in wheat increased. However, a skip-row pattern in the wheat minimized the yield loss during the soybean planting operation. Duncan et al. (1990) found that wheat yields were reduced 13% in skip row patterns, whereas the yield reduction was 4% in solid patterned wheat. While not significantly different, the soybean yields in the skip-row pattern were greater than the yields in the solid pattern.

METHOD AND MATERIALS

A single location in 1990 (Colt, Arkansas) and four locations in 1991 (Marianna, Clarkedale, Colt and Fayetteville, Arkansas) comprised the study (Table 1). The wheat cultivar for each location was selected so as to adapt to the location and the soil involved. Wheat was planted in October of the preceding calendar year at recommended rates with plots 13 ft wide and 30 ft long. At the locations in 1991 the wheat was planted solid, and the appropriate rows were removed for each spacing in late winter. At each location a treatment of solid-planted wheat with Group V soybean planted after wheat harvest (doublecrop) was included. Also a fallow plot was planted to Group IV soybeans at the same time the relay planting occurred (Table 2). Four replications were used in 1990 and eight replications in 1991. All locations were dryland.

CONCLUSION

The ability of the relay planting to escape the hot, dry summer period necessitates a normal optimum planting date of 10 April for Group IV soybeans. The late April 1990 planting did not allow the crop to escape the July-August weather during its pod-filling period. The soybean appeared to germinate without stress, and though plant height was observed to be greater than normal at wheat harvest, the plants did not exhibit weak, elongated stems. Also, the soybean were not of sufficient height to interfere with harvesting of wheat.

Row spacing appears to be a major concern in relay planting. In 1989 with the 36-in. rows, the soybean crop never achieved full canopy cover. Also the wheat stubble had a shading effect that appeared to reduce weed pressure. No herbicides were used in either year.

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Table 1. Location and soil series of experimental sites.

Location	Soil series	Suborder
Cotton Branch Station, Marianna	Loring silt loam	Typic Fragiudalfs
Delta Branch Station, Clarkedale	Sharkey silty clay	Vertic Haplaquepts
Pine Tree Branch Station, Colt	Calhoun silt loam	Typic Glossaqualfs
Main Experiment Station. Fayetteville	Captina silt loam	Typic Fraaiudults

Table 2. Row spacing and planting dates for relay planting of soybeans into wheat

Description	Spring crop	Wheat row spacing	Spacing	Plantinzl date
Doublecrop	Wheat	7 in. (normal)	28 in.	10 June
Row Spacing	Wheat	14 in. @ 28-in. center	28 in.	10 April
Tram Une	Wheat	14 in. @ 56-in. center	28 in.	10 April
Soybean	Fallow	—	28 in.	10 April

LITERATURE CITED

1. Chan, L.M., R.R. Johnson and C.M. Brown. 1980. Relay intercropping soybeans into winter wheat and spring oats. Agron J. 723539.
2. Darwinkle, A. 1984. Yield responses of winter wheat to plant removal and to wheelings. Neth. J. of Agr. Sci 32:293-300.
3. Duncan, S.R., W.T. Schapaugh, Jr. and J.P. Shroyer. 1990. Relay intercmpping soybeans into wheat in Kansas. J. Prod. Agric. 3:576-581.
4. Reinbatt, 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.

Temporal Variability of Selected Properties of Two Grand Prairie Soils as Affected by Cropping

H.D. Scott, I.P. Handuyani and A Mauromoustakos[1]

ABSTRACT

Quantification of the temporal variability of soil properties is needed in order to under stand the effects of cropping on soils. A study was conducted to determine the short- and long-term variability of selected soil properties of two loessial soils in the Grand Prairie of Arkansas. The surface 15 cm of both soils had a silt loam texture. Four adjacent fields were used for the study and included a prairie and three fields that had been cropped for 3, 14 and 32 years, respectively. The statistical analyses indicated that the magnitude of the soil properties varies with duration of cropping (long-term variability), depth interval and sampling time within a year (short-term variability). The amount of variability was dependent on soil property. Temporal changes such as increases in soil solution pH up to an optimum pH are beneficial whereas increases in bulk density and decreases in Ksat, total porosity, total C content and the ability to retain or store water generally are considered to be detrimental for maximum crop production. The variability of total C content in the soils could adequately describe the variability of log Ksat, bulk density, porosity and water retained at 10 kPa.

INTRODUCTION

Generally, tillage practices are used to provide more favorable soil conditions for crop growth and development. Moderate tillage facilitates root growth by loosening surface and subsurface soil and improves aeration and water infiltration of the soil profile. On a short-term basis, tillage may be beneficial to crop production and soil productivity (Baver et al., 1973). On the other hand, over many years frequent tillage operations using moldboard plows, disk or chisel or a combination of disk-chisel or disk cultivators have been used within a growing season. The cumulative effect of these frequent tillage operations and cropping leads to changes in soil physical, chemical and biological properties. As a result, extensive tillage of the soil over long periods of time may have detrimental effects on crop establishment and yield.

Temporal variability of soil properties is defined as the changes in the magnitude of soil properties with respect to time. The temporal changes of soil properties can occur over long-term (more than a year) or short-term (equal to or less than a year) periods of time. Temporal variations in soil properties have been reported to be associated with total porosity, bulk density and water retention (Gantzer and Blake, 1978; Cassel, 1983), saturated hydraulic conductivity and macroporosity (Carter, 1988). These soil properties are dynamic even in prairies (never cultivated) where factors such as freezing and thawing, root growth and exudates, wetting and drying cycles, carbon turnover and biological activity may strongly effect their magnitude. This temporal variability is called intrinsic variability (Low, 1972; Cassel and Nelson, 1985; Scott and Wood, 1989). In cultivated fields, seasonal changes in soil properties can be affected by tillage operations such as planting, cultivating and chiseling and are related to wheel traffic. This variability is called extrinsic variability (*Scott* and Wood, 1989).

These published studies have demonstrated that tillage affects both the magnitude and the variability of soil properties. Therefore, the objectives of this research were to determine and quantify the temporal changes in selected soil physical and chemical, properties of a loessial soil due to short- and long-term cropping. This work was conducted in an area in which rice, soybean and wheat are the dominant cropping systems.

MATERIALS AND METHODS

The study was conducted on the Fred Seidenstricker Farm, which is located south of Hazen in Prairie County, Arkansas. At the study site, the latitude is 34° N, the longitude is 91.5" W, and the average annual rainfall is 1338 mm. The soil is classified as a fine, montmorillonitic, thermic Typic Albaqualfs or a fine-silty, mixed, thermic Typic Glossaqualfs. The soil in the study location is an association of Crowley and Calhoun series and has poor 'internal drainage (SCS, 1981; Scott and Wood,

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1989). The texture in the 0- to 0.15-m depth interval is silt loam.

Four adjacent fields were sampled on an approximately monthly basis (Fig. 1). These fields include a prairie and three fields that had mostly been in rotation of rice *(Oryza sativa)*, soybean *[Glycine max* (L.)] and wheat *(Triticum aestivum)* for 3, 14 and 32 years, respectively. During the 1989 growing season, the 3-years-in-cultivation field was fallowed but was disked in June and November. Soybeans were grown in the 14-year field from May to October 1989, and rice was grown in the 32-year field from April to September 1989. Wheat was grown in the 14- and 32-year fields from December 1989 until May 1990.

Soil samples were collected at 15-m intervals along a transect at depth intervals of 0 to 0.05 m and 0.05 to 0.10 m before the crops were planted during March 1989, during the growing season from May to September 1989 and after the crops were harvested on November 1989, December 1989, January 1990 and March 1990. Both undisturbed and disturbed samples were collected at each sampling time. Undisturbed soil samples were collected using steel cores having a diameter of 0.06 m and a height of 0.05 m. Soil physical properties determined on these undisturbed cores included saturated hydraulic conductivity (log Ksat), bulk density, soil porosity and soil water retention at pressures of 10, 20, 30, 50, 80, 100, 500 and 1500 kPa. Disturbed soil samples were collected at 30- and 45-m intervals along the same transect and taken to the laboratory for analysis of particle size distribution, particle density, total carbon (TC) and pH in water and in $CaCl_2$.

For each soil property, exploratory statistics were performed to characterize the data at each field and depth interval. Computations were made of measures of central tendency and dispersion. Tests for normality were determined, and normal probability plots were constructed by field and depth interval averaged over sampling times.

Two statistical approaches were considered in order to quantify the temporal variability of the soil due to cropping. When the fields, depth interval and sampling times were fixed, the ANOVA was performed using a split-split plot in time. The computations were carried out using SAS's GLM procedure.

RESULTS AND DISCUSSION

Characterization of the Soil Properties

Selected properties of the soil profile in the prairie and 32-year fields were determined. The results for the first two depth intervals are presented in Table 1 and show that the texture was silt loam, the

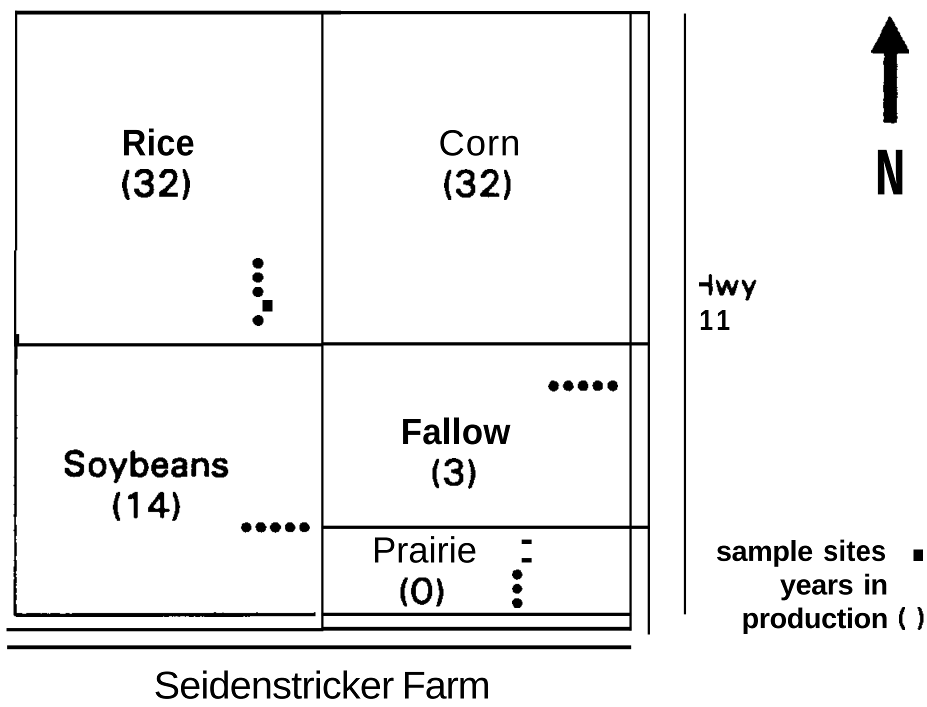

Fig. 1. Pictoriai representation of the four fields sampled on the Seidenstricker farm at Hazen, Arkansas.

TC content decreased with depth interval and time in cropping, and the pH of the prairie was more acid than that of the 32-year field. In general, the color of the prairie was darker in the surface than that of the 32-year field, a fact that can be attributed to its greater TC content. The particle density of the surface 10 cm was 2.62 and 2.66 g/cm^3 in the prairie and 32-year field, respectively.

Table 1. *Selected* **soil properties of the prairie and 32-year field.**

	Field			
	Prairie		32-year field	
Soil property	0-8 cm	8-15 cm	0-8 cm	8-15 cm
Particle size distribution				
% sand	16.8	16.4	14.0	15.8
% silt	67.3	67.4	70.2	68.6
% clay	15.9	15.2	15.8	15.6
Total carbon (g/kg)	21.3	12.6	11.2	7.6
pH (in water)	4.9	4.7	5.4	5.4
pH (in $CaCl_2$)	4.6	4.4	5.1	5.2

Temporal Variability of Selected Soil Properties

The ANOVA of each soil property involved three level factors (main, sub and sub-sub): cropping duration, depth interval and sampling time, respectively. The short-term variability of Log Ksat, bulk density and TC is shown in Fig. 2, 3 and 4, respectively. For all three soil properties the main effects of cropping time (field) and depth interval were highly significant. Sampling time was significant for Ksat, highly significant for bulk density and non-significant for TC. The interaction term of field x depth interval was highly significant for bulk density and TC. These results show that both short- and long-term variability are important considerations in evaluating the effects of cropping on soil properties.

Statistical Analyses

The means of each soil property for a given field (cropping duration) at each depth interval were computed for several soil properties taken over time. These results are presented in Table 2 and were the average of all of the samples taken from March 1989 to March 1990. In general, the lowest values of Ksat,

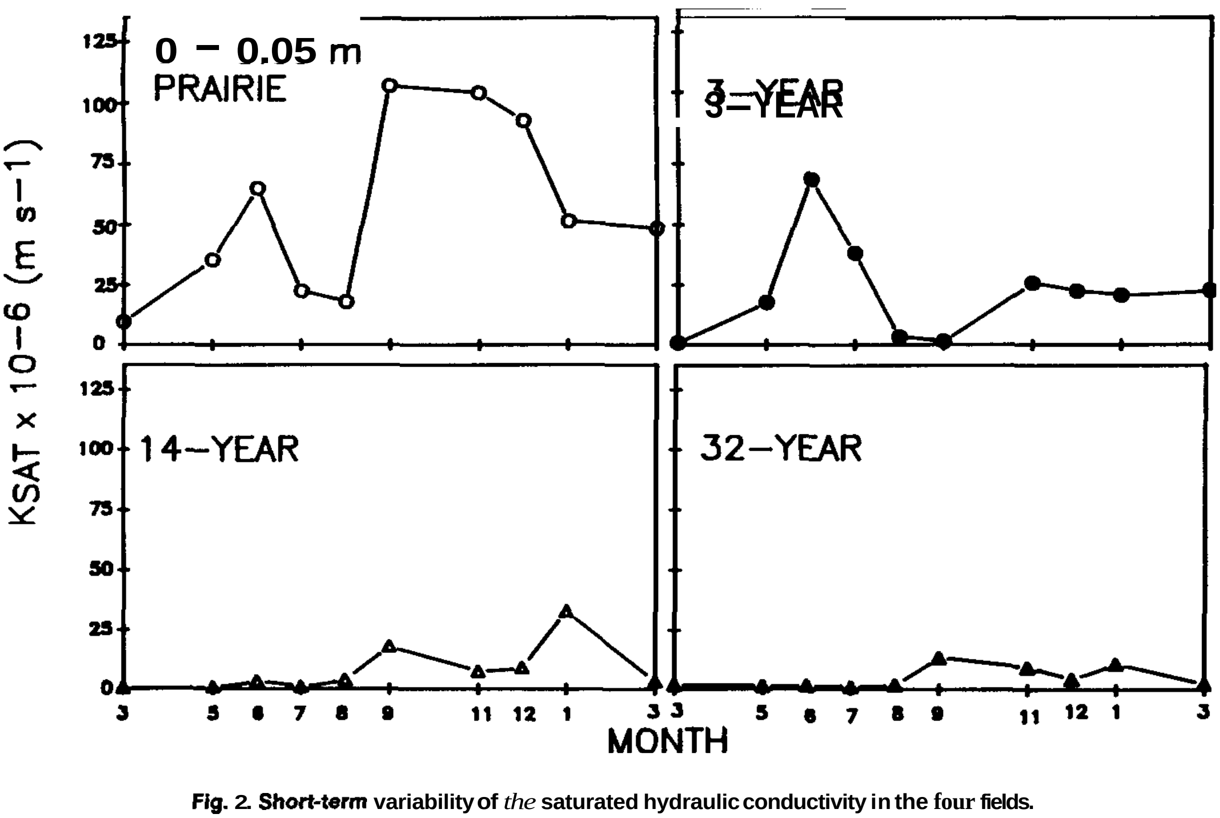

Fig. 2. **Short-term variability of** *the* **saturated hydraulic conductivity in the four fields.**

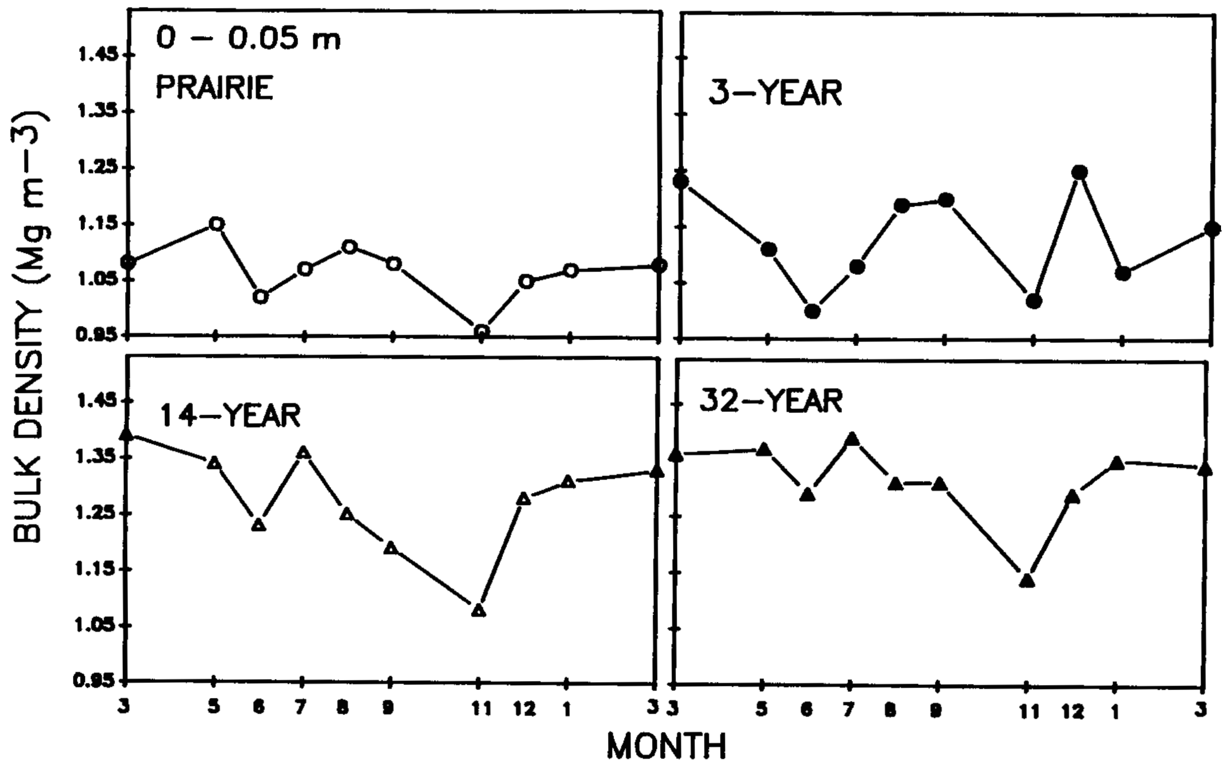

Fig. 3. Short-term variability of bulk density In the four fields.

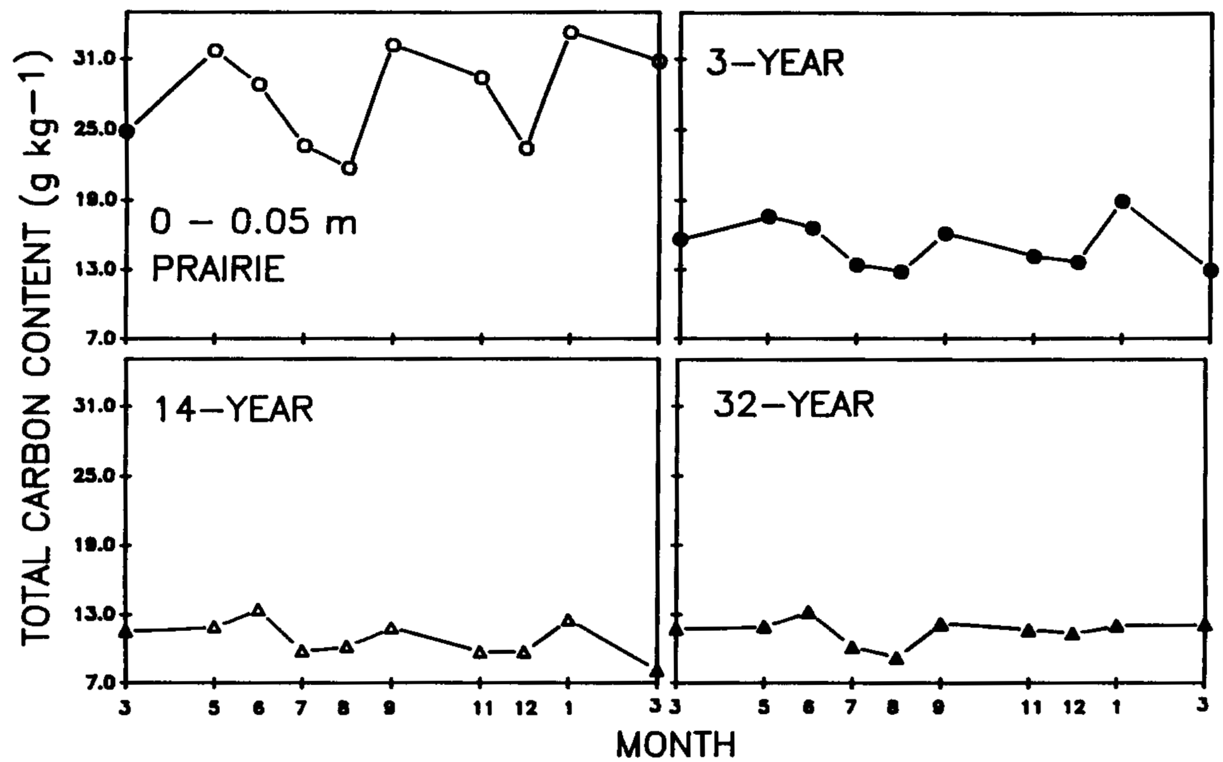

Fig. 4. Short-term variability of *total* carbon In the four fields.

Table 2. Summary statistics for Ksat by years In cropping and depth interval.

	Years in cropping							
	0		3		14		32	
Soil property	1'	2	1	2	1	2	1	2
Log Ksat(/ms x 10^5)	7.9	2.5	4.0	2.0	4.0	1.6	1.3	0.1
Bulk density(mg/m^3)	1.07	1.22	1.13	1.19	1.27	1.35	1.31	1.40
Total carbon(g/kg)	28.1	14.3	15.2	13.7	10.9	10.4	11.4	10.5
porosity(m^3/m^3)	0.59	0.53	0.57	0.54	0.52	0.49	0.51	0.48
pH in $CaCl_2$	4.3	4.1	5.2	5.1	5.4	5.5	5.1	5.2
10 kPa water ret.	0.443	0.425	0.400	0.408	0.381	0.376	0.397	0.393
1500 kPa water ret.	0.075	0.084	0.078	0.081	0.070	0.078	0.077	0.086

'Depth interval 1 = 0-5 cm; depth interval 2 = 5-10 cm.

TC and porosity were found in the 32-year field and in the 5- to 10-cm depth interval. The highest values of bulk density and pH in $CaCl_2$ were found in the 32-year field. From a practical view, decreases in Ksat may be beneficial in rice production but harmful in soybean production.

The means of TC in the four fields and two depth intervals were linearly regressed with the means of the soil parameters given in Table 2. The relationships are presented in Table 3. These results show that variations in TC alone could explain most of the variations in log Ksat, bulk density, porosity and 10 kPa water retention. The coefficients of determination associated with the variations of pH and water retained at 1500 kPa were low. Of interest is the fact that positive slopes were obtained for the relationships between TC and the dependent variables log Ksat, porosity and 10 kPa water retained, and this indicates that as TC increased, values of these parameters also increased. Negative slopes were obtained between TC and bulk density and pH in $CaCl_2$. The close relationship between TC and several of these soil properties suggests that losses of TC due to cropping in these soils were closely associated with the changes in the magnitude of the soil properties.

Table 3. Linear relationships between selected soil properties and total carbon (TC) content of the soil.

Dependent variable	Intercept	Slope	R^2
Log Ksat (x 10^5)	-2.245	0.361	0.778
Bulk density	1.465	-0.0156	0.670
Porosity	0.452	*0.0054*	0.704
pH in $CaCl_2$	5.81	-0.058	0.443
10 kPa WR	0.356	0.0032	0.731
1500 kPa WR	0.081	-0.0002	0.044

LITERATURE CITED

1. Baver, L.D., W.H. Gardner and W.R. Gardner. 1973. Soil physics. 4th Edition. New York John Wiley and Sons, Inc
2. Carter, M.R. 1988. Temporal variability of soil macroporosity h a fine sandy loam under moldboard ploughing and direct drilling. Soil Tillage Res. 12:37-51.
3. Cassel, D.K. 1983. Spatial and temporal variability of soil physical properties following tillage of Norfolk loamy sand. Soil Sci. Soc Am. J. 47:196-201.
4. Cassel, D.K., and L.A. Nelson. 1985. Spatial and temporal variability of soil physical properties following tillage of Norfolk loamy sand. Soil Sci. Soc Am. J. 47:196-201.
5. Gantzer, C.J., and G.R. Blake. 1978. Physical characteristics of Le Sueur clay loam soil following no-till and conventional tillage. Agron. J. 70:853-857.
6. Low, A.J. 1972. The effect of cultivation on the structure and other physical characteristics of grassland and arable soils (1945-1970). J. Soil Sci 23:363-380.
7. Scott, H.D., and L.S. Wood. 1989. Impact of crop production on the physical status of Typic Albaqualf. Soil Sci Am. J. 53:1819-1825.
8. Soil Conservation Service. 1981. Soil survey of Lonoke and Prairie counties. USDA-SCS and the University of Arkansas. p. 57-58.

Reduced- and No-Tillage Systems for Rice

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INTRODUCTION

Conventional tillage is a soil management system that depends on tillage to control all weeds and volunteer crop plants before seeding (Stobbe, 1990). Conservation tillage is a soil management system that leaves the soil surface resistant to erosion and conserves soil moisture. Conservation tillage methods include 1) zero or no-tillage, 2) minimum or reduced-tillage and 3) mulch tillage. No-tillage and reduced-tillage systems also may have less adverse impact on the environment, especially in areas where trace amounts of chemical pesticides have been detected in groundwater and surface water (Felsot et al., 1988; Stobbe, 1990).

In Arkansas, mechanical operations used prior to planting rice vary considerably both in timing and in number from farm to farm, and this variability is quite large even among farmers from the same county who are farming the same type of soil. For example, in eastern Arkansas, the number of mechanical operations prior to planting rice can vary from a minimum of four to a maximum of eight, and the cost per hectare of these operations varies from $64 to $148.

There is a need to investigate whether the number of mechanical operations usually performed prior to planting rice can be reduced and what impact this reduction will have on weed control, grain yields and, ultimately, on net profit. Research conducted in the Philippines and in Japan in rice has demonstrated that considerable savings in time, labor, capital and energy can be achieved in land preparation without loss in yield (Brown and Quantrill, 1973; Mabbayad and Buencosa, 1967). The objective of this research was to investigate the feasibility and profitability of implementing conservation tillage practices in rice in Arkansas.

MATERIALS AND METHODS

During the first year, soybeans were grown conventionally in rows spaced 81 cm. In the second year, rice was drill-seeded in 20-cm rows. Two separate experiments were conducted with initiation of the first experiment in 1988 and the second experiment in 1989. Hence, rice was grown in the first and second experiments in 1989 and 1990, respectively.

Both experiments were located on Crowley silt loam (Typic Albaqualfs) with pH 5.8 and 0.9% organic matter at the Rice Research and Extension Center, Stuttgart, Arkansas. In both experiments, 'Newbonnet' rice was drill-seeded in late April or early May with crop emergence in May each year. Plots 30 by 8 m were arranged in randomized complete blocks with four replications.

Nitrogen fertilizer at 152 kg/ha was applied in a 3-way split with 84 kg/ha applied before flooding, 34 kg/ha applied when internodes were 1.3 cm and 34 kg/ha applied 14 days later. Water management was conventional with flooding at early tillering and draining for straighthead control. Benomyl [methyl l-(butylcarbamoyl)-2-benzimidazolecarbamate] at 0.56 kg/ha was applied twice at midseason for control of rice diseases.

Tillage treatments were as follows:

1. Conventional tillage, which included the following operations: one fall disking, one spring disking, one field cultivating, land planing twice and field cultivating again just before drill-seeding rice.
2. Reduced-tillage, which included spring disking once, land planing once and then field cultivating once just before drill-seeding rice.
3. Reduced-tillage, which consisted only of field cultivating three times just before drill-seeding rice.
4. Reduced-tillage, which consisted of field cultivating once and land planing once just before drill-seeding rice.
5. No-tillage with glyphosate [N-(phosphonomethy1)glycinel at 0.42 kg/ha applied 14 days before drill-seeding rice. A nonionic surfactant at 0.5% v/v was added to the herbicide mixture.
6. No-tillage with glyphosate at 0.42 kg/ha + V-53482 (2-[7-fluoro-4-(2-propynyl)-2H-1,4-benzoxazine-3-one-6-yl]-4,5,6,7-tetrahydro-2H-isoindole-1,3-dione) at 0.086 kg/ha applied 14 days before drill-seeding rice. A crop oil concentrate at 1% v/v was added to the herbicide mixture.

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Tillage was performed with standard commercial equipment including disk-harrows, land levellers and field cultivators. Rice was seeded in 1989 with a commercial heavy-duty grain drill and in 1990 with a commercial no-till grain drill. In the two no-till systems, burndown herbicide treatments were applied with a tractor plot sprayer in 190 L/ha spray mixture pressurized with CO,.

In all treatments, weeds were controlled in rice with propanil [N-(3,4-dichlorophenyl)propanamide] at 3.4 or 4.5 kg/ha applied sequentially early postemergence or with propanil and thiobencarb [S-[(4-chlorophenyl)methyl] diethylcarbamothioatel each at 3.4 kg/ha applied in a tank mixture. Herbicides were applied to rice with a CO_2-pressurized backpack sprayer in 190 L/ha of spray mixture.

Data collected included weed control and crop injury ratings (0 = no control or crop injury; 100 = all weeds or crop plants killed), rough rice grain yield (kg/ha), total mill and head rice and bran yield (%), seed weight (g/1000 grains), days from emergence to 50% heading and seed germination (%). A partial economic analysis was conducted to obtain net returns from each plot using standard costs of production inputs and the market value for rice grain. Average values of $0.30, $0.20 and $O.O6/kg were used for head rice, broken kernels and bran, respectively. Also, an average deficiency payment of $0.10/kg was an added value. All data were analyzed by analysis of variance with significant means separated by Duncans multiple range test ($P \leq 0.05$).

RESULTS AND DISCUSSION

Glyphosate applied alone or tank mixed with V-53482 burned down winter vegetation to provide a soil environment suitable for rice germination and stand establishment comparable to that in conventional tillage. The winter weed complex included annual bluegrass *(Poa annua* L.), horseweed *[Conyza canadensis* (L) Crong.], corn buttercup *(Ranunculus arvensis* L.), little barley *(Hordeurn pusillum* Nutt.) and dwarf dandelion *[Krigia cespitosa (Raf.)* KL. Chambers]. Glyphosate + V-53482 provided quicker and more complete burndown of winter vegetation than did glyphosate alone. For example, in 1990 glyphosate with surfactant burned down 75% of the vegetation by 14 days after application (when seeding rice) while glyphosate + V-53482 with crop oil burned down 95% of the vegetation during the same period.

Conventional herbicide treatments of propanil applied sequentially or tank-mixed with thiobencarb controlled barnyardgrass *[Echinochloa crusgalli* (L.) Beauv.], broadleaf signalgrass *(Brachiaria platyphylla* (Griseb.) Nash] and large crabgrass *[Digitaria sanguinalis* (L.) Scop.]. In both years, ducksalad *[Hetemnthera limosa* (Sw.) Willd.] infestations were moderate to high in conventional tillage plots while they were low in no-till plots. Ducksalad infestations in reduced-tillage systems were intermediate compared to those in conventional and no-tillage systems.

Excellent rice stands occurred both years in all tillage treatments. Grain yields were not significantly different for the various tillage systems and ranged from 6500 to 7200.

Net returns were significantly higher from reduced- and no-tillage systems than from conventionally tilled rice. Compared to conventional tillage, reduced- and no-tillage systems increased net returns from $168 to $245/ha. Reduced- and no-tillage systems decreased preplant costs for land preparation and herbicides, ranging from $20 to $50/ha compared with conventional tillage.

Tillage systems did not influence maturity of rice, total milled or head rice yields, 1000-grain weight or seed germination.

CONCLUSION

In summary, rice grown in reduced- and no-tillage systems produced grain yields comparable to rice grown in a conventional tillage system. However, costs of producing rice in reduced- and no-tillage systems were lower than costs of producing it in a conventional tillage system. Therefore, rice grown in reduced- or no-tillage systems produced higher net returns than that grown by conventional tillage. Standard herbicides controlled weeds in rice grown in reduced- and no-tillage systems as well as that grown in a conventional tillage system. Ducksalad infestations were frequently lower in reduced- and no-tillage systems than in conventional tillage. Also, glyphosate alone or tank mixed with V-53482 applied preplant burned down winter weeds in no-till rice sufficiently to permit excellent stand establishment.

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Promotion Board. Deere and Co. provided a no-till grain drill through the Rice Foundation.

LITERATURE CITED

1. Brown, J.A. and R.A. Quantrill 1973. The role of minimal tillage in rice, with particular reference to Japan. Outlook on Agriculture 7:178-183.

2. Felsot, A.S., LF. Welsh, W.S. Curran, E.L. Knake and W.G. Ruesink. 1988. Effects of agrochemicals in conservation tillage on the environment. Illinois Research 30(3-4):11-15.

3. Mabbayad, B.B., and I.A. Buencosa 1967. Tests on "minimal tillage" in transplanted rice Philippine Agr. 51:541-551.

4. Stobbe, E.H. 1990. Economic management of weeds under conservation tillage. pp. 5-15. *In* Weed problems and their economic management. Symposium in the 12th Conf. Asian-Pacific Weed Sci. Soc. Seoul, Republic of Korea, August 21-26, 1989. p. 174.

Alternative Intensive Cropping with Corn

R.E. Sojka and W.J. Busscher[1]

ABSTRACT

Corn (*Zea mays* L.) was continuously cropped in seven systems, with or without irrigation. Baseline irrigated corn yields of 200-210 bu/acre were reduced 65-75 bu/acre by not utilizing standard rotational practices. The best continuous corn yields were from systems with disking in some phase of the operation. The only follow-crop to consistently approach an economically attractive level was sunflower (*Helianthus annuus* L.), but continuous corn yields remained depressed in this system. Corn yields benefitted from soybean (*Glycine max* L.) as a follow-crop, but soybean itself yielded well only 1 of 4 years. In the absence of a follow-crop, delaying disking until immediately before spring corn planting yielded as well as any other treatment compared.

INTRODUCTION

Corn is consistently an economically attractive crop in the Southeastern Coastal Plains; however, continuous corn has been avoided. Research from various physiographic areas has shown that yields can decline over time without rotation. Varieties and chemicals have increased the flexibility of cropping systems. The effects of double cropping with alternative post-corn species in a single cropping year have not been explored in the southeast. The Southeastern Coastal Plain has an average frost free growing season approaching 300 days in much of the region (US Dept. of Commerce, 1968). This might allow the use of various species of alternative post-corn crops for potential enhanced annual return, for nitrogen production or as conservation crops to hold soil and prevent leaching of chemicals and fertilizer.

It was hypothesized that with appropriate pest and weed control, several intensive alternative systems might sustain year-to-year corn yields compared to conventional cropping systems. To test this hypothesis, a multi-year study was established in Florence, SC, to compare conventional continuous corn with reduced tillage and multi-cropped management systems.

METHODS AND MATERIALS

In the spring of 1982 a field of Norfolk loamy sand (fine, loamy, siliceous, thermic, Typic Paleudult) near Florence, SC, was cropped to field corn. The hybrid Pioneer 3572[2] was planted in 1982 and 1983, and the hybrid Pioneer 3950 was planted in 1984 and 1985. Field preparation in 1982 included multiple diskings of the previous soybean crop stubble and broadcast incorporation of lime (1000 lb/acre to maintain pH near 6.5), fertilizer (180 lb/acre N, 15 lb/acre P and 30 lb/acre K) and herbicide (alachlor and atrazine). Fertilizer and lime applications in following years were similar and were adjusted according to soil test. Corn was in-row subsoil planted at approximately 40,000 viable seeds/acre using a Brown-Harden Super Seeder on 30-in. row centers, which subsoiled 0.45 m deep in line with and ahead of the trailing John Deere 71 flex planters in a single integrated operation. Pests were controlled with terbufos or carbofuran banded above the row at planting and lightly incorporated. No-till corn planting used the same implement and chemical regime as the conventional plots. Plots were 6 rows wide by 100 ft long, and cropping main-plots were split into 50-ft halves for application or absence of irrigation. Irrigation was by inverted drip-lines between rows, operated under 12 $lb/in.^2$ pressure to provide uniform "sprinkling" in each plot. Corn was irrigated when tensiometers read >0.4 bar tension at 1-ft soil depth. After the 1982 corn harvest, seven treatments were imposed. The experiment used a randomized split plot design with 4 replications. Treatment and interaction means were also compared using years as a further factorial. Hybrid changes contributed to variance among years. The treatments imposed after initial corn crop establishment were as follows:

1. Multiple winter disking following corn harvest followed by conventional corn planting in spring.

[1] Soil scientists, USDA Agricultural Research Service, Kimberly, ID, and Florence, SC, respectively.

[2] Mention of trademark, proprietary product or vendor does not constitute a guarantee of warranty of the product by the US Department of Agriculture and does not imply its approval to the exclusion of other products or vendors that may also be suitable.

2. Inter-seeding at black-layer initiation with soybean (cv Cobb), controlling weeds in soybean with acifluorfen or sethoxydim and winter weeds with paraquat or glyphosate. No-till corn production in spring.
3. Stover left standing, winter weeds controlled with paraquat or glyphosate, disked immediately before planting in spring.
4. Stover left standing, winter weeds controlled with paraquat, no-till planting in spring.
5. Inter-seeding with 17 lb/acre crimson clover (*Trifolium incarnatum* L. cv Tibee) at black layer initiation, killing clover with paraquat immediately following no-till corn planting in spring.
6. Drilling 90 lb/acre soybean (cv Cobb) into corn stover after corn harvest, controlling weeds in soybean with glyphosate, alachlor and metribuzin. Winter weeds in soybean/corn stover were controlled with glyphosate or paraquat. Corn was no-till planted in spring.
7. After corn harvest, the land was disked once, and PPI chloramben was used to control weeds in sunflowers. Planting was as for corn. Sunflower hybrid availability differed among years. Two hybrids were used in a split-split plot in 1982, 1983 and 1984 (DO-844 and MCF610, DO-844 and Sheyenne 24906, DO-855 and Sheyenne 24906, respectively). Only one hybrid, IS-7000, was used in 1985. Since hybrid effects were seldom statistically significant (P> 5%), they were averaged for comparison of years, thereby contributing their variance to the year effect. Winter weeds were controlled with paraquat or glyphosate, followed with no-till corn production in spring.

All pesticides and herbicides were applied at label rates; broadleaf weeds were controlled in corn as needed with 2,4-D. Inter-seeding in treatment 2 was by hand-operated Planet Jr. Inter-seeding in treatment 5 was hand broadcast (1982-1984) or drilled (1985). Treatments 5 and 6 used a grain drill with disk openers on 13-in. centers. All corn and sunflower were planted to 40,000 seeds/acre and thinned to 35,000 irrigated and 20,000 non-irrigated plants/acre 7-10 days after full emergence. Planting dates are presented in Table 1.

RESULTS AND DISCUSSION

Corn in 1982 was all conventionally planted. The 1982 corn had no antecedent cropping system treatments. Instead the study had high and low populations of 20,000 or 35,000 plants/acre, with four irrigation regimes related to corn growth stage. Rainfall and irrigation regimes are described in Tables 2 and 3. Mean non-irrigated corn yield at the low population was 161.2 bu/acre, and mean irrigated yield at the high population was 201.9 bu/acre. The highest treatment yield was 209.4 bu/acre for irrigation of a high population from tasselling until harvest only. The preceding crop had been soybean. Therefore, these yields represent a reasonable baseline for corn grown conventionally in a standard corn/soybean rotation at the populations used in the subsequent treatments and were similar to previous findings (Karlen and Sojka, 1985).

Table 1. Planting dates (mo/day).

Year	Corn	#2	x5	#6	x7
1982	3/23	7/27	10/1	8/6	8/10
1983	3/16	7/20	9/16	8/3	8/18
1984	4/2	7/19	9/18	8/16	8/17
1985	4/1	7/16	9/17	8/14	8/14

In 1983 there was a substantial decline in baseline corn yields (Tables 4 and 5). This reduction was 65-75 bu/acre for irrigated conventional corn and approximately 50 bu/acre for non-irrigated conventional corn. Mean annual yields from 1983-1985 were 129.5, 125.3 and 127.7 for irrigated plots and 107.6, 102.9 and 100.9 for non-irrigated plots, respectively. Furthermore, the yield advantage of irrigation was reduced from about 40 bu/acre to about 20 bu/acre. This sharp yield decline prompted changing hybrids in 1984 to one more suited to intensive cropping. No further decline in baseline yields occurred after 1983.

In both irrigated and non-irrigated treatments, corn yields were generally favored by disking at some point in the system (treatments 1, 3 and 7). This is consistent with other reports of a 10% yield reduction with no-till in the Coastal Plains (Karlen and Sojka, 1985; Sojka and Busscher, 1989). Even though soybean yielded poorly between corn crops (treatments 2 and 6), corn yields appeared to benefit somewhat. Corn yields were usually lowest with crimson clover between corn crops. This was probably a result of soil water depletion in spring, which has been reported before (Campbell et al., 1984). Irrigation did not maintain yields in treatment 5 because system installation could not be completed each vear until well after stand establishment.

Yield of soybean after corn was good only in 1985, particularly for treatment 6 (drilled). The month of August in 1985 had the highest rainfall during the course of the study. This aided soybean

Table 2. Rainfall by month of year (mm).

Year	Jan	Feb	Mar	Apr	Mav'	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1982	117	119	29	104	87	151	141	61	71	92	35	135	95
1983	109	169	236	42	60	66	97	59	85	74	91	164	104
1984	70	102	140	90	146	28	343	61	20	30	8	37	90
1985	119	107	26	22	54	148	194	128	101	29	170	17	93
Mean	104	124	108	65	87	98	194	77	69	56	76	88	96

[1]In 1984 includes 13 mm irrigation to all plots (including "non-irrigated").

Table 3. Irrigation plus rainfall by month of year (mm).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1982	117	119	29	104	87	208	166	61	105	92	35	135	105
1983	109	169	236	42	60	116	135	04	124	74	91	164	117
1984	70	102	140	90	177	110	343	86	70	30	8	37	105
1985	119	107	26	72	98	148	194	128	139	29	170	17	104
Mean	104	124	108	77	106	146	210	90	110	56	76	88	108

Table 4. *Crop* Yields[1].

		Corn (bu/acre)				Soybean (bu/acre) or sunflower (lb/acre)				
Treatment		1983	1984	1985	**Mean**	1982	1983	1984	1985	**Mean**
Irrigated	1	137.9	132.7	131.8	134.1					
	2	128.6	130.9	135.8	131.8	4.0	8.5	6.8	14.3	8.4
	3	139.6	134.0	121.2	131.6					
	4	119.5	132.2	108.5	120.1					
	5	105.7	102.0	118.7	108.8					
	6	143.4	128.4	136.3	136.0	9.5	6.3	6.7	25.0	11.9
	7	131.7	116.6	141.3	129.9	1065	312	898	728	751
	5% LSD	16.9	17.2	23.4	12.8	7.22	4.9	7.0	2.2	3.3
Non-irrigated	1	110.6	110.3	113.3	111.4					
	2	109.4	111.7	108.6	109.9	6.7	12.7	4.2	11.8	8.9
	3	114.1	112.0	100.0	108.7					
	4	102.7	101.2	98.1	100.7					
	5	107.5	90.7	79.9	92.7					
	6	100.9	101.3	104.8	102.4	6.2	5.4	3.4	19.9	8.7
	7	108.1	93.1	101.5	100.9	1022	226	1052	1052	838
	5% LSD	14.4	12.9	13.5	8.2	2.8	8.5	2.2	7.1	3.0

'Corn, soybean and sunflower are at 15.5, 13.0 and 9.0% moisture, respectively.
[2]For follow-crops, 5% LSD could be calculated only to compare soybean treatments (treatments 2 and 6)

stand establishment. Inter-seeded soybean (treatment 2) consistently suffered mechanical damage during corn harvest and also possibly atrazine damage in some years. The intensity of harvest activity in August made it difficult to insure timely cultural practices and irrigation for treatments 2 and 6. The most promising follow-crop yields were from sunflower, which are known to yield well after corn in the Coastal Plains if planted by mid-August (Sojka et al., 1989). The lowest sunflower yields occurred in 1983 as a result of poor stand establishment, possibly due to poor seed viability (low germination percentage). Given the numbers of additional operations, the additional cost of herbicides and the generally poor corn and follow-crop yields, it is apparent that these cropping systems cannot substitute for rotation of the main crop. Yields of sunflower (treatment 7) were the most consistently promising, but only in association with reduced corn yields. If the rationale for adopting an intensive

Table 5. Analysis of variance (P>F.

Crop	Variance source	1982	1983	1984	1985	Mean
Corn	Treatment	—	2.60	0.03	1.33	0.01
	Irrigation	—	0.01	0.01	0.01	0.01
	Treatment x irrigation	—	0.50	N.S.[1]	N.S.[2]	N.S.
Soybean	Treatment	7.69	5.91	N.S.	0.54	6.89
	Irrigation	N.S.	N.S.	5.13	4.97	9.54
	Treatment x irrigation	4.61	N.S.[2]	N.S.	N.S.	3.87
Sunflower	Hybrid	N.S.	N.S.	1.70	—	N.S.
	Irrigation	N.S.	N.S.	N.S.	2.27	N.S.
	Hybrid x irrigation	N.S.	N.S.	N.S.	—	N.S.

[1]Comparisons were considered non-significant at $P > 10\%$.
[2]$P < 15\%$ and $> 10\%$ = trends.

cropping system is to provide ground cover against soil erosion, the yields from treatment 2 suggest that delaying primary tillage until immediately before planting in spring does not significantly reduce corn yield.

LITERATURE CITED

1. Campbell, R.B., D. L. Karlen and R E. Sojka 1984. Conservation tillage for maize production in the U.S. Southeastern Coastal Plain. Soil and Tillage Res. 4511-529.
2. Karlen, D. L., and R. E. Sojka 1985. Hybrid and irrigation effects on conservation tillage corn in the Coastal Plain. Agron. J. 77561-567.
3. Sojka, RE., F. B. Arnold, W. H. Morrison III, and W. J. Busscher. 1989. Effect of early and late planting on sunflower performance in the southeastern United States. Appl. Agric. Res. 4:37-46.
4. Sojka, R.E., and W. J. Busscher. 1989. Conservation tillage in soybean and corn in the South Carolina Coastal Plain. Proceedings Southern Regional Conservation Tillage Conference, Tallahassee, FL. 12-13 July, 1989. IFAS Special Bulletin 89-1. p. 46-48.
5. U.S. Dept. of Commerce. 1968. Climatic atlas of the United States. Natl. Climatic Data Center, Ashville, NC.

Scope and Objectives: South Central Family Farm Research Center, Booneville, Arkansas

Tim L. Springer[1]

The South Central Family Farm Research Center is one of over 120 research locations funded by the United States Department of Agriculture, Agricultural Research Service. The Booneville, Arkansas, location was established in 1980 in cooperation with the University of Arkansas. In 1986 the United States Department of Agriculture, Soil Conservation Service co-located a Plant Materials Center at the Center. The Center is located north of the Ouachita National Forest in western Arkansas, south of Booneville.

AGRICULTURAL RESEARCH SERVICE

The mission of the Center is to develop, refine and validate technology for family farm production systems that will enhance biological and economic production efficiencies and product qualities. Because the scope, diversity and interactions among commodities and environments are complex, accomplishment of this mission will require many years of long-term innovative research approaches by the scientists involved. The family farm is an integral component of our agricultural industry and contributes to low-cost food, clothing and housing enjoyed by the American public. The family farm also provides for the production of export commodities to make the United States competitive in world markets; for national security by providing necessities that maintain our self-sufficiency; and for the economic stability of the community by providing much-needed jobs.

To accomplish this mission, research has been initiated in the areas of forage/livestock production and horticultural production systems. Research with forage/livestock production systems is concerned ultimately with identifying optimal combinations of grasses, legumes, animals and management practices with respect to biological and economic efficiencies. Research initiated in these areas includes forage variety research, forage management research, plant genotype by environment interaction research, cell grazing research, beef/forage management research, plant-animal interface research, animal genotype by environment interaction research, forage legume research and plant protection research.

Research in horticultural production systems is concerned with the identification and management of horticultural crops that can be incorporated into existing family farm production systems. Research has been initiated in the following areas: small fruits research involving raspberries, strawberries, grapes and blueberries; and vegetable research with crops such as European cucumbers, asparagus and vegetable amaranth.

SOIL CONSERVATION SERVICE

The Plant Materials Center program was initiated by the Soil Conservation Service to provide vegetative solutions to soil and water conservation problems. The nationwide system of plant materials centers is critical to identifying the best vegetative solutions in a particular region under the soil and climatic conditions found in that region. High priority vegetative needs of the Booneville Plant Materials Center include protection of water quality, improvement of grasslands and reclamation of critical areas. These needs are addressed by the evaluation of current, commercially available vegetative species on problem sites. Similarly, new varieties are released from plant materials collected within the region after extensive evaluation and selection. These regionally selected varieties may have a wide adaptation and may be used to solve conservation problems in other regions.

UNIVERSITY OF ARKANSAS - ARKANSAS COOPERATIVE EXTENSION SERVICE

The mission of the Cooperative Extension Service at the Center is to provide a linkage between the Center and various clientele groups in the center's ten-state service area. Our goal is to identify, develop, produce and distribute technological information pertinent to family farms in the areas of agricultural marketing, beef cattle/forage, farm management, financial management and horticulture.

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Tropical Corn Hybrids in a No-tillage System

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INTRODUCTION

Tropical corn *(Zea mays* (L.)] can provide a much-needed energy source (grain and silage) for dairy and livestock operations in Florida (Wright and Prichard, 1988; Wright and Chambliss, 1989). It is well suited because of its long growing seasonand tolerance to diseases (Teare et al., 1989) and insects, with the exception of the fall armyworm *[Spodoptea frugiperda* (J.E. Smith)] (Teare et al., 1990). Dry weather normally keeps yields around 60 to 80 bu/acre for spring-planted, non-irrigated temperate corn in the Coastal Plain of the Southern states and around 30 bu/acre for summer-planted corn (Teare and Wright, 199Oa). Low yields and low prices have dramatically reduced acreage of temperate corn in the southeast.

Farmer acreage of tropical corn increased from 5,000 acres in 1986 to almost 40,000 acres in 1989 in the southern U.S. because growers wanted a more consistent grain or silage crop that could be grown under natural rainfall conditions to increase profitability and cash flow and provide a rotation crop in lieu of summer legumes (soybean and peanut, Teare et al., 1989) to reduce nematode numbers that build up from the continuous cropping of summer legumes. Since tropical corn is grown after wheat harvest during the summer months when rainfall is most bountiful, it should perform more consistently in the southeast than temperate corn. Initially, there was only one commercially available tropical hybrid ('Pioneer X304C'), and that hybrid is known for its tolerance to insects and diseases and its difficulty in threshing. Tropical corn yields and quality from these summer plantings of Pioneer X-304C have been equal to or better than the state average for temperate corn planted at the normal time.

Fall armyworm infestations were heavy in 1989. Avoidance of pest injury by producing a crop at times when pest populations are in non-damaging stages or at low population levels is recognized as one of the more successful integrated pest management practices (Herzog and Funderburk, 1986). After our experiences in 1989 with fall armyworm damage on tropical corn, we felt we could recommend a planting date that would reduce fall armyworm damage on Pioneer X-304C in a wheat-tropical corn double-crop system by planting before 10 June in north Florida (Teare et al., 1990).

However, growers wanted improved hybrids that would produce higher grain yields with increased energy content of silage. The objective of this study was to provide further information on fall armyworm avoidance and grain yield results of tropical corn hybrids grown in a no-tillage system in relation to drought and insect stress.

MATERIALS AND METHODS

These studies were conducted on a Norfolk sandy loam (fine, loamy siliceous, thermic Typic Kandiudult) located on the North Florida Research and Education Center, Quincy, Florida. The soil has a compacted layer located 7 to 14 in. below the surface.

In 1989, the fall armyworm devastated late-planted tropical corn fields, but avoidance of the fall armyworm damage appeared to be correlated with planting before 10 June in north Florida. Thus planting dates were selected before and after 10 June to provide two levels of fall armyworm infestation. The only successful 1989 planting date study was a planting date x N rate study conducted on Pioneer X-304C with planting dates of 29 May, 15 June and 14 July. Planting date x N rate studies were continued with Pioneer X-304C in 1990 comparing the same five N rates of 0, 50, 100, 150 and 200 lb N/acre with three planting dates (8 June, 14 June and 12 July; the early 29 May planting in 1990 was delayed by rain to 8 June).

In 1989, a rainfed tropical corn hybrid study (normally planted on 10 June) was delayed by excess rainfall and late-planted on 29 June (Fig. 1), setting up the situation for heavy fall armyworm infestation. The tropical corn hybrid study in 1990 was grown under rainfed conditions (summer drought) and limited irrigated conditions (limited to applications at the early vegetative stage--Fig.l). The planting dates were 11 June and 3 July for both water regimes.

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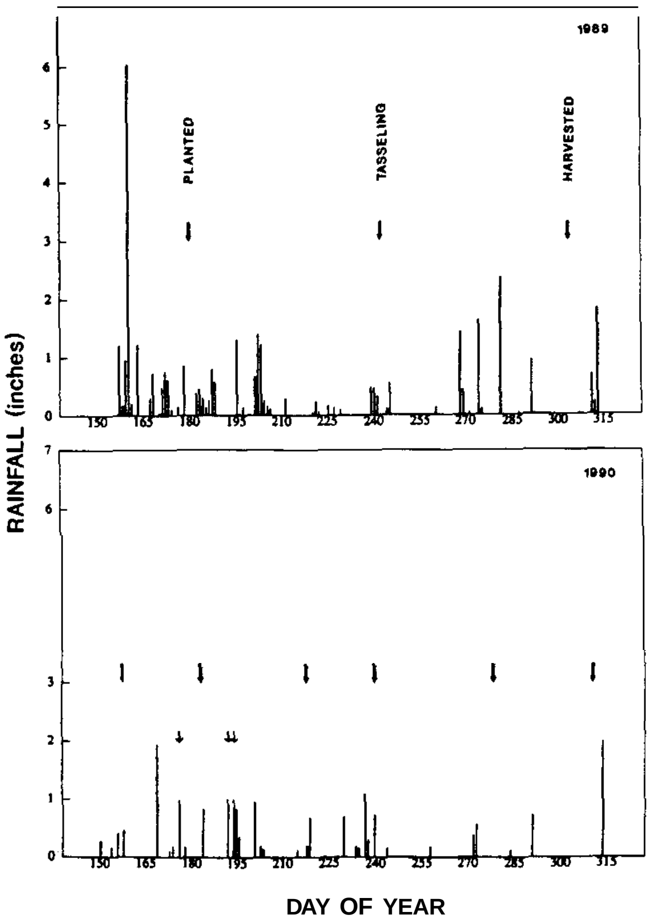

Fig. 1. Rainfall, planting date, 50% tasseling and harvest date during the 1989 and 1990 growing season. Three small arrows in 1990 indicate the limited irrigation. Days of year reported in days Julian.

The moderate energy input used in these experiments is the one described by Teare et al. (1989). A Brown Ro-Till™ planter was used to plant the tropical corn into standing wheat stubble at a plant population of 20,000 plants/acre. Twenty pounds N/acre was applied as starter fertilizer at planting and 100 lb N/acre when the corn was 12 in. tall. The experiments were not irrigated except as stated. Most of the tropical corn acreage planted in the southeast from 1988 to 1990 was based upon these recommendations.

The experiment was a randomized complete block design with four replications except for the 1990 irrigated and rainfed hybrid trial, which was a split plot with four replications. Interactions are illustrated according to Teare and Wright (1990b). The rows were 25 ft long with 30 in. between rows. Severe drought was experienced in 1990. Rainfall data, planting date, 50% tasseling and harvest date for 1989 and 1990 are shown for comparison in Fig. 1.

Fall armyworm adults were trapped in 1989, but the traps were located 200 to 800 yards from the tropical corn plots. This was considered too far from the experiment for realistic fall armyworm counts. Therefore, in 1990, larvae counts were made on ten tropical corn plants per replication for each of two hybrids and one open pollinated line of tropical corn.

RESULTS AND DISCUSSION

Environment and Phenology

In 1989, high rainfall (20 in. of rain fell from 21 May to 27 June 1989) delayed tropical corn planting from 10 June until after 27 June with severe fall armyworm injury and resulting yields of less than 40 bu/acre. Historically, the average tropical corn yield for Pioneer X-304C at this location has been 94 bu/acre when 120 lb N/acre has been applied. Tropical corn phenology for 1989 is shown in Fig. 1.

The year of 1990 was dry from early spring to late fall. The rainfall events and amounts resulting in severe drought are illustrated in Fig. 1. For this reason a limited irrigated companion study was included with the rainfed hybrid yield study. Irrigations are illustrated in Fig. 1 but were limited to applications at the early vegetative stage of tropical corn development. Tropical corn phenology is shown for 1990 in Fig. 1.

Planting Date

In 1989 and 1990, double-cropped Pioneer X-304C was studied at three planting dates and five nitrogen rates. Yield of no-till tropical corn in 1989 was highest from the May planting and decreased with each successive planting date (Table 1). Insect pressure from the fall armyworm also increased as planting dates were delayed (Fig. 2). The 1989 tropical corn yield data from the planting date by N rate study shows that the yields of Pioneer X-304C were 113 bu/acre on the 28 May planting date, 68 bu/acre on the 15 June planting date and 40 bu/acre on the 14 July planting date under rainfed conditions (Table 1). When the fall armyworm larvae counts (Fig. 2) are added to the previous information, it becomes evident that planting prior to 15 June results in greater yields and lower fall armyworm larvae counts than later planting dates. With the availability of 'Florida 303' wheat, which has the desirable traits of high yield, resistance to leaf rust and powdery mildew and early maturity (14 May, Teare et al., 1990), early tropical corn planting

Table 1. Planting date' and N rate influence on Pioneer X-304C yield, Quincy, Florida, 1989 and 1990).

N Rate	28 May 1989	15 June 1989	14 July 1989
lb/acre	bu/acre		
0	71 a	39 a	41 a
50	96 b	69 b	44 a
100	113 c	68 b	40 a
150	112 c	81 b	42 a
200	115 c	72 b	43 a
Average	101	66	42
	8 June 1990	14 June 1990	12 July 1990
0	45 a	44 a	47 a
50	49 a	48 a	43 a
100	48 a	48 a	38 a
150	46.	53 a	43 a
200	51 a	45 a	47 a
Average	48	48	44

'All planted after florida 303 wheat was harvested in May.

dates will be practical. Common sense dictates that plantings of tropical corn should not occur after 1 June to avoid fall armyworms.

Nitrogen Rate

Higher rates of nitrogen in 1989 were most beneficial for early planting dates (Table 1). The trend was insignificant in 1990 because of the drought. In 1989, nitrogen rates that were sufficient for highest yields were 100 lb/acre for May planting, 50 lb/acre for June planting and 0 lb/acre for July planting.

Hybrid Yield Response

The yield expression of tropical corn hybrids studied in 1989 (severe fall armyworm damage) and 1990 (severe drought and fall armyworm damage) is shown in Table 2. Under severe fall armyworm stress (1989), the highest yield was that of Pioneer X-304C at 42 bu/acre, and other hybrid yields were as low as 7 bu/acre. The low yields of the rainfed hybrids in 1990 are a confounded expression of drought (Fig. 1) and fall armyworm damage (Fig. 2). Early-planted rainfed tropical corn yields in 1990 ranged from 18 to 44 bu/acre, and the late-planted rainfed tropical corn yields in 1990 ranged from 21 to 47 bu/acre. Pioneer X-304C yielded 21 and 40 bu/acre when planted early or late, respectively.

Limited early irrigation increased tropical corn yields of many of the new entries. Five early-planted hybrids yielded more than 100 bu/acre, and the range was 36 to 156 bu/acre under irrigation. The late-planted, irrigated tropical corn yields ranged from 18 bu to 140 bu/acre. Two of the hybrids ('Pioneer 3072' and 'Pioneer 3098') maintained high yields for both early and late plantings. Two other tropical corn hybrids also yielded 100 bu/acre. 'Sunbelt 1876' (a temperate corn) was grown for reference both years with consistently low yields at each planting date.

Since most of the useful data on tropical corn hybrid yield come from 1990, the data should be used cautiously because of the significant interaction of hybrid x water regime and hybrid x planting date.

Table 2. Tropical corn hybrid yields for 1989 (severe fall armyworm damage) and 1990 (fail armyworm damage and severe drought).

	29 May 1989	7 June 1990		3 July 1990	
Line	Rain-fed	Rain-fed	Irri-gated	Rain-fed	Irri-gated
	bu/acre				
Flopup	30				
Pioneer XCJ 66	36				
Pioneer XCH 53	11				
Pioneer XCE72	12				
Pioneer 3212	16				
Pioneer X8965	12				
Pioneer 3226	20				
Pioneer 3238	7				
DeKalb B840	27				
DeKalb XL604	14				
DeKalb XL678C	14	21	75	34	84
Pioneer X-304X	42	21	73	40	73
Pioneer 6875	9	18	36	24	51
Cargill C343	26	32	85	36	79
Cargill C-381	18	26	77	36	a6
Pioneer 3230	16	24	52	33	49
Pioneer 3210	20	28	76	39	81
Pioneer 3072		38	122	41	140
Pioneer 3214		19	88	34	81
Pioneer 3098		31	130	37	107
Pioneer 3078		25	85	38	94
Sunbelt 1876 (Temperate)		15	25	20	33
Cargill C-333		39	156	35	74
Cargill C-501		27	54	21	101
Cargill C-611		34	102	42	83
Cargill T-327		23	103	25	55
Cargill T-321		44	78	36	52
Cargill T-320		31	92	32	66
Cargill C-805				37	32
Cargill C-701				47	91
Cargill C-803				42	105
Cargill C-955				38	18
Cargill C-606				48	80

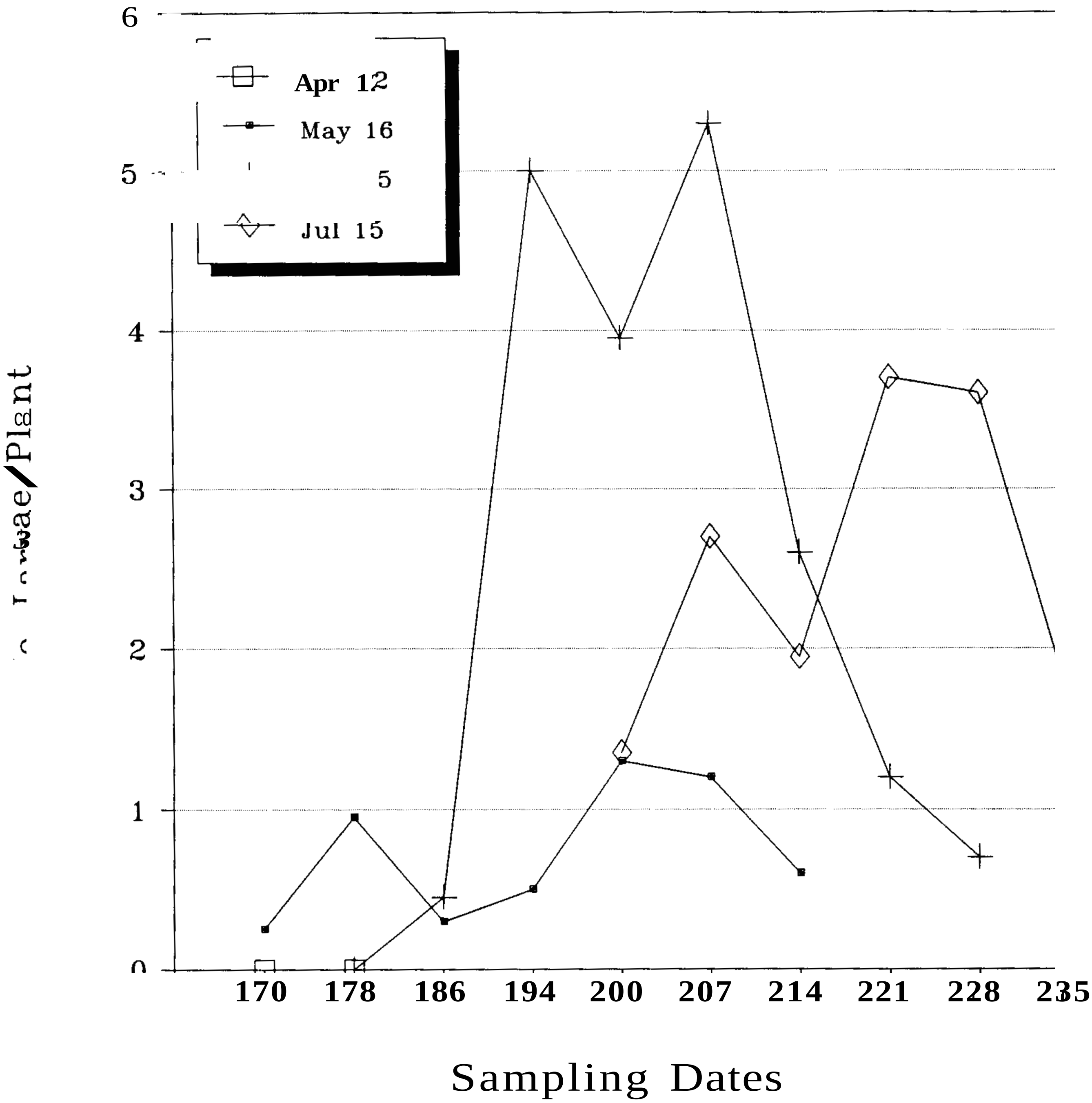

Fig. 2. Fall armyworm larvae counts in relation to days after planting for tropical corn planted on four planting dates (12 Apr, 16 May, 15 June and 15 July) In 1990.

Hybrid x Water Regime

A comparison of the interaction of corn hybrid yield in relation to water regime determines which hybrids did best under rainfed conditions and which did best under limited irrigation (positive changers) or remained the same (non-changers) (Fig. 3) for the two planting dates.

The asymptote (a line that is the limiting position that the tangent to a curve approaches) was used for isolating the positive changers and the non-changers from the median grouping. Seven hybrids were found with a wide range in yield in relation *to* water regime, and five hybrids were found with a narrow range in yield in relation *to* water regime in the early planting study.

In the late planting study, four wide-range hybrids in relation to water regime contained two of the same hybrids as in the early planting study (Pioneer 3072 and Pioneer 3098) and four of the same narrow-range hybrids in the late planting as in the early planting. *'Cargill* C-501', a narrow-range hybrid in the early planting, became a wide-range hybrid in the late planting, possibly indicating a favorable response of **this** hybrid to late planting.

Hybrid x Planting Date

The interaction of hybrid x planting date is illustrated in Fig. 4 for rainfed and irrigated conditions. Four positive changers ('DeKalb XL 678C', Pioneer X-304C, Pioneer 3214 and 'Pioneer 3078') having a wider range of yield than the others were noted in relation to planting date under rainfed conditions. The irrigated condition gave a wider range response. Three positive changers that did best when planted on 3 July were Cargill C-501, Pioneer 3072 and 'Pioneer 6875' with three negative changers that did best when planted on 7 June ('Cargill C-333', 'Cargill T-327' and 'Cargill T-320'). Three other negative changers that did well when planted on 7 June were 'CafgillT-321', Pioneer 3098 and 'Cargill C-611'.

Fall Armyworm Preference

Fall armyworm seem to have definite preferences for certain tropical corn hybrids. In 1989, Pioneer X-304C showed that it was less susceptible to fall armyworm than other hybrids tested with resulting higher yields (Table 2). More evidence for fall armyworm preference is shown in Fig. 5 where Pioneer X-304C had significantly fewer fall armyworm than Flopup (a Florida open pollinated line) and Sunbelt 1876 (a temperate line) for all dates counted. In the 1990 limited irrigation hybrid tropical corn trials, fall armyworm definitely reduced yields of certain hybrids that have higher yield potentials in the absence of fall armyworm. Any hy-

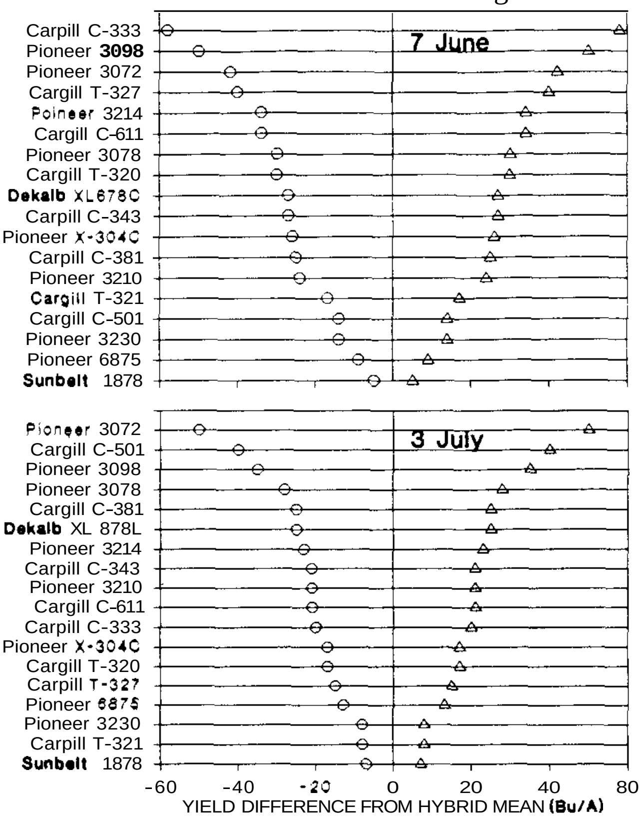

Fig. 3. Tropical corn hybrid yield interaction with water regime for early and late planting dates in 1990.

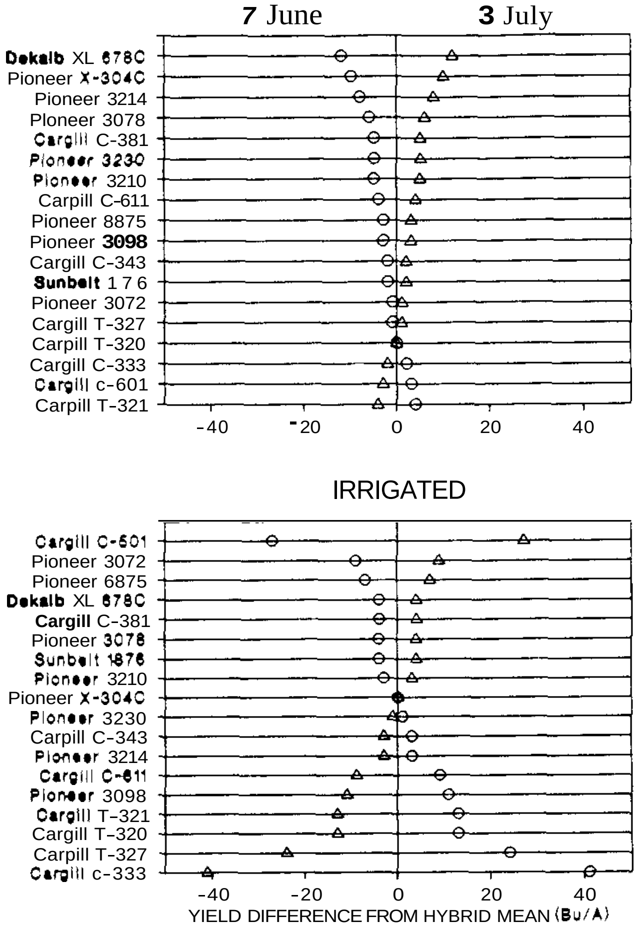

Fig. 4. Tropical corn hybrid yield interaction with planting date for rainfed and irrigated water regimes in 1990.

brid with a grain yield greater than 75 bu/acre was considered somewhat resistant to fall armyworm.

ACKNOWLEDGEMENT

Our thanks to E. Brown, Agricultural Technician IV and B.T. Kidd, Biological Scientist II, North Fla. Res. and Educ. Ctr. Univ. of Fla., Quincy, FL; for plot preparation and management, data collection, computer processing and data illustration.

LITERATURE CITED

1. Herzog, D.G., and J.E. Funderburk. 1986. Ecological basis for habitat management and pest cultural control. pp. 217-250. *In* M. Kogan (ed.). Ecological theory and integrated pest management practice. New York John Wiley & Sons.
2. Teare, I.D. and D.L. Wright. 1990a Crop yield comparisons and economic analysis for single and double-crop systems, Univ. of Fla, NFREC, Quincy, FL.Res. Rep. NF 90-6.
3. Teare, I.D., and D.L. Wright. 1990b. Corn hybrid-starter fertilizer interaction for yield and lodging. Crop Sci. 301298-1303.
4. Teare, I.D., D.L. Wright and R.K. Sprenkel. 1990. Early planting reduces fall armyworm problems in no-till tropical corn. pp. 3841. *In* J.P. Mueller and M.G. Wagner (eds.). 1990 So. Cons.Til. Conf. SB 90-1. Raleigh, NC. 16-17 July, 1990. N. Carolina State Univ. Raleigh, NC .
6. Teare, I.D., D.L. Wright and D.J. Zimet. 1989. No-till research with tropical corn in a double-crop system. pp. 4345. *In* I. D. Teare, E. Brown, and C.A. Trimble (eds.). 1989 So. Cons. Til. Conf. Proe. Quincy, FL,12 July - 13 July 1989. Univ of Fla., Quincy, FL
6. Wright, D.L., D.P. Lilly and I.D. Teare. 1990. Planting tropical corn in minimum tillage systems. pp. 81-83. In J.P. Mueller and M.G. Wagner (eds.). 1990 So. Cons. Til. Conf. SB 90-1. Raleigh, NC. 16-17 July, 1990. N. Carolina State Univ. Raleigh, NC
7. Wright, D.L.,and C.G. Chambliss. 1989. Results of corn hybrid tests in Florida in 1988, a tropical corn test and results from S. Georgia trials. Univ. of Fla Agr. Facts No. SS AGR-926.
8. Wright, D.L., and D.L. Prichard. 1988. Tropical corn oroduction and use. Univ. of Fla Agr.Facts No. 228.

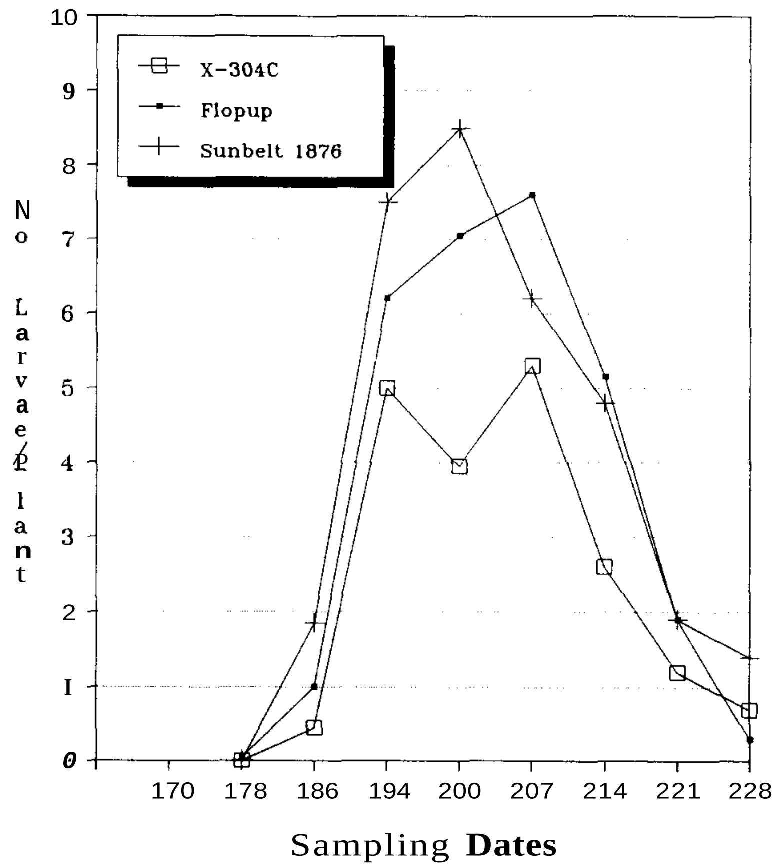

Fig. 5. Fall armyworm larvae counts In relation to two hybrids and one open pollinated lines of tropical corn In 1990 when planted on 15 June.

Yield Response and Nitrogen Requirement of Cotton as Affected by Tillage and Traffic

H.A. Torbert and D. W. Reeves[1]

INTRODUCTION

There are many tillage systems available to farmers for cotton production in the Southeast. Among these are conservation tillage systems, which have been shown under some growing conditions to have a beneficial effect for cotton production in the sandy coastal plain soils of this region (Touchton and Reeves, 1988). The formation of tillage pans due to soil compaction has also been recognized as a possible limitation for cotton production with these soils (Touchton and Reeves, 1988). There are a number of methods for alleviating soil compaction, including deep plowing, subsoiling, chiseling, crop rotation and controlled traffic (Bowen, 1981), but the most commonly used practice is some form of deep tillage. Because of this, the use of strip-tillage, which combines deep tillage and conservation tillage, has recently begun to be used for cotton production in this region (Touchton and Reeves, 1988).

Controlled traffic has also been investigated as a possible means of relieving soil compaction and the formation of hardpans. Williford (1982) found that cotton yield was significantly increased with controlled traffic beds and suggested that subsoiling every year was unnecessary with controlled traffic systems. Dumas et al. (1973) evaluated systems utilizing controlled traffic and deep tillage (subsoiling) for cotton production. They found that deep tillage, regardless of traffic, resulted in larger cotton plants. Without deep tillage, controlled traffic resulted in a 9% increase in plant height. Both deep tillage and controlled traffic were necessary to obtain maximum yield (4214 lb/acre seed cotton).

Research conducted on controlled traffic has focused on interactions with deep tillage such as subsoiling. There is also a need to investigate tillage systems, including conservation cropping systems, that utiliize controlled traffic and compare them to conventionally trafficked tillage systems. The USDA-ARS National Soils Dynamics Laboratory has recently begun research utilizing a wide frame tractive vehicle (WFTV) designed to allow for 20-ft-wide, untrafficked research plots. A detailed description of the vehicle and its capabilities has been published by Monroe and Burt (1989). Utilization of the WFTV allows for the use of various tillage systems in a zero-traffic environment. The objective of this experiment was to determine the effect of traffic and tillage systems, including a strip-tillage system, on cotton production.

Preliminary results from this experiment indicated that N fertility may also be affected by tillage and traffic. The level at which soil is compacted and the area that roots are able to explore in the soil profile can affect N application efficiency (Jenkinson et al., 1985). The tillage system used can strongly affect fertilizer N utilization by cotton. Factors such as soil moisture and temperature (which are changed with different tillage practices) can lead to great changes in N efficiency (Jansson and Persson, 1982). Furthermore, N fertilizer practices are complicated with the use of conservation tillage, with both increased (Meisinger et al., 1985) and decreased (Moschler and Martens, 1975) N fertilizer application needs reported under different experimental conditions. Therefore, additional research was initiated in 1989 to identify the effects that tillage and traffic have on the N fertilizer requirement for cotton.

MATERIALS AND METHODS

A field study was initiated at the Alabama Agricultural Experiment Station, Auburn University, Agricultural Engineering Research Farm at Shorter, AL. Cotton was grown in a double-cropping system with wheat, with wheat stubble used as surface residue for the conservation tillage treatments. The soil is a Cahaba-Wickham-Bassfeld sandy loam complex (Typic Hapludults). Cation exchange capacity (CEC) and organic matter content for the test site averaged 6.31 meq/100 g and 1.19%, respectively. The site has a well-developed 3-to-6-in.-thick hardpan from 8 to 12 in. deep. To reduce variation, an effort was made to form a uniform hardpan at a depth of 8 in. by running a motor grader repeatedly in plowed furrows incremental across the experiment site.

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The experiment design was a split-plot with 4 replications. Main plots (20 ft wide and 600 ft long) were 1) conventional traffic and 2) zero-traffic Main plots were split into subplots (120 ft long) of tillage systems: 1) complete surface tillage without subsoiling (not SS), 2) complete surface tillage and annual in-row subsoiling to 16-in. depth (SS prior cotton), 3) complete surface tillage with one-time-only complete disruption of tillage pan (initial SS) and 4) no surface tillage but planted with in-row subsoiling (strip-tillage). The study was initiated in June of 1987; however, because wheat stubble was needed to implement the strip-tillage treatment, the full complement of treatments was not accomplished until 1988. Complete surface tillage consisted of disking, chisel plowing (8-in. depth), diking and field cultivation. The one-time-only complete disruption of the tillage pan was accomplished by subsoiling to a 20-in. depth on 10-in. centers using a V-ripper in November 1987. The strip-tilled cotton was planted into wheat stubble with a KMC in-row subsoiler planter. In 1990, the tillage subplots were split into sub-subplots (28.5 ft long) of four N rates. The N rates were 0, 40, 80 and 120 lb N/acre, creating a split-split-plot design.

Cotton, 'McNair 220', was planted on 30-in. rows at 90,000 seed/acre as close to 1 June as possible (equipment problems delayed cotton planting in 1988 and 1989). All tillage operations were performed with the WFTV. On the conventionally trafficked plots, a 4440 John Deere tractor or a Hi-boy sprayer was driven through the plots to simulate traffic that would have been applied with each operation. Traffic patterns followed those needed with 4 row equipment. Application of 34 lb N/acre at planting and 76 lb N/acre at first square was made each year through 1989. In 1990, application of 20 lb N/acre as NH_4NO_3 was made at planting to all but the 0 N rate plots. The remaining N fertilizer for each N rate was applied broadcast at first square.

Recommended cultural practices for insect and weed control were used throughout the season on all plots. Cotton was hand picked for yield from 100 ft of row in 1987 through 1989 and from 40 ft of row in 1990 on approximately 1 November of each year. Plant samples were taken from 10 ft of row for dry matter determination.

In 1990 plant and seed samples were analyzed for N content and combined for total plant N uptake. Because of variability of soil type and weed control problems in the fourth replicate, only three replications were used for analysis in the 1990 growing season.

RESULTS AND DISCUSSION

Cotton Yield

Cotton yield was limited in 1988 due to late planting date of cotton. In this year, there was a significant traffic x tillage interaction effect on seed cotton yield (Fig. 1). The SS prior to cotton treatment resulted in maximum yield in the zero-trafficked plots (1580 lb/acre) but lowest yield in the trafficked plots (1140 lb/acre). Within zero-trafficked plots, the initial SS treatment (subsoiling 20 in. deep on 10-in. centers prior to first wheat crop) reduced yields compared to in-row subsoiling at planting. In trafficked plots, however, the initial SS treatment increased seed cotton yield compared to SS prior to cotton. Traffic had little effect on the strip-tillage and the not SS treatments.

The 1989 growing season had a very cool and excessively wet spring with only short periods of water stress for the cotton during the growing season. In this year, there were no significant differences between tillage ($P \leq 0.24$) and traffic ($P \leq 0.27$) treatments for seed cotton yield (data not shown). Strip-tillage resulted in the lowest yields for both the trafficked and zero-trafficked plots, with an average of 1252 lb/acre. This non-significant trend may have been caused by reduced stand vigor due

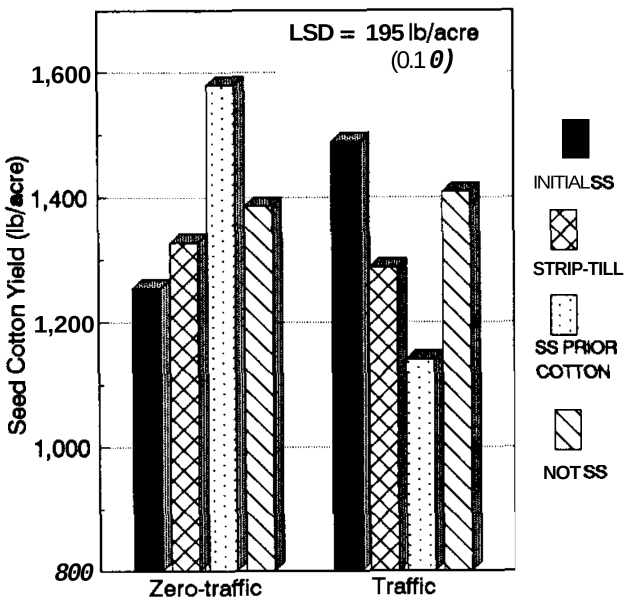

Fig. 1. Seed cotton yield as affected by traffic and tillage system, 1988. Not SS = conventional surface tillage; SS prior cotton = conventional surface tillage with In-row subsoiling; Initial SS = one time only complete disruption of hardpan; and Strip-till = no-till with In-row subsolling into wheat stubble.

to cool and wet conditions in the strip-tillage plots. Reduced N availability under these wet conditions may also have contributed to the yield reductions in these plots. Maximum yield was achieved in the zero-trafficked and not SS plots 1626 lb/acre).

The 1990 growing season was very dry, causing water stress in the cotton plants throughout most of the growing season. While no differences were found among the tillage treatments for seed cotton yield, seed production was significantly affected by tillage, with strip-tillage having significantly higher seed yield than SS prior to cotton when averaged over traffic treatment (787 and 662 lb/acre, respectively). Similar but non-significant trends were seen in cotton lint production (data not shown).

In this year, a significant decrease in both seed and lint production resulted from the zero-traffic treatment, with 1338 vs. 1213 lb seed cotton/acre produced for traffic and zero-traffic, respectively. Seed yield increased with traffic, with 763vs. 707 lb/acre ($P \leq$ 0.10 for traffic and zero-traflic, respectively. Yield reductions in soybeans and wheat have also been reported for controlled traffic systems in dry years (Reeves et al., 1990; Voorhees, 1989; Voorhees et al, 1985). As in 1988, traffic in the strip-tillage or not SS treatments resulted in relatively constant yields compared to the SS prior to cotton treatment.

Total dry matter production at harvest was highest for the not SS plots (Fig. 2). A significant reduction in total dry matter occurred when complete surface tillage was combined with subsoiling, with 2659 lb/acre dry matter compared to 3075 lb/acre with and without subsoiling, respectively. No significant difference occurred between the not SS and the strip-tillage treatments.

Total dry matter was significantly increased with increasing fertilizer N application similarly in all tillage and traffic treatments (Fig. 3), but no significant difference in seed or lint production was seen. Percent lint of seed cotton was signiiicantly decreased with increasing fertilizer N application, with 42.7% with no N application vs. 41.1% with 120 lb N/acre application. Similar N response to lint percentage was reported by Perkins and Douglas (1965). Consequently, while cotton seed production tended to increase with increased application of N, lint production was highest for the 0 lb/acre N application (1.12 and 1.09 bales/acre with 0 and 120 lb N/acre application, respectively). This indicates that the beneficial response of cotton to fertilizer N application may be limited under extremely dry growing conditions.

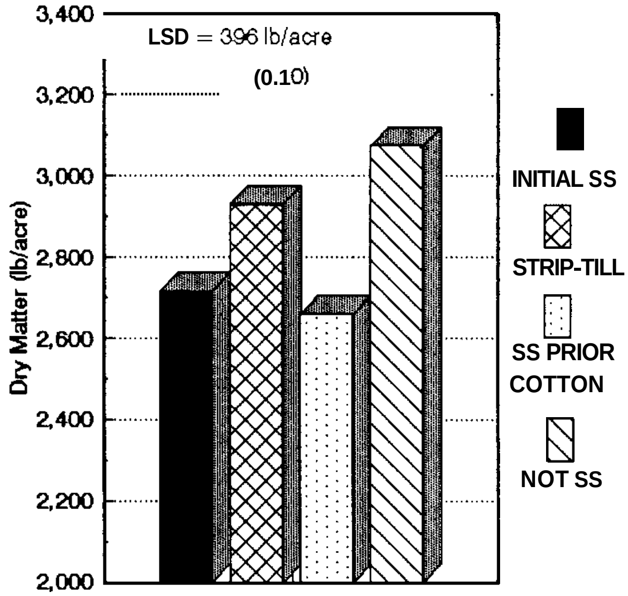

Fig. 2. Cotton dry matter production as affected by tillage system, 1990. Not SS = conventional surface tillage; SS prior cotton = conventional surface tillage with in-row subwiling; Initial SS = one time only complete disruption of hardpan; and Strip-till = no-till with In-row subsoiling into wheat stubble.

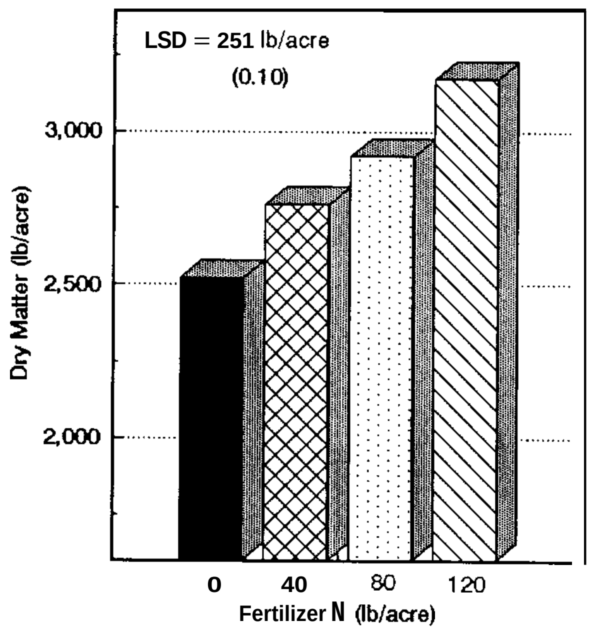

Fig. 3. Cotton dry matter production as affected by fertilizer N application, 1990.

Nitrogen Uptake

The dry growing season of 1990 resulted in extremely limited fertilizer N uptake by the cotton plants, with an average fertilizer N uptake efficiency of 17% for the 120 Ib N/acre rate. Increased rate of fertilizer N application significantly increased total N uptake in the plant, with most of the differences in plant N being accounted for in the stalks (Fig. 4). Fertilizer N application had very little effect on seed N content, with only the 120 lb N/acre rate having significantly higher N content in the seed than the no fertilizer N application.

Total N uptake significantly increased with tractor traffic compared to zero-traffic, increasing from 65 to 69 lb N/acre. While N uptake in the stalk had the greatest response to differences in N rate application (Fig. 4) no difference in stalk N uptake was found for tractor traffic. This indicates that differences in N uptake due to traffic were most likely due to differences in dry matter production, especially seed production, among treatments rather than to differences in N availability.

N uptake was significantly affected by tillage treatment, with not SS having the greatest N uptake (Fig. 5). The not SS treatment resulted in 72 lb N/acre compared to 62 lb N/acre for the SS prior to cotton treatment. Most of these differences can also be explained by differences in dry matter production among treatments. However, some differences due to N availability were evident in the strip-tillage treatment. While stalk dry matter production was not significantly different for the strip-tillage treatment compared to the not SS, N uptake in the stalks was significantly reduced (Fig. 6). A probable explanation for this is that increased organic matter in the strip-tillage plots may have tied up available N and resulted in some reduction in N uptake. This indicates that in years when moisture conditions will allow better utilization of available N, strip-tillage may require additional fertilizer N application for maximum yield.

CONCLUSIONS

Results from this study indicate that the effect of tillage and tractor traffic on cotton production is variable depending on the moisture condition during the growing season. In years of below-normal rainfall during the growing season, strip-tillage was found to maintain seed cotton yields near the maximum, even though the effect of subsoiling was variable with both beneficial and detrimental effects occurring. Zero-traffic resulted in a non-significant increase in seed cotton yield in most years but was

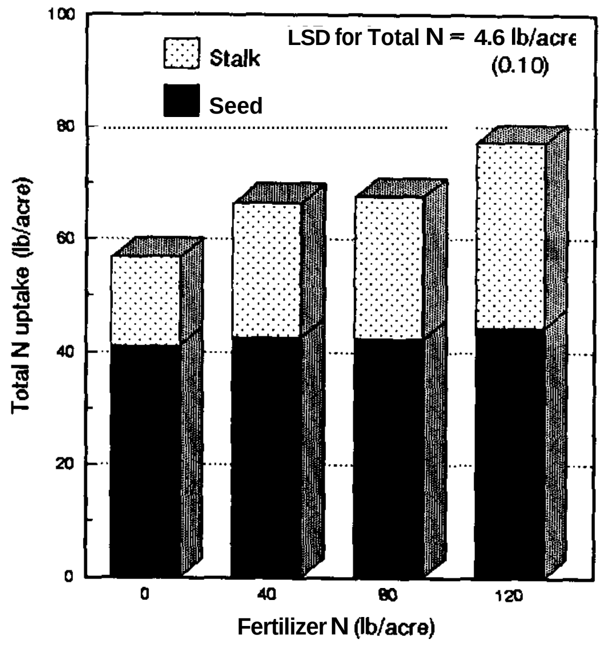

Fig. 4. Total N uptake in cotton 66 affected by fertilizer N application, 1990. Stalk = N uptake in cotton stalk, Seed = N uptake In the cotton seed.

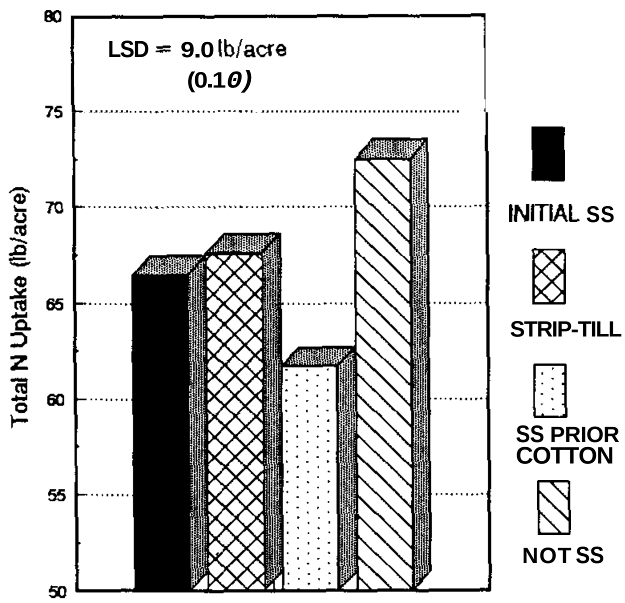

Fig. 5. Total N uptake by cotton 6s affected by tillage system, 1990. Not SS = conventional surface tillage; SS prior cotton = conventional surface tillage with in-row subsoiling; Initial SS = one time only complete disruption of hardpan; and Strip-till = no-till with in-row subsoiling Into wheat stubble.

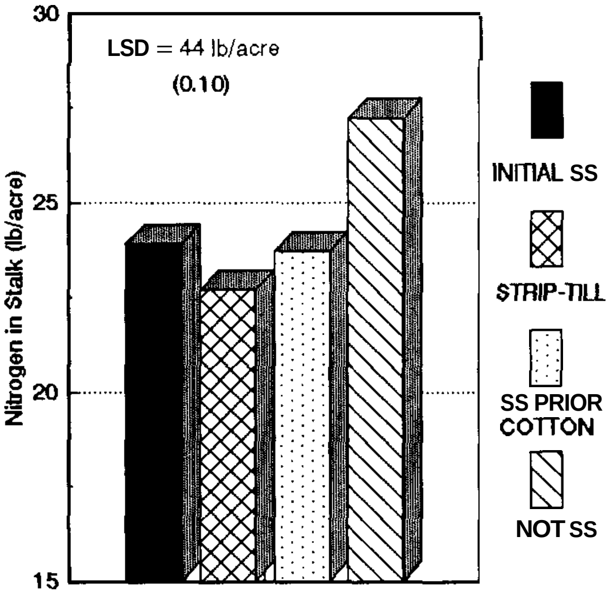

Fig.6. Cotton stalk N uptake as affected by tillage system, 1990. Not SS = conventional surface tillage; SS prior cotton = conventional surface tillage with in-row subsoiling; Initial SS = one time only complete disruption of hardpan; and Strip-till = no-till with in-row subsoiling into wheat stubble.

found to significantly reduce seedcotton yield and total N uptake in an extremely dry year. Fertilizer N application had no effect on cotton yield in an extremely dry growing season, indicating that the beneficial effect of fertilizer N may be limited under these conditions. Plant uptake of N was affected by tillage system, with most of the differences being attributed to differences in dry matter production. However, results indicate that reduced N uptake in the strip-tillage plots may have resulted from reduced N availability in these plots. This research will be continued to examine the effect of traffic on conservation tillage systems under different weather conditions during the growing season.

LITERATURE CITED

1. Bowen, H.D. 1981. Alleviating mechanical impedance. *In* G.F. Arkin. and H.M. Taylor (eds.). Modifying the root environment to reduce crop stress. pp. 21-53. Amer. Soc of Agric Eng., St. Joseph, MI.
2. Dumas, W.T., A.C. Trouse, L.A. Smith, F.A. Kummer and W.R Gill. 1973. Development and evaluation of tillage and other cultural practices in a controlled traffic system for cotton in the Southern Coastal Plains. Trans. ASAE 16:872-876.
3. Jansson, S.L., and J. Persson. 1982. Mineralization and immobilization of soil nitrogen. p. 229-252 *In* F. J. Stevenson et al. (ed.). Nitrogen in agricultural soils. Agron. Monogr. 22. ASA and SSSA, Madison, WI.
4. Jenkinson, D.S., RH. Fox and J.H. Rayner. 1985. Interactions between fertilizer nitrogen and soil nitrogen--the so-called 'priming' effect. J. Soil Sci. 36425-444.
5. Meisinger, J.J., V.A. Bandel, G. Standford and J.O. Legg. 1985. Nitrogen utilization of corn under minimal tillage end moldboard plow tillage. I. Four-year results using labeled N fertilizer on an Atlantic Coastal Plain soil. Agron. J. 77:602-611.
6. Monroe, G.E., and E.C. Burt. 1989. Wide frame tractive vehicle for controlled traffic research. Applied Eng. in Agric 5:40-43.
7. Moschler, W.W., and D.C. Martens. 1975. Nitrogen, phosphorus, and potassium requirements in no-tillage and conventional tilled corn. Soil Sci Soc Amer. Proc 39:886-891.
8. Perkins, H.F., and A.G. Douglas. 1965. Effects of nitrogen on the yield and certain properties of cotton. Agron J. 57383384.
9. Reeves, D.W., J.A. Droppers and J.B. Powell. 1990. Controlled traffic: influence of tillage requirements for corn and soybean. p. 323. *In* Agronomy Abstracts, ASA, Madison, WI.
10. Touchton, J.T., and D.W. Reeves. 1988. A Beltwide look at conservation tillage for cotton. *In* Proceedings of the 1988 Beltwide Cotton Production Conference, Highlights of Cotton Prod. Res. Conf. Jan. 3-8, 1988. New Orleans, LA. National Cotton Council of America, Memphis, Tn.pp. 36-41.
11. Voorhees, W.B. 1989. Root activity related to shallow and deep compaction. *In:* W.E. Larson, G.R. Blake, RR. Allmaras, W.B. Voorhees and S.C. Gupta (eds.). Mechanics and related processes in structured agricultural soils. pp. 173-186. Norwell, MA. Kluwer Academic Publishers.
12. Voorhees, W.B., S.D. Evans and D.D. Warnes. 1985. Effect of preplant wheel traffic on soil compaction, water use, and growth of spring wheat. Soil Sci Soc Am. J. 49:215-220.
13. Williford, J.R. 1982. Residual effect of subsoiling in a controlled-traffic system. ASAE paper no. 82-1044.

Tillage and Rotation Effects on Soil Organic Matter

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INTRODUCTION

Maintenance of soil organic matter with its associated physical, chemical and biological benefits has been a problem in arable, humid region soils such as those of the southeastern states. Tillage practices used to produce crops on many southeastern soils over the past two centuries have resulted in widespread erosion and enhanced soil organic matter decomposition rates (Langdale et al., 1985).

Over the past 30 years, however, minimum or no-till practices have been developed that may maintain or even increase surface soil organic matter contents of degraded southeastern soils (Langdale et al., 1985). Minimum or no-tillage is utilized on approximately 48% of arable land in the southeastern states (Follett et al., 1987). These systems employ less tillage, allow greater surface residue cover and have been shown to inhibit soil organic matter losses when compared to conventional tillage systems (Lamb et al., 1985; Havlin et al., 1990; Hargrove, 1990). In addition, reduced tillage systems have been shown to enhance microbial activity and the nutrient supplying capability of surface soils when compared to conventional till systems (Doran, 1980; Hargrove, 1990; Wood et al., 1990).

Crop rotation (or lack of it) and crop type have also been factors controlling surface soil organic matter contents. Row crop culture, and in particular continuous cotton, diminished soil organic matter contents across several land classes in Georgia, while losses of soil organic matter were prevented and in many cases substantial soil organic matter gains were obtained with rotations including cereals or legumes (Gosdin et al., 1949). Similar findings were reported by Hargrove (1990) who concluded that levels of surface soil organic matter contents under no-till were a function of the amount of plant residues added to the soil. Cropping systems with more crops per unit time have been shown to conserve soil organic C and N Wood et al., 1991), and, in particular, double cropping systems in the southeast have prevented losses of soil organic matter (Langdale et al., 1985).

Most previous studies concerning the effect of cultural practices on surface soil organic matter content have concerned tillage. Little information exists, especially on southeastern U.S. soils, on the interactive effects of tillage and crop rotation on soil organic matter content. The objective of this study was to determine the impact of long-term tillage and crop rotation practices on soil organic C and N contents.

MATERIALS AND METHODS

Soil organic C and organic N were measured on soil samples from a long-term tillage/rotation study at Crossville, Alabama (34° 18' N, 86° 01' W), that was established in 1980. Prior to 1980, the study site had been used for row crop production for more than 50 years. The soil was a Hartsell fine sandy loam (fine-loamy, siliceous, thermic Typic Hapludults). The experimental design was a two (tillage) by three (rotation) factorial with four replications arranged as a split plot with tillage treatments as main plots. Rotations included continuous soybean (*Glycine max* L.) - wheat (*Triticum aestiuum* L.) cover (SW); continuous corn (*Zea mays* L.) - wheat cover (CW); and corn -wheat cover - soybean -wheat cover (CWSW). Tillage treatments included conventional tillage (CT) (moldboard plowing the wheat cover in the spring followed by incorporation of herbicide with a disk) and no-till (NT) (planting in killed wheat residue with a double disk opener planter). Weed control, fertilization and other cultural practices utilized in the study were detailed by Edwards et al. (1988).

Soils from each tillage and rotation combination were sampled on 31 October 1990. Soils were sampled in 0- to 5-, 5- to 10- and 10- to 20-cm depth increments. Thirty soil cores (2.6-cm diameter) were collected per tillage/rotation combination and composited by depth increment. Surface plant residues were excluded from soil cores before sampling. Soil samples collected in the field were sieved to pass 2 mm. Soil organic C was determined with a LECO CHN analyzer. Total N was determined by a Kjeldahl procedure (Bremner and Mulvaney, 1982). Nitrate-N (NO_3-N) plus nitrite-N (NO_2-N) and ammonium-N (NH_4-N) were extracted with 2*M* KCl

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and measured with a Wescan Ammonia Analyzer. Organic N was calculated as the difference between soil total N NO_3-N plus NO_2-N plus NH_4-N.

Amounts of crop residues returned to the various cropping systems were summed for the years 1980 to 1990. Corn and soybean residues returned to the OIl were estimated from grain yields by multiplying grain production for each plot by a residue weight to grain weight ratio of 1.0 and 1.5 for corn and soybean, respectively (Larson et al., 1978). Wheat vegetation returned to the soil was determined from direct areal measurements.

Analyses of variance were performed using the SAS Package SAS Institute, Inc., 1988). Unless noted otherwise, all statistical tests were made at the $a = 0.05$ level.

RESULTS AND DISCUSSION

After 10 years of cropping, when averaged across soil depth and crop rotation effects, NT had 48% and 47% more soil organic C and N, respectively, than CT management (Table 1). No-till also exhibited a different depth distribution of soil organic C and N than CT; greater amounts of soil organic C and N were found in 0- to 5- and 5- to 10-cm soil layers of NT than in CT. Below 10 cm, amounts of soil organic C and N did not differ between tillage treatments, as evidenced by the significant tillage by soil depth interaction.

Previous studies have shown that amounts of organic C and N stored in surface soils is a function of amount of plant residues added to the soil and soil organic matter decomposition rates (Wood et al., 1990, 1991). In this study it appears that differ-

Table 1. Soil organic C, organic N and C N as affected by 10 years of Ullage and crop rotation management at Crossville, Alabama.

		Organic C			Organic N			C:N		
Rotation[1]	Depth	CT[2]	NT	Mean	CT	NT	Mean	CT	NT	Mean
	cm	g/kg								
SW	0-5	5.7	9.3	7.5	0.51	0.77	0.64	11.3	12.2	11.7
	5-10	5.6	8.8	7.2	0.48	0.75	0.61	11.6	11.8	11.7
	10-20	5.8	5.8	5.8	0.48	0.44	0.46	11.9	13.2	12.6
	Mean	5.7	8.0	6.8	0.49	0.65	0.57	11.6	12.4	12.0
CW	0-5	6.2	12.0	9.1	0.44	0.99	0.71	46.5	11.9	14.2
	5-10	6.2	10.5	8.4	0.53	0.68	0.60	11.8	20.2	16.0
	10-20	5.8	6.3	6.1	0.47	0.68	0.58	12.1	10.5	11.3
	Mean	6.1	9.6	7.8	0.48	0.78	0.63	13.5	14.2	13.0
CWSW	0-5	5.9	10.7	8.3	0.53	0.95	0.74	11.2	11.2	11.2
	5-10	5.8	9.3	7.6	0.51	0.80	0.65	11.6	11.5	11.5
	10-20	5.2	5.1	5.1	0.46	0.44	0.45	11.2	11.5	11.4
	Mean	5.6	8.4	7.0	0.50	0.73	0.61	11.3	11.5	11.4
Rotation Mean	0=5	6.0	10.6	8.3	0.49	0.90	0.70	13.0	11.8	12.4
	5-10	5.9	9.5	7.7	0.50	0.74	0.62	11.7	14.5	13.1
	10-20	5.6	5.7	5.7	0.47	0.72	0.60	12.2	12.7	12.4
Tillage Mean		5.8	8.6	7.2	0.49	0.72	0.60	12.2	12.7	12.4

Analysis of Variance[3]	P>F	$LSD_{.05}$	P>F	$LSD_{.05}$	P>F	$LSD_{.05}$
Tillage (T)	<0.001		<0.001		0.628	
Rotation (R)	<0.001	0.3	0.389		0.205	
Depth (D)	<0.001	0.3	0.001	0.09	0.631	
TXR	<0.001	0.4	0.296		0.967	
TXD	<0.001	0.4	0.002	0.09	0.332	
RXD	0.002	0.5	0.464		0.533	
TXRXD	0.124		0.312		0.246	

[1]SW = continuous soybean, CW = continuous corn, and CWSW = alternate corn-soybean; wheat (W) was used for a winter cover crop in all systems.

[2]CT = conventional till; NT = no-till.

[3]Tillage has only two means; no LSD value given.

ent amounts and distribution of soil organic C and N between tillage systems were due to differences in crop residue management that lowered soil organic matter decomposition rates under NT in comparison to CT management. Conventional tillage mixed crop residues into the surface soils and promoted a nearly even distribution of soil organic C and an even distribution of soil organic N (Table 1). Greater soil organic C and N under NT than under CT were not due to greater additions of crop residues under NT because amounts of crop residues added to the soil over the 10-year cropping period did not differ between tillage systems (Fig. 1).

Crop rotation interacted with tillage to impact soil organic C concentrations (Table 1). Soil organic C concentrations under no-till increased in the order of SW < CWSW < CW. Lower organic C concentrations were found with CT than with NT management with all cropping systems, and under CT management CW had greater soil organic C concentrations than CWSW or SW. Depth distribution of soil organic C differed among crop rotation treatments with clear stratification of organic C between 0- to 5-, 5- to 10- and 10- to 20-cm depth increments in CW and CWSW systems. Less stratification of organic C was evident in the SW system than in the CW or CWSW systems, as shown by the significant rotation by soil depth interaction. Although no significant rotation effects were observed, soil organic N followed trends similar to soil organic C.

Greater soil organic C and a trend towards greater soil organic N under the CW system followed by the SW and CWSW systems was likely due to greater inputs of crop residues into the CW system (Fig. 1). Several long-term studies have shown a strong relationship between soil organic C and N levels and plant residue inputs into the soil (Havlin et al., 1990; Hargrove, 1990; Parr and Papendick, 1978). Soils under crop rotations including soybeans have been shown to have less soil organic C and N than soils under rotations including grain sorghum (Havlin et al., 1990), and this agrees with the findings of this study when rotations including corn and soybeans are compared.

Greater soil organic C and N under the CW system than under the CWSW or SW systems may not have been due entirely to greater additions of crop residues under CW, because crop residues added over the 10-year cropping period did not differ between the CW and CWSW systems (Fig. 1). Higher C:N ratios of corn residues than of soybean residues and subsequent greater resistance to decomposition of corn residues in comparison to soybean residues (Parr and Papendick, 1978) may have been factors promoting greater soil organic C and N concentrations in the CW system than in CWSW or SW systems.

Soil C:N ratios generally widen with decreased tillage and increased addition of crop residues (Black, 1973). In this study, soil C:N ratios tended to be higher in CW systems and under no-till management, although no significant effects were observed (Table 1). Lack of difference in soil C:N ratios between tillage or rotation systems was probably due to similar magnitude of difference in soil organic C and N between the various tillage and rotation treatments.

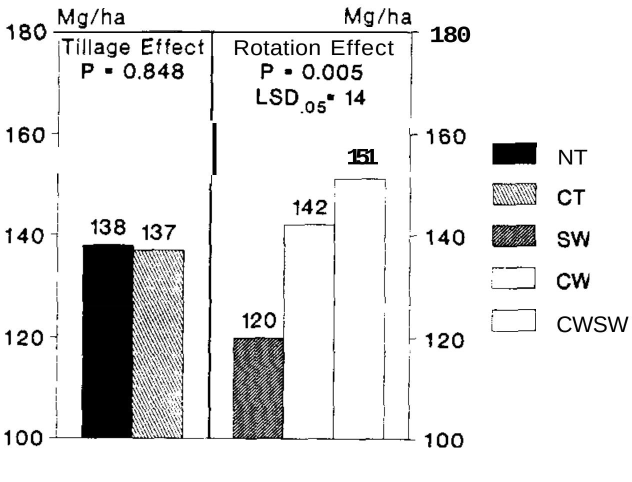

Fig. 1. Amount of crop residues added to the soil between 1980 and 1990 at Crossville, Alabama as affected by tillage and crop rotation.

CONCLUSIONS

Soil organic C and N waa greater under NT than under CT management after 10 crop years. Differences in soil organic matter between tillage systems were a function of crop residue management instead of total crop residue inputs over the 10-year period. The results of this study indicate that rotations including corn conserve more organic C and N than those including soybean. Greater soil organic C and N under rotations including corn (CW and CWSW) than those with soybean only were a function of amount of crop residue added to the soil under CW and CWSW and were probably enhanced by slower decomposition rates of corn in comparison to soybean residues.

LITERATURE CITED

1. Black, A.L. 1973. Soil property changes associated with crop residue management in a wheat fallow rotation. Soil Sci Soc Amer. Proc 37:943-946.

2. Bremner, J.M., and C.S. Mulvaney. 1982. Nitrogen-total. pp. 595-629. *In* A.L. Page (ed.). Methods of soil analysis. Part 2. 2nd ed. Madison, WI: ASA.

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

4. 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. 8076-80.

5. Follett, RF., S.C. Gupta and P.G. Hunt. 1987. Conservation practices: Relation to the management of plant nutrients for crop production. *In* RF. Follett, J.W.B. Stewart and C.V. Cole (eds.). Soil fertility and organic matter as critical components of production systems. SSSA Spec Publ. 19. Madison, WI: ASA, CSSA, SSSA.

6. Gosdin, G.W., M. Stelley and W.E. Adams. 1949. The organic matter and nitrogen content and carbon-nitrogen ratio of cecil soil as influenced by different cropping systems on classes 11, 111, and IV land. Soil Sci. Soc Amer. Proc 14203-209.

7. Hargrove, W.L. 1990. Role of conservation tillage in sustainable agriculture. pp. 28-32. *In* J.P. Mueller and M.G. Wagger (eds.). Proc of 1990 South. Reg. Cons. Till. Conf., July 26-17, 1990. North Carolina State Univ., Raleigh, NC.

8. Havlin, J.L., D.E. Kissel, LD. Maddux, M.M. Claassen and J.H. Long. 1990. Crop rotation and tillage effects on soil carbon and nitrogen. Soil Sci. Soc Amer. J. 54:448-452.

9. Lamb, J.A., G.A. Peterson and C.R Fenster. 1985. Wheat fallow systems' effect on a newly cultivated grassland soils' nitrogen budget. Soil Sci Soc Amer. J. 49352356.

10. Langdale, G.W., H.P. Denton, A.W. White, Jr., J.W. Gilliam and W.W. Frye. 1985. Effects of soil erosion on crop productivity of southern soils. pp. 252-270. *In* RF. Follett and B.A. Stewart (eds.). Soil erosion and crop productivity. Madison WI: ASA, CSSA, SSSA.

11. Larson, W.E., RF. Holt and C.W. Carlson. 1978. Residues for soil conservation pp. 1-15. *In* W.R Oschwald (ed). Crop residue management systems. ASA Spec Publ. 31. Madison, WI: ASA, CSSA, SSSA.

12. Parr, J.F., and R.I. Papendick. 1978. Factors affecting the decomposition of crop residues by microorganisms. pp. 101-129. *In* W.R. Oschwald (ed). Crop residue management systems. ASA Spec Publ. 31. Madison, WI: ASA, CSSA, SSSA,.

13. SAS Institute, Inc. 1988. SAS/STAT user's guide, release 6.03 edition. SAS Institute, Inc, Cary, NC.

14. Wood, C.W., D.G. Westfall, G.A. Peterson and LC. Burke. 1990. Impacts of cropping intensity on potential C and N mineralization in no-till dryland agroecosystems. Agron. J. 821115-1120.

15. Wood, C.W., D.G. Westfall and G.A. Peterson. 1991. Soil carbon and nitrogen changes on initiation of no-till cropping systems. Soil Sci Soc Amer. J. 55:(in press).

Silage Comparisons of Tropical and Temperate Corn at Four Planting Dates for Multiple Cropping Systems

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ABSTRACT

Tropical corn (*Zea mays* L.) offers a silage or grain crop other than legume crops (soybean, peanuts) that may be planted after winter grains or vegetables. Rotation and the need for grain and silage in the Southeast make tropical corn an attractive alternative to legumes. A study was initiated in 1990 to determine silage and grain yields of a tropical corn (Pioneer Brand X304C in comparison with a temperate corn (Sunbelt 1876) planted on four dates (12April, 16 May, 15 June, 13 July) grown on a Norfolk sandy loam soil (fine-loamy, siliceous, thermic, Typic Kandiudult). Rainfall during the 1990 season was less than half of normal, resulting in lower silage and grain yields than might be expected. Grain yields were reduced by a larger factor than were silage yields. Grain and silage yields were better from the temperate hybrid planted in April than from the tropical hybrid. Plantings made a month later, out of the normally recommended corn planting season, resulted in a drastically reduced silage yield for the temperate hybrid. Tropical corn silage yield dropped slightly from later plantings but remained much higher than the temperate hybrid. Later plantings of temperate corn continued to show a drop in silage yield while there was no significant drop in silage yield for the tropical hybrid. This data would indicate that tropical corn could be grown successfully for silage in multicropping systems and should be used when corn is desired to be grown outside of the normal corn planting season.

INTRODUCTION

Cropping system studies and farmer experience have shown that tropical corn fits well into current cropping systems and may replace soybeans in the wheat no-till soybeans system for rotation (Wright et al., (1990). Only a few thousand acres of tropical corn were grown in the mid to late 1970s and early 1980s as a late silage crop after an early silage crop of temperate corn in Florida. As research efforts focused on not only silage but grain production in the mid 1980s, many growers began looking at tropical corn as a potential grain crop for rotation with peanuts and soybeans. Acreage increased from a few thousand acres to over 40,000 acres in 1990. Dairies and grain producers all over the South are trying tropical corn to see where it fits into their operation, especially after winter grazing. Additional work is being done on tropical corn for silage (Overman and Gallaher, 1989; Bustillo and Gallaher, 1989) and grain (Wright and Chambliss, 1989).

Management of tropical corn, with a few exceptions, is very similar to management of temperate corn (Teare et al., 1990). Tropical corn insect and disease resistance is much better than that of temperate corn (Wright and Prichard, 1998). Recent research in Florida has shown that it is possible to manage around insects (Wright et al., 1990; Teare et al., 1990) by early or late planting. Future research will focus on use of biological control agents and timely pesticide applications. Limited data have been collected regarding insect damage, and much more work is needed in this area.

Silage yield and quality are very important factors for dairy farmers to know when selecting corn hybrids. Most corn trials measure grain yields, grain quality, lodging, shuck coverage, ear height and maturity. The few silage trials run usually have a limited number of hybrids, and few quality factors, such as digestibility, are determined. Silage studies require more time, equipment and money for labor and sample analysis than grain trials. Gipson et al. (1990), in a corn silage trial in Georgia, showed about a 30% difference in digestibility of grain, 13% digestibility difference in the fodder and 25% difference in silage yields in a trial with 25 different temperate hybrids. These types of differences between hybrids could mean a substantial savings or increase in milk production for dairymen if information on hybrids were available. It was noted by Ippersiel et al. (1989) that little published information was available on the effect that cultural practices have on silage quality. Most of the data available on quality

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relates to grain (Williams et al., 1984, Myer et al., 1990) Wright et al. (1987) showed a 25% difference in grain protein level among temperate hybrids in a hybrid trial. There are limited data on management effects on corn silage yield and quality.

Many new tropical corn hybrids are being evaluated for silage yield and quality as well as grain yield and other agronomic characteristics. Many Southern states are beginning to work with tropical corn and systems of adaption. Gipson et al. (1990) pointed out that the most desirable silage corn should have high fodder digestibility with a grain content of 40% or less to prevent acidosis in the rumen and to maintain high silage intake. Most of our mid-season temperate hybrids have a grain component amounting to almost 50% of the silage while tropicals tend to have less grain in relation to fodder.

The objective of the study was to evaluate tropical corn for silage yield at four summer planting dates compared with temperate corn.

MATERIALS AND METHODS

Pioneer Brand X304C (a tropical hybrid) and Sunbelt 1876 (a hybrid temperate corn) were planted at four planting dates shown in Table 1 on a Norfolk sandy loam soil (fine-loamy, siliceous, thermic, Typic Kandiudult). Fertilization, herbicide rates and dates of application are also shown in Table 1. All plots were grown during 1990 under rainfed conditions. Each plot contained eight rows 25 ft long so that grain and silage yield could both be determined. Both hybrids were planted at 24,000 plants/acre and thinned back to 20,000 plants. Date of 50% tassel emergence was determined for each hybrid and planting date. Plant and ear heights were measured approximately one week prior to cutting corn for silage. Lodging percentage was determined approximately one week prior to grain harvest. Each hybrid at each planting date was evaluated for insect injury, and no insecticide applications were made for foliage-feeding insects.

RESULTS AND DISCUSSION

Tropical corn (Pioneer X304C was compared to a full-season temperate hybrid (Sunbelt 1876) over four planting dates for both silage and grain. The mid-April date is at the last of the recommended planting period for temperate hybrids. The period of May 15 to June 10 has been recommended to growers in north Florida who are planting tropical corn after winter grazing or small grain for grain. Table 2 shows the average rainfall normally received during the April through October period. The 1990 rainfall during this period was less than half of normal. Tropical corn planted in mid to late May would be silking and tasseling by mid-July and would normally receive another eight weeks of abundant rainfall before drying off in mid to late September.

Figure 1 graphically illustrates rainfall in relation to planting, tassel dates and grain harvest. Tassel dates are closer than planting dates and harvest dates except for the last planting date, which was maturing in the short, cool days of fall. Silage and grain yields from the April planting (Table 3) show the benefit of more timely rains that were received in June, July and August. Silage yields of both the temperate and tropical hybrids were best from the April planting.

These data also indicate that when corn is planted in mid-April for either grain or silage, tem-

Table 1. Dates and rates of actlvltles of each planting date.

	Planting Dates			
Activity	April 12	Mav 16	June 15	Julv 13
Emergence Date	9/18	5/21	6/20	7/17
Fertilizer	500 lb 3/9/18-9/11	500 lb 3/9/18-5/7	500 lb 3/9/18-6/19	500 lb 3/9/18-7/16
Thinned *to* 20,000 pl/acre	5/1	5/30	6/26	7/23
Aatrex and Lasso	9/25 (Aatrex & Lasso)	5/30 (Aatrex & Lasso)	6/28 (Aatrex & Lasso)	7/23 (Atrazine & Lasso)
Accent	5/22	6/5	6/25	7/27
50% Tasseling Date	6/14 Sunbelt 1876 6/18 Pioneer X304C	7/12 Sunbelt 1876 7/15 Pioneer X304C	8/13 Sunbelt 1876 8/17 Pioneer X304C	9/5 Sunbelt 1876 9/7 Pioneer X304C
100 lb/acre N applied	5/2	6/9	6/27	7/25
Pl. ht. and Ear ht.	8/2	8/2	9/6	9/26
% Lodged	8/28	9/6	9/25	11/5
Silage harvest	8/8	8/17	9/14	10/12
Grain harvested	8/31	9/17	10/3	11/19

perate hybrids may be preferred. However, by mid-May silage and grain yields were significantly lower from both hybrids. The tropical hybrid produced approximately 5 tons more silage than did the temperate hybrid but had similar grain yield. Grain yields should be much higher than reported for 1990 in a normal rainfall year (Teare et al., 1990).

The June 15 planting date resulted in a severe drop in both silage and grain yield of the temperate hybrid, but no significant drop was noted for the tropical corn silage or grain yield. Insect damage (not reported here) was much more severe on the temperate hybrid than on the tropical hybrid. Silage yields were almost 8 tons/acre better at this planting date for the tropical hybrid as compared to the temperate hybrid. Mid-July plantings were essentially no different from mid-June plantings. However, insect pressure may have been less because insect numbers seem to level off late in the season when temperatures become cooler. Moisture deficiencies often affect grain yields more than fodder yields because the vegetative stage of growth is longer than the grain fill period and short-term drought may reduce tonnage of silage very little.

Table 2. Rainfall In north Florida durlng the growing season of this study.

Month	20-Year Average Precip.	1990 Rainfall
	in.	in.
April	4.9	2.2
May	4.3	2.0
June	5.2	3.5
July	6.9	3.5
Aug	5.8	3.4
Sep	5.0	0.6
Oct	2.5	0.9
Total	34.6	16.1

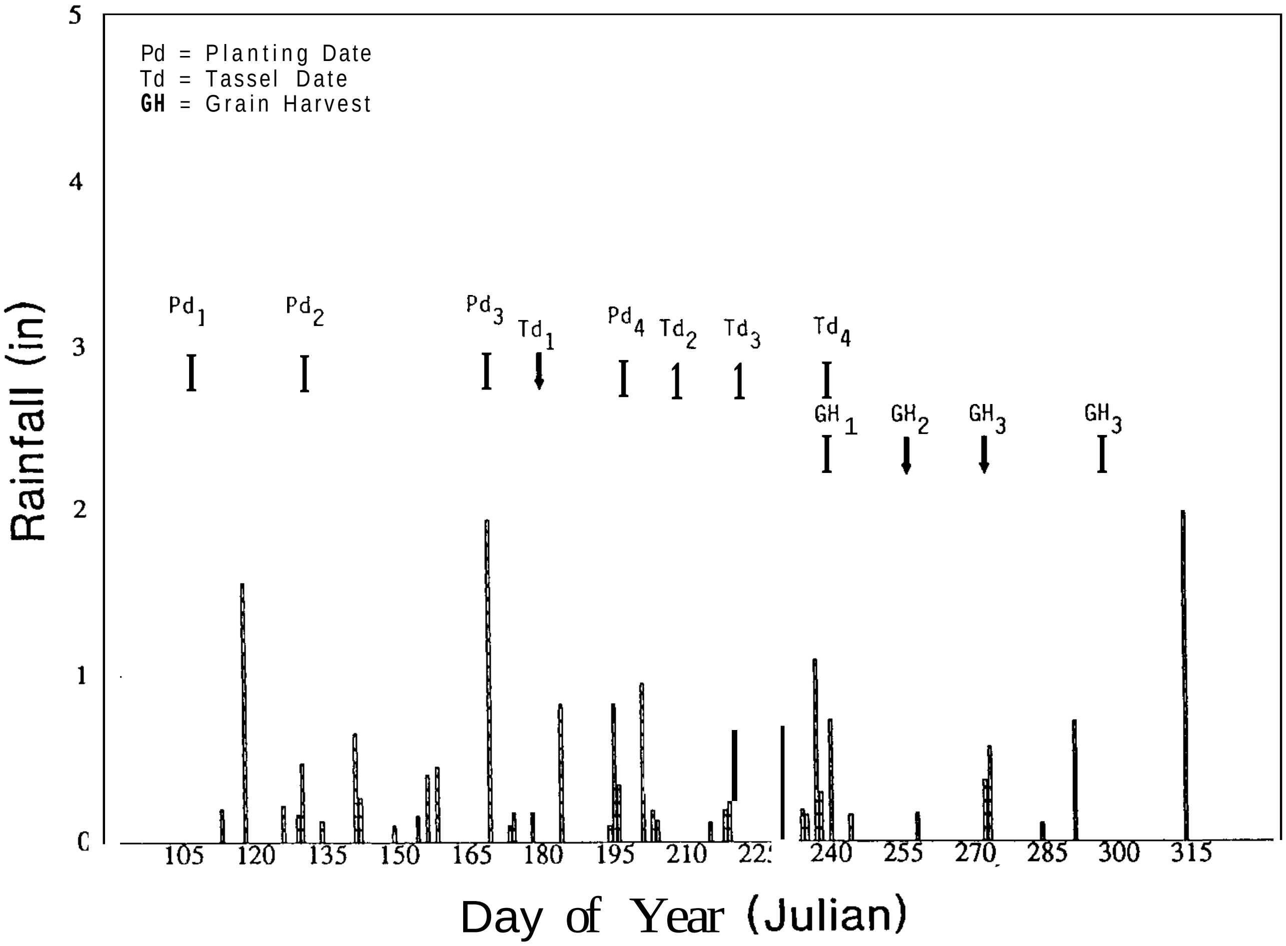

Fig. 1. Rainfall, planting dates, 50% tassel dates and grain harvest dates for the 1990 growing season.

Tabla 3. Comparison of rainfed temperate vs tropical corn silage and grain yields overseveral planting date8 in • dry year, Quincy, Florida, 1990.

Planting date	Tropical Pioneer 304C			Temperate Sunbelt 1876		
	Wet wt.	Dry wt.	Grain yield	Wet wt.	Dry wt.	Grain yield
	lb/acre	lb/acre	bu/acre	lb/acre	lb/acre	bu/acre
April 12	36017 a'	18222 a	45	38175 a	21534 a	68
May 16	28643 b	12668 b	23	19040 b	9044 b	26
June 15	27221 b	10586 bc	35	12964 c	5090 c	8
July 13	22170 b	8094 c	38	14200 bc	4869 c	19

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

CONCLUSION

These results indicate that corn plantings made in the recommended period for temperate corn should be made with temperate hybrids because silage and grain yields will probably be higher than for tropical hybrids. As planting dates are delayed because of multiple crops, the tropical corn hybrids should be planted to obtain a higher and more consistent silage or grain yield. There are other tropical hybrids that have yielded more silage and have almost doubled the grain yield over Pioneer X304C (Wright, unpublished data). As better tropical hybrids are identified, farmers may double crop more corn with varied winter crops. Plantings should be made as early as possible after winter crops are harvested since later plantings have more insect damage. Several years of research have shown that tropical corn can be planted no-till into almost any previous crop stubble successfully. Mid- and la-e summer plantings of temperate corn are normally unsuccessful because of severe insect and disease problems. Tropical corn is not immune to these problems, but it has some resistance and can produce acceptable silage or grain yields when planted during May and early June without insecticide applications.

LITERATURE CITED

1. Bustillo, J.J., and RN. Gallaher. 1989. Dry matter partitioning in no-tillage tropical corn in Florida pp. 4042. *In* I.D. Teare, E. Brown and C.A. Trimble (ed). 1989 Southern Conservation Tillage Conf. Proc Tallahassee, FL. Univ. of Fla Spec. Bull. 89-1.
2. Gipson, RD., P.L. Raymer and J.L. Day. 1990. 1990 Corn performance tests. Ga Agr. Expt. Sta, Univ. of Ga Res. Rep. 598.
3. Ippersiel, D., I. Alli, A.F. Mackenzie and G.R Meyuys. 1989. Nitrogen distribution, yield, and quality of silage corn after foliage nitrogen fertilization. Agron. J. 81:783-786.
4. Myer, RO., D.L. Wright and D.W. Gorbet. 1990. Feeding value of tropical corn for young growing pigs. Univ. of Fla An. Sci. Res. Rep. MA-1990-2.
5. Overman, D.L., and RN. Gallaher. 1989. Growth and partitioning of dry matter between temperate and tropical corn. pp. 3840. *In* I.D. Teare, E. Brown and C.A. Trimble (ed). 1989 Southern Conservation Tillage Conf. Proc Tallahasse, FL. Univ. of Fla. Spec. Bull. 89-1.
6. Teare, I.D., D.L. Wright and R.K. Sprenkel. 1990. Early planting reduces fall armyworm problems in tropical corn. Univ. of Fla NFREC Quincy, FL Res. Rep. NF 90-7.
7. Williams, A.C., M.T. Coffey and G.E. Combs. 1984. Comparison of the value of feeding tropical corn with commercial yellow corn in grower-finisher diets. Univ. Fla. An. Sci Res. Rep. AL-19844.
8. Wright, D.L., and C.G. Chamblis. 1989. Results of corn hybrid tests in Florida in 1988, a tropical corn test and results from South Georgia trials. Univ. of Fla. Agron. Facts No. SS AGR-926.
9. Wright, D.L., B.T. Kidd and I.D. Teare. 1987. Protein levels and yield from several corn hybrids. Univ. of Fla Agron. Facts No. 218.
10. Wright, D.L., D.P. Lilly and I.D. Teare. 1990. Planting tropical corn in minimum tillage systems. pp. 81-83. *In* J. P. Mueller and M. G. Wagger (eds.). 1990 Southern Conservation Tillage Conf. Proc, Raleigh, NC, NCSU Spec Bull. 90-1.
11. Wright, D.L., and D.L. Prichard. 1988. Tropical corn production and use. Univ. of Fla Agron. Facts No. 228.

Appendix

Past Conferences and Contact Persons

Year	Location	Contact
1978	Griffin, Georgia	W.L. Hargrove Agronomy Department Georgia Station 1109 Experiment Street Griffin, GA 30223-1797 (404) 228-7330
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