CONSERVATION MANAGEMENT PRACTICES IN MISSISSIPPI DELTA AGRICULTURE: IMPLICATIONS FOR CROP PRODUCTION AND ENVIRONMENTAL QUALITY

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ABSTRACT

For wider acceptance of conservation management systems, e.g., reduced tillage and cover crops, experimental information is needed to guide growers in implementing these systems and also to critically evaluate environmental impacts. This paper summarizes a series of laboratory and field experiments assessing the effects of conservation management on soil properties, herbicide fate, weed control and yield. Adoption of conservation management practices alters organic matter distribution, especially in the soil surface. Enhanced organic matter typically increases microbial activity and often increases the capacity of the soil to sorb herbicides. Increased herbicide retention and microbial activity affect the degradation of herbicides and bioavailability for weed control. Results from an on-farm study showed that balansa clover (*Trifolium balansae*) was successfully established in a cotton (*Gossypium hirsutum L.*) production field, altered certain indices of soil quality (e.g., microbiological indicators, N availability), and provided some weed control and slight yield benefit. However, the economics of using legume cover crops such as balansa clover in cotton is in question and needs more critical evaluation over several additional years of study and multiple sites.

KEYWORDS

Soil organic matter, *Trifolium balansae*, herbicide sorption, and herbicide degradation

INTRODUCTION

Conservation systems such as reduced tillage have gained increased acceptability in the Mississippi Delta Region, especially with the use of transgenic herbicide resistant crops such as cotton and soybean (*Glycine max.*) (Locke *et al.*, 2002). Some growers are also integrating fall cover crops into their crop management programs. Both reduced tillage and cover crops have applicability for growers in attaining water quality standards that are being sought under the U.S. Environmental Protection Agency Total Maximum Daily Load (TMDL) regulations. To achieve wider grower acceptance, more information is needed to guide them in the management of conservation systems or to determine the potential impacts that these systems have on receiving waters and soil quality.

Adoption of practices such as reduced tillage and cover crops usually results in changes in soil characteristics (Locke and Bryson, 1997; Reeves, 1997). Associated with enhanced levels of organic carbon in the surface of conservation management soils are increased microbial populations and microbial activity (Wagner *et al.*, 1995; Zablotowicz *et al.*, 1998; Zablotowicz *et al.*, 2000). Increasing plant residue cover on soil reduces the loss of soil and nutrients in runoff, thus improving the quality of receiving waters and preserving valuable soil resources (Zablotowicz *et al.*, 2001; Knight *et al.*, 2001). Long-term accumulation of organic residues gradually improves soil quality in terms of tilth, nutrient availability, and structure, especially in the soil surface.

Some aspects of plant residue management improve the potential to influence management of weeds (Locke *et al.*, 2002). For example, cover crops may shade the soil, thus reducing germination and growth of weeds. Leaving the soil undisturbed by tillage prevents exposure of weed seeds to conditions suitable for germination. The use of cover crops, however, may not always be economical and, depending on the management system, may not contribute significantly to reducing other weed management inputs (e.g., herbicides). Also, increased soil organic carbon can increase the binding of herbicides in soil (e.g., Locke *et al.*, 1996; Reddy *et al.*, 1997), possibly rendering the herbicide less bioactive for weed control (Gaston *et al.*, 2001). Longer retention of herbicides in a conservation managed soil surface may result in negative carryover effects to the next crop, especially in crop rotations.

This paper summarizes results from some conservation management studies that evaluated trends in soil character-

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istics, herbicide dissipation, and potential effects on weed management and crop production.

METHODS AND MATERIALS

TILLAGE EFFECTS ON HERBICIDE SORPTION

Surface soil (0 to 5 cm) was sampled from a long-term (12 y) study under no-tillage and conventional tillage soybean production near Stoneville, MS. The soil was a Dundee silt loam. Soil was air-dried and ground to pass through a 2-mm sieve. Sorption of several herbicides, 2,4-D (2,4-dichlorophenoxy acetic acid), acifluorfen (5-[2-chloro-4-(trifluoromethyl)phenoxy]- 2-nitrobenzoic acid), alachlor (2-chloro-N-(2,6-diethylphenyl)-N-(methoxymethyl)acetamide), bentazon (3-(1-methylethyl)-(1H)- 2,1,3 benzothia diazin-4(3H)-one 2,2-dioxide), and chlorimuron (2-[[[[4-chloro-6-methoxy-2-pyrimidinyl)amino]carbonyl] amino]sulfonyl] benzoic acid) to Dundee soil were evaluated using batch methods similar to those described in Locke *et al.* (1997). Briefly, for each herbicide a solution was prepared in 0.01 M $CaCl_2$ using technical grade and ^{14}C-labelled herbicide stocks. Sorption was evaluated at one concentration for each herbicide, and concentrations ranged from one to two $\mu g\ mL^{-1}$. Air-dried soil was weighed into 25-mL centrifuge tubes, and herbicide solution was added at a ratio of 1:2 (w:v). The samples were shaken for 24 h, centrifuged, and decanted. Radioactivity (i.e., herbicide concentration) in the supernatant was measured using a liquid scintillation counter (Packard TriCarb 4000 Series, Packard Instruments, Meriden, CT). Herbicide sorption was calculated by difference between concentration added and concentration in solution after equilibration.

Technical grade 2,4-D (98% purity), acifluorfen (98% purity), alachlor (97% purity), and bentazon (98% purity) were obtained from Chem Service (West Chester, PA), and chlorimuron (98.7% purity) was obtained from DuPont Agricultural Products (Wilmington, DE). The

^{14}C-labelled herbicides were obtained as follows: acifluorfen (CF_3-ring-UL-label, 99% purity, specific activity [s.a.] 18.03 mCi $mmol^{-1}$) and bentazon (ring label, 98% purity, s.a. 10.54 mCi $mmol^{-1}$) from BASF (Research Triangle Park, NC), 2,4-D (carboxyl label, 98% purity, s.a., 9.0 mCi $mmol^{-1}$) and alachlor ([UL]-ring label, 99%, s.a. 27.0 mCi $mmol^{-1}$) from Sigma Chemical (St. Louis, MO), and chlorimuron ([UL]-phenyl label, 99% purity, s.a. 24.25 mCi $mmol^{-1}$) from DuPont Agricultural Products.

HERBICIDE PERSISTENCE IN A COTTON TILLAGE AND COVER CROP FIELD STUDY

A split plot (four replications) experiment was established in Stoneville, MS in 1990 to evaluate tillage (conventional *vs*. no-tillage) as a main effect and ryegrass (*Lolium multiforum* Lam.) cover crop (cover *vs*. no-cover) as a split effect on herbicide dissipation. The soil was a Dundee (fine-silty, mixed, thermic Aeric Ochraqualf), ranging from silt loam to silty clay loam. Norflurazon (4-chloro-5-(methyl amino)-2-(3-(trifluoromethyl)phenyl)-3(2H)-pyridazinone) was applied as a pre-emergence herbicide at a rate of 0.8 kg ha^{-1}.

Surface soil (0 to 2 cm) was sampled periodically during the 1994 season beginning at planting. Soil samples were frozen until processing. For determination of norflurazon concentrations in soil, samples were extracted in 90% methanol (1:1 w:v) for 24 h, centrifuged, and filtered through Whatman 42 (Whatman Paper, Clifton, NJ) and Gelman Acrodisc PVDF 25 µm (Gelman Laboratory, Ann Arbor, MI) filters. Extracts were analyzed with a 2690 Waters, Inc. HPLC System (Waters, Inc., Milford, MA). HPLC analytical conditions included Waters, Inc., Photo Diode Array UV Detector at 235 nm wavelength, Waters, Inc., Scanning Fluorescence Detector 470 at Ex. 294 nm and Em. 398 nm wavelengths, Alltech C18 Econosil column, 250 mm x 4.6 mm, 5 µm (Alltech, Deerfield, IL), Gradient with initial 55% HPLC grade water / 45% ACN to 70% ACN at one mL min^{-1} flow rate, 50-µL injection volume, and a retention time of 11 min.

ON-FARM NO-TILLAGE COTTON COVER CROP STUDY

In fall, 1999, balansa clover was seeded (6.5 kg ha^{-1}) on a 24-ha no-tillage field near Swiftown, MS. The field was a mixture of soil series including Forrestdale (fine, smectitic, thermic Typic Endoaqualfs) silt loam and silty clay loam with some areas of Dowling (very-fine, smectitic, thermic Vertic Epiaquepts) clay, Alligator (very-fine, smectitic, thermic Alic Dystraquerts) silty clay, and Dundee silt loam, and very fine sandy loam. In March of 2000, six 0.37-ha areas (each 60 m x 60 m) located throughout the field were desiccated with paraquat to maintain no-cover crop plots. Clover in the remainder of the field was allowed to mature to produce seed before desiccation in mid-May, 2000. Sorghum was planted May 25, 2000.

On May 12, 2000, two 16-m^2 sub-plots (4 m x 4 m) were selected from within each of the six no-cover crop areas, and locations were geo-referenced. Two 16 m^2 sub-plots were also selected in the cover crop areas adjacent to each of the six no-cover crop areas. Two composite soil samples (0 to 5 cm) were collected from each no-cover and cover crop sub-plot. Clover was also removed from the cover crop sub-plots for biomass determination. The only weed evaluations in no-cover crop and cover crop areas were made at the same time as the soil sampling.

In fall 2000, the clover reseeded naturally and was allowed to develop until desiccation on April 10, 2001. On

April 6, 2001, sub-plots (16 m^2) were selected near (within 30 m) to the location of the sub-plots sampled in 2000. Soil was collected from these sub-plots at depths of 0 to 2 cm and 2 to 10 cm. Clover biomass was determined in the sub-plots, and weeds were evaluated (April 6, 2001) just prior to desiccation with Roundup™ (N-(phosphonomethyl) glycine). Roundup Ready™ cotton was planted on May 7 and was managed as a dryland crop. Roundup was applied three times during the season, once over-the-top before the four-leaf stage of cotton and twice post-directed. Weeds were evaluated again later in the season (June 14 and August 23). All cotton received N fertilizer (70 kg ha^{-1}), regardless of cover crop. At maturity, cotton bolls were hand picked from a 4 m^2 no-cover crop or cover crop areas near the sub-plots and ginned to measure lint yield.

Soils from both 2000 and 2001 were characterized for microbial activity, enzyme activity, and chemistry. Total bacterial and fungal populations in soil samples were determined by serial dilution and spiral plating as described elsewhere (Wagner *et al.*, 1995). Tetrazolium chloride (TTC)-dehydrogenase activity in presence of yeast extract and fluorescein diacetate activity (FDA) was determined using techniques described elsewhere (Staddon *et al.*, 2001). Organic matter and soil nutrients were determined on air-dried soil samples from both years (Soil Testing Laboratory, University of Arkansas). Exchangeable nutrients were extracted from soil using Mehlich 3 (1:7, w:v), whereas pH and electrical conductivity (EC) were measured in water (1:2, soil:water).

RESULTS AND DISCUSSION

Tillage Effects on Soil Characteristics and Herbicide Sorption

Several reports from our research program have demonstrated how organic matter is increased in the surface of no-tillage soils as compared to conventional tillage (e.g., Locke *et al.*, 1997; Reddy and Locke, 1998). In one study, after 11 years of continuous no-tillage practices on a Dundee silt loam at Stoneville, MS, the organic carbon content of the surface 0 to 2 cm of no-tilled (NT) soil was 47% greater than that of the conventionally tilled (CT) soil, while no significant differences were observed at lower soil depths (Zablotowicz *et al.*, 2000). In the upper 2 cm of soil, both microbial biomass and FDA hydrolytic activity were 106 and 127% greater, respectively, than that of conventionally tilled soil. Mixing of soil due to tillage, however, resulted in greater microbial biomass and FDA hydrolytic activity in CT compared to NT at the 2 to 10 cm soil depth.

Similar increases in soil organic carbon were measured for the Dundee NT surface (0 to 5 cm) soil used in the present study evaluating sorption of five herbicides to soil (NT 22.4 and CT 11.9 g organic carbon kg^{-1}, Locke *et al.*, 1997). Sorption was higher in no-tillage than in conventional tillage for all herbicides except bentazon (Table 1). Chemical characteristics of the individual herbicides play a role in their sorption to soil. Nonpolar molecules have a strong hydrophobic attraction for organic components in soil. Different functional groups on the herbicide molecules, such as carboxyls and amines have varying affinities for sorption sites in the organic matter. Bentazon has a negative charge that reduces its attraction to soil. The other herbicides possess both hydrophobic and hydrophilic characteristics, and as the ratio of hydrophilicity and hydrophobicity varies from herbicide to herbicide, so does their attraction to organic matter. From top to bottom in Table 1, the herbicides tend to become more polar, or more hydrophilic. This is reflected in the size of the K_d value; the larger the K_d, the higher the sorption to soil.

Table 1. Effect of tillage on sorption (K_d) of herbicides in the soil surface (0 to 5 cm).

Herbicide	NT	CT
	---------Sorption K_d---------	
Alachlor	5.62	3.61
Acifluorfen	5.22	2.04
2,4-D	3.24	2.16
Chlorimuron	2.15	1.64
Bentazon	0.13	0.13

Norflurazon Persistence in the Field as Affected by Tillage and Cover Crop

Norflurazon dissipation in the surface soil from no-tillage with no-cover crop plots was more rapid than in conventional tillage surface soils with either no-cover crop or ryegrass cover (Fig 1). In the no-tillage, no-cover crop treatment, extractable norflurazon was about 1 mg kg^{-1} seven days after application, while similar soil concentrations were found in the conventional tillage treatments 14 days after application. For the remainder of the season, norflurazon in the surface soil did not differ among tillage or cover crop treatments.

The dissipation of norflurazon in the surface soil of the no-tillage cover crop treatment was a distinctly different pattern from the other treatments. Only low concentrations of norflurazon (~ 1 mg kg^{-1}) were measured in the no-tillage cover crop surface soil throughout the season. Lack of norflurazon in surface soil indicates that the norflurazon was intercepted by the cover crop, retained and released slowly into the soil during the course of the season as a result of wash-off from the cover crop residue and as the cover crop decomposed. In a laboratory study with another

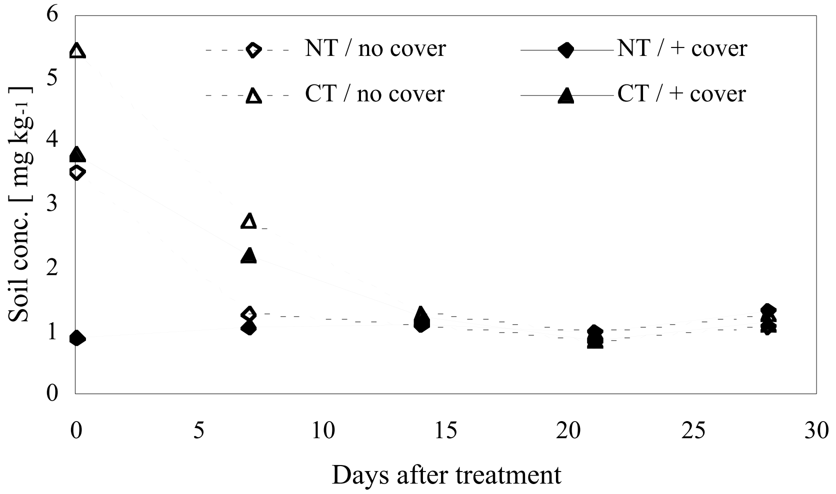

Fig. 1. Effect of ryegrass cover crop on norflurazon persistence in conventional tillage and no-tillage surface (0 to 2 cm) soils.

herbicide, fluometuron (N,N-dimethyl-N'-[3-(trifluoro methyl)phenyl]urea), sorption to soil was compared with sorption to rye (*Secale cereale*) cover crop material (Locke *et al.*, 1995). The Freundlich sorption parameter K_f for fluometuron sorption to rye was 21.8 ($n^{-1} = 0.96$) *vs.* 2.60 ($n^{-1} = 0.86$) for soil, indicating a much larger capacity for herbicide sorption in the cover crop material than in soil. Relating results from the fluometuron laboratory study may help explain the present field study where only low concentrations of norflurazon were observed in the soil surface of no-tillage cover crop throughout the season, indicating norflurazon movement to soil was impeded by retention to ryegrass material. The cover crop material also may have provided an environment conducive for more rapid biodegradation of norflurazon. For example, in laboratory studies with fluometuron (Locke *et al.*, 1995; Zablotowicz *et al.*, 1998), biodegradation was enhanced when soil was amended with cover crop material.

EFFECT OF COVER CROP IN A FARMER'S FIELD

Balansa clover may have potential as a cover crop for the Mississsippi Delta region because it flowers early enough to reseed itself and still permits a relatively late cotton planting. In the first year of establishment, balansa clover yielded a biomass of 2330 kg ha^{-1}, contributing 47 kg N ha^{-1}. The clover successfully reseeded in fall, 2000, following the first crop. By the time of cotton planting in May, 2001, the clover cover produced a biomass of 3360 kg ha^{-1} that contained about 97 kg N ha^{-1}.

Yield assessments in 2001 indicated a numerical 8% greater harvest of cotton lint in the cover crop area as compared to the no-cover crop area (Fig. 2). Yields across the field were variable, however, and standard deviations indicated no statistical difference. Although a detailed economic analysis was not done in this study, any slight yield effect likely did not translate into an economic advantage. In this study, both areas received nitrogen fertilizer, thus we were unable to ascertain the contribution of nitrogen from the clover. The cost of desiccating the cover crop also may offset any yield advantage and nitrogen contributed by the cover crop. In other studies on Mississippi Delta soybean production, the cost of using annual cover crops, especially annual legumes such as subterranean clover and crimson clover, was not justified (Reddy, 2001).

Table 2. Effect of cover crop on weed population in May, 2000.

Treatment	Broad leaf	Grass	Sedge	Total Weeds (SE)	Vines
	------------- % of	total area covered	--------------		
Cover	4.2	0.1	0.4	4.6 (3.9)	1.4
No-cover	37.8	29.3	0.0	67.2 (8.5)	27.1

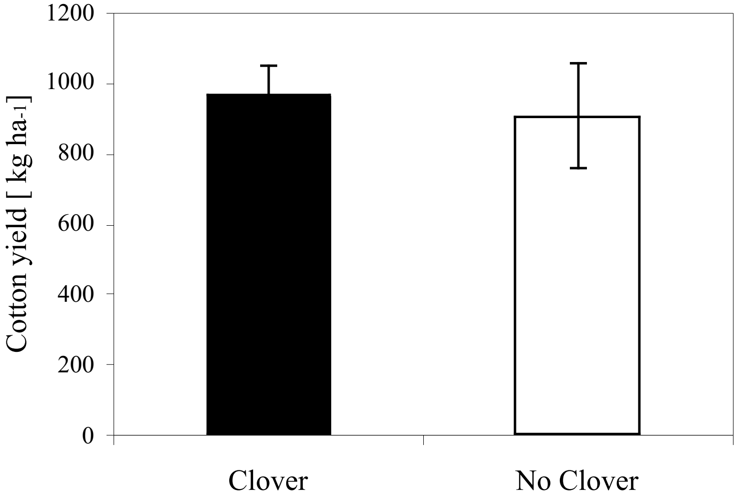

Fig. 2. Effect of balansa clover cover crop on cotton lint yield under no-tillage management.

Table 3. Effect of cover crop on weed population in 2001.

Treatment	Broad leaf	Grass	Sedge	Total Weeds (SE)	Vines
	------------ % of	total area	covered	-------------	
April 6, 2001					
Cover	0.5	0.4	0	0.9 (0.8)	0.1
No-cover	19.6	35.0	0	54.6 (14.6)	14.5
June 14, 2001					
Cover	15.6	0.4	0.3	16.3 (5.8)	13.1
No-cover	24.6	0.3	0.1	25.0 (11.7)	24.3
August 23, 2001					
Cover	7.1	0.1	0.4	7.5 (7.1)	4.5
No-cover	17.5	0.1	0.1	17.7 (15.6)	17.2

Successful establishment of the balansa clover provided sufficient cover to augment weed control from herbicide both years (Tables 2 and 3). In the spring of 2000 and 2001 just prior to planting, clover cover crop residues occupied 95 to 99% of the surface in the cover crop areas, effectively shading most existing weeds and inhibiting germination and sprouting of summer weeds. Evening primrose (*Oenothera* spp.), horseweed (*Conyza canadensis*), redvine (*Brunnichia ovata*), and annual bluegrass (*Poa annua*) were the predominant early season weeds in no-cover crop areas both years. By mid-June, 2001, much of the clover had decomposed and weed pressure increased in the cover crop areas to a level comparable with no-cover crop areas (Table 3). By this time, vine-like species such as morningglories (*Ipomoea* spp.), redvine, and trumpetcreeper (*Campsis radicans*) were the major weeds present in both cover crop treatments. Overall weed pressure decreased by August with slightly more in the no-cover crop areas (Table 3). Although overall weed pressure was lower in the cover crop areas, suppression attributed to cover crops was variable, especially with regard to the troublesome perennial, vine-like weed species. This study suggests that residues of cover crops alone may not be a sufficient weed management tool, as postemergence herbicides were needed to control weeds, especially for perennial species.

In both years of the study, total bacterial propagules were significantly greater in the surface soil under clover compared to soil from the no-cover crop areas (Table 4). Fungal propagules also were significantly greater in the surface soil (0 to 5 cm) under clover compared to soil from the no-cover plots in 2000, but in 2001 differences between clover and non cover plots were significant at a lower probability level ($P = 0.10$). In the lower 2 to 10 cm soil depth in 2001, there was no effect of the clover on either bacterial or fungal propagules. The effects of balansa clover cover crop on enhancing bacterial and fungal populations in surface soils are similar in magnitude to effects reported for other cover crops (Wagner *et al.*, 1995; Zablotowicz *et al.,* 1998).

In 2000, TTC-dehydrogenase activity was significantly higher in soils under clover compared to soils from no-cover crop areas (Table 4). In 2001, however, the opposite effect was observed, where TTC-dehydrogenase activity was significantly greater ($P = 0.05$) in the surface (0 to 2 cm) soils from the no-cover compared to clover areas. In the TTC-dehydrogenase assay, yeast extract was added as an exogenous substrate, and the lower TTC-dehydrogenase in the clover soils the second year may be due to a repression of dehydrogenase activity as was reported in soils from vegetative filter strips by Staddon *et al.* (2001). In 2001,

Table 4. Microbial populations and soil enzyme activity (Tetrazolium chloride dehydrogenase and fluorescein diacetate hydrolysis) associated with soil under balansa clover or no-cover soils. Means within rows followed by the same letter are not significantly different at $P = 0.05$.

Year	Depth (cm)	Clover	None
Total bacteria , $\log_{10}$ CFU g^{-1} soil			
2000	0 - 5	8.65 a	7.89 b
2001	0 - 2	8.56 a	8.02 b
2001	2- 10	8.07 a	7.81 a
Total fungi , $\log_{10}$ CFU g^{-1} soil			
2000	0 - 5	5.73 a	5.14 b
2001	0 - 2	6.32 a	6.02 b
2001	2- 10	5.74 a	5.71 a
TTC, nmol product formed g $soil^{-1}$ h^{-1}			
2000	0 - 5	50 a	38 b
2001	0 - 2	18 b	34 a
2001	2- 10	11 a	14 a
FDA, nmol product formed g $soil^{-1}$ h^{-1}			
2000	0 - 5	ND	ND
2001	0 - 2	2979 a	2190 b
2001	2- 10	2134 a	1903 a

Table 5. Soil chemical changes associated with soil under balansa clover or no-cover soils.

Year	Depth	Clover	(SE)	No cover	(SE)
	--- cm ---				
Organic matter, %					
2000	0 - 5	1.98	(0.45)	1.9	(0.80)
2001	0 - 2	3.83	(1.08)	3.22	(0.93)
2001	2 -10	3.31	(1.00)	3.43	(0.97)
Nitrate-N (kg ha^{-1})					
2000	0 - 5	10	(6)	17	(10)
2001	0 - 2	97	(23)	40	(8)
2001	2 -10	38	(11)	21	(3)
P (kg ha^{-1})					
2000	0 - 5	86	(20)	95	(22)
2001	0 - 2	101	(24)	142	(26)
2001	2 -10	65	(16)	79	(20)
K (kg ha^{-1})					
2000	0 - 5	571	(164)	614	(197)
2001	0 - 2	554	(87)	680	(137)
2001	2 -10	384	(90)	453	(142)
pH, (1:2 Soil:Water)					
2000	0 - 5	6.3	(0.5)	6.2	(0.5)
2001	0 - 2	6.2	(0.5)	6.8	(0.5)
2001	2 -10	6	(0.6)	6.6	(0.5)
EC, 1:2 Water, µmhos cm^{-1}					
2000	0 - 5	81	(34)	86	(37)
2001	0 - 2	143	(52)	81	(22)
2001	2 -10	69	(30)	55	(9)

FDA-hydrolytic activity was higher in the surface 0 to 2 cm soils under clover compared to no-cover plots (Table 4). No effect of cover crop on either FDA-hydrolytic activity or TTC-dehydrogenase was observed at the lower 2 to 10 cm soil depth sampled in 2001 (Table 4). These results indicate that surface soils under balansa clover were showing improved microbiological productivity and may reflect improved potential for carbon and nitrogen cycling as biological indicators of soil quality.

Chemical analysis of soils collected in 2000 and 2001 are summarized in Table 5. In the first year of establishment there was no effect of the clover cover crop on any of the six parameters measured. It also should be noted that in the first year of the study there was some establishment of clover in the no-cover crop areas before killing with paraquat (1,1'-dimethyl-4,4'-bipyridinium ion) in early spring, 2000. However, in May, 2000, when soil samples were collected, live clover present in the no-cover crop plots was only about 3 percent of the total area. In no-cover areas, soil samples were not collected where clover was present.

In 2001, there was approximately a two-fold increase in extractable nitrate in both soil depths under balansa clover compared to the no-cover crop areas, indicating a benefit from nitrogen fixation via rhizobial symbiosis (Table 5). Annual pasture legumes can contribute 30 to 160 kg ha^{-1} N in a season (Puckridge and French, 1983). As this study covered a large area and several soil types, a rather high variance was observed. Organic matter in 2001 was about 19% higher in the clover 0 to 2 cm soil depth as compared with no-cover. Under clover, soil pH was lower than no-cover, as might be expected with a higher rate of nitrification and organic matter decomposition. Electrical conductivity has been considered a useful index in soil quality assessment, having value as a practical estimator of soil nitrate and leachable salts (Doran and Parkin, 1996). Electrical conductivity was greater in soil under balansa clover compared to no-cover soil, although key nutrients such as potassium and phosphate were lower. A decrease in potassium and phosphate might be expected as they were assimilated by the clover and still associated with the clover biomass at time of sampling.

CONCLUSIONS

The following general observations can be made from these studies assessing reduced tillage and cover crop management:

1. Organic matter and microbial activity are greater in the surface of no-tillage and cover crop soils as compared to conventional tillage and no-cover crop.
2. Herbicide sorption capacity is higher in no-tillage and cover crop surface soils due to the increases in organic matter.

3. Norflurazon dissipation was slightly faster in the surface of no-tillage soil, perhaps due to higher microbial activity and associated degradation.
4. Cover crop residues intercepted norflurazon in the no-tillage treatment and did not release it in great quantity. The herbicide may have degraded as the cover crop decomposed, or been retained by the cover crop and released slowly.
5. Balansa clover residues repressed some weed growth throughout the crop season. The most difficult type of weeds observed in this no-tillage were the perennial vine-like species.
6. Balansa clover cover crop enhanced microbial activity and nitrate in the surface soil.
7. Balansa clover had only a marginal effect on yield, and economic benefit is questionable.

LITERATURE CITED

Doran, J.W. and T.B. Parkin. 1996. Quantitative indicators of soil quality: A minimum data set. pp. 25-47. *IN* J.W. Doran and A.J. Jones (ed.) Methods for assessing Soil Quality. Soil Sci. Soc. Am. Spec. Publ. No 49, SSSA, Madison, WI.

Gaston, L.A., M.A. Locke, R.M. Zablotowicz, and K.N. Reddy. 2001. Spatial variability of soil properties and weed populations in the Mississippi Delta. *Soil Sci. Soc. Am. J.* 65:449-459.

Knight, S.S., C.M. Cooper, and B. Cash. 2001. Effects of agricultural systems on Mississippi Delta MSEA lake water quality. *IN* The Mississippi Delta Management Systems Evaluation Areas project, 1995-1999. R.A. Rebich and S.S. Knight, eds. Mississippi Agric. Forestry Exp. Station Information Bulletin 377:128-138.

Locke, M.A., and C.T. Bryson. 1997. Herbicide-soil interactions in reduced tillage and plant residue management systems. *Weed Sci.* 45:307-320.

Locke, M.A., L.A. Gaston, and R.M. Zablotowicz. 1996. Alachlor biotransformation and sorption in soil from two soybean tillage systems. *J. Agric. Food Chem.* 44:1128-1134.

Locke, M.A., L.A. Gaston, and R.M. Zablotowicz. 1997. Acifluorfen sorption and sorption kinetics in soil.*J. Agric. Food Chem.* 45:286-293.

Locke, M.A., K.N. Reddy, and R.M. Zablotowicz. 2002. Weed management in conservation production systems. *Weed Biol. Management* 2(3):(in press).

Locke, M.A., R.M. Zablotowicz, and L.A. Gaston. 1995. Fluometuron interactions in crop residue-managed soils. pp. 55-58 *IN* W.L. Kingery and N. Buehring (eds.) *Conservation farming: A focus on water quality.* MAFES Special Bull. 88-7.

Puckridge, D.W. and R.J. French. 1983. The annual legume pasture in cereal-ley farming systems in southern Australia: a review. *Agriculture, Ecosystems, and Environment* 9:229-267.

Reddy, K.N. 2001. Effects of cereal and legume cover crop residues on weeds, yield, and net return in soybean (*Glycine max*). Weed Technol. 15:660-668.

Reddy, K.N., and M.A. Locke. 1998. Sulfentrazone sorption, desorption, and mineralization in soils from two tillage systems. *Weed Sci.* 46:494-500.

Reddy, K.N., M.A. Locke, and R.M. Zablotowicz. 1997. Soil type and tillage effects on sorption of cyanazine and degradation products. *Weed Sci.* 45:727-732.

Reeves, D.W. 1997. The role of soil organic matter in maintaining soil quality in continuous cropping systems.*Soil Tillage Res.* 43:131-167.

Staddon, W.J., M.A. Locke, and R.M. Zablotowicz. 2001. Microbiological characteristics of a vegetative buffer strip soil and degradation and sorption of metolachlor. *Soil Sci. Soc. Am. J.* 65:1136-1142.

Wagner, S.C., R.M. Zablotowicz, M.A. Locke, R.J. Smeda, and C.T. Bryson. 1995. Influence of herbicide-desiccated cover crops on biological soil quality in the Mississippi Delta. pp. 86-89 *IN* W.L. Kingery and N. Buehring (eds.) *Conservation farming: A focus on water quality*. MAFES Special Bull. 88-7.

Zablotowicz, R.M., M.A. Locke, L.A. Gaston, and C.T. Bryson. 2000. Interactions of tillage and soil depth on fluometuron degradation in a Dundee silt loam soil. *Soil and Tillage Research* 57:61-68.

Zablotowicz, R.M., M.A. Locke, and S.S. Knight. 2001. Microbiological characteristics and fluometuron concentrations in Mississippi Delta oxbow lakes. *IN* The Mississippi Delta Management Systems Evaluation Areas project, 1995-1999. R.A. Rebich and S.S. Knight (eds.) Mississippi Agric. Forestry Exp. Station Information Bulletin 377:214-217.

Zablotowicz, R. M., M.A. Locke, and R.J. Smeda. 1998. Degradation of 2,4-D and fluometuron in cover crop residues. *Chemosphere* 37:87-101.