CONSERVATION AGRICULTURE, A WORLDWIDE CHALLENGE

Edited by
L. García-Torres,
J. Benites,
A. Martínez-Vilela

I World Congress on Conservation Agriculture,

Volume II: Offered Contributions,

Environment
Farmers experiences
Innovations
Socio-economy
Policy

FAO

ECAF

CONSERVATION AGRICULTURE,
A WORLDWIDE CHALLENGE

Volume II: Offered Contributions,
Environment
Farmers experiences
Innovations
Socio- economy
Policy

Organising & Technical Committee

Prof. Dr. Luis García-Torres, ECAF President, Chairman.
Dr. Jose Benites, AGLL- FAO, Italy, Co-Chairman

Prof. Dr. Gottlieb Bash, APOSOLO, Portugal
Dr. Lawrence Clarke, AGSE, FAO, Italy
Dr. Theodore Friedrich, AGSE- FAO, Italy
Dr. Pedro González Fernández, AEAC.SV, Spain
Mr. Klaus Johanssen, FRDK, Denmark
Dr. Victor Jordan SMI, UK
Prof. Dr. Michele Pisante, AIGACoS, Italy
Dr. José Luis Rubio, European Soil Science Society (ESSS)
Dr. Wolfgang Sturny, SNTA, Switzerland
Prof. Dr. Friedrich Tebrugge, GKB, Germany

Mr. Armando Martínez-Vilela, ECAF Director, Co-ordinator

Editorial Committee

Dr. L. García-Torres,
Dr. J. Benítes,
Mr. A. Martínez-Vilela

Congress Secretariat

Mr. Armando Martínez-Vilela, ECAF Executive Director,
Mr. Emilio J. González Sánchez, ECAF
Mr. Antonio Holgado Cabrera, ECAF
Mr. José Luis de Prado Ruiz-Santaella, AEAC.SV, Spain
Ms. Mª Carmen Fernández Ruíz, CSIC & ECAF
Ms. Mª Pilar Hernández Maya, CSIC & ECAF
e-mail: *conservation.agriculture@ecaf.org*

The 1st.World Congress on Conservation Agriculture (Madrid, 1-5.October.2001) was jointly organised by the Food and Agriculture Organisation of the United Nations (FAO) and the European Conservation Agriculture Federation (ECAF)

A C.I.P. catalogue record for this book is available from the Library of Congress

ISBN: 84-932237-1-9 Vol. I
ISBN: 84-932237-2-7 Vol. II
ISBN: 84-932237-0-0 Set of two vols.
D.L.: CO-1180-2001

Published by
XUL
Avda. Medina Azahara 49, pasaje,
14005 Córdoba, Spain,
e-mail: *cliente@xul.es*

Printed in Spain

I World Congress on Conservation Agriculture
Madrid, 1-5 October, 2001

Management systems to improve soil quality for cotton production in a degraded silt loam soil in Alabama (USA)

A.C.V. MOTTA[*a,c], D.W. REEVES [b], Y. FENG [c], C. H BURMESTER [c], and R.L. RAPER [b]*
[a]Universidade Federal do Parana and CAPES - Brazil. [b]USDA-ARS National Soil Dynamics Laboratory, 411 S. Donahue Dr., Auburn, AL - USA 36832. [c]Agronomy and Soils Department, 201 Funchess Hall, Auburn University, Auburn, AL - USA 36849

Summary

Soil quality indicators were determined after five years from a silty-clay loam cropped to cotton (*Gossypium hirsutum* L.) and managed with four conservation tillage systems that used a rye (*Secale cereale* L.) cover crop. Tillage systems included: 1) no-tillage, 2) spring strip-tillage, 3) fall in-row paratilling, and 4) fall in-row subsoiling. In addition, conventional tillage (chiseling and disking/cultivation) and no-tillage, both without a rye cover, were evaluated. Soil samples were collected at 0-3, 3-6, 6-12, and 12-24 cm depth increments. In general, there was no clear effect of tillage system on soil chemical properties. Soil organic C (SOC), particulate organic matter (POM), and microbial biomass (MB) values for the upper layer (0-3 cm) were 86 to 130%, 78 to 113%, and 44 to 183 % greater for conservation tillage systems compared to conventional tillage, respectively. Fall paratilling and subsoiling increased MB, POM, and SOC, and decreased bulk density compared to other treatments within the 3-6 cm depth. Conservation systems sequestered between 3 to 7 Mg ha^{-1} more C within the 0-24 cm depth than conventional tillage. Conservation tillage systems, particularly those using a rye cover crop, improved many soil quality indicators, which paralleled cotton yield performance observed during the previous five years.
Key words: Conservation tillage, C sequestration, particulate organic matter, POM, microbial biomass, soil fertility, cover crop, soil quality, cotton

Introduction

Cotton production in the southern USA is generally characterized by intensive tillage operations and monoculture without use of cover crops (Reeves, 1994). This system provides little C input to soil, increases erosion, and promotes oxidation of existing soil C. The consequence of this management practice is soil degradation; with consequent needs for increased inputs to offset decreased soil productivity.

Adoption of no-tillage can reduce C losses, however, previous attempts at no-tillage in the region resulted in decreased cotton yields due to soil compaction (Burmester et al., 1993). We found that a conservation tillage system that included a rye cover crop to provide moisture conserving residue, coupled with zonal (under-the-row) non-inversion tillage in fall improved cotton yields. However, the mechanism of this improvement in productivity was unclear, and this research was conducted to evaluate changes in soil properties that might explain the increased productivity. Specifically, we determined the impact of various tillage management practices on selected soil quality indicators after 5 years of cotton production on this silty-clay loam in the Tennessee Valley region of north Alabama.

Materials and Methods

Cotton tillage systems were initiated in 1994 at the Alabama Agricultural Experiment Station's Tennessee Valley Research and Extension Center (latitude: 34° 41' 30", longitude: 86° 53' 25", altitude: 156 m) in northern Alabama. The study was located on a Decatur silty-clay loam soil (clayey, kaolinitic, thermic, Rhodic Paleudult) formed from limestone. The experimental design was a randomized complete block with four replications and eight tillage management systems. Six tillage systems were selected and sampled from fall 1999 through winter 2000 for changes in selected soil quality indicators.

Four conservation cotton production systems which included a rye winter cover crop were evaluated: 1) strict no-tillage, 2) shallow in-row spring strip-tillage (15-cm deep, 30-cm wide), 3) fall paratilling/no-tillage cotton planting, and 4) fall in-row subsoiling/no-tillage cotton planting. Conventional tillage (fall chiseling and spring disking/cultivation) and astrict no-tillage controls (both without a cover crop) were also included. The rye cover crop was sown in fall following cotton harvest, and was terminated with glyphosate in spring approximately three weeks before planting cotton. In-row subsoiling (40-cm depth) was accomplished using a narrow-shanked (3-cm) subsoiler prior to rye planting. Paratilling (40-cm depth) was performed under-the-row prior to rye planting with a bent-leg subsoiler which lifts the soil without surface disruption. Spring in-row strip tillage was accomplished with a shorter subsoil shank (15 to 18-cm), a no-till coulter and a group of disks to create a 30-cm wide strip of disturbed soil surface just prior to cotton planting.

Soil samples (39-mm diameter) were collected in December, 1999 and March, and December 2000. Cores were separated to 0-3, 3-6, 6-12, and 12-24 cm depths. Soil samples at field moisture were sieved (6-mm) for evaluation of microbial biomass by fumigation incubation process (Alef & Nannipieri, 1995). Soil Ca, Mg, K, Na, P, Fe, Mn, Zn, and Cu were extracted using Mehlich-1 (double acid) solution (Hue & Evans, 1986) and determined by Inductively Coupled Air Plasma Emission Spectrometry (ICAP). Soil pH and soil electrical conductivity were determined in a 1:1 soil/water suspension. Soil particulate organic matter (Cambardella & Elliott, 1992) was determined from samples (0-3 and 3-6 cm depths) collected in December 2000. Soil carbon and total soil N was determined by dry combustion using a N/C analyzer (Fisons Instruments, Beverly, MA 01915). There is no appreciable carbonate-C in this inherently acid soil, thus SOC is equivalent to total C. Soil cores were collected to determine soil bulk density. Aggregate size-distribution and wet aggregate stability (Kemper &

Rosenau,1986) were determined from samples collected within the 0-5 cm depth. Analyses of variance was conducted prior to determination of protected least significant difference (LSD) values at the 95 % level of confidence. Sampling depths were analyzed as a split in the design.

Results and Discussion

Both SOC (Table 1) and soil N (data not shown) within the upper 3-cm, were almost double for conservation tillage systems compared to conventional tillage. Furthermore, fall non-inversion deep tillage (subsoiling and paratilling) increased SOC to the 6-cm depth, probably as a result of increased root growth and C deposition to this depth. About 6.9, 3.6, and 3.0 Mg ha^{-1} more C was sequestered (to 24-cm depth) by no-tillage with rye cover, fall deep tilled with rye cover (paratill or subsoiled), and spring strip-tilled with rye systems compared to conventional tillage, respectively (data not shown). No-tillage without rye cover sequestered similar C as no-tillage with rye, likely due to decreased microbial oxidation of C below the 6-cm depth compared to no-tillage with the rye.

Conservation systems increased POM in the top 3-cm of soil from 78 to 113 % compared to conventional tillage (Table 1). However, there were no significant differences in POM among the conservation tillage systems. Regardless of tillage, POM decreased sharply from the 0-3 cm depth to the 3-6 cm depth. Within the 3- 6 cm depth, no-tillage (with or without rye cover) slightly decreased POM compared to conventional tillage, likely due to the total lack of soil disturbance in the strict no-tillage systems, and stratification of roots nearer the soil surface. Deep tillage in fall (either paratilling or subsoiling) increased POM within the 3-6 cm depth.

Averaged over sampling times, microbial biomass (0-3 cm depth) was 44, 91, 143, 160, and 183 % greater with no-tillage without rye cover, spring strip-tillage with rye, fall paratilled with rye systems, fall subsoiled with rye, and no-tillage with rye cover, respectively, than for conventional tillage. Fall non-inversion deep tillage (either paratilling or subsoiling) tended to increase microbial biomass to the 12-cm depth as well (Table 1). The percentage of microbial biomass C in relation to total C (SOC) was greater for paratill, subsoiling, and no-tillage with rye (3.3 to 3.7 %) compared to conventional tillage (2.7 %) within the 0-6 cm depth (data not shown).

No-tillage increased bulk density (regardless of cover crop) (1.61 Mg m^{-3}) compared to conventional tillage (1.52 Mg m^{-3})within the 3-6 cm depth (data not shown). However, fall subsoiling and paratilling both decreased bulk density (1.47 Mg m^{-3}), which is favorable to cotton seedling radicle emergence following planting.

Despite the increase of SOC with conservation tillage systems, aggregate stability (1-2 mm particle size fraction) was greater for conventional tillage (72 %) than conservation tillage systems (56 to 61 %), likely due to organic-mineral interactions (data not shown). Further investigation involving aggregate stability is required.

In general, there was no clear effect of tillage systems on soil pH, electrical conductivity, and extractable P, Ca, Mg, Cu and Fe (data not shown). However, higher levels of extractable Mn, Zn, and K were obtained under conservation tillage systems.

Table. 1. Selected soil quality indicators following five years of cotton production on a silty-clay loam in northern Alabama (USA) as affected by tillage system

Depth (cm)	Soil Organic Carbon (g kg^{-1})				Microbial Biomass (mg kg^{-1})				POM (%)	
Tillage	**0-3**	**3-6**	**6-12**	**12-24**	**0-3**	**3-6**	**6-12**	**12-24**	**0-3**	**3-6**
Conventional	7.7	7.7	7.0	5.4	220	185	171	118	23	19
No-till w/o rye	15.0	8.0	7.2	7.3	316	149	114	106	41	11
No-till	17.7	7.3	6.4	5.8	623	218	179	162	49	15
Paratill	14.3	10.3	6.7	5.7	535	381	230	150	43	28
Subsoil	15.9	10.0	6.9	7.1	571	335	215	171	48	25
Strip-till	14.6	8.2	6.3	5.7	421	206	157	130	45	21
LSD (0.05)	2.8	1.4	1.0	1.3	90	88	72	61	8	4

Conclusions

An appreciable improvement in many soil quality indicators, especially in the soil surface, was obtained after five years of cotton production using conservation tillage systems, especially those that used a rye cover crop. Systems that used fall in-row non-inversion deep tillage also decreased bulk density. Our results showed a clear benefit of conservation tillage systems, particularly those using a rye cover crop, on soil quality indicators, which paralleled cotton yield performance observed during the previous 5 years.

References

Alef, K. and Nannipieri, P. (1995) *Methods in Applied Soil Microbiology and Biochemistry.* Academic Press. London. 569 pp.

Burmester, C.H., Patterson, M. and Reeves, D.W. (1993) Cover system and starter fertilizer placement for no-till cotton. p. 1292-1294. *In.* 1993 Southern Conservation Tillage Conference for Sustainable Agriculture. Monroe, LA. 15-17 June 1993.

Cambardella, C.A. and Elliott, E.T. (1992) Particulate soil organic matter changes across a grassland cultivation sequence. *Soil Sci. Soc. Am. J.* **56**: 777-783.

Hue, N.V. and Evans, C.E. (1986) *Procedures used for soil and plant analysis by the Auburn University Soil Testing Laboratory.* Department of Agronomy and Soils, Department Series No.106, Auburn, AL.

Kemper, W.D. and Rosenau, R.C. (1986) Aggregate stability and size distribution. *In.* A. Klute (Editor), *Methods of Soil Analysis*, Part 1. Physical and Mineralogical Methods-Agronomy Monograph No. 9 (2nd edition), American Society of Agronomy - Soil Science Society of America, Madison, WI, USA, pp. 425-462.

Reeves, D.W. (1994) Cover crops and rotations. *In.* J L Hatfield and B A Stewart (ed.) Advances in Soil Science: Crops Residue Management. pp. 125-172. Lewis Publishers, CRC Press, Inc., Boca Raton, FL.