A Multidisciplinary Approach to Conservation

Proceedings of the 31st Southern Conservation Agricultural Systems Conference

Virginia Cooperative Extension Publication #2910-1417

Eastern Shore Agricultural Research & Extension Center

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July 20-23, 2009
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A Multidisciplinary Approach to Conservation

Proceedings of the 31st Southern Conservation Agricultural Systems Conference, Melfa, VA, USA
July 20-23, 2009

Mark S. Reiter
(Editor)

Virginia Cooperative Extension Publication #2910-1417

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FORWARD

Conservation agricultural systems need technology and expertise from all areas of agricultural exploration, including but not limited to soil science, nutrient management, plant pathology, entomology, and weed science. Changing one aspect of an agricultural production system, such as implementation of no-tillage or addition of high-residue cover crops, may impact other production system practices. In-depth discussion and investigation needs to be conducted amongst all agricultural fields to ensure sustainable production for years to come.

Virginia farmers are at the forefront of conservation agricultural systems implementation. Most farmers in Virginia have adopted conservation tillage and other soil improvement practices. However, vegetable production is one of the last frontiers for implementation of conservation tillage technologies. Current production practices and necessities often make use of many conservation system technologies impractical. We hope that the multidisciplinary discussion of agronomic and vegetable crops may offer some insight into improving vegetable conservation agricultural system practices.

The organizing committee would like to thank all sponsors, authors, faculty, and staff that helped make the 31st Conservation Agricultural Systems Conference possible.

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ABOUT SERA-IEG-20

The Southern Conservation Agricultural Systems Conference (SCASC) is the main activity of the Southern Extension and Research Activity – Information Exchange Group 20 (SERA-IEG-20). It is sponsored by the Southern Association of Agricultural Experiment Station Directors (SAAESD), the Association of Southern Region Extension Directors (ASRED), the USDA Cooperative State Research, Education and Extension Service (CSREES), and the participating state universities and federal agencies.

The primary mission of the SCASC is to provide a medium for exchanging information about conservation tillage and related technology between and among researchers, extension personnel, NRCS personnel, crop consultants, agrochemical companies, and farmers. The primary goal of most conservation sustainable agricultural systems research is to develop improved technology to increase yields and/or profitability of agricultural crops and livestock while maintaining or improving the quality of soil and water resources available for agricultural, domestic, and recreational uses. The overall objective of the SCASC is to expand the conservation agricultural systems in the South for the purpose of controlling erosion and reducing environmental degradation.

SUGGESTED REFERENCE INFORMATION

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MULTIDISCIPLINARY PROBLEMS AND SOLUTIONS WITH CONSERVATION AGRICULTURAL SYSTEMS

CONSERVATION TILLAGE TRENDS IN VIRGINIA AGRICULTURAL PRODUCTION

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SUMMARY

Data from the Conservation Technology Information Center's (CTIC) National Crop Residue Management Survey was used to establish trend lines for Virginia agricultural commodities. In 2007, double crop soybeans had the highest use of conservation tillage at 95.6% while 100% of potatoes were planted using conventional tillage. Most Virginia producers are integrating conservation tillage into their cropping systems, but vegetable crops have challenges that make adoption more difficult. Higher value vegetable and specialty crops are the last frontier for conquering the widespread use of conventional tillage and should be the main focus of research and Extension education programs to implement reduced and conservation tillage when systematically feasible.

INTRODUCTION

Documentation of crops being grown without tillage has been recorded throughout history by many cultures. For instance, the Incas that thrived in the South American Andes documented planting their crops by forming a hole with a stick, inserting the seed, and covering the seed with soil using their foot (Derpsch, 1998). A historical review by Derpsch (1998) documented no-tillage of soil for food production since civilization primarily lacked the power to plow using available tools. Cultivation techniques drastically changed when technology advanced to easily make cultivation possible. Cultivation techniques again began to evolve around 1915 when the Department of Agriculture published a scientific bulletin noting the benefits of soil surface residue as a protectant from wind and water erosion (Duley and Mathews, 1947).

Research of modern agricultural conservation tillage techniques initiated in the 1920s by demonstrating that small grains could be grown without plowing every season, which became known as stubble mulch farming (Duley and Mathews, 1947). Interests in conservation tillage increased and research picked up steam after the Dust Bowl in the 1930s as more researchers began projects that demonstrated the benefits of leaving a surface residue to protect the soil from wind erosion (Derpsch, 1998). Research progressed and modern conservation agricultural systems as we know them improved with the implementation of modern herbicides. In the 1960s, research in Virginia, Kentucky, North Carolina, and other states were initiated and demonstrated the possibility of true chemically controlled no-tillage systems (Thomas and Blevins, 1996; Blevins, 1998). Equipment and chemical advancements have led to the current status of conservation agricultural systems being the predominant production systems for many crops (Brock et. al., 2000; Bradley, 2002; CTIC, 2009).

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Virginia has been on the forefront of conservation tillage technology since modern implementation in the 1960s. The objective of this report is to discuss trends in acceptance of conservation agricultural systems in Virginia.

MATERIALS AND METHODS

Data from the CTIC's National Crop Residue Management Survey (2009b) was used to establish trend lines for Virginia agricultural commodities. The CTIC composites road transect data from various stakeholders to summarize residue trends in localities across the United States. The procedures for taking transect data can be found on CTIC's website in their publication entitled, Cropland Roadside Transect Survey (CTIC, 2009a). Residue measurements divide cropland into 3 different categories that include conservation tillage (>30% residue cover), reduced tillage (15-30% residue cover), and conventional tillage (<15% residue cover). The CTIC survey data has a certainty of 90% or higher when compared to actual planted total acreage in a locality.

Data from 1989 to 1998 are segregated into 11 commodity categories that include full season corn (*Zea mays*), spring planted small grain, winter planted small grain, full season soybeans (*Glycine max*), double crop soybeans, cotton (*Gossypium hirsutum*), sorghum (*Sorghum bicolor*), forages, pasture, and fallow, with remaining crops grouped into the "other" category. Data from 2000 to 2007 are divided into 23 commodity categories that include corn, full season soybeans, double crop soybeans, cotton, spring wheat (*Triticum aestivum*), winter wheat, oats (*Avena sativa*), sorghum, edible beans and peas (*Pisum sativum* ssp. *Sativum*), barley (*Hordeum vulgare*), canola (*Brassica napus*), forage crops, peanuts (*Arachis hypogaea*), potatoes (*Solanum tuberosum*), rice (*Oryza sativa*), rye (*Secale cereal*), sunflowers (*Helianthus annuus*), sugar beets (*Beta vulgaris*), sugarcane (*Saccharum officinarum*), tobacco (*Nicotiana tabacum*), vegetables, permanent pasture, and fallow. Transect data, in acres for each tillage practice, were converted to % by dividing the acreage of each surface residue bracket by total acreage for each year for each crop. Tread lines were established by graphing percentage of each crop under each residue regime over time from 1989 to 2007. The best fit correlation along with the R^2 is presented and is a quadratic or linear relationship.

RESULTS AND DISCUSSION

Virginia crop production acreage has decreased from over 2.1 million acres in 1989 to 1.6 million acres in 2007 (Table 1). Virginia farmland is under pressure from other use categories, similar to other parts of the United States. Table 1 also demonstrates the crop shifts that occurred in Virginia over time due to commodity price shifts and changes in federal government programs, such as the peanut quota system.

Acreage from the CTIC National Crop Residue Management Survey for Virginia crops shows that acreage amongst crops varies on a yearly basis (Table 2). Therefore, the best way to compare crop reside trends from year to year is on a percentage basis (Table 3). Overall, total acreage indicates that conservation is on the rise among Virginia crops and has increased from 48.2% to 67.6% for 1989 and 2007, respectively (Table 3). Likewise, conventional tillage has decreased from 40.8% in 1989 to 23.2% in 2007. Reduced tillage has remained relatively constant over the 1989 to 2007 time period. Positive trends in increased surface residue indicates that Virginia farmers are cognizant of the benefits of low and no-tillage regimes and are consistently improving their production systems to move towards sustainability.

Regarding specific trends over time, double crop soybeans have consistently been predominated by conservation tillage systems with less than 8% being planted as conventional or reduced tillage (Fig. 1). However, a significant trend towards full season soybeans shifting from conventional to conservation tillage is observed (Fig. 2). Inverse quadratic functions correlate with and R^2 of 0.88 and 0.81 for conservation and conventional tillage, respectively. By 2007, 71.5% of full season soybeans were planted with conservation tillage while 21.1% were planted with conventional tillage (Table 3). Full season corn conservation tillage acreage is linearly increasing over time with an inverse reduction in conventional tillage (77.3 and 13.7% for 2007, respectively; Fig. 3 and Table 3). Conservation tillage winter small grain acreage has recently surpassed conventional tillage acreage and is currently increasing as a quadratic function (Fig. 4). By 2007, 53.6% of winter wheat was planted with conservation tillage and 29.4% was planted using conventional tillage (Table 3).

Vegetable crops remain one of the last frontiers for transition to conservation or reduced tillage systems since 91.3% of vegetable crops were planted using conventional tillage in 2007 (Fig. 5 and Table 3). The only cropping systems utilizing more conventional tillage than vegetable crops was edible beans and peas (99.2%), peanuts (98.4%), potatoes (100%), and tobacco (98.6%). All of the cropping systems predominantly utilizing conventional tillage has challenges that make adoption of conservation tillage difficult. For instance, the necessity to dig potatoes and peanuts means that soil inversion must occur for harvest while use of plasticulture in tomatoes necessitates bed formation. A renewed technology and education effort needs to be executed to promote reduced and conservation tillage in vegetable and specialty crops.

CONCLUSION

In conclusion, most Virginia cropping systems are trending towards increased use of conservation tillage with an inverse decrease in conventional tillage. An upwards trend for conservation tillage is especially noticeable in agronomic crops such as soybeans, wheat, and corn. Higher value vegetable and specialty crops are the last frontiers for conquering conventional tillage and should be the main focus of research and Extension education programs to implement reduced and conventional tillage when systematically feasible.

REFERENCES

Blevins, R.L., R. Lal, J.W. Doran, G.W. Langdale, and W.W. Frye. 1998. Conservation tillage for erosion control and soil quality. p. 51-68. *In* F.J. Pierce and W.W. Frye (eds.) Advances in Soil and Water Conservation. Sleeping Bear Press, Chelsea, MI.

Bradley, J.F. 2002. Twenty five year review of conservation tillage in the southern U.S.: Perspective from industry. p. 20-24. *In* E. van Santen (ed.) 2002. Marking conservation tillage conventional: Building a future on 25 years of research. Proc. of 25th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Auburn, AL. 24-26 June 2002. Special Report no. 1. Alabama Agric. Expt. Stn. and Auburn University, Auburn University, AL.

Brock, B.G., J.H. Canterberry, and G.C. Naderman. 2000. Ten milestones in conservation tillage: History and role in the North Carolina conservation program. p. 13-18. *In* J.L. Sutherland (ed.) Proc. of the 43rd ann. meeting of the Soil Sci. Soc. of North Carolina. 18-19 Jan. 2000. Raleigh, NC. Also available at: http://www.soil.ncsu.edu/about/century/tenmilestones.html (accessed 15 July 2009; verified 23 Nov. 2009).

Conservation Technology Information Center. 2009a. Cropland roadside transect survey [Online]. Available at: http://www.crmsurvey.org/CRM/2009CTICTransectProceedures.pdf (accessed 15 July 2009; verified 23 Nov. 2009). CTIC, West Lafayette, IN.

Conservation Technology Information Center. 2009b. National crop residue management survey [Online]. Available at: http://www.conservationinformation.org/?action=members_crm (accessed 15 July 2009; verified 23 Nov. 2009). CTIC, West Lafayette, IN.

Derpsch, R. 1998. Historical review of no-tillage cultivation of crops. p. 1-18. Proc. 1st JIRCAS seminar on soybean research, no-tillage cultivation and future needs. 5-6 Mar. 1998. CIRCAS Working Rep. No. 13. Also available at: http://www.rolf-derpsch.com/notill.htm (accessed 15 July 2009; verified 23 Nov. 2009). JIRCAS, Iguassu Falls, Brazil.

Duley, F.L., and O.R. Mathews. 1947. Ways to till the soil. p. 518-526. *In* Lambert et. al. (eds.) The yearbook of Agriculture 1943-1947. USDA, Washington, D.C.

Thomas, G.W., and R.L. Blevins. 1996. The development and importance of no- tillage crop production in Kentucky. p. 5-6. Agronomy Res. Rep. 1996. Progress Rep. No. 385. Kentucky Agric. Exp. Stn., Lexington.

USDA-National Agricultural Statistics Service. 2009. Virginia data – Crops [Online]. Available at: http://www.nass.usda.gov/Statistics_by_State/Virginia/index.asp (accessed 15 July 2009; verified 23 Nov. 2009). USDA-NASS, Washington, D.C.

TABLES AND FIGURES

Table 1. Total acres grown in Virginia cropping systems for 1989, 2000, and 2007. Data derived from the Conservation Technology Information Center (CTIC) National Crop Management Residue Survey (CTIC, 2009b).

Crop	1989	2000	2007
	----------%	----------	
Corn	562,523	455,908	482,882
Soybeans, Full Season	372,712	221,483	294,532
Soybeans, Double Crop	257,846	250,909	200,362
Cotton	2,539	91,766	60,842
Spring Wheat	24,785	3,842	980
Winter Wheat	300,000†	266,066	209,088
Oats	27,000†	6,054	10,742
Sorghum	16,878	11,544	4,222
Edible Beans, Peas	NA†	1,838	3,143
Barley	95,000†	50,056	38,764
Forage Crops	73,505	82,365	71,988
Peanuts	91,000†	61,087	21,938
Potatoes	13,000†	2,830	3,491
Rye	8,000†	18,158	45,165
Sunflowers	NA‡	125	754
Tobacco	49,590†	25,842	22,626
Vegetables	46,664§	50,023	24,508
Permanent Pasture	84,271	90,907	90,370
Fallow	84,245	14,229	34,526
Total	2,121,103¶	1,705,032	1,620,946

†Acreage information is from the USDA-National Agricultural Statistics Service (2009). Crop specific data was not available from CTIC and was lumped together in a general “winter small grains” or “other” category in their survey.

‡Data was not available from CTIC or the USDA-National Agricultural Statistics Service (2009).

§Vegetables for 1989 = CTIC “Other” category – peanuts – potatoes – rye – tobacco from USDA-NASS survey.

¶Total acreage is from the CTIC National Crop Residue Management Survey and does not equal the above column due to insertion of unknown CTIC data from USDA-NASS (2009).

Table 2. Percentage of acres grown with surface residue representing conservation tillage (>30% surface residue), reduced tillage (15 to 30% surface residue), and conventional tillage (<15% surface residue) in Virginia cropping systems for 1989, 2000, and 2007. Data derived from the Conservation Technology Information Center (CTIC) National Residue Management Survey (CTIC, 2009b).

	Conservation			Reduced			Conventional		
Crop	1989	2000	2007	1989	2000	2007	1989	2000	2007
	----------	----------	----------	----------	%----------	----------	----------	----------	----------
Corn	324,891	301,730	373,063	64,324	39,690	43,881	173,308	114,488	65,938
Soybeans, Full Season	132,229	84,591	210,495	54,373	18,510	22,018	186,110	118,382	62,019
Soybeans, Double Crop	246,788	229,124	191,466	2,190	3,903	2,642	8,868	17,882	6,254
Cotton	350	18,550	38,302	0	1,623	6,970	2,189	71,593	15,570
Spring Wheat	6,761	2,637	580	1,735	330	230	16,289	875	170
Winter Wheat	158,518†	71,356	112,160	64,026†	29,357	35,507	219,001†	165,353	61,421
Oats	158,518†	2,509	2,474	64,026†	1,064	1,260	219,001†	2,481	7,008
Sorghum	9,542	6,813	2,127	720	481	634	6,616	4,250	1,461
Edible Beans, Peas	5,597‡	0	25	5,672‡	90	0	188,985‡	1,748	3,118
Barley	158,518†	17,806	22,499	64,026†	17,599	7,788	219,001†	14,651	8,477
Forage Crops	48,240	49,433	44,503	4,940	8,982	8,189	20,325	23,950	19,296
Peanuts	5,597‡	218	307	5,672‡	1,949	50	188,985‡	58,920	21,581
Potatoes	5,597‡	0	0	5,672‡	0	0	188,985‡	2,830	3,491
Rye	158,518†	8,977	16,129	64,026†	3,952	12,727	219,001†	5,229	16,309
Sunflowers	5,597‡	9	192	5,672‡	0	106	188,985‡	116	456
Tobacco	5,597‡	120	314	5,672‡	38	0	188,985‡	25,684	22,312
Vegetables	5,597‡	3,699	1,164	5,672‡	714	973	188,985‡	45,610	22,371
Permanent Pasture	63,014	65,568	61,026	4,945	8,074	4,104	16,312	17,265	25,240
Fallow	25,770	1,451	18,179	30,435	3,774	2,304	28,040	9,004	14,043
Total	1,021,700	864,591	1,095,005	233,360	140,130	149,383	866,043	700,311	376,558

†In 1989, CTIC data only had select crops categorized and discrete numbers for these crops are not known. The given number is the 1989 number for small grains planted in the fall that encompasses that crop.

‡In 1989, CTIC data only had select crops categorized and discrete numbers for these crops are not known. The given number is the 1989 number for the “Other” category that encompasses that crop.

Table 3. Percentage of acres grown with surface residue representing conservation tillage (>30% surface residue), reduced tillage (15 to 30% surface residue), and conventional tillage (<15% surface residue) in Virginia cropping systems for 1989, 2000, and 2007. Data derived from the Conservation Technology Information Center (CTIC) National Residue Management Survey (CTIC, 2009b).

	Conservation			Reduced			Conventional		
Crop	1989	2000	2007	1989	2000	2007	1989	2000	2007
	---%---								
Corn	57.8	66.2	77.3	11.4	8.7	9.1	30.8	25.1	13.7
Soybeans, Full Season	35.5	38.2	71.5	14.6	8.4	7.5	49.9	53.4	21.1
Soybeans, Double Crop	95.7	91.3	95.6	0.8	1.6	1.3	3.4	7.1	3.1
Cotton	13.8	20.2	63.0	0.0	1.8	11.5	86.2	78.0	25.6
Spring Wheat	27.3	68.6	59.2	7.0	8.6	23.5	65.7	22.8	17.3
Winter Wheat	35.9†	26.8	53.6	14.5†	11.0	17.0	49.6†	62.1	29.4
Oats	35.9†	41.4	23.0	14.5†	17.6	11.7	49.6†	41.0	65.2
Sorghum	56.5	59.0	50.4	4.3	4.2	15.0	39.2	36.8	34.6
Edible Beans, Peas	2.8‡	0.0	0.8	2.8‡	4.9	0.0	94.4‡	95.1	99.2
Barley	74.8	35.6	58.0	5.9	35.2	20.1	19.4	29.3	21.9
Forage Crops	65.6	60.0	61.8	6.7	10.9	11.4	27.7	29.1	26.8
Peanuts	2.8‡	0.4	1.4	2.8‡	3.2	0.2	94.4‡	96.5	98.4
Potatoes	2.8‡	0.0	0.0	2.8‡	0.0	0.0	94.4‡	100.0	100.0
Rye	35.9†	49.4	35.7	14.5†	21.8	28.2	49.6†	28.8	36.1
Sunflowers	2.8‡	7.2	25.5	2.8‡	0.0	14.1	94.4‡	92.8	60.5
Tobacco	2.8‡	0.5	1.4	2.8‡	0.1	0.0	94.4‡	99.4	98.6
Vegetables	2.8‡	7.4	4.7	2.8‡	1.4	4.0	94.4‡	91.2	91.3
Permanent Pasture	74.8	72.1	67.5	5.9	8.9	4.5	19.4	19.0	27.9
Fallow	30.6	10.2	52.7	36.1	26.5	6.7	33.3	63.3	40.7
Total	48.2	50.7	67.6	11.0	8.2	9.2	40.8	41.1	23.2

†In 1989, CTIC data only had select crops categorized and discrete numbers for these crops are not known. The given number is the 1989 number for small grains planted in the fall that encompasses that crop.

‡In 1989, CTIC data only had select crops categorized and discrete numbers for these crops are not known. The given number is the 1989 number for the “Other” category that encompasses that crop.

Figure 1. Double crop soybean tillage trends based on surface residue for Virginia farms from 1989 to 2007 using data from the Conservation Technology Information Center's National Residue Management Survey (CTIC, 2009b).

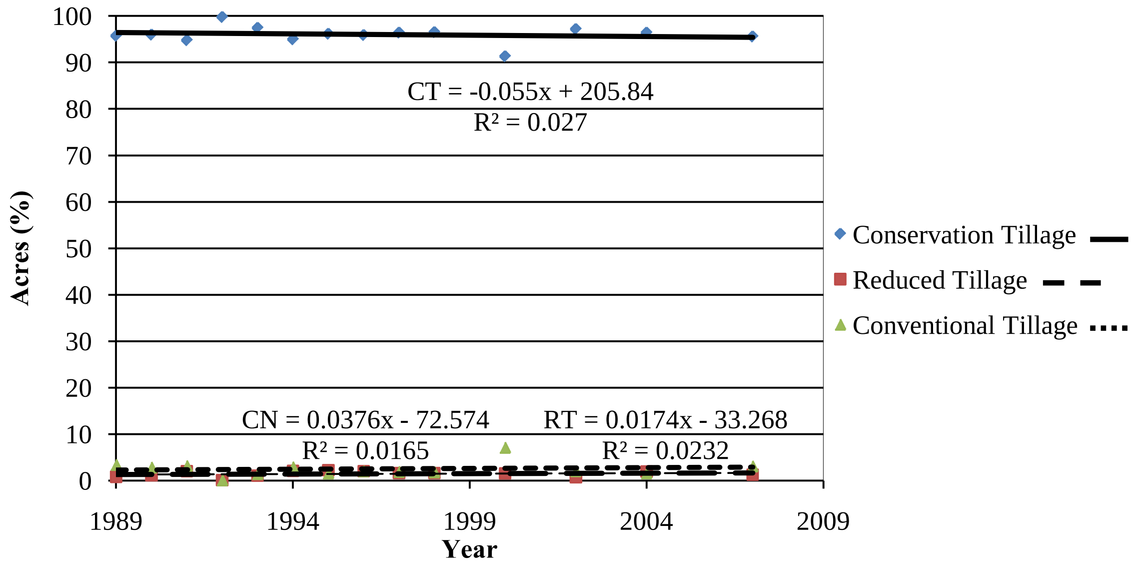


Figure 2. Full season soybean tillage trends based on surface residue for Virginia farms from 1989 to 2007 using data from the Conservation Technology Information Center's National Residue Management Survey (CTIC, 2009b).

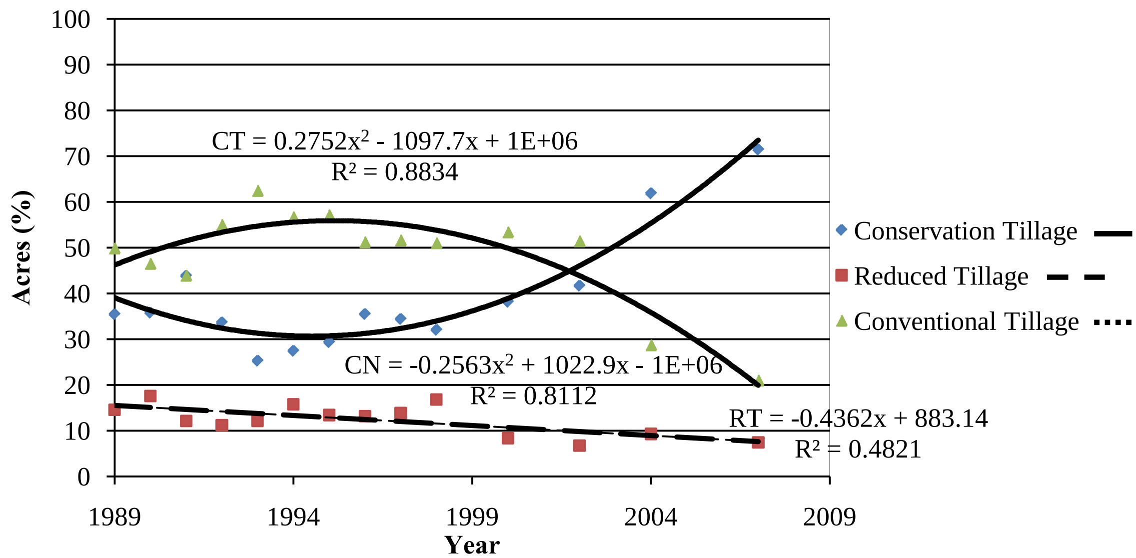


Figure 3. Full season corn tillage trends based on surface residue for Virginia farms from 1989 to 2007 using data from the Conservation Technology Information Center's National Residue Management Survey (CTIC, 2009b).

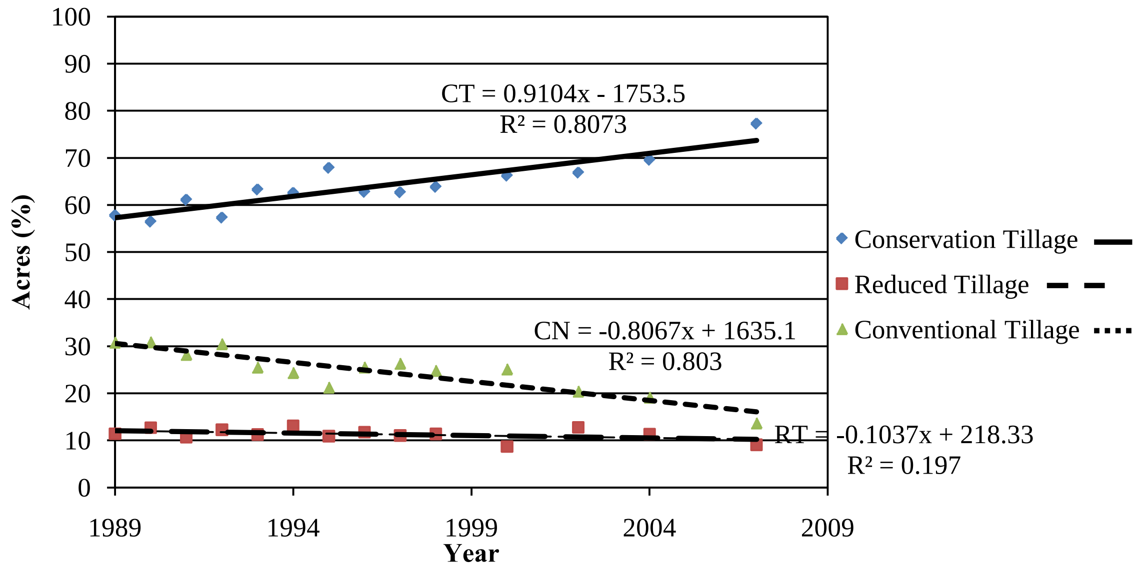


Figure 4. Winter small grain tillage trends based on surface residue for Virginia farms from 1989 to 2007 using data from the Conservation Technology Information Center's National Residue Management Survey (CTIC, 2009b).

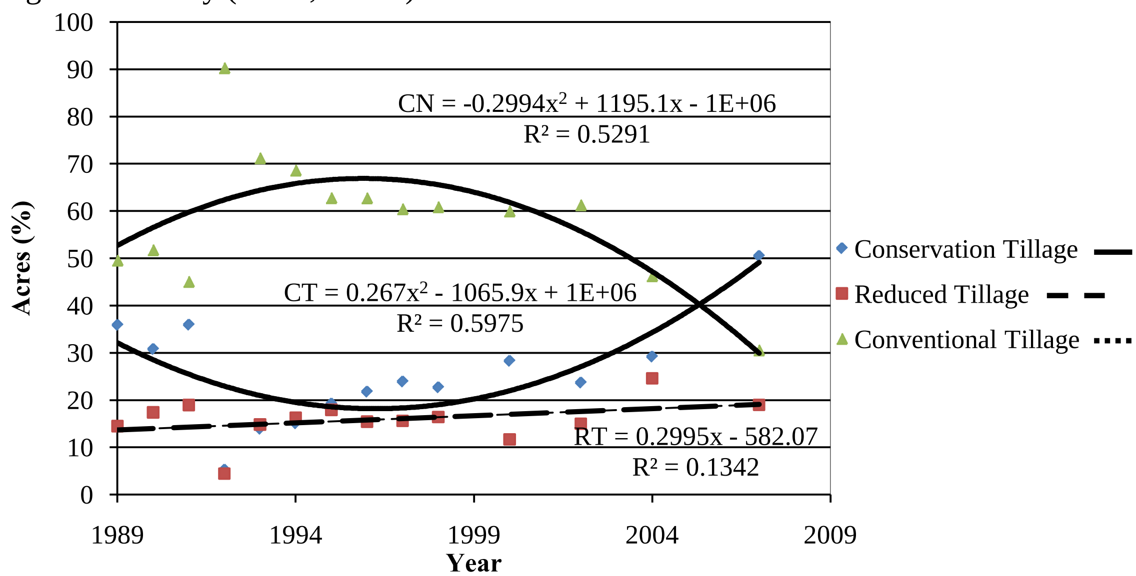
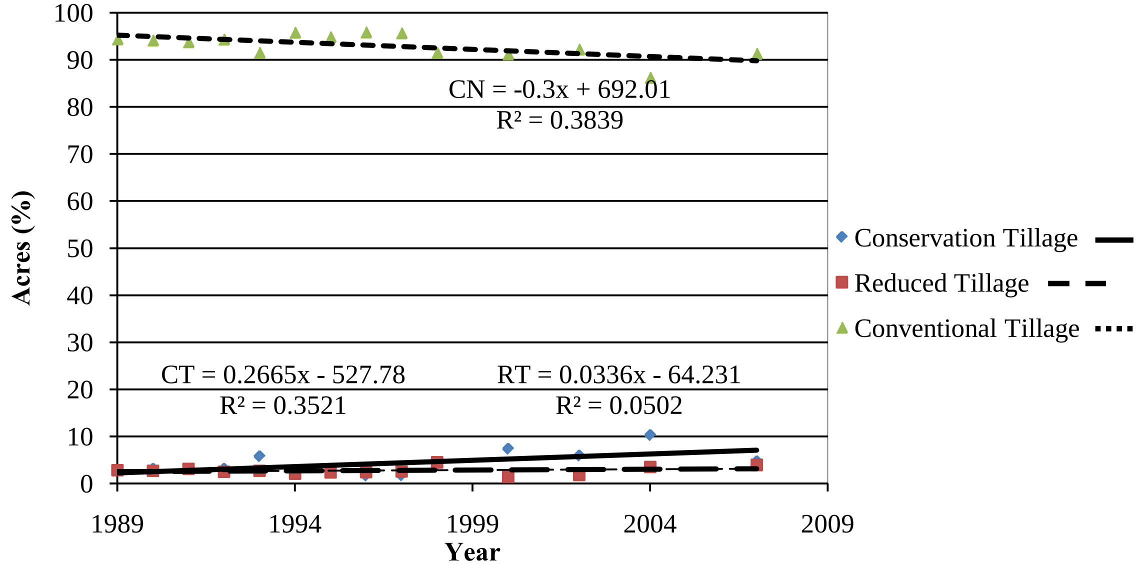


Figure 5. Vegetable tillage trends based on surface residue for Virginia farms from 1989 to 2007 using data from the Conservation Technology Information Center's National Residue Management Survey (CTIC, 2009b). The "other" category data was used for years 1989 to 1998 since vegetables were lumped into this category.



INSECT PEST CONCERNS IN REDUCED-TILLAGE CROPS

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INTERPRETIVE SUMMARY

Conservation tillage can impact pest management in crops such as corn, soybeans, wheat, and pumpkins. Crop residue can provide an ideal habitat for certain pest insects as well as some beneficial organisms. This presentation will summarize how reduced tillage might affect different insects of agricultural importance.

Reduced tillage in corn could have the following effects:

1. Increased pest pressure from cutworms. Black cutworm moths prefer to lay eggs in weedy fields and in fields with unincorporated crop residue.
2. Increased slug infestations. Slug densities are higher in fields with unincorporated crop residues and cooler, wetter conditions can lead to outbreaks.
3. Increased pest pressure from armyworms and stalk borers. Moths of these species prefer to lay eggs in fields with more grass weeds.
4. Increased pest pressure from seedcorn maggot. Although no-till corn stubble is less attractive to egg-laying seedcorn maggot flies than where crop residue has been partially incorporated into the soil, a cooler, wetter soil, and an increase in decaying organic matter can lead to problems with this pest, particularly when germination is delayed.
5. Increased pest pressure from wireworms and white grubs. Less soil disturbance and grassy weeds favor survival of white grubs and wireworms in soils.
6. Increased abundance of ground predators such as carabid and staphylinid beetles, which feed on many of the aforementioned pests.

Reduced tillage in soybeans could have the following effects:

1. Increased slug infestations.
2. Increased pest pressure from grasshoppers. Reducing tillage favors the survival of grasshopper species that lay eggs within fields.
3. Possibly less problems with spider mites. Where crop residues slow moisture loss, plants may be less drought-stressed than in conventional tillage. Reducing drought stress reduces mite outbreaks. Also, a reduction in windblown sand onto leaves, provides a less favorable habitat for spider mites to hide from predators.

Reduced tillage in wheat could have the following effects:

1. Increased Hessian fly pest problems. Populations of this pest carry over where wheat stubble is not tilled and volunteer wheat is not controlled. No-till seeding of wheat into other (non-wheat) crop residues poses no problem.
2. Increased infestations of winter grain mite. This mite species spends the summer in the soil at the base of plants in grass residue. Planting directly into residue can lead to mites invading new seedling wheat.

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3. Decreased aphid pest pressure. Crop residues may decrease the attractiveness of new wheat stands to airborne aphids in the fall. By spring, it is unlikely that crop residues will affect aphid invasions. In addition, a number of arthropod natural enemies of aphids may overwinter in crop residue and be more prevalent the following spring to eliminate aphid populations.

Reduced tillage in pumpkins could have the following effects:

1. Increased squash bug problems. Squash bug adults prefer to hide in fields with increased crop residue, which provides cover. Densities of this pest are generally higher in no-till pumpkin fields.
2. Decreased aphid pest pressure. Crop residues may decrease the attractiveness of pumpkin fields to airborne aphids. A number of arthropod predators of aphids prefer crop residue as opposed to bare ground, and will be more prevalent to help eliminate aphid populations.

TILLAGE PRACTICES, WEED MANAGEMENT, AND HERBICIDE RESISTANCE

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ABSTRACT

Farmers on the Eastern Shore of Virginia produce a diversity of vegetable and agronomic crops using conventional and reduced tillage production practices. A high percentage of land has been in continuous no-till production for five or more years. Vegetables are generally produced using conventional tillage systems since soils generally warm up and dry out more readily in the spring under tillage. Where vegetables are planted for fall harvest, no-till production is more feasible.

Research conducted at this station confirms that snap beans planted for fall harvest can be produced efficiently planted no-till as an alternative to soybeans.

Stubble height of 6 to 12 inches resulted in the most efficient harvest and yields equaled or exceeded those of conventional tillage.

Weed control was limited by the low number of herbicides registered for snap beans but registrations now include several non-selective, preemergence and postemergence herbicides. We have had little adoption of this practice in Virginia but all snap beans in Maryland and Delaware planted after barley and wheat are planted no-till.

Pumpkin is an additional crop planted no-till into a small grain cover crop or planted no-till behind small grain harvest. We are currently investigating additional herbicides for no-till double-crop pumpkins.

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CONSERVATION AGRICULTURAL SYSTEMS

WIND ENERGY FOR AGRICULTURE

George Stricker

Farms of the past

- Symbol of water pumping windmills
- Open lands and useful or harmful winds
- Understanding of and dependence on the weather
- Resourceful farm mechanics and inventors

Planning needed for a wind energy installation on a farm

- Statement of purpose(s)
    - Save on electrical bill
    - Earn money – royalty from wind turbine lease
    - Make a green statement
    - Interested in the concept
    - Grew up with a windmill on the farm
- Wind speed data – the free "fuel"
    - Your own anemometer or weather station
    - Wind data sources
- Energy need (load) analysis
    - What you can learn from your electric bill
- Economic Analysis
    - Revenue and expense
    - Payback period
- Funding
    - Loan or cash
    - Government subsidies and incentives
- Site
    - Topography, trees, buildings
    - Other obstructions (center pivot sprinklers, roads, easements, etc.)
- Permit (probably not needed for own use on Ag zoned land)
    - As "appurtenant" farm structure
    - Conditional Use Permit for windfarm
- Interconnection Agreement with your utility
    - Net metering
    - Location of power lines, substations, etc.
- Storage batteries (maybe – for standalone systems)
- Turbine selection
    - Bergey, Jacobs, John Deere, Skystream, Northern Power, or other
- Installer
    - Or do-it-yourself
- The Internet as a tool and information resource
    - AWEA, NREL, NOAA, Airports, NWS and much more

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Farms of the future

Ag school curriculum
Energy for the farm
“Windfarms” for utility power

CAN THE SOIL CONDITIONING INDEX PREDICT SOIL ORGANIC CARBON SEQUESTRATION WITH CONSERVATION AGRICULTURAL SYSTEMS IN THE SOUTH?

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SUMMARY

The soil conditioning index (SCI) is a relatively simple model used by NRCS to predict changes in soil organic C. It is based on three important conditions: (1) organic material (OM), (2) field operations (FO), and (3) erosion (ER). Our objective was to develop quantitative relationships between (1) published soil organic C data derived from field experiments under various management systems and (2) SCI values predicted from those management systems. Within a field study, SCI was usually highly related to soil organic C content. The SCI appears to reasonably estimate changes in soil organic C with adoption of conservation agricultural systems in the southeastern USA.

INTRODUCTION

Rapid and reliable assessments of the potential of various agricultural management systems to sequester soil organic C are needed to promote conservation and help mitigate greenhouse gas emissions. A growing database is emerging from detailed field experiments on how conservation agricultural systems can sequester soil organic C (Franzluebbers, 2005; 2009). Unfortunately, many results appear to be site-, soil- and cropping system-specific, resulting in uncertainty of how to predict the effect of management in different environments, soil types, and crop management systems (Sainju et al., 2007; Franzluebbers and Stuedemann, 2008; Novak et al., 2009).

The soil conditioning index is a relatively simple model used by the USDA Natural Resources Conservation Service that could be useful to predict changes in soil organic C. It is based on three important conditions: (1) organic material (OM) grown or added to the soil, (2) field operations (FO) that alter organic material placement in the soil profile and that stimulate organic matter breakdown, and (3) erosion (ER) that removes and sorts surface soil organic matter. Our objective was to develop quantitative relationships between (1) published soil organic C data derived from field experiments under various management systems throughout the southeastern USA and (2) index values predicted from those management systems using the soil conditioning index.

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MATERIALS AND METHODS

Soil organic C content data from various field studies comparing conventional and conservation agricultural management approaches were summarized in two recent publications (Franzluebbers, 2005; 2009). The soil conditioning index (SCI) was run for individual management conditions under the soil and geographical conditions of sites listed in Table 1. Soil organic C and SCI values were analyzed separately by regression from within individual field studies with multiple management conditions. Multiple field studies were then pooled within the same major land resource and/or state to test if relationships were stable.

RESULTS AND DISCUSSION

On a Cecil sandy loam in Watkinsville GA, soil organic C increased with decreasing tillage intensity and time since last tillage (Franzluebbers et al., 1999). The SCI varied similarly and resulted in a curvilinear relationship between soil organic C content at the end of 4 years of management and SCI (Fig. 1). The hockey stick shape of the curve suggests that when SCI is positive, very large increases in soil organic C could occur (as compared to relatively small changes in soil organic C with large variations when SCI was negative).

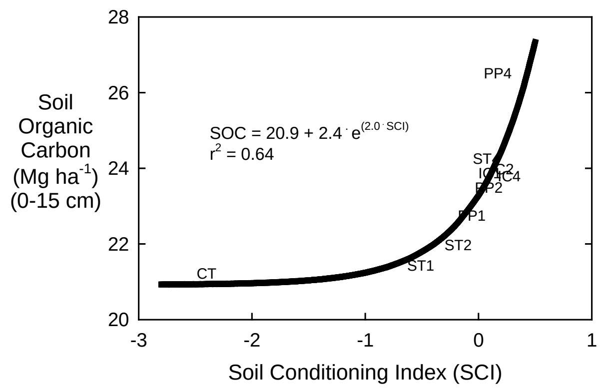

Figure 1. Relationship of soil organic C at the end of 4 yr of management to the soil conditioning index on a Cecil sandy loam in Watkinsville GA. Management was crimson clover / pearl millet rotated with crimson clover / cotton under conventional disk tillage (CT) and no-tillage planting with either paraplow (PP), in-row chisel (IC), or shallow cultivation tillage (ST) with frequencies of 1, 2, and 4 yr ago. Soil organic C data from Franzluebbers et al. (1999).

On a Pacolet sandy loam in Auburn AL, soil organic C increased in all crop rotations following 3.5 yr of conservation tillage (Siri-Prieto et al. (2002). The average rate of soil organic C sequestration was 1402 lb/acre/yr (1.57 $\pm$ 0.26 Mg C ha^{-1} yr^{-1} among the five rotations investigated). The SCI was linearly related to the soil organic C content in these cotton management systems that were previously managed for 100 yr under conventional tillage (Fig. 2). The SCI allowed only 800 lb/acre of dry matter accumulation with annual clover as cover crop. Changing the cover crop to wheat allowed 4080 lb/acre of dry matter accumulation and this increased the strength of the relationship between soil organic C and SCI from r^2 = 0.40 to r^2 = 0.58. This adjustment suggests that some modification is likely needed to adjust cover crop growth dynamics to the conditions prevalent in the

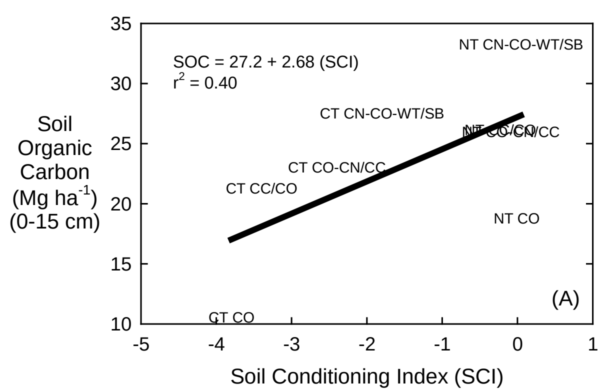

Figure 2. Relationship of soil organic C at the end of 3.5 yr of management to the soil conditioning index on a Pacolet sandy loam in Auburn AL. Management was continuous cotton (CO), crimson clover (CC) / cotton, crimson clover / cotton – crimson clover / corn (CN), and crimson clover / cotton – crimson clover / corn – wheat (WT) / soybean (SB) under conventional tillage (CT) and no tillage (NT). Soil organic C data from Siri-Prieto et al. (2002).

southeastern USA (rather than the Pacific Northwest region, in which annual clover was derived in the SCI simulation).

On a Weswood silty clay loam in College Station TX, soil organic C increased with a change from conventional tillage to no tillage and also with greater complexity of crop rotations (Fig. 3). The changes in soil organic C were highly related to the SCI values for these cropping systems. Since published studies varied in the depth of soil sampled and the number of years that cropping systems had been implemented, soil organic C were averaged over time and normalized to a common sampling depth. Soil organic C averaged 11.5 kg C m^{-3} under conventional tillage and 14.3 kg C m^{-3} under no tillage ($p < 0.01$), while SCI was -2.7 ± 0.7 under conventional tillage and -0.3 ± 0.3 under no tillage. The normalization step that was necessary in this evaluation suggests that consistency in estimating soil organic C sequestration (with regards to soil depth and time) is needed to obtain the most robust comparisons. Further work is needed to obtain peer-reviewed and verifiable relationships between soil organic C and SCI under a diversity of evaluation conditions.

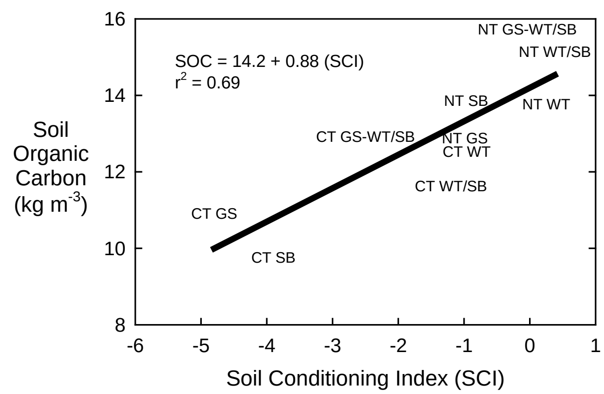

Figure 3. Relationship of soil organic C to the soil conditioning index on a Weswood silty clay loam in College Station TX. Management was continuous grain sorghum (GS), continuous soybean (SB), continuous wheat (WT), wheat / soybean, and sorghum – wheat / soybean under conventional tillage (CT) and no tillage (NT). Soil organic C data were collected at the end of 9, 10, and 20 yr of management at depths of 15, 20, and 30 cm from a number of studies, including Franzluebbers et al. (1994, 1995, 1998), Wright and Hons (2004, 2005), and Dou and Hons (2006).

Comparing across three locations in North Carolina and South Carolina, relationships of SCI to soil organic C were all linear within a location, but non-linear across locations (Fig. 4). Similar to the result in Georgia in Figure 1, a sharp increase in soil organic C was observed with a small change in SCI when positive. This curvilinear feature was also observed when SCI was compared against simulated soil organic C using the process-based model, EPIC (Abrahamson et al. 2007, 2009). Further work will be needed to explore cropping systems with positive SCI values to understand if soil organic C more typically follows a curvilinear or linear relationship with SCI. This will likely require more complex crop rotations, and especially with sod-based grasses and legumes in rotation with grain and fiber crops (Franzluebbers, 2007).

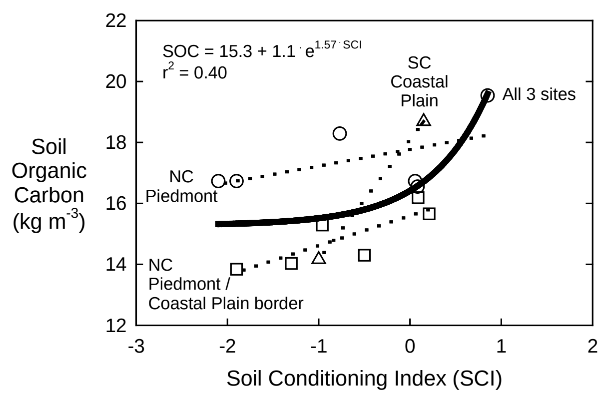

Figure 4. Relationship of soil organic C to the soil conditioning index at a Piedmont, Coastal Plain, and border location in North Carolina and South Carolina. Soil organic C data in South Carolina were from Karlen et al. (1989), Hun et al. (1996), Novak et al. (1996, 2007), Ding et al. (2002), and Bauer et al. (2006). Soil organic C data in North Carolina were from Naderman et al. (2004) and Franzluebbers and Brock (2007).

From 260 observations throughout the region, SCI was only weakly related to soil organic C (Fig. 5). However, soil organic C was greater ($p < 0.001$) under no tillage (14.7 $\pm$ 0.4 kg m^{-3}) than under conventional tillage (12.8 $\pm$ 0.5 kg m^{-3}). As well, SCI was greater under no tillage (0.2 $\pm$ 0.1) than under conventional tillage (-1.7 $\pm$ 0.2). The weak strength of all data together may be as much a function of how soil organic C inherently differs among locations and studies as much as the influence of SCI. We plan to further investigate how to better express soil organic C and SCI relationships, as there certainly may be other ways of presenting the strong differences in both SCI and soil organic C between these two contrasting tillage systems.

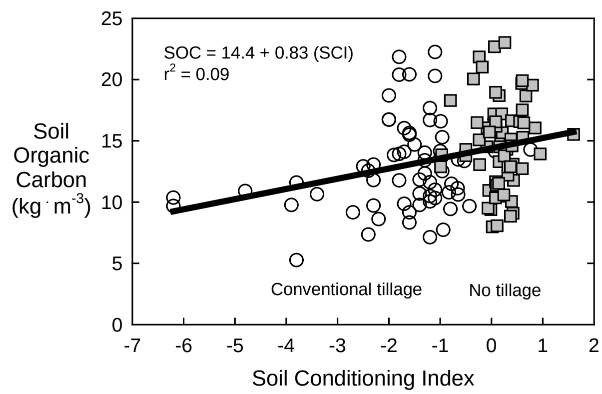

Figure 5. Relationship of soil organic C to the soil conditioning index across the 27 locations listed in Table 1.

CONCLUSIONS

The soil conditioning index was highly sensitive to the extent of tillage. This was especially true within each location investigated. When all data were compiled into a common analysis, only a weak relationship was found between soil organic C and SCI. However, there was clear separation between conventional and no tillage systems in both soil organic C content and SCI value.

Modifications to SCI management input variables may be necessary, since some conditions were not developed specifically for cropping systems in the southeastern USA. In addition, variations in soil organic C measurement protocol require some method of standardization to be able to pool data across studies, locations, and soil types.

Further work is needed to better define the relationships between soil conditioning index and soil organic C at higher index values, since variation in response was greatest and fewer observations were available at this end of the spectrum.

ACKNOWLEDGEMENTS

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REFERENCES

Abrahamson, D.A., M.L. Norfleet, H.J. Causarano, J.R. Williams, J.N. Shaw, and A.J. Franzluebbers. 2007. Effectiveness of the soil conditioning index as a carbon management tool in the southeastern USA based on comparison with EPIC. J. Soil Water Conserv. 62:94-102.

Abrahamson, D.A., H.J. Causarano, J.R. Williams, M.L. Norfleet, and A.J. Franzluebbers. 2009. Predicting soil organic carbon sequestration in the southeastern United States with EPIC and the soil conditioning index. J. Soil Water Conserv. 64:134-144.

Bauer, P.J., J.R. Frederick, J.M. Novak, and P.G. Hunt. 2006. Soil CO2 flux from a norfolk loamy sand after 25 years of conventional and conservation tillage. Soil Till. Res. 90:205-211.

Beare, M.H., P.F. Hendrix, and D.C. Coleman. 1994. Water-stable aggregates and organic matter fractions in conventional- and no-tillage soils. Soil Sci. Soc. Am. J. 58:777-786.

Ding, G., J.M. Novak, D. Amarasiriwardena, P.G. Hunt, and B. Xing. 2002. Soil organic matter characteristics as affected by tillage management. Soil Sci. Soc. Am. J. 66:421-429.

Dou, F., and F.M. Hons. 2006. Tillage and nitrogen effects on soil organic matter fractions in wheat-based systems. Soil Sci. Soc. Am. J. 70:1896-1905.

Edwards, J.H., C.W. Wood, D.L. Thurlow, and M.E. Ruf. 1992. Tillage and crop rotation effects on fertility status of a Hapludult soil. Soil Sci. Soc. Am. J. 56:1577-1582.

Feng, Y., A.C. Motta, C.H. Burmester, D.W. Reeves, E. van Santen, and J.A. Osborne. 2002. Effects of tillage systems on soil microbial community structure under a continuous cotton cropping system. p. 222-226. *In* E. van Santen (ed.) Making Conservation Tillage Conventional: Building a Future on 25 Years of Research, Special Report No. 1, Alabama Agric. Expt. Stn., Auburn Univ.

Fesha, I.G., J.N. Shaw, D.W. Reeves, C.W. Wood, Y. Feng, M.L. Norfleet, and E. van Santen. 2002. Land use effects on soil quality parameters for identical soil taxa. p. 233-238. *In* E. van Santen (ed.) Making Conservation Tillage Conventional: Building a Future on 25 Years of Research, Special Report No. 1, Alabama Agric. Expt. Stn., Auburn Univ.

Franzluebbers, A.J. 2005. Soil organic carbon sequestration and agricultural greenhouse gas emissions in the southeastern USA. Soil Till. Res. 83:120-147.

Franzluebbers, A.J. 2007. Integrated crop-livestock systems in the southeastern USA. Agron. J. 99:361-372.

Franzluebbers, A.J. 2009. Achieving soil organic carbon sequestration with conservation agricultural systems in the southeastern USA. Soil Sci. Soc. Am. J. (in press).

Franzluebbers, A.J., and B.G. Brock. 2007. Surface soil responses to silage cropping intensity on a Typic Kanhapludult in the piedmont of North Carolina. Soil Till. Res. 93:126-137.

Franzluebbers, A.J., F.M. Hons, and D.A. Zuberer. 1994. Long-term changes in soil carbon and nitrogen pools in wheat management systems. Soil Sci. Soc. Am. J. 58:1639-1645.

Franzluebbers, A.J., F.M. Hons, and D.A. Zuberer. 1995. Soil organic carbon, microbial biomass, and mineralizable carbon and nitrogen in sorghum. Soil Sci. Soc. Am. J. 59:460-466.

Franzluebbers, A.J., F.M. Hons, and D.A. Zuberer. 1998. *In situ* and potential CO_2 evolution from a fluventic Ustochrept in southcentral Texas as affected by tillage and crop management. Soil Till. Res. 47:303-308.

Franzluebbers, A.J., G.W. Langdale, and H.H. Schomberg. 1999. Soil carbon, nitrogen, and aggregation in response to type and frequency of tillage. Soil Sci. Soc. Am. J. 63:349-355.

Franzluebbers, A.J., H.H. Schomberg, and D.M. Endale. 2007. Surface-soil responses to paraplowing of long-term no-tillage cropland in the Southern Piedmont USA. Soil Till. Res. 96:303-315.

Franzluebbers, A.J., and J.A. Stuedemann. 2008. Early response of soil organic fractions to tillage and integrated crop-livestock production. Soil Sci. Soc. Am. J. 72:613-625.

Grofffman, P.M. 1984. Nitrification and denitrification in conventional and no-tillage soils. Soil Sci. Soc. Am. J. 49:329-334.
Hendrix, P.F., A.J. Franzluebbers, and D.V. McCracken. 1998. Management effects on C accumulation and loss in soils of the southern Appalachian Piedmont of Georgia. Soil Till. Res. 47:245-251.
Hu, S., D.C. Coleman, M.H. Beare, and P.F. Hendrix. 1995. Soil carbohydrates in aggrading and degrading agroecosystems: Influences of fungi and aggregates. Agric. Ecosys. Environ. 54:77-88.
Hu, S., D.C. Coleman, C.R. Carroll, P.F. Hendrix, and M.H. Beare. 1997. Labile soil carbon pools in subtropical forest and agricultural ecosystems as influenced by management practices and vegetation types. Agric. Ecosys. Environ. 65:69-78.
Hunt, P.G., D.L. Karlen, T.A. Matheny, and V.L. Quisenberry. 1996. Changes in carbon content of a Norfolk loamy sand after 14 years of conservation or conventional tillage. J. Soil Water Conserv. 51:255-258.
Karlen, D.L., W.R. Berti, P.G. Hunt, and T.A. Matheny. 1989. Soil-test values after eight years of tillage research on a Norfolk loamy sand. Commun. Soil Sci. Plant Anal. 20:1413-1426.
McCarty, G.W., and J.J. Meisinger. 1997. Effects of N fertilizer treatments on biologically active N pools in soils under plow and no tillage. Biol. Fertil. Soils 24:406-412.
Motta, A.C.V., D.W. Reeves, and J.T. Touchton. 2002. Tillage intensity effects on chemical indicators of soil quality in two Coastal Plain soils. Commun. Soil Sci. Plant Anal. 33:913-932.
Naderman, G.C., B.G. Brock, G.B. Reddy, and C.W. Raczkowski. 2004. Six years of continuous conservation tillage at the Center for Environmental Farming Systems (CEFS). Part I. Impacts on soil bulk density and carbon content for differing soils and crop rotations. Ann. Mtg. Soil Sci. Soc. North Carolina, 21 January 2004, Raleigh, NC.
Novak, J.M., P.J. Bauer, and P.G. Hunt. 2007. Carbon dynamics under long-term conservation and disk tillage management in a Norfolk loamy sand. Soil Sci. Soc. Am. J. 71:453-456.
Novak, J.M., J.R. Frederick, P.J. Bauer, and D.W. Watts. 2009. Rebuilding organic carbon contents in Coastal Plain soils using conservation tillage systems. Soil Sci. Soc. Am. J. 73:622-629.
Novak, J.M., D.W. Watts, and P.G. Hunt. 1996. Long-term tillage effects on atrazine and fluometuron sorption in Coastal Plain soils. Agric. Ecosys. Environ. 60:165-173.
Potter, K.N., and F.W. Chichester. 1993. Physical and chemical properties of a Vertisol with continuous controlled-traffic, no-till management. Trans. ASAE 36:95-99.
Potter, K.N., H.A. Torbert, O.R. Jones, J.E. Matocha, J.E. Morrison, Jr., and P.W. Unger. 1998. Distribution and amount of soil organic C in long-term management systems in Texas. Soil Till. Res. 47:309-321.
Reeves, D.W., and D.P. Delaney. 2002. Conservation rotations for cotton production and carbon storage. p. 344-348. *In* E. van Santen (ed.) Making Conservation Tillage Conventional: Building a Future on 25 Years of Research, Special Report No. 1, Alabama Agric. Expt. Stn., Auburn Univ.
Reicosky, D.C., W.A. Dugas, and H.A. Torbert. 1997. Tillage-induced soil carbon dioxide loss from different cropping systems. Soil Till. Res. 41:105-118.
Reicosky, D.C., D.W. Reeves, S.A. Prior, G.B. Runion, H.H. Rogers, and R.L. Raper. 1999. Effects of residue management and controlled traffic on carbon dioxide and water loss. Soil Till. Res. 52:153-165.

Rhoton, F.E. 2002. Influence of time on soil response to no-till practices. Soil Sci. Soc. Am. J. 64:700-709.

Rhoton, F.E., M.J. Shipitalo, and D.L. Lindbo. 2002. Runoff and soil loss from midwestern and southeastern US silt loam soils as affected by tillage practice and soil organic matter content. Soil Till. Res. 66:1-11.

Sainju, U.M., H.H. Schomberg, B.P. Singh, W.F. Whitehead, P.G. Tillman, and S.L. Lachnicht-Weyers. 2007. Cover crop effect on soil carbon fractions under conservation tillage cotton. Soil Till. Res. 96:205-218.

Sainju, U.M., Z.N. Senwo, E.Z. Nyakatawa, I.A. Tazisong, and K.C. Keddy. 2008. Tillage, cropping systems, and nitrogen fertilizer source effects on soil carbon sequestration and fractions. J. Environ. Qual. 37:880-888.

Sainju, U.M., B.P. Singh, and W.F. Whitehead. 2002. Long-term effects of tillage, cover crops, and nitrogen fertilization on organic carbon and nitrogen concentrations in sandy loam soils in Georgia, USA. Soil Till. Res. 63:167-179.

Sainju, U.M., B.P. Singh, W.F. Whitehead, and S. Wang. 2006. Carbon supply and storage in tilled and nontilled soils as influenced by cover crops and nitrogen fertilization. J. Environ. Qual. 35:1507-1517.

Salinas-Garcia, J.R., F.M. Hons, and J.E. Matocha. 1997. Long-term effects of tillage and fertilization on soil organic matter dynamics. Soil Sci. Soc. Am. J. 61:152-159.

Siri-Prieto, G., D.W. Reeves, and R.L. Raper. 2007. Tillage systems for a cotton-peanut rotation with winter-annual grazing: Impacts on soil carbon, nitrogen and physical properties. Soil Till. Res. 96:260-268.

Siri-Prieto, G., D.W. Reeves, J.N. Shaw, and C.C. Mitchell. 2002. Impact of conservation tillage on soil carbon in the 'Old Rotation'. p. 277-282. *In* E. van Santen (ed.) Making Conservation Tillage Conventional: Building a Future on 25 Years of Research, Special Report No. 1, Alabama Agric. Expt. Stn., Auburn Univ.

Spargo, J.T., M.M. Alley, R.F. Follett, and J.V. Wallace. 2008. Soil carbon sequestration with continuous no-till management of grain cropping systems in the Virginia coastal plain. Soil Till. Res. 100:133-140.

Terra, J.A., D.W. Reeves, J.N. Shaw, and R.L. Raper. 2005. Impacts of landscape attributes on carbon sequestration during the transition from conventional to conservation management practices on a Coastal Plain field. J. Soil Water Conserv. 60:438-446.

Torbert, H.A., S.A. Prior, and G.B. Runion. 2004. Impact of the return to cultivation on carbon (C) sequestration. J. Soil Water Conserv. 59:1-8.

Truman, C.C., D.W. Reeves, J.N. Shaw, A.C. Motta, C.H. Burmester, R.L. Raper, and E.B. Schwab. 2003. Tillage impacts on soil property, runoff, and soil loss variations from a Rhodic Paleudult under simulated rainfall. J. Soil Water Conserv. 58:258-267.

Weil, R.R., P.W. Benedetto, L.J. Sikora, and V.A. Bandel. 1988. Influence of tillage practices on phosphorus distribution and forms in three Ultisols. Agron. J. 80:503-509.

Weil, R.R., K.A. Lowell, and H.M. Shade. 1993. Effects of intensity of agronomic practices on a soil ecosystem. Am. J. Altern. Agric. 8:5-14.

Wright, A.L., and F.M. Hons. 2004. Soil aggregation and carbon and nitrogen storage under soybean cropping sequences. Soil Sci. Soc. Am. J. 68:507-513.

Wright, A.L., and F.M. Hons. 2005. Soil carbon and nitrogen storage in aggregates from different tillage and crop regimes. Soil Sci. Soc. Am. J. 69:141-147.

Zibilske, L.M., J.M. Bradford, and J.R. Smart. 2002. Conservation tillage induced changes in organic carbon, total nitrogen and available phosphorus in a semi-arid alkaline subtropical soil. Soil Till. Res. 66:153-163.

Table 1. Locations and conditions for comparing soil organic C and soil conditioning index in the southeastern USA.

Location	Soil	Management variables	Source
AL Escambia Co.	Benndale fSL	Tillage	Motta et al. (2002)
AL DeKalb Co.	Hartsells fSL	Tillage, rotation	Edwards et al. (1992), Fesha et al. (2002)
AL Henry Co.	Norfolk LS	Tillage	Siri-Prieto et al. (2007)
AL, Lee Co.	Blanton LS, Pacolet SL	Tillage, rotation, cover crop	Siri-Prieto et al. (2002), Torbert et al. (2004)
AL Limestone Co.	Decatur SiL	Tillage, rotation, manure	Feng et al. (2002), Truman et al. (2003), Sainju et al. (2008)
AL Macon Co.	Compass LS	Tillage, rotation, manure	Reicosky et al. (1999), Terra et al. (2005), Reeves and Delaney (2002)
GA Bartow Co.	Dothan SL	Tillage	Sainju et al. (2007)
GA Clarke Co.	Wehadkee L	Tillage	Groffman (1984), Beare et al. (1994), Hu et al. (1995, 1997), Hendrix et al. (1998)
GA Oconee Co.	Cecil SL	Tillage, rotation, cover crop	Franzluebbers et al. (1999, 2007), Franzluebbers and Stuedemann (2008)
GA Peach Co.	Norfolk LfS	Tillage, rotation, cover crop	Sainju et al. (2002, 2006)
GA Spalding Co.	Cecil SL	Tillage	Hu et al. (1997), Hendrix et al. (1998)
GA Tift Co.	Tifton LS	Tillage	Sainju et al. (2007)
MD Howard Co.	Delanco SiL	Tillage, fertilizer	McCarty and Meisinger (1997)
MD Prince Georges Co.	Woodstown SL	Tillage	Weil et al. (1993)
MD Queen Annes Co.	Matapeake SiL	Tillage, fertilizer	McCarty and Meisinger (1997)
MD Wicomico Co.	Mattapex SiL	Tillage	Weil et al. (1998)
MS Tate Co.	Grenada SiL	Tillage, rotation	Rhoton (2002), Rhoton et al. (2002)
NC Iredell Co.	Iredell L	Tillage, rotation	Franzluebbers and Brock (2007)
NC Wayne Co.	Altavista fSL	Tillage, rotation	Naderman et al. (2004)
SC Florence Co.	Norfolk LS	Tillage	Karlen et al. (1989), Hunt et al. (1996), Novak et al. (1996, 2007), Ding et al. (2002), Bauer et al. (2006)
TX Bell Co.	Houston Black C	Tillage, rotation	Potter and Chichester (1993), Reicosky et al. (1997), Potter et al. (1998)
TX Brazos Co.	Weswood SiCL	Tillage, rotation	Franzluebbers et al. (1994, 1995, 1998), Wright and Hons (2004, 2005), Dou and Hons (2006)
TX Hidalgo Co.	Hidalgo SCL	Tillage	Zibilske et al. (2002)
TX Nueces Co.	Orelia L	Tillage	Salinas-Garcia et al. (1997), Potter et al. (1998)
VA Richmond Co.	Altavista fSL, Pamunkey L, Emporia L	Tillage, manure	Spargo et al. (2008)

C is clay, fSL is fine sandy loam, L is loam, LfS is loamy fine sand, LS is loamy sand, SCL is sandy clay loam, SiL is silt loam, and SL is sandy loam.

EXTENSION AGENT PERSPECTIVE ON USING GOATS AND SHEEP FOR BRUSH AND GRASS CONTROL IN VIRGINIA

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ABSTRACT

The steep and forested terrain of Nelson County Virginia makes brush hogging and land clearing operations difficult for both forest landowners and people seeking to produce high value crops. Although the use of "brush goats" has had isolated success for individuals, public interest in learning about successful employment of small ruminant foragers has increased in the past ten years as people seek alternatives to either chemical weed control materials or hiring of manual labor. Small farmers are also interested in sheep and goat meat production to answer increased demand from local residents and regional ethic markets. Michael Lachance, an Extension agent working in central Virginia reports on successful use of Kiko goats in a start-up land clearing business as well as the use of sheep to control vegetation in a commercial vineyard and winery operation. The presentation includes information about ruminant based land clearing economics, successful enclosure technology, and predator control. Future work will focus on better evaluation of small ruminants for brush management on small Virginia farms and vineyards.

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THE INFLUENCE OF CATTLE GRAZING ALONE AND WITH GOATS ON FORAGE BIOMASS, BOTANICAL COMPOSITION AND BROWSE SPECIES ON RECLAIMED COAL-MINE PASTURES

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INTRODUCTION

An estimated one million acres of Appalachian land have been mined and reclaimed by coal mining operations since the Public Law 95-87, Surface Mining Control and Reclamation Act of 1977 (SMCRA) was implemented, in addition to hundreds of thousands of acres that were mined prior to its passage. SMCRA mandates that mined land be reclaimed and restored to a use capability that is equal to or better than its pre-mining condition. Although much of the land that is created by coal-mining operations is restored to a condition that is suitable for livestock grazing, these lands are sometimes abandoned from grazing use after mining. Difficulty of controlling woody vegetation is one factor that causes such sites to be abandoned, as the unmanaged land slowly succumbs to brushy, woody vegetation with little or no commercial value. Thus, lands restored by mining operations constitute an unused resource with the potential to support economic activity in a region that is suffering economically.

Reclaimed coal mined lands at the Powell River Project Research and Education Center in Wise County, Virginia, are in use as cattle pastures. When established in 1989 and 1990, the pastures at this experimental site were primarily tall fescue (*Festuca arundinacea* Schreb.), orchardgrass (*Dactylis glomerata* L.) and ladino white clover (Trifolium repens L.). For the last few years, however, the pastures have been increasingly infested with brushy vegetation including multiflora rose (*Rosa multiflora* Thunb.), brambles (*Rubu*s spp.), honeysuckle (*Lonicera japonica*), honey locust (*Gleditsia triacanthos* L.), mulberry (*Morus alba*, *Morus rubra*, *Morus negra*)**,** black locust (*Robinia pseudoacacia* L.), autumn olive (*Eleaganus umbellata* Thunb.), as well as many broadleaf weeds such as thistle (*Cirsium* spp.). These species have infested potential pasture and crop lands on coal mined landscapes throughout the Appalachian regions of Virginia and adjacent states. Several of these species are especially prone to invade pastures in the coalfield region (esp. honey locust, black locust, and autumn olive), because they are currently or have in the past been used commonly for reclamation of coal-mined sites. Due to the nature of the land and its soil, and the low economic returns to cattle grazing in this landscape, restoration of pasture vegetation on these areas using a conventional system such as the use of herbicide and re-planting is not a viable option. Low cost, environmentally safe and economically viable invasive brush control techniques are needed to maintain productive and sustainable grazing systems. The narrow margins of profit for most cattle and goat enterprises necessitate the development of methods to increase efficiency of forage use.

Different species of animals differ in grazing habits (Van Keuren and Parker, 1967), offering opportunities for complementary pasture use. For example, sheep consume forage near dung, whereas cattle often reject such forage (Brelin, 1979). Moreover, sheep graze a variety of

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weeds, even in the presence of other forages considered more desirable (Van Keuren and Parker, 1967). Sheep graze more selectively than cattle (Dudzinski and Arnold, 1973) generally preferring broadleaf plants (legumes and other forbs) and the smaller stems and leaves although they will eat large leaves and flowers (Ely, 1995). In some areas output per unit area has been greater than with single-species grazing (Bennett et al., 1970). Mixed grazing with sheep and cattle resulted in earlier weaning and increased lamb performance and body weight (Abaye et al., 1994). Advantages from mixed grazing may occur if the beneficial effects of sheep on herbage production from the mixed-stock sward cause higher levels of herbage consumption by either sheep or cattle under mixed stocking (Hodgson et al, 1987). There may be greater advantages to mixed grazing where pasture composition is more complex (Bell, 1970).

Whereas effects of mixed grazing systems has been explored experimentally with cattle and sheep, few such investigations have been conducted that utilize cattle and goats; to our knowledge, none have been conducted on mined lands. Research in North Carolina has shown that mixed grazing goats with cattle has been successful in converting brush-infested pasture into a desirable mix of grasses and legumes beneficial for cattle (Luginbuhl et al. 1996). The total animal output for mixed grazing is generally improved over single species grazing as animal performance or carrying capacity of pasture is improved. Improvement of total animal output of mixed grazing can be as high as 24% over single animal grazing.

Given that goats, unlike sheep, have dietary preferences that include woody species such as those which invade pastures in coal-mined Appalachian pastures, we conducted a study of co-grazing utilizing cattle and goats on reclaimed mine pastures at Powell River Project Research and Education Center, The study hypothesis was that cattle and goat grazing together would improve pasture utilization and pasture botanical composition to a greater degree compared with cattle grazing alone.

MATERIALS AND METHODS

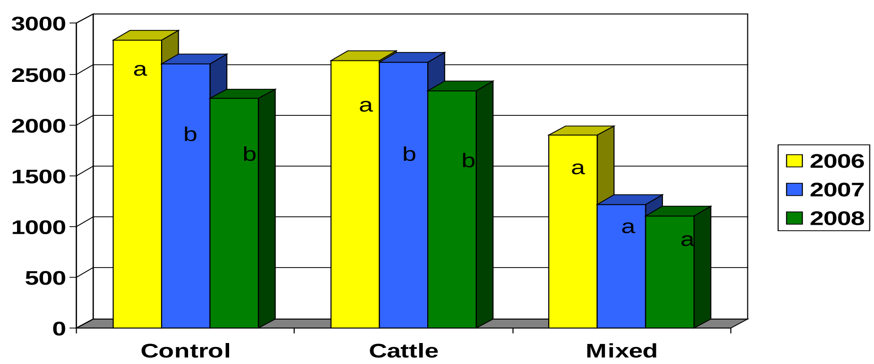
An experiment was conducted in 2006, 2007 and 2008 at the Powell River Research and Education Center near Wise, VA to determine the effects of grazing practices on forage biomass, relative plant abundance and browse species. The three treatments included an ungrazed control, cattle grazing alone, and mixed grazing goats with cattle. Experimental design was a randomized complete block with two replicates for the control and three replicates for the grazed treatments. Replicate paddocks for grazing treatment were 4.5 acres each and control replicates were 0.5 acre each. Three steers (616 lbs ac^{-1} ± 8.0 lbs SE) were allocated to each grazing treatment. The stocking rate was based on 0.6 ha $steer^{-1}$. The mixed grazing treatment included 15 young intact male goats (44 lbs ac^{-1} ± 5.5 lbs SE). Animals were rotationally stocked among replicates by grazing one replicate for two weeks and then allowing 4 weeks rest for that replicate area. Water and trace minerals were provided free choice at all times.

Pastures were evaluated for forage biomass, nutritive values, species diversity and effect of grazing on browse species during spring, summer, and fall of each grazing season. Forage biomass was determined by clipping 8-2.7 ft^2 square quadrants per grazing treatment and 4-2.7 ft^2 to a 1 inch height. Samples were dried in a forced-air oven for at least 48 h. Results are presented on a dry weight basis. Prior to harvesting the forages within each quadrant, the area was visually evaluated by trained evaluators for botanical composition using the Double DAFFOR scale (Brodie, 1985). Autumn olive shrub height was measured with a clinometer from a distance of 10 m from the shrub. Branch length was measured with a tape measure from the base of the branch to the end tip. Shrub survival was measured by counting shrubs in each replicate and determining visually percent leaf-out.

RESULTS AND DISCUSSION

Forage biomass was influenced by year ($P < 0\ .01$) and season ($P < 0.1$). When compared to control and cattle alone grazing, forage availability was lower for mixed grazing over the three growing seasons (Figure 1). Each year by the end of each grazing season, forage biomass was always lower in pastures occupied by the mixed animals species compared to cattle alone or the control treatments.

Figure 1. Influence of cattle alone and mixed grazing vs. no grazing control on total forage biomass (lbs/acre) by year (values followed by same letter not significant at P = 0.05)



In 2006, initially, forage biomass was similar among treatments. By summer, forage biomass was high in control, intermediate for cattle alone grazing and lowest for mixed grazing ($P < 0.05$), reflecting effects of differences in grazing pressure exerted by the treatments. In the fall, forage biomass declined relative to summer levels for all treatments, but fall forage declined relative to spring measured values only where cattle grazed in mix with goats (Figure 2A). The seasonal forage distribution curve for control and cattle alone grazing (Figure 2A) reflected a warm-season forage distribution curve where most of the forage is produced during the summer months.

Forage biomass during the 2007 growing season was negatively impacted by the dry conditions that prevailed over much of the growing season (Figure 2B). Forage biomass was similar for control and cattle alone grazing but was lowest in mixed grazing for all sampling dates. By summer, the decline in forage biomass relative to spring levels was 42 and 61% in cattle alone and mixed grazing treatments, respectively (Figure 2B). Due to the less than optimum available forage driven by the severe drought, animals were removed from pastures much earlier than the previous year allowing some forage recovery to occur by fall. Seasonal forage biomass distribution in 2007 followed a pattern typical of a cool-season grass, highest in spring, declining in summer, and increasing in fall. The overall forage biomass was much lower than in 2008 compared to 2006 for the control and cattle treatments, but mixed grazing biomass remained relatively constant. However the seasonal forage distribution observed in 2008 was similar to 2006. This reflects the dominance of the warm-season species (in this case mostly sericea lespedeza), especially in the ungrazed control, which responded to the resumed summer rainfall; and continued grazing pressure in the mixed grazing treatment.

Forage biomass in the mixed grazing treatment declined throughout both 2006 and 2008, and in 2007 prior to animal removal due to drought conditions, in mixed grazing treatment, demonstrating that forages were being fully utilized by the grazing animals, but standing biomass recovered by spring in both 2007 and 2008.

The weed component of forage standing biomass, comprised primarily of sericea lespedeza, declined throughout all three years, and over the prior to animal removal in 2007, in the mixed grazing treatment; this decline was evident as both kg/ha quantity and as proportionate share; in contrast, the weed component of forage increased from spring through fall in all three years for both the cattle-alone and ungrazed treatments, but with summer peaks for non-drought years,. This finding demonstrates the favorable effects of the goats on animal utilization of this forage component. However, in the mixed grazing treatment, legumes and grasses standing biomass quantities also demonstrated declining trends over the full year in 2006 and 2008, and prior to animal removal in 2007; the mixed-grazing-impacted decline in standing biomass was especially significant for the legumes, leaving grasses as the primary forage component (>70% grass) of the forage mix in the mixed-grazed pastures at the conclusion of each grazing season (data not shown).

In terms of the relative abundance of species, grazing treatment resulted in a shift in botanical composition that is more desirable by both animal species than the control treatment. When compared to an ungrazed control, both cattle alone and mixed grazed treatments resulted in an increase in persistence of grass species, such as tall fescue, orchardgrass, and bluegrass (data not shown). At the end of the two year experiment, white and red clovers disappeared from the control but although not in a great abundance remained part of the pasture component in the grazed treatments. Sericea lespedeza became a dominant weed in the control treatment mostly due to the lack of grazing pressure. The high grazing preference of goats for sericea lespedeza and of other weeds influenced the morphological characteristics of these plants. The growth pattern of sericea lespedeza was changed from an erect, woody, less leafy plant to a shorter, more palatable, and leafier plant due to goat grazing. The shorter and leafier sericea lespedeza was more acceptable and thus was readily grazed by cattle (Figure 3).

Figure 2. Influence of cattle alone and mixed grazing vs. no grazing control on total forage biomass 9lbs/acre) for the years 2006-2008. (values followed by same letter not significant at P = 0.05).

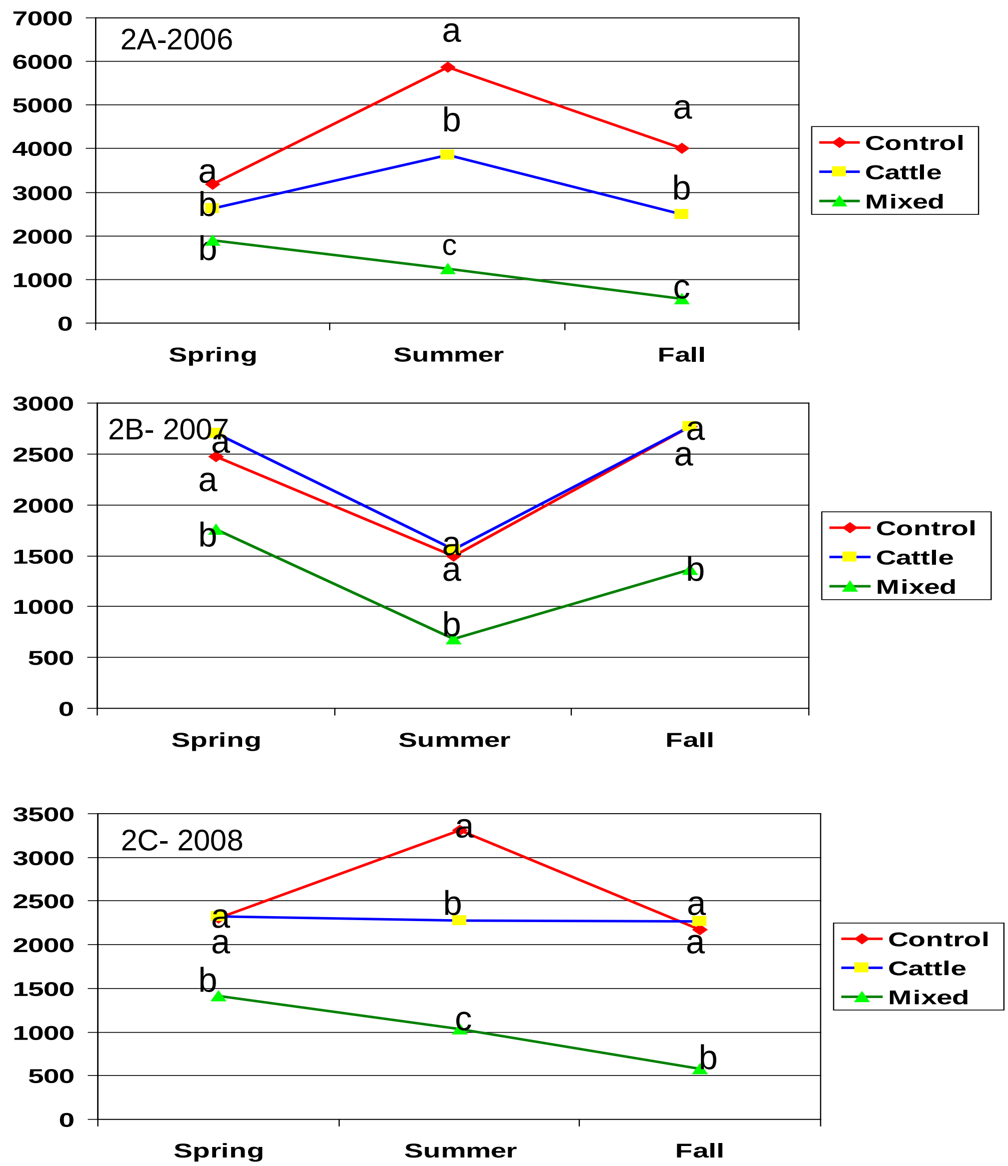


Figure 3. Effect of cattle grazing with goats vs cattle grazing alone on botanical composition of Sericea lespedeza.

Goat browsing had negative impact on autumn olive branch length and shrub height. In 2006 and 2008, branch length was negatively impacted by goat browsing but not in 2007, which was an excessive drought year. There was a decline of autumn olive shrub height in 2008 that may be attributed to reduced vigor caused by defoliation, bark-stripping, and girdling by the goats over the prior two growing seasons. Standing on their hind legs and placing their weight on branches resulted in the development of a browse line, broken, and dead branches (Webb and others 2009). Despite these severe and excessive browsings (Figure 4), autumn olive illustrated a degree of resiliency. After hard browsing and branch death, the shrub would occasionally produce numerous suckers from the base of the plant. This lush growth was highly preferred and accessible to goats (data not shown).

Figure 4. Goats browsing autumn olive, 2007

CONCLUSION

Incorporating goats into existing cattle operations in the Appalachian region may serve as a possible biological control for invasive plant species. Goats prefer browsing shrub species over grazing and foraging, and are well adapted to grazing on steep lands. They tolerate plant species that contain bitter compounds, such as tannins, that are unpalatable to cattle. Both sericea lespedeza and autumn olive, non-native invasive species that were present in the pastures used for this experiment, contain such compounds. The mixed grazing of goats with cattle is possible as each species selects for their preferred diet and competition between species for conventional forages is minimal. Overall, mixed grazing of goats with cattle can have positive influences on botanical composition and invasive plant species control on reclaimed coal-mined lands in the Appalachian region.

REFERENCES

Abaye, O. A. 1991. Influence of grazing sheep and cattle together and separately on soils, plants, and animals. Ph.D. Diss. Virginia Polytechnic Instit. State Univ. Blacksburg. Diss. Abst. 53:1114-B.

Abaye, O. A., V. G. Allen, and J. P. Fontenot. 1994. Influence of grazing cattle and sheep together and separately on animal performance and forage quality. J. Anim. Sci. 72:1013-1022.

Bell, R. H. V. 1970. The use of the herb layer by grazing ungulates in the Serengeti. In: A. Watson (ed.). Animal populations in relation to their food resources. Proc. Symp. British Ecological Society, Aberdeen. Blackwell, Oxford. pp. 111-124.

Bennett, D.., F. H. W. Morley, K. W. Clarke, and M. L. Dudzinski. 1970. The effect of grazing cattle and sheep together. Aust. J. Exp. Agric. Anim.. Husb. 10:696-702.

Brelin, B. 1979. Mixed grazing with sheep and cattle compared with single grazing. Swed. J. Agric. Res. 9:113-116

Brodie, J. 1985. Vegetation analysis. p. 7-9. *In*: Grassland studies. George Allen & Unwin, Boston.

Dudzinski, M. L., and G. W. Arnold. 1973. Comparisons of diets of sheep and cattle grazing together on sown pastures on the southern tablelands of New South Wales by principal components analysis. Aust. J. Agric. Res. 24:899-912.

Ely, D. G. 1995. Forage for sheep, goats, and rabbits. In: R. F Barnes, D. A. Miller, and C. J. Nelson (ed) Forages. Vol I. The Science of Grassland Agriculture. Iowa State Univ. Press, Ames.

Hodgson, J., J. C. Arosteguy, and T. D. A. Forbes. 1987. Mixed grazing by sheep and cattle: Effects of herbage production and use. p. 65-71.Grazing-lands research at the plant animal interface. Proceedings of a special session. Winrock International.

Hughes, H. D., M. E. Heath, and D. S. Metcalfe (ed). 1962. Forages: The Science of Grassland Agriculture. Rev. 2nd Ed. Iowa State Univ. Press, Ames. p 685.

Luginbuhl, J. M., J.T. Green, J. P. Mueller and M. Poore. 1996. Meat Goats in Land and Forage Management. Proceedings of the Southeast Regional Meat Goat Production Symposium "Meat Goat Production in Southeast – Today and Tomorrow" February 21-24, 1996. Florida A&M University, Tallasassee.

Van Keuren, R. W., and C. F. Parker, 1967. Better pasture utilization grazing sheep and cattle together. Ohio Report 57:12-17.

Webb, D.M. 2008. Assessing the potential of mixed grazing goats with beef cattle to improve animal performance and increase the utilization of marginal pasturelands in Appalachian coal region. Master's thesis. Virginia Polytechnic and State Univ. Blacksburg, VA.

Webb D.M., O. Abaye, C.Teutsch, J. Luginbuhl, G. Scaglia, and C. Zipper. 2009. Effects of mixed grazing goats with cattle on forage biomass, botanical composition, and browse species on reclaimed pastures in the Appalachian coal region. Manuscript in prep for Journal of Agroforestry Systems.

IMPROVING CROP PRODUCTIVITY USING RAISED BEDS IN NORTHEAST OKLAHOMA

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ABSTRACT

Nearly level, poorly drained soils are common in Northeast Oklahoma. Subsurface drainage of these soils is not practical because they are generally comprised of silty clay surface soils and clay textured subsoil. A series of field trials were initiated to evaluate the impact of planting corn, wheat, canola, and soybeans on raised beds. The beds were constructed with a disk bedder to provide beds on 30 inch spacing. Preliminary data suggest that planting on raised beds will provide protection against water logging during prolonged periods of spring rain. In addition, crops grown on raised beds do not appear to be adversely susceptible to drought conditions. Continued efforts will focus on the persistence of the bed and using them within a conservation tillage system.

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TEFF: WHAT DO WE KNOW AND WHAT DO WE NEED TO KNOW?

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INTRODUCTION

Having warm-season grasses in a forage system could save producers money because less hay would be fed during the hottest part of summer. The main benefit is that warm-season annual grasses are most productive during hot weather and can provide badly needed forage during times of water deficit. Teff (*Erogrostis tef* (Zucc.)) is an annual warm-season grass from Ethiopia, that has potential to help fulfill this need. Teff has several advantages that make it a viable alternative over other summer annual forages, including its ability to thrive both in moisture-stressed and waterlogged soils, and its lack of anti-quality compounds as found in sorghum-related annuals (Ketema, 1997, Ketema, et al., 1993). Teff is a bunch type grass (Figure 1). Despite its small seed size (Figure 1), it germinates within 3-5 days and is an aggressive competitor once established (Figure 3). In its native habitat, maximum production of Teff occurs with a growing season rainfall of 11 to 22 inches and a temperature range of 50 to 85°F. During extremely dry summers such as 2007, a crop such as Teff might make the difference between financial success or disaster.

Producer demand for suitable warm-season annual forages will likely grow in the future as our climate warms and droughts may become more common. Increased surface temperatures (IPCC, 2001) will almost certainly influence regional precipitation patterns (Jackson et al., 2001). Many climate change prediction models suggest that periodic droughts will become more common and extreme rainfall events more frequent (Frederick and Major, 1997). A combination of increased dry periods interspersed with larger individual rainfall events will result in extended periods of soil moisture deficit and greater variability in soil water content (Jackson et al., 2001). Climate change in the coming decades may well require a shift from a cool-season forage base (that requires high moisture and soil fertility) to forages that use resources more efficiently and that can be grown in a wide array of soils. Although Teff has great potential for grazing and hay production (Fig. 4), more information is needed about its cultural practice, establishment and overall management.

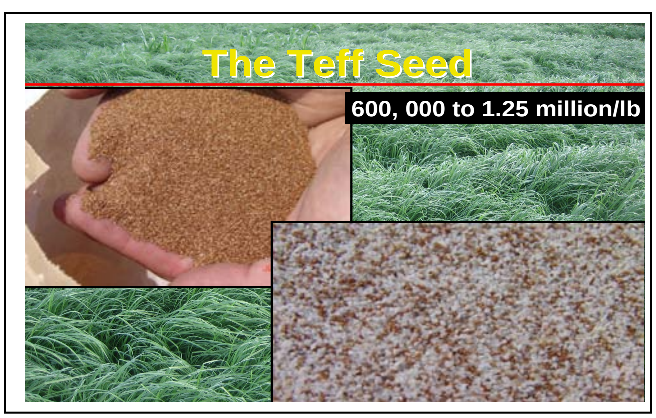

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Figure 2. The Teff plant has a bunch type of growth habit

Figure 3. Teff 28 days after planting. (Blacksburg, Virginia – June, 2008).

Figure 4. Animals grazing Teff (Willow Bend , West Virginia, 2007). Teff hayed in the background

RESEARCH UPDATE

In 2008, various Teff experiments were conducted at Kentland farm near Blacksburg, VA, to determine effects of cutting height, planting date and fertilization on biomass yield and nutritive value of Teff. Tiffany Teff was established on May 23rd and harvested on June 30th, August 10th and September 26th at the cutting heights of 2, 4 and 6 inches from the ground. A second experiment was also established on May 23rd to determine the effect of nitrogen fertilization and planting date on biomass yield and nutritive value.

Effect of cutting height on biomass yield

The effect of cutting height on biomass yield was obvious. At the initial harvest, yields from plots harvested at the 2 inch height exceeded the yields from plots harvested at the 4 and 6 inch heights (Figure 5). However, in subsequent harvests, Teff cut at 2 inch and 6 inch heights yielded sharply less forage than Teff cut at the 4 inch height. The influence of cutting height on yield was more pronounced for the second and third cutting dates (August and September) compared to the first (June

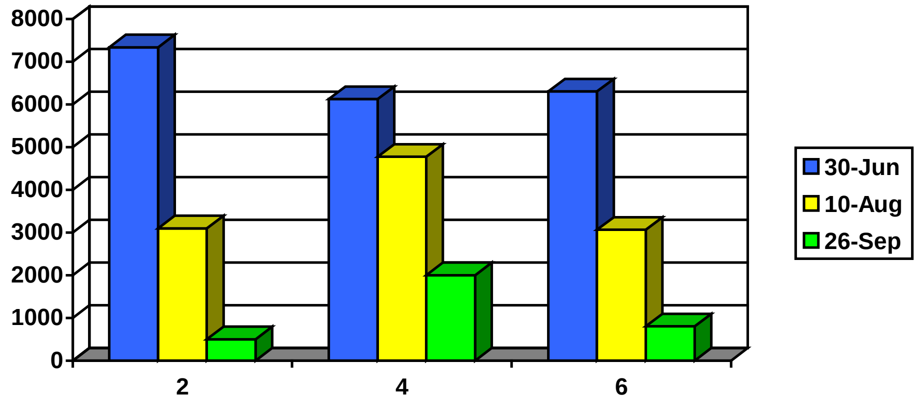


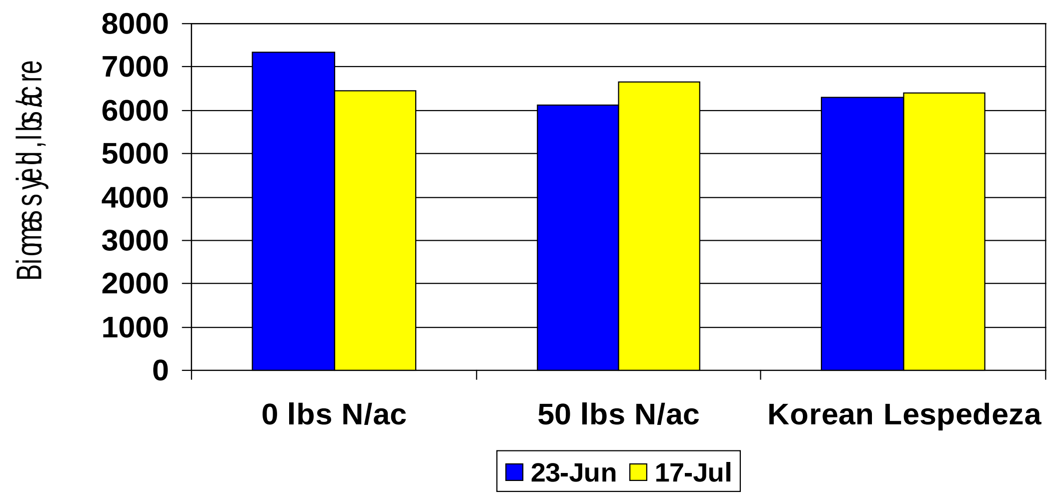
Figure 5. Effect of cutting height on biomass yield of Teff planted May 23 and harvested on June 30, August 10, and September the 26.

The effect planting dates and nitrogen fertilization on the developmental stages of Teff

There was no difference in biomass yield at first harvest between Teff planted in June vs July (Figure 6). Similarly, there was no nitrogen effect on the biomass yield of Teff. The Korean lespedeza that was planted with Teff, established successfully, although this legume was not expected to have impacted the nitrogen status of the plots by the time of the first harvest. Teff planted in June reached maturity and headed out in 38 days vs Teff planted in July (45 days). The 1st planting date, potentially would result in an earlier first harvest and more subsequent harvests, which translates into overall more yield for the grower. There was no effect of nitrogen fertilization on nutritive value of Teff. However, crude protein (Figure 7) and fiber content (data not shown) of Teff was affected by plant maturity. As the plant progressed from 3-leaf stage to late boot/head stages, crude protein declined (25-15%) while fiber increased.

CONCLUSION

The results of our experiments showed that Teff re-growth is affected by cutting height. The 2 inch cutting height initially resulted in higher biomass but subsequent yield and stand density was compromised. Based on our first year results, and previous work, the 4 inch cutting height will result in a favorable yield without affecting subsequent harvests and stand density. Teff reached its final stage in 38 and 45 days for June and July planting dates, respectively. The 1st planting date should result in multiple subsequent harvests and overall more biomass yield. Including summer annual grasses such as Teff increases crop diversity in farming systems and makes them more resilient to environmental stresses and more sustainable in the long-run.



Treatment 1 = Teff + 0 lbs N acN
Treatment 2 = Teff + 50 lbs N ac
Treatment 3 = Teff + Korean lespedeza

Figure 6. Effect of nitrogen treatments and planting date on the biomass yield on Teff - 2008

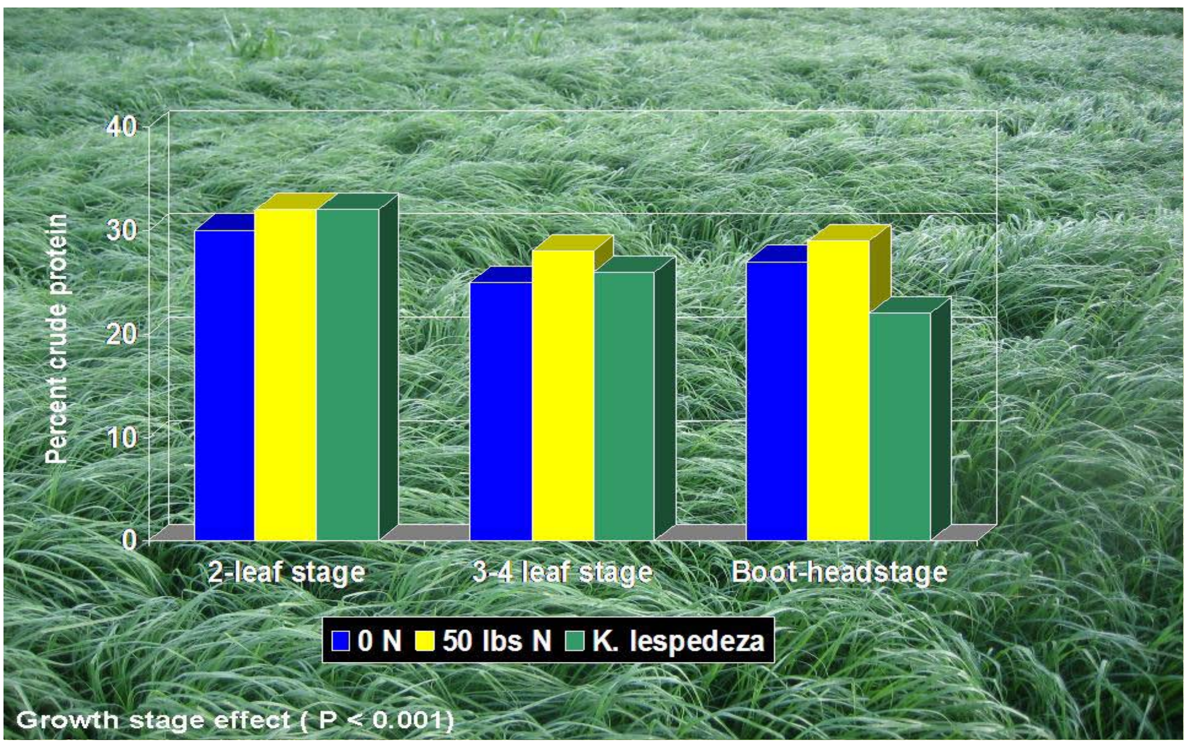


Figure 7. Effect of growth stages and nitrogen fertilization on percent crude protein - 2008

REFERENCES

Frederick, K.D, and DC Major 1997. Climatic Change, . Kluwer Academic Publishers. Printed in the Netherlands. 37: 7-23

Intergovernmental Panel on Climate Changes (IPCC). 2001. The Science of Climate Change. Cambridge University Press.

Jackson, R.B, S.R Carpenter, C.N Dahm, D.M McKnight, R.J Naiman, S.L Postel, and S.W Running. *2001*. Water in a changing world. Ecological Applications 11:1027-1045.

Ketema, S. 1993. Teff (*Eragrostis tef*): breeding, genetics, resources, agronomy utilization and role in Ethiopian agriculture. Institute of Agricultural Research, Addis Abeba, Ethiopia.

Ketema, S. 1997. Teff *Eragrostis tef* (Zucc.) Trotter. Promoting the conservation and use of underutilized and neglected crops. 12. Institute of Plant Genetics and Crop Plant Research, Gatersleben/International Plant Genetic Resources Institute, Rome, Italy.

EFFECTS OF THREE TILLAGE SYSTEMS ON WHEAT YIELD AND DOUBLE CROP SOYBEAN YIELD

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INTRODUCTION

Increasingly southeast Virginia farmers are limiting tillage to build up soil organic matter and decrease erosion. Slagle, a fine, sandy loam soil common in this area, is an excellent productive soil. However these sandy soils are prone to developing hardpans from discing and vehicular traffic during the growing and harvest season (Busscher et al., 1986). These hardpans limit root growth and thereby the acquisition of moisture and nutrients by the plant. Subsoiling has been investigated as a technique to break up the hardpan while limiting disturbance to the soil surface. Busscher and coworkers (2006) demonstrated an increase in wheat yield in subsoiled plots when compared to non deep tilled. Also corn yields were greater after subsoiling when compared to no tillage or slit tillage (Busscher et al., 1995). The objective of this research trial was to determine the effect of deep tillage, compared to no tillage and traditional discing and planting on wheat yields and subsequent double crop soybean yields in a sandy loam field determined to have a hardpan.

MATERIALS AND METHODS

Following cotton harvest, stalks were mowed and three tillage treatments were employed. Each treatment was replicated four times in a randomized complete block design. Treatment 1 (TRT 1) consisted of traditional discing, followed by drilling wheat on 7 inch rows. Treatment 2 (TRT 2) was drilled wheat with no additional tillage. Treatment 3 (TRT 3) included ripping 36 inch on center (between previously ripped cotton rows) followed by drilled wheat, on 7 inch rows. Wheat was harvested and yield, test weight and moisture were determined. Soybeans were no-till drilled in 7-inch rows in the same treatment plots as the wheat. At harvest soybean yield and moisture were measured. There was a significant wheat yield increase for TRT 3 when compared to TRT 1 and TRT 2. There was no difference between TRT 1 and TRT 2. TRT 3 also produced a significant yield increase in double-cropped soybeans when compared to TRT 2.

A Slagle fine sandy loam field was tested using a penetrometer and found to have a uniform hardpan at a 6-8 inch depth. Following cotton harvest, three treatments were replicated four times across the field in 30 foot by approximately 500 foot plots. The first treatment consisted of discing the plots. There was no tillage prior to drilling wheat in Treatment 2. Treatment 3 consisted of ripping to a depth of 12 inches, 36 inch on center between cotton rows ripped at planting. All three treatments were followed by drilling wheat in 7.5 inch rows at a 1.5 inch depth with 22 seeds per foot. Fertilization and pest management followed Virginia Cooperative Extension recommendations and were applied the same across all treatments. A 22 foot swath of wheat was harvested from the center of each plot, weighed, moisture tested and yield per acre calculated. Soybeans were no-till drilled into wheat stubble. Once again, seeding rate, fertilization and pest management were the same across treatments. Soybeans were

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harvested from a 20 foot swath in the center of each plot, weighed, moisture tested, and yield determined. Treatment effect was compared for yields of wheat and soybean using analysis of variance (SAS; Cary NC) followed by multiple comparisons between means.

RESULTS

There was a significant wheat yield increase with deep tillage when compared to traditional discing and no tillage. There was no difference between traditional discing and no tillage. Deep tillage also produced a significant yield increase in double-cropped soybeans when compared to no tillage.

Table 1. Effect of three tillage types on wheat yields.

TREATMENT	YIELD (BU/ACRE)
Traditional discing	99.87[a]
No tillage	98.33[a]
Deep tillage (ripped)	104.08[b]

Treatments with different letters indicate a statistically significant difference in yield ($P < .05$).

Table 2. Effect of three tillage types on soybean yields.

TREATMENT	YIELD (BU/ACRE)
Traditional discing	44.00[ab]
No tillage	42.75[a]
Deep tillage (ripped)	44.45[b]

Treatment with different letters indicate a statistically significant difference in yield ($P< .05$)

CONCLUSION

Deep tillage increased wheat and soybean yields in a continuous no till field affected by hardpan. However there was no difference in double crop soybean yields between deep tillage and discing prior to drilling wheat. Coventry and coworkers (1987) demonstrated that deep ripping increased the amount of root growth and decreased the negative impact of the hardpan on the depth of root growth. They found that wheat yield was increased by deep ripping during a drought year. Rainfall was not a limiting factor in crop production in the year this trial was performed. While differences in yield were evidenced it is likely those differences would be amplified in a drier growing season. Deep tillage may be a valuable tool to increase production in continuous no till fields with uniform hardpan.

REFERENCES

Busscher, W.J., P.J. Bauer, J.R.Frederick. 2006. Deep tillage management for high strength southeastern USA Coastal Plain soils. *Soil and Tillage Res*. 85:178-185

Busscher, W.J., P.J. Bauer, J. R. Frederick. 2002. Recompaction of coastal loamy sand after deep tillage as a function of subsequent cumulative rainfall. *Soil Till Res.* 68:49-57.

Busscher, W.J., J.H. Edwards, M.J. Vepraskas, D.L. Karlen. 1995. Residual effects of slit tillage and subsoiling in a hardpan soil. *Soil and Tillage Research* 35:115-123.

Coventry, D.R., T.G. Reeves, H.D. Brooke, A. Ellington, W. J. Slattery. 1987. Increasing wheat yields in north-eastern Victoria by liming and deep ripping. *Am. J. Exp. Agric.* 27:679-685.

TRANSITIONING TO ORGANIC GRAIN PRODUCTION: CAN CONSERVATION TILLAGE PRACTICES BE EFFECTIVE?

Alan Meijer

ABSTRACT

Organic grain production is increasing in North Carolina, where NC State University researchers are teaming to discover effective ways of managing organic crops, and helping growers transition into this relatively new sector of the agricultural economy. Unfortunately, many organic weed control practices rely heavily on tillage/cultivation. This presents problems for growers who have been partial to conservation tillage methods over the years. Conservation tillage has allowed these growers to keep their soil in place, preventing sandblasting, improve their drainage, and save the time, labor, fuel, and equipment required by tillage. Organic growers, teamed up with research and extension from NC State have been working to develop practices that enable conservation tillage to have its place in organic grain production.

This poster will highlight some of the issues faced by growers and researchers in eastern NC in light of their transition experience, as well as the results of the various tests and trials implemented by the NC transition team.

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EVALUATING SOIL COMPACTION FOR AN ANNUAL WINTER GRAZING/VEGETABLE PRODUCTION ROTATION IN NORTH-CENTRAL ALABAMA

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ABSTRACT

Degraded soils of Alabama have demonstrated the ability to respond well to conservation tillage in a large variety of crops. However, farmers are always looking for new and better ways to increase profits as well as reduce risks. Winter annual grazing/sod-based rotations with summer vegetable production can offer reduced economic risks for producers but may change tillage requirements for vegetable production. More information is needed to know if current conservation tillage methods are compatible with winter annual grazing vegetable rotation systems.

A 3-year field study was conducted on a Wynnville fine sandy loam, in north-central Alabama to evaluate soil compaction in vegetable production systems after winter annual grazing. In the fall, all plots were planted to ryegrass [Lolium multiflorum (L.)] and grazed from early December to mid-April at a stocking rate of 2.7 cattle per acre. After grazing, a rotation of sweet corn [*Zea mays,* (L.)], southern field pea [*Vigna unguiculata* (L.)], and watermelon [*Citrullus lanatus* (L.)] was established. All three crops were grown simultaneously in a factorial arrangement of three surface tillage treatments (chisel/disk/level, disk/level & no surface tillage) and three deep tillage treatments (no deep tillage, in-row subsoiling & paratilling) in a randomized complete block design with four replications. Soil strength measurements were taken using a tractor-mounted multiple-probe soil cone penetrometer to evaluate the level of soil compaction in all of the plots.

In-row cone index values near the soil surface peaked greater than the critical 300 psi root limiting value for the strict no-till plots (no surface/no deep tillage) in all three crops. In-row subsoiling and paratilling without surface tillage were equally effective in reducing cone index values to the tillage depth (16 in). Surface tillage (chisel/disk/level and disk/level) without deep tillage reduced the in-row cone index values at the peak (2 to 4 in) but had little effect on cone index values below this depth. In-row subsoiling had cone index values equal to or less than both the paratill and no deep tillage in the surface tillage plots (chisel/disk/level and disk/level). However, paratilling was less effective in reducing in-row soil compaction compared to the in-row subsoiling treatment in the same surface tillage plots.

Yields for all three crops responded differently to tillage treatments. Corn yields were greater with surface tillage (chisel/disk/level and disk/level) all three years compared to

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no surface tillage. Data shows that in two of the three years in-row subsoiling had greater yields than no deep tillage. Paratilling only increased corn yields in one year. Maximum corn yield was achieved with the combination of both deep tillage and surface tillage. Southern field pea yields increased with surface tillage (chisel/disk/level and disk/level) two of the three years although deep tillage had no effect. Watermelon yields were not affected by surface tillage but in two of the three years in-row subsoiling had greater yields compared to no deep tillage.

Soil compaction problems from winter annual grazing can be reduced by either surface tillage and/or deep tillage. Although field peas and corn remain a viable option, watermelon appears to be the best choice to eliminate the need for surface tillage and promote soil quality.

THE ROLE OF LONGLEAF PINE IN THE CONSERVATION FRAMEWORK OF THE SOUTHEAST UNITED STATES

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ABSTRACT

If forests are considered within the overall conservation framework of our land use in the United States, the longleaf pine ecosystem is an oft overlooked component at the landscape scale. This is changing now as biological diversity is being recognized as an important component of a balanced ecosystem. Longleaf forests currently only occupy about 3% of their former extent due to many cultural practice changes, predominantly fire exclusion. Efforts are underway to restore longleaf as a larger proportion of our forested land base to diversify the portfolio of economic, ecological, and social conservation. This paper serves to summarize the resurgence of this ecosystem, identify some hurdles in its restoration, and present some logic on its importance.

INTRODUCTION

Since the introduction of agriculture to the New World that we now know as the United States, forests have been antithetical to most systems of food-based agriculture. Yet after the Dust Bowl days of the 1930s and the Clean Water Act of 1972 there became a greater appreciation of the role trees play in ameliorating soil erosion. In the decades since those realizations the challenges of finding the correct balance and spatial arrangement of types and ages of forests, grasslands, and open lands and agriculture within the landscape has been the challenge of conservationists. Many of the forestry conservation practices "ordained" by federal agencies have defaulted to a mixture of hardwood tree species, likely due to their successional stability and reduced maintenance requirements over a long time horizon. Since cooperative conservation is now being sought, more and more the conservation of multiple resources are being considered on a given area. Here enters the longleaf pine ecosystem as it has been long-abandoned and remains the "missing link" of conservation on the landscape-scale.

Longleaf pine (Pinus palustris Mill.) is estimated to have historically covered 60 million acres (Burns and Honkala 1990), with some estimates as much as 90 million acres (Frost 1993). Spatial arrangement of land types is important for ecosystem function as well as risk mitigation (i.e., fire, storm, insect, or disease). At one scale it is desirable to group longleaf together (i.e., for woodpecker habitat continuum over time), but at other scales it is necessary to segment this ecosystem into smaller units for firebreaks and to create microsites for habitat enhancement. It is this variability inherent within the fire-dependent longleaf communities that contribute to its great value for the conservation of flora, fauna, soil, water, and other natural resource values.

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Longleaf Values

Economic

Timber is a long-term investment, and as-such, either not given too much thought, or the thinking changes several times during the crop's rotation. Currently we may be wondering about the future of markets as a large amount of our manufacturing is moving overseas and many of our wood products are being imported. However, with increasing populations and overall wealth the basic principles of supply and demand seem to indicate that there will be a wood products market, especially for high quality materials. Aside from wood products, some of these ecologically important lands are achieving great prices for their ecosystem services. So, if we are going to obligate a portion of our land to forests, we might as well aim to optimize its overall return by growing trees that have a good chance of finding a market in the future rather than an unproductive thicket of invasive species.

<u>Stand Establishment and Regeneration</u>

Historically, planting bare-root has shown problems with survivability and delay caused by lack of competition control resulting in longleaf to remain too long in the grass stage. Shoulders 1989 showed longleaf survivability only at 32-63 percent compared to over 75% for other southern yellow pines. Though machine planting of bare root seedlings is viable, the planting of containerized stock by contract planting crews is currently the industry standard. This results in great success across a wider range of sites with an extended planting season (Demers and Long 2006) giving some insurance against drought (Hainds 2009). A region-wide survey in 1995 showed an 85% survival for containerized seedlings where bareroot only averaged 65%. It should be pointed out that this is highly contractor-dependent and many contractors can consistently average 90% survival with bare root depending on conditions (Georgia Forestry Commission 2009). Planting depth is critical as planting too shallow can result in moisture wicking (Sasnett et al. 1989) and too deep may cover the bud or cause inundation on wet sites. These reasons also add to containerized seedlings being favored to minimize drought problems and planting depth issues. The natural range of longleaf may have been limited to frost-heaving of seed, but this has perhaps been overcome with current planting strategies.

Early planting before January increases success (Hainds 2009). Ripping of the hardpan has been found to be beneficial, but planting directly in the ripped channel should be avoided due to excess air or water exposure. Planting adjacent to the rip is recommended as the root will find the rip as it grows. Fallowing for a year combined with herbicide site preparation, burning, and scalping is necessary if planting occurs in a recently active agricultural field. Brownspot needle blight is an associated disease, but this problem is economically alleviated with artificial regeneration of good disease-free stock.

It is crucial to control competing vegetation in a young longleaf stand, still in its grass-phase. Most other tree species sharing the longleaf habitat will outgrow these young seedlings, emphasizing their dependence on the presence of fire. On many sites it may also be necessary to remove much of the native loblolly seedlings which may seed in during the pre-canopy cover years. Longleaf typically exhibits a lack of uniformity based on differing timing from coming out of grass stage. This breaks the stand into number of crown classes reducing the need for precommercial thinning.

Establishment Costs and Incentives

At the present time, there are many avenues of financial assistance available to a landowner aspiring to establish a longleaf stand. Cost-share incentive payments from Farm Service Agency (FSA) were allocated for 250,000 acres in 2006 (Jenkins 2007). The Natural Resources Conservation Service (NRCS) provides technical and financial assistance for site preparation, establishment, and maintenance of longleaf stands. There are also funds available to states within the Southern Pine Beetle (SPB) (*Dendroctonus frontalis* Zimmerman) prevention programs (Nowak et al. 2008) and even private partnerships like the Longleaf Legacy Program (NFWF 2009) sponsored by the Southern Company which gains carbon offset credits from funding longleaf pine restoration. Many of these incentive programs pay for a proportion of site preparation, planting, and stand establishment costs helping absorb some of the expenses involved in managing this ecosystem.

Pine straw production

Pine straw can provide $100 to $500 per acre per year (Johnson 2009) which can also encourage the choice to grow longleaf pine. Straw is sold baled, by volume to contractors who collect onsite, or loose at buying stations. Yields of 50-100 bales per acre are typical (every 2 years after crown closure ~ age 15). Commercial pine straw production is most efficient where the understory is free from hardwood brush and where sufficient space available for equipment maneuvering. As straw raking precludes burning, many of the ecological benefits of this ecosystem are reduced by intensive pine straw production. Because of this, landowner objectives should be carefully considered and careful attention paid to cost-share provisions, many of which disallow straw raking during the contract period.

High-value wood products

Trees that qualify for pole timber bring much greater prices, sometimes as much as 50% more per unit volume. Since much wood is currently bought by weight, it has been noted by some that there can be as much as a 20% “premium” gained for the same volume due to the higher specific gravity of longleaf. Williston et al. (1989) showed that in one forest area of similar site and management, 63% of longleaf pines qualified as poles compared to 25% of slash and only 3% of loblolly. Less than 35% of longleaf grown on site index 60 or less qualify for poles at any age, however at site index 70 over 50% poletimber can be attained by age 40. There is also a precipitous drop over age 60, assumedly due to decay or lack of plantation-grown longleaf (Williston et al. 1989). However Williston makes clear that proper management is required for this level of results, which would likely not be met under low planting densities (< 55 square feet of basal area). This emphasizes the need to examine the cost-share parameters to make sure it is compatible with other objectives. Most of the cost-share planting densities are between 300-500 trees per acre. Recommended planting densities are decreasing under falling pulpwood and chip markets. Introduction of biomass energy could change this, but longleaf would not be well suited for this purpose.

It is historically documented that longleaf pine has better characteristics for lumber. While this may have been true with the naturally-grown trees that were the victors on poor sites over long time horizons, if longleaf is managed intensively to grow for volume, it will likely more closely resemble the wood characteristics of any rapidly grown conifer more so than its dense-ringed ancestors from which it garnered its illustrious reputation.

High-value products (poles), annual pine straw, increased wildlife, and future conservation values can all offset the extended timeframe between harvests. Cubbage & Hodges (1989) found that, under their assumptions, longer rotations for longleaf were better than shorter rotations, this would definitely be borne out where there are premiums for high-quality timber.

Risk reduction

Risks are reduced as longleaf is less susceptible to SPB (Nowak et al. 2008), fire (Franklin 1997), and hurricane damage (South Carolina 2006). Twenty year-old loblollys and longleafs growing on the same site, thinned 4 years prior to Hurricane Katrina showed remarkable evidence of this risk reduction. A startling 84% of the loblolly pines were damaged in the storm, yet only 36% of the longleaf pines were damaged. And for the longleaf pines damaged, more were just blown over or leaning rather than snapped (South Carolina 2006). This risk reduction, coupled with a longer lifespan and higher likelihood of durable solid wood products gives longleaf an advantage for longer-term carbon sequestration (Kush et al. 2004).

It is often a misconception that longleaf pines prefer poor sites with acidic, sandy soils. In fact, they are simply more apt to survive in these locations than many other tree species sharing their native range. A longleaf can thrive in fertile soils, yet the increased competition of other vegetation growing on these sites calls for a higher regime of management; mainly fire. If competition is controlled during establishment and into the height-growth stage and fire is not over-applied in the formative years, its productivity is comparable to other southern pines (Shoulders 1989).

Ecological

The diverse ecosystem of the longleaf pine sets it apart from its profuse cousin, the loblolly pine. Though it is possible for a loblolly stand on a prescribed burn regime to attain similar ecological functions as the longleaf, there are certain characteristics setting the two apart. The variations of individual longleaf specimen growth rates results in a mimicked variation of its neighboring vegetation. Certain areas of undergrowth in a longleaf stand receive more sunlight, while other areas may see a higher concentration of needle cover from a mature canopy. It is this variability, coupled with the renewing effects of fire generated from the natural fuel produced by these trees (long needles) that create such a great diversity within a longleaf stand.

Multiple-use management has long recognized that trade-offs exist and that management for one element sometimes precludes another. The unique components of a fire-dependent longleaf forest are the longer rotation, irregular stand structure, lack of dominant midstory, and greater canopy openings allowing increased grasses and forbs. Irregular thinning and cutting of irregular patches (Franklin 1997) are techniques can be used as a tool to create canopy openings as the stand matures creating an uneven-aged forest of multiple age classes.

Fire

Fire is the keystone to a functional longleaf pine ecosystem. If wildlife and ecosystem services are the primary objectives this element needs to be incorporated and will limit some of the economic gains from growth and pine straw income. Herbicide site prep and release may be used for stand establishment for fire-restricted areas, but will limit many of the fire-related benefits for wildlife and threatened and endangered species. Frequent burning and large canopy openings provide soft mast producing understory.

Though fire is a necessity for this ecosystem function, it is becoming increasingly difficult to implement in our current culture. Air quality laws, smoke and property damage liability concerns, and increasing numbers of structures and population pressures all threaten to limit the use of fire as a tool. Most states have responded by establishing legislation and training individuals to become prescribed burn managers. Some states have even formed prescribed fire strike teams to overcome the lack of service providers in this sector (America's Longleaf Initiative 2009). This will allow fires for these ecological purposes and protect the owners and agents from some of the associated risks.

Frequently managers are too timid with the intensity of burning. Scrub components will return if the burn was a little more severe than estimated, but ground cover may not return after too much midstory gets established (Landers et al. 1989). Occasional growing season burns are essential for setting back the midstory shrub species, and necessary for wiregrass seed production (Miller and Miller 1999). This can be done in patches and with ring around shrubby clumps to not disrupt ground nesting species which incorporate over 30% of the species of concern (Landers et al. 1989).

Wildlife

Twenty-seven threatened and endangered plant and animal species as well as 99 additional candidate species (Noss et al. 1995) are associated with functional longleaf pine ecosystems. Some of these species are listed in Table 1. Additionally, culturally important species, such as the northern bobwhite quail (*Colinus virginianus*) and wild turkey (*Meleagris gallopavo*) will thrive in this fire-managed community (Godbois et al. 2004).

Table 1. Sampling of Species of Concern Associated with Longleaf Pine Ecotypes.

Red-cockaded Woodpecker (*Picoides borealis*)
Gopher Tortoise (*Gopherus polyphemus*)
Bachman's Sparrow (*Aimophila aestivalis*)
Chuck-will's-widow (*Caprimulgus carolinensis*)
Red-headed Woodpecker (*Melanerpes erythrocephalus*)
Brown-headed Nuthatch (*Sitta pusilla*)
Henslow's Sparrow (*Ammodramus henslowii*)
Southeastern American Kestrel (*Falco sparverius* paulus)
Loggerhead Shrike (*Lanius ludovicianus*)
Eastern Indigo Snake(*Drymarchon corais couperi*)
Frosted Flatwoods Salamander (*Ambystoma cingulatum*)
Reticulated Flatwoods Salamander (*Ambystoma bishopi*)
Mississippi Gopher Frog (*Rana capito sevosa*)
Striped Newt (*Notophthalmus perstriatus*)
Black Pine Snake (*Pituophis melanoleucus* lodingi)
Louisiana Pine Snake (*Pituophis ruthveni*)
Southern Hognose Snake (*Heterodon simus*)
Gopher Frogs (*Rana capito Rana capito* aesopus *Rana capito* capito)
Eastern Diamond-backed Rattlesnake (*Crotalus adamanteus*)
Panama City Crayfish (*Procambarus econfinae*)
Camp Shelby Burrowing Crayfish (*Fallicambarus gordoni*)
Beautiful Pawpaw (*Deeringothamnus pulchellus*)
Rugel's Pawpaw (*Deeringothamnus rugelii*)
Chapman's Rododendron (*Rhododendron chapmanii*)
American Chaffseed (*Schwalbea americana*)
Hairy Rattleweed (*Baptisia arachnifera*)
Navasota Ladies'-tresses (*Spiranthes parksii*)
Texas-trailing phlox (*Phlox nivalis* ssp. texensis)

Although each of the species listed in Table 1 have a unique life cycle with specific needs, adequate management of a longleaf stand should simply strive to create variability using strategic harvesting times and patterns, burning, creating snags and openings, and restoring native plants. Clumps of shrubs and unscathed vegetation should be formed by exclusion areas or moist areas during burning (Franklin 1997).

Restoration of native grass such as wiregrass (*Aristida beyrichiana* Trin. & Rupr.), bluestem (*Andropogon* spp.), as well as other important grasses and native forbs such as partridge pea (*Chamaecrista fasciculata*), and lespedeza (GNPG 2008) is important for ecosystem function. Currently much of the native seed needed for longleaf restoration is unavailable or in limited supply, but work is being done to address this (America's Longleaf Initiative 2009). Legumes and chufa are encouraged for wildlife plantings Franklin (1997).

Control of invasive and colonizing species (America's Longleaf Initiative 2009) is also essential for long-term native ecosystem success. Wild hog (*Sus scrofa*) control is essential during the early regeneration years (Franklin 1997). One favorite food on which wild hogs fed voraciously during the times of early American settlement was the soft root system of young longleaf pine seedlings. These animals, introduced by the settlers, have been said to be one of the main destructors of native longleaf stock. One hog can destroy hundreds of seedlings per day. In the absence of large predators, mid-sized mammals (raccoons, fox, Mustelids, etc.) as well as deer, should be kept at desired population limits to achieve the ecosystem functions desired.

Social

Social aspects are on the push and pull of land use and conservation efforts from the federal to local levels. People desire a high quality of living and a safe environment free from air, water, noise, and blight pollution. There are sometimes conflicting objectives, such as the need for prescribed fire to promote a functional longleaf ecosystem which creates some amount of air quality degradation and some economic and safety risk. Other conflicts result from perspective values of land and public funds uses. Much of the land base in the longleaf range is increasingly being controlled by exurban, absentee owners and forest industry ownership has reverted to real estate investment trusts (REITs) and timberland investment management organizations (TIMOs). There is increasing pressure for food and fiber products to attain certification standards to assure consumers that they were grown by certain sustainability practices. Climate change is currently a critical topic that may have wide-ranging effects on agriculture and forestry as well as manufacturing and overall energy production and consumption. Ecosystem services markets may soon be integrated into a compliance framework and certain agriculture and forestry practices may earn credits. There is some understandable fear inherent in growing long rotation timber that may be host to threatened and endangered species, which has been involved in many investments being jeopardized by the Endangered Species Act in the recent past. Safe harbor agreements (America's Longleaf Initiative 2009, Miller et al. 2003) have been established in attempts to alleviate these fears while at the same time removing perverse incentives to avoid providing habitat for these rare species. Many of these social aspects are quite complex but are too ephemeral or value-laden to elaborate on in a scientific manner without presenting survey results.

CONCLUSIONS

A typical landowner will not likely be able to provide the land management attention that a staff of managers would perform on public lands. With a personal desire, coupled with technical and financial assistance from State and Federal agency professionals as well as private consultants, a landowner can make great strides in longleaf ecosystem restoration among the southeastern U.S.'s privately held lands.

Though industrial "free market" economics have borne out that longleaf pine does not produce the hassle-free economic returns of other southern yellow pine species, its addition to the biodiversity of the landscape alone is enough reason to expand its presence over more of the landscape, adding the better risk management, carbon sequestration (Kush et al. 2004), wildlife values, in addition to the core ecosystem conservation values.

REFERENCES

America's Longleaf Initiative. 2009. Range-wide Conservation Plan for Longleaf Pine. Available at: http://www.americaslongleaf.org/resources/the-conservation-plan. Last accessed: July 7, 2009.

Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 p.

Cubbage, F. and D. Hodges. 1989. The economics of managing longleaf pine. In Proceedings of the Symposium on the Management of Longleaf Pine. GTR-SO-75. 215 – 231.

Demers, C. and A. Long. 2006. Longleaf Pine Regeneration. Publication #SS-FOR-13. Florida Cooperative Extension. University of Florida. Available at: http://edis.ifas.ufl.edu/FR064. Last accessed: July 7, 2009.

Franklin, R.M. 1997. Stewardship of Longleaf Pine Forests: A Guide for Landowners. Longleaf Alliance Report No. 2. Andalusia, AL. 41p

Frost, C.C. 1993. Four centuries of changing landscape patterns in the longleaf pine ecosystem. Proceedings, Tall Timbers Fire Ecology Conference 18: 17 – 43, Tallahassee, FL: Tall Timbers.

Georgia Forestry Commission. 2009. Keys to successfully planting longleaf pine. 2p. Available at: http://www.gfc.state.ga.us/Resources/Publications/ForestManagement/KeysToSuccessfullyPlantingLongleafPine-English.pdf . Last accessed: July 7, 2009.

GNPG. 2008. Georgia Native Plant Material Guide for Longleaf Pine Understory. 61 p. Available at: http://www.plant-materials.nrcs.usda.gov/pubs/gapmcpu7898.pdf. Last Accessed: July 7, 2009.

Godbois, I.; Warren, R.; and Mike Conner. 2004. Habitat preference, diet, and scat degredation on a managed northern bobwhite plantation in southwest Georgia. In Proceedings of the Fourth Longleaf Alliance Regional Conference. 54 – 56.

Grelen, H.E. and V.L. Duvall. 1966. Common plants of longleaf pine- bluestem range. Southern Forest Exp. Sta., New Orleans, Louisiana. 96 pp., illus. (U.S. Forest Service Res. Pap. SO-23).

Sasnett, P.; Liarson, D.; and John W. Foster, Jr. 1989. Establishment of Longleaf Pine at Gulf States Paper Corporation. In Proceedings of the Symposium on the Management of Longleaf Pine. GTR-SO-75. 232 – 236.

Hainds, M. 2009. Longleaf Note #6 - Planting Longleaf Pine on Cutover Forestland. http://www.auburn.edu/academic/forestry_wildlife/longleafalliance/landowners/forestrestoration/images/longleafnote6.pdf. Last accessed: July 7, 2009.

Jenkins, Claude. 2007. Farm Service Agency Introduces New Initiative to Restore Longleaf Pine Forests. *Alabama's TREASURED Forests*. 26(1): 13 – 14.

Johnson, R. 2009. Does Longleaf Make Dollars and $ense? 2p. Available at: http://www.auburn.edu/academic/forestry_wildlife/longleafalliance/landowners/longleafeconomics/dollarandsensearticle.pdf. Last accessed: July 7, 2009.

Kush, J.S.; Meldahl, R.S., McMahon, C.K.; and W.D. Boyer. 2004. Longleaf pine: a sustainable approach for increasing terrestrial carbon in the southern United States. Envir. Man. 33(1):139 – 147.

Landers, J.L.; Byrd, N.A.; and R. Komarek. 1989. A holistic approach to managing longleaf pine communities. In Proceedings of the Symposium on the Management of Longleaf Pine. GTR-SO-75. 135 – 167.

Miller, J.H. and K.V. Miller. 1999. Forest plants of the southeast and their wildlife uses. Southern Weed Science Society. Craftmasters Printers, Incorporated Auburn, AL. 454p.

Miller, S.L.; Campbell, P.V.; and M.A. Cantrell. 2003. North Carolina sandhills red-cockaded woodpecker safe harbor HCP: current status and lessons learned. In Proceedings of the Fourth Longleaf Alliance Regional Conference. Longleaf Alliance Report No. 6. 180 p.

NFWF. 2009. Southern Company Longleaf Legacy. Available at: http://www.nfwf.org/AM/Template.cfm?Section=Charter_Programs_List&Template=/TaggedPage/TaggedPageDisplay.cfm&TPLID=60&ContentID=12314

Noss, R. F., E. T. LaRoe, and J. M. Scott. 1995. Endangered ecosystems of the United States: A preliminary assessment of loss and degradation. U.S. Department of Interior, National Biological Service, Biological Report 28, 58 pp.

Nowak, J; Asaro, C.; Klepzig, K.; and R. Billings. The Southern Pine Beetle Prevention Initiative: Working for Healthier Forests. Journal of Forestry. 106(5): 261 – 267.

Shoulders 1989. Identifying Longleaf Pine Sites. In Proceedings of the Symposium on the Management of Longleaf Pine. GTR-SO-75. 23 – 37.

South Carolina. 2006. Longleaf pine stood firm to Hurricane Katrina's winds . Available at: http://sc.gov/NewsCenter/DNR/pine.htm. Last visited July 6, 2009.

Williston, H.L.; Guthrie, J.G.; and C.A. Hood. 1989. Managing and harvesting longleaf pine for specialty products. In Proceedings of the Symposium on the Management of Longleaf Pine. GTR-SO-75. 209 – 214.

IMPACT OF SOD-BASED ROTATION ON PEANUT DISEASES USING CONSERVATION TECHNOLOGY

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ABSTRACT

Perennial grass used in rotation with peanuts using conservation tillage has shown positive impacts on peanut disease reduction as compared to conventional rotations. The onset of disease was delayed and the rate of disease increase was reduced in peanuts planted after bahia grass compared to peanuts planted after cotton in a conservation tillage system. Under drought conditions aflatoxin production was also reduced or eliminated in peanuts after bahia grass. Other parameters such as leaf area index, water potential and root biomass were improved.

INTRODUCTION

In the southeast USA, peanut, cotton and corn are predominate summer agronomic crops. The major challenges to an economically viable and sustained production system are multiple pests, infertile soils, low soil organic matter, and low soil water holding capacity. A series of studies begun in 1999 attempted to address these challenges by integration of perennial grasses, bahia grass, into the current rotation system of peanut and cotton (Katsvairo et al., 2007; Wright et al., 2007). For example, including bahiagrass in the rotation adds significantly to the soil organic and nitrogen pools as well as helps diminish nematodes and other pests normally found with annual row crops (Tsigbey, et al, 2009). Many aspects of the production system have been and are being studied. In this paper we address the impact of the rotation on peanut plant diseases.

MATERIALS AND METHODS

Experiments were conducted in field plots at the IFAS NFREC facilities in Quincy and Marianna, Florida. The general experimental design was replicated plots that consisted of bahiagrass (cv. Pensacola) rotation with peanut and a conventional cotton-peanut rotation for peanut. The cropping sequence for the bahiagrass rotation involved the growing of cotton in the first year and then followed by bahiagrass for two consecutive years and in the fourth year the plots were planted to peanut for one year (CBBP), whereas the conventional rotation consisted of growing peanut in the first year with cotton in the two subsequent years followed by peanut in the fourth year (PCCP). Each plot in the rotation cycle was split into a fungicide spray and non-sprayed sections resulting in a split-plot design. Plots received scheduled applications of irrigation water according to standard extension recommendations for peanut production in Florida. Weed and other crop management practices were done based on the Florida Cooperative Extension Services recommendations for peanut. Each sub-plot (rotation* fungicide) was 22.8m in length by 9.2 m (10 peanut rows).

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Tomato spotted wilt. Plots were surveyed by examining twenty plants within two rows at each time of assessment, and different rows were assessed at each point in time. Plants were examined at 2 m intervals within rows for TSW symptoms on leaves and scored using a modified scale of 0-3: where 0 = no visible symptoms; 1= presence of TSW symptoms on at least one leaf on the plant; 2 = symptoms on majority of leaves with moderate stunting of plant; and 3 = severe stunting of plant and associated death. This method of assessment was chosen in order to assess the progression of TSW over time. TSW incidence was determined as the number of peanut plants showing visible symptoms on the twenty plants assessed on each plot and rotation, expressed as a percentage. TSW severity index was then computed from severity ratings; [Severity Index = {Σ(Ratings for 20 plants)/20} * 100], and was used to compute the Standard Area Under the Disease Progress Curve (SAUDPC) over the period of assessment. In 2008 a trial was conducted in Quincy and Marianna where peanuts were planted after bahia grass or fallow field the middle of April and May to determine if the reduced TSW pressure would allow for farmers to return to their traditional earlier planting.

Southern Stem Rot: In 2003 southern stem rot occurred in the plots. SSR incidence was assessed by examining twenty plants for signs of the pathogen, *Sclerotium rolfsii*

Peanut Leaf Spots: Early leaf spot (ELS) and late leaf spot (LLS) were assessed in all four years using the Florida 1 -10 scale (where 1 = no leaf spot; 2 = very few spots on leaves with none on upper canopy leaves; 3 = few lesions on the leaves, very few on upper canopy; 4 = some lesions with more on the upper canopy, 5 % defoliation; 5 = lesions noticeable on upper canopy, 20% defoliation; 6 = lesions numerous and very evident on upper canopy, 50 % defoliation; 7 = lesions numerous on upper canopy, 75 % defoliation; 8 = upper canopy covered with lesions, 90 % defoliation; 9 = very few leaves remaining and those covered with lesions, 98 % defoliation; and 10 = plants completely defoliated and killed by leaf spot). Twenty plants were randomly scored in all plots. Disease severity data were analyzed separately for each year for the non-fungicide sprayed plots, and area under the disease progress curve (SAUDPC) was computed. Disease assessments were converted into proportions [y = (Florida rating – 1) / 9], and transformed using the linearizing transformation for the logistic model, which consistently had the highest R^2 value. Effects of rotation on SAUDPC and r were determined for each rotation and year separately.

Root Knot Nematode: Plant-parasitic nematode population densities were monitored at peanut harvest in October of each year by randomly collecting 10 soil cores (2.5-cm-diam) to 20 cm deep and in-row from each plot. The 10 soil cores were combined, mixed well, and nematodes were extracted from a 100 cm^3 sub-sample from each plot by centrifugal flotation. Nematodes were counted under a stereo-microscope using a 2 mm gridded (60 x15 mm) Petri dish Corning® (Corning, New York). Identification of nematodes to species was done at the Florida Department of Agriculture Division of Plant Industry.

RESULTS

Epidemics of TSW. Although TSW epidemics varied each year, the incidence (Fig. 1) and severity (Fig. 2) were consistently and significantly greater in the PCCP rotation than in the CBBP rotation regardless of which variety was planted (Table 1).

Table 1. Effect of rotations on final TSW incidence and SAUDPC, on peanut in Quincy in 2003-2006.

Year	Variety/Rotation[a]	Final TSW incidence (%)[b]	SAUDPC[c]
2003	Georgia Green		
	CBBP	16.9	10.7
	PCCP	21.3	28.5
	LSD ($P < 0.05$)	12.3	4.4
2004	Georgia Green		
	CBBP	31.7	44.5
	PCCP	71.9	103.7
	LSD ($P < 0.05$)	13.7	43.7
2005	Georgia Green		
	CBBP	30.8	59.6
	PCCP	59.2	121.1
	LSD ($P < 0.05$)	18.6	29.2
2006	Georgia Green		
	CBBP	22.5	33.6
	PCCP	53.1	90.1
	LSD ($P < 0.05$)	7.1	30.4

[a] CBBP = Cotton followed by two years of bahiagrass then peanut and PCCP = Peanut followed by two years of cotton then peanut.

[b] Incidence represents the proportion of twenty plants assessed for TSW symptoms on a scale of 0-3: where 0 = no visible symptoms; 1= presence of TSW symptoms on at least one leaf on the plant; 2 = symptoms on majority of leaves with moderate stunting of plant; and 3 = severe stunting of plant, and associated death. Means in the same column for the same year with the same letter do not differ at 5% level.

[c] Standardized area under the disease progress curve throughout the assessment period. Means in the same column for the same year with the same letter do not differ at 5% level.

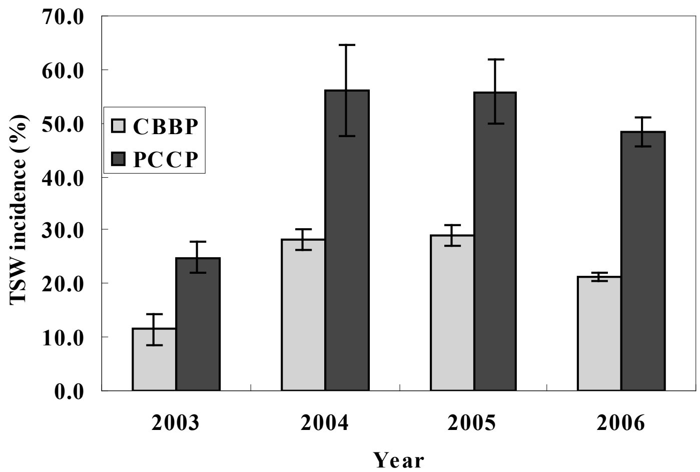

Figure. 1. Effect of rotations on the average incidence of TSW on peanut. From a minimum of 4 assessment dates within a cropping cycle. CBBP = Cotton followed by two years of bahiagrass then peanut. PCCP = Peanut followed by two years of cotton then peanut

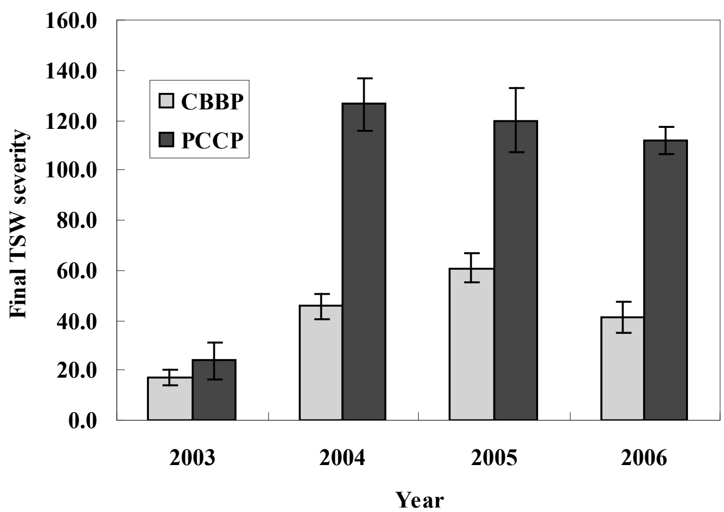

Figure 2. Effect of rotations on the final TSW severity on peanut. CBBP = Cotton followed by two years of bahiagrass then peanut. PCCP = Peanut followed by two years of cotton then peanut.

Southern Stem Rot: SSR was severe only in 2003. However, there was a significant reduction in disease in the bahia grass rotations (Fig. 3). This was consistent with previous studies on the ability of bahiagrass to suppress peanut SSR (Johnson et al., 1999; Brenneman et al., 1995). Incidence of SSR was significantly lower on the CBBP than the PCCP rotation for most part of the season, and the fluctuations was attributed to changing weather during the growth period. The sharp decline in incidence between 75 and 100 DAP was attributed to pronounced dry period. However, the improved leaf retention by peanut in the CBBP rotation 100 DAP produced a conducive microclimate for survival of *S. rolfsii* even though there was a dry period, thus resulting in the slightly higher incidence on the CBBP rotation. Pathogen signs on peanut in the field under the CBBP rotation were atypical for SSR, as they showed signs of degeneration.

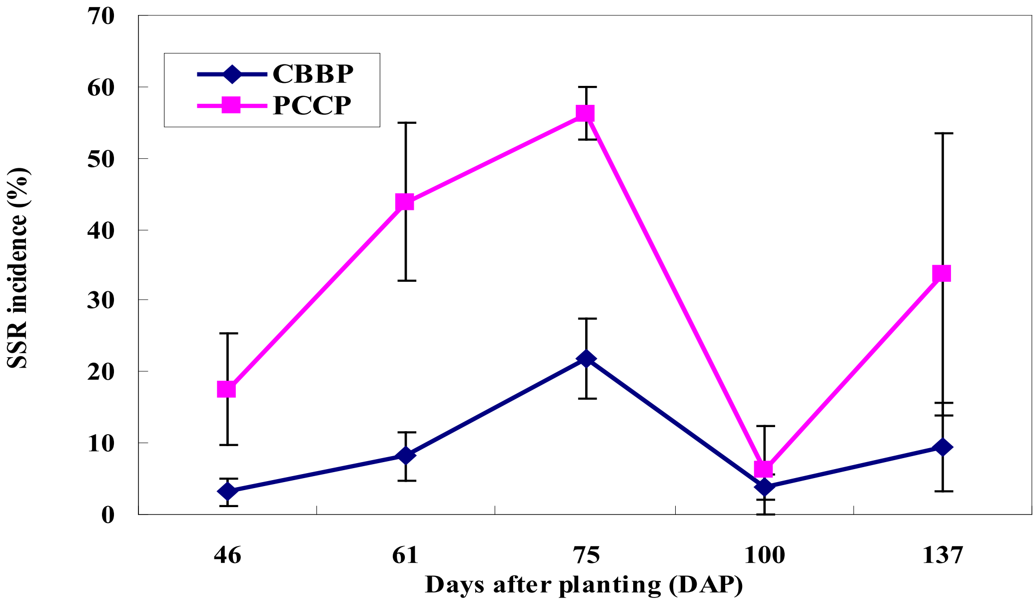

Figure 3. Effect of bahiagrass (CBBP) and conventional (PCCP) rotation on the incidence of southern stem rot (SSR) in Quincy, FL during 2003. Incidence represents the percentage number of plants out of 20 showing pathogen signs. Data represents means of 8 and 4 replications. Standard error bars are displayed for each rotation and assessment time.

Peanut Leaf Spot: Two years of a bahiagrass rotation (CBBP) significantly reduced ELS and LLS when compared to the conventional (PCCP) system. The increase in disease severity over time was best described by the logistic model for each plot rotation in all years; R^2 = 0.92 and 0.91 for the PCCP an CBBP rotations, respectively. ELS in 2003 began appearing on plants barely 32 DAP (Fig. 4), and progressed gradually over time. Estimates of the apparent infection rate of epidemics (r) computed from the slope of the linearized logistic model was comparable for both rotations but slightly higher (0.024) for the PCCP than (0.019) for the CBBP rotation. Leaf spot epidemics measured by the standardized area under the disease progress curve (SAUDPC) was not significant for either rotation (Table 2). Initial infections on peanuts were found to be ELS which later were predominated by LLS which started showing three months after planting and became the predominant disease until harvest throughout the four years of the study. Since no distinctions were made during the scoring between ELS and LLS, the mean severity was a combined score for both types and hereafter referred to as leaf spots. Leaf spot assessment on Georgia Green peanut in the rotation were done 32, 46, 61, 75, 100, and 137 DAP. There was no significant difference in severity rating between the CBBP and PCCP peanuts at earlier dates of disease assessment, but thereafter was consistently significant ($P \leq 0.05$) until harvest (Fig. 4). Similarly, the proportion of plants showing higher ratings were more in the

PCCP rotation than in CBBP rotation resulting in a significantly ($P \leq 0.05$) higher proportion of disease throughout 2003. Similar to the observations in 2003, leaf spot in 2004 appeared to have started significantly earlier ($P \leq 0.05$) on the PCCP rotation compared to the CBBP rotation (Fig. 4). Except at 132 DAP, severity ratings were higher on the PCCP rotation than on the CBBP, and were significantly ($P \leq 0.05$) different until harvest. Estimates of the apparent infection rate of epidemics (r) computed from the slope of the linearized logistic model was significantly ($P \leq 0.05$) higher in 2004 than 2003 and was comparable for the PCCP and the CBBP rotation (Table 2). Leaf spot epidemics measured by the standardized area under the disease progress curve (SAUDPC) was not significant for either rotation (Table 2). There was a significantly higher disease in the PCCP rotation on the individual assessment dates.

Table 2. Effect of rotations on final severity (Florida 1-10 scale), apparent infection rate (r) and SAUDPC on peanut during 2003-2006.

Year, Variety	Rotation[a]	Final severity rating[b]	r[c]	SAUDPC[d]
2003, Georgia Green	BBP	5	0.019	72.3
	CCP	7	0.024	92.7
2004, Georgia Green	BBP	6	0.039	35.8
	CCP	8	0.04	52.6
2005, AP3	BBP	6	0.047	38.8
	CCP	7	0.05	52.6
2006, AP3	BBP	6	0.04	70.4
	CCP	8	0.044	92.5

[a] B = bahiagrass; C = cotton; P = peanut represents the yearly rotation of the crop
[b] Severity represents the proportion of twenty plants assessed
[c] Epidemic rate determined from the slope of the linearized disease progress curve
[d] Standardized area under the disease progress curve throughout the assessment period

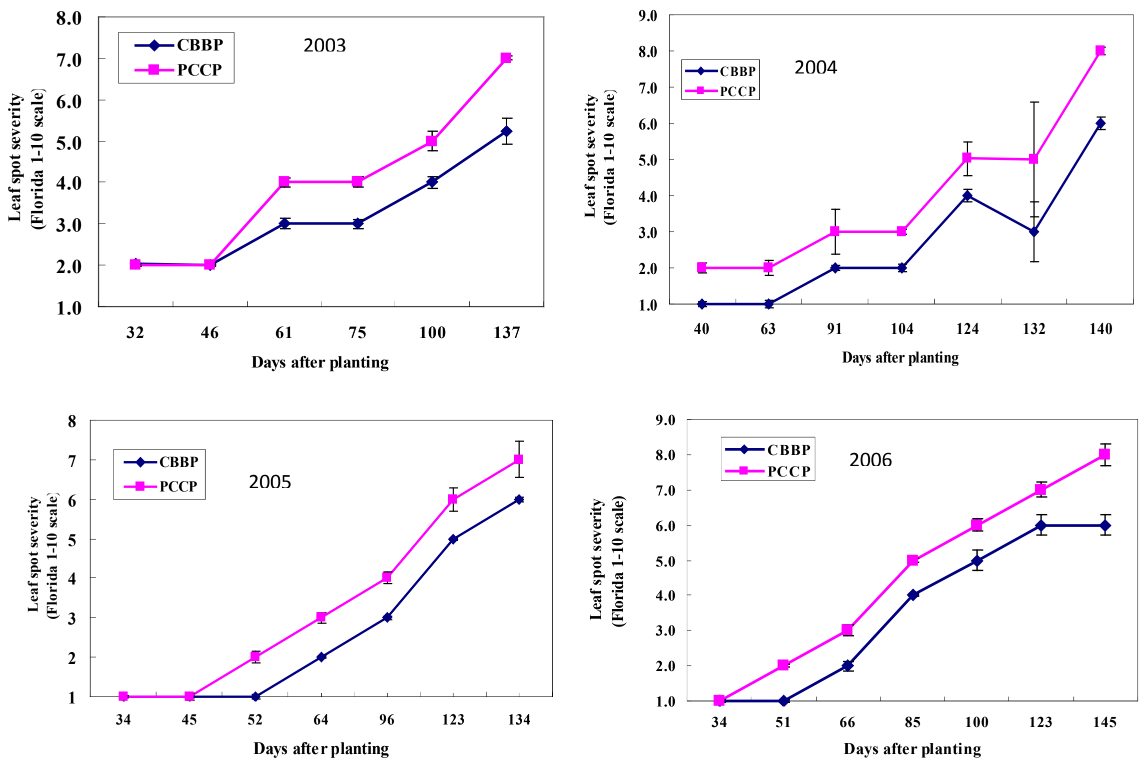

Figure. 4. Effect of bahiagrass (CBBP) and conventional (PCCP) rotation on disease progress leaf spot severity measured using the Florida 1-10 scale, over time.

Nematodes: Soil population densities of ring (*Mesocriconema ornatum*), spiral (*Helicotylenchus dihystera*), reniform (*Rotylenchulus reniformis*), and root-knot nematode (*Meloidogyne incognita* race 3) in the rotations varied from year to year. Populations of spiral, reniform, and root-knot nematodes remained consistently greater in the PCCP than in CBBP rotation soils throughout the four years. With the exception of 2004, populations of ring nematodes were significantly ($P \leq 0.05$) greater in the bahiagrass (CBBP) rotation than in the conventional (PCCP). Across the four years (2003-2006), populations of ring nematodes were greater following bahiagrass than cotton in the conventional rotation. Across the four years, both reniform and root-knot nematodes were lower in the bahiagrass rotation than in the conventional rotation.

DISCUSSION

Tomato spotted wilt: TSW incidence and severity measured by the SAUDPC on peanut was significantly suppressed by two years of bahiagrass rotation (CBBP) compared to the conventional (PCCP) rotation system over the course of four years (2003-2006). Incidence and severity of TSW varied between years but was consistently higher for the PCCP rotation than on the CBBP rotation. TSW was particularly severe in 2004 and 2005 for the PCCP rotated peanut but remained significantly less in the CBBP peanuts in those years. The lowest incidence and disease severity in both rotations was recorded in 2003. The disease was suppressed in the

CBBP rotation throughout 2003-2006 (12-32%) compared to the PCCP rotation (21-72%), with the highest severity in 2004 for both rotations. Except for 2003, when TSW incidence was high 32 DAP and suddenly dropped at 46 DAP, incidence in all other years increased more rapidly in the PCCP rotation compared to the CBBP rotation. The sudden decrease in 2003 May was due to the death and decay of highly infected plants, thus removing them from the assessment.

Peanut Leaf Spot: In this study, epidemics of peanut leaf spot were suppressed by three years of a cotton- bahiagrass rotation (BBP) when compared to a conventional two-year cotton-peanut (CCP) rotation. Under a no fungicide spray regime, the cotton-bahiagrass rotation significantly reduced the severity of leaf spots on peanut delaying disease onset when compared to the CCP system. Although leaf spot disease suppression in a bahiagrass rotation has been extensively reported, such studies involved bahiagrass plots that were either burned before planting peanut or the peanuts were sprayed with fungicide, making it difficult to estimate the actual contribution of bahiagrass rotation to leaf spot suppression since there were confounding effects due to the fungicide spray or burning. The fluctuations in disease severity across years could be attributed to weather variations among years. Rainfall and relative humidity varied greatly across and within years. The epidemic rate parameter (r) calculated from the logistic transformation was similar for both rotations. Fluctuations in leaf spot severity as a result of environmental conditions could have lowered the epidemic rate in the logistic model. The influence of rotation on leaf spot severity was most noticeable in 2006 when disease severity was high in the CCP rotation and the BBP rotations still had moderate disease. Nearly 60% defoliation occurred in the BBP in 2006 compared to nearly 90% for the CCP rotation. Since the rate of disease increase was comparable for both rotations in all four years, the impact of the rotations on leaf spot severity was mainly due to the delayed onset in the BBP rotation based on the disease progress curve.

Southern Stem Rot: Reduction of SSR observed here is consistent with previous studies on the ability of bahiagrass to suppress peanut SSR (Johnson et al., 1999; Brenneman et al., 2003). Incidence of SSR was significantly lower on the CBBP than the PCCP rotation for most part of the season, and the fluctuations was attributed to changing weather during the growth period. The sharp decline in incidence between 75 and 100 DAP was attributed to pronounced dry period. However, the improved leaf retention by peanut in the CBBP rotation 100 DAP produced a conducive microclimate for survival of *S. rolfsii* even though there was a dry period, thus resulting in the slightly higher incidence on the CBBP rotation. Pathogen signs on peanut in the field under the CBBP rotation were atypical for SSR, as they showed signs of degeneration.

Nematodes: Plant-parasitic nematode population densities were lower in the bahiagrass (CBBP) than the conventional (PCCP) rotation, particularly in relation to J2 of *M. incognita* race 3. Previous studies have demonstrated population reductions of both *M. incognita* and *M. arenaria* after bahiagrass rotation (Rodríguez-Kábana *et al*., 1994; Johnson et al., 1999; Sumner *et al*., 1999). Mechanisms of *Meloidogyne* population reduction under a bahiagrass rotation were attributed to the non-host status of bahiagrass and the possible stimulation of nematode antagonists such as *Pasteuria penetrans* (Timper *et al.*, 2001). The bahiagrass rotation did not suppress the ring (*M. xenoplax*) nematode populations, although it has previously been used to suppress populations of ring nematode in young peach orchards (Nyczepir and Bertrand, 2000). Similarly, Zehr *et al*. (1990) reported that bahiagrass did not support *M. xenoplax* population under greenhouse conditions when seedlings were inoculated with the nematode. The high population of ring nematode could not be explained from these present data.

REFERENCES

Brenneman, T. B., Summer, D. R., Baird, R. E., Burton, G. W., and Minton, N. A. 1995. Suppression of foliar and soilborne peanut diseases in bahiagrass rotations. Phytopathology 85:948-952.

Johnson, A. W., Minton, N. A., Brenneman, T. B., Burton, G. W., Culbreath, A. K.,

Gasco, G. J., and Baker, S. H. 1999. Bahiagrass, corn cotton rotations, and pesticides for managing nematode diseases, and insects on peanut. Journal of Nematolology. 31:191-200.

Katsvairo, T. W., Wright, D. L., Marois, J. J., Hartzog, D. L., and Rich, J. R. 2007. Performance of peanut and cotton in a bahiagrass cropping system. Agronomy Journal 99:1245-1251.

Tsigbey, F. K., J. R. Rich, J. J. Marois, and D. L. Wright. 2009. Effect of bahiagrass on nematode populations in the field and their behavior under greenhouse and laboratory conditions. Nematropica In Press

Wright, D.L., Marois, J.J., and Katsvario, T. W. 2007. Bahiagrass impacts on cotton in a peanut/cotton rotation. Proceedings of Beltwide Cotton Production Research Conference. National Cotton Council of America. Pp. 1770-1774.

EFFECT OF CONSERVATION SYSTEMS AND IRRIGATION ON POTENTIAL BIOENERGY CROPS

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SUMMARY

Renewable energy production in the United States should increase due to economic, environmental, and national security concerns. In the Southeastern US, annual cellulosic crops could be integrated in rotation systems to produce biofuels. An experiment conducted in South Central Alabama evaluated three sorghum varieties (1990, SS506 and NK300) and a corn hybrid (31G65) under different irrigation and tillage treatments. SS506 showed higher biomass production at 14 weeks after planting, but 1990 had higher yields after the 18th week. Irrigation affected yields positively. Tillage showed no differences in yield. Thus, a conservation system was recommended due to productivity and environmental concerns.

INTRODUCTION

Seeking alternative and renewable sources of energy is necessary due to oil price fluctuations and environmental concerns. Additionally, Central and South Alabama agriculture has been negatively affected by drought conditions over the last several years which have dramatically reduced corn production. For these reasons, sorghum may be a reasonable alternative as an energy crop in this region, because it is considered drought resistant (Habyarimana et al., 2004). Sorghum could be integrated in a conservation system as part of a crop rotation with typical cash crops (peanuts, cotton), where part of its biomass would be used as soil cover and any additional amount of biomass would be harvested for potential biofuel production. While much emphasis has been placed on perennials for biofuel production, annual crops could provide a major source of biomass for cellulosic ethanol production. These annual crops for bioenergy production have largely been ignored. Because summer days in Southeastern U.S. are extremely long, a photo-sensitive variety (1990), which needs less than 12 hours and 20 minutes of daily light to flowering, is presented as a potential alternative. Thus, this variety is described as having tall plant height from 10 to over 12 feet, good stalk strength, very high tonnage yield performance and average stalk sweetness (Sorghum Partners, 2008)

MATERIALS AND METHODS

In order to evaluate sorghum and corn biomass quantity for potential biofuel production, and to determine the effect of tillage and drought stress on sorghum and corn biomass production for different tillage management systems, an experiment was begun at the E.V. Smith Research Station, Shorter, AL (85º :53’50” W, 32º:25’22” N) in April, 2008. The soil at the experimental field was classified as fine-loamy, kaolinitic, thermic, typic Kanhapludults included in Marvyn

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series. The total field was set with rye cover (*Secale cereale L.*) before planting corn (*Zea may L.*) and sorghum (*Sorghum bicolor L.*).

Three different sorghum varieties were evaluated in this experiment; (1) grain sorghum, NK300 (GS), (2) forage sorghum, SS506 (GS), and (3) photoperiod-sensitive sorghum, 1990 (PS). Also, the hybrid corn 31G65 was included in the experiment which was classified as drought tolerant with high plant height and residue production (Pioneer, 2009).

The plots were managed with two different irrigation treatments: non-irrigated and irrigated. In the irrigated plots, water was applied in appropriate timing and amounts to provide plants with good water availability during the growing season. Additionally, two different tillage systems were applied: conservation system and conventional system. Conservation plots received in-row subsoiling 12 in. deep while conventional plots received both in-row subsoiling 12 in. deep and discing 6 in. deep.

The total number of experimental plots were 64, composed of 4 crops (GS, FS, PS and corn) x 2 irrigation treatments (non-irrigated and irrigated) x 2 tillage systems (conservation and conventional) x 4 replications. Figure 1 shows how the experiment was arranged in the field.

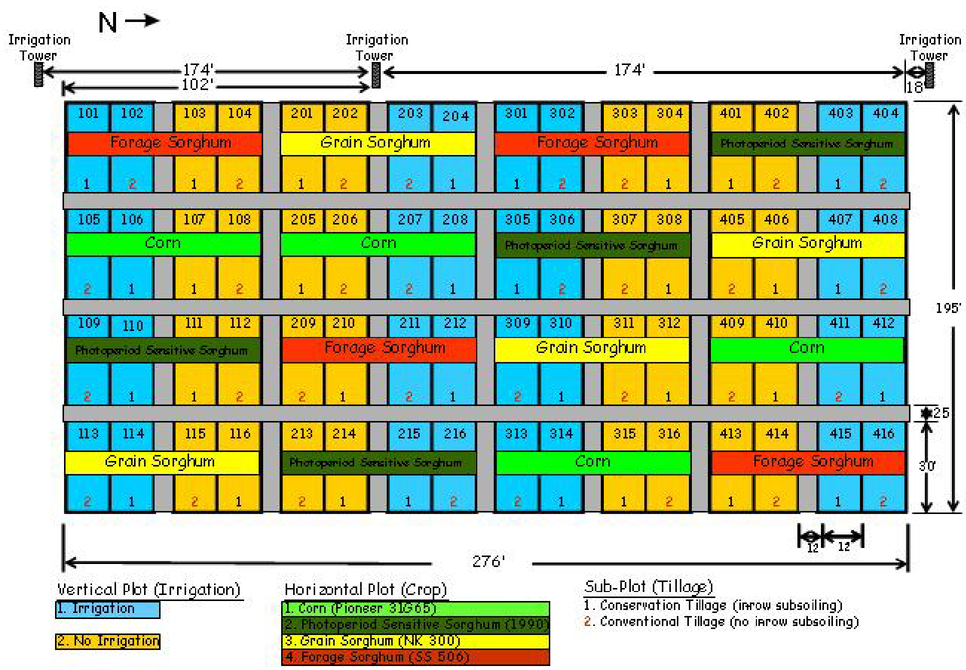

Figure 1: Experiment layout illustrating the 3 treatments arrangement at field.

Plots with the same irrigation treatment were grouped vertically, but plots under different irrigation regimes were separated by borders. Both plots and borders were 12 ft. wide and 30 ft. long, in which 4 rows were cropped 3 in. spaced. However, all samples and readings were collected from the two middle rows of each plot.

Dry aboveground biomass samples were collected during three different time periods: 14, 18, and 24 weeks after planting. Five ft. of biomass samples were harvested from each two middle rows. Corn and GS biomass samples were not collected at the 24th week, because those crops were terminated at 18 weeks after planting. The total harvested dry aboveground biomass weight of each plot was recorded. Samples for each plot were collected and dried at 55º F until constant weight to estimate dry aboveground matter.

Plant height was measured in 5 different time periods, where 2 time periods were performed early during the growing season at 6 and 9 weeks after planting and the 3 remaining time periods were performed during the dry aboveground biomass collection. Ten different plants in the two middle rows of each plot were randomly selected and measured.

Statistical analyses were performed in a strip-split-plot design with crop as horizontal plots, irrigation as vertical plots and tillage as sub-plots. The predetermined significance level was $P \leq 0.10$ and Fisher's least-significant-difference test (LSD) was performed for means comparisons. The data were analyzed with GLM procedure using software SAS 9.1. Thus, regression analyses were also performed for the 4 different crops under the different interactions over time between irrigation and tillage treatments with GPLOT procedure.

RESULTS AND DISCUSSION

DRY MATTER

Comparing each time period of dry matter collection separately, all crops were statistically significant different from each other at 14 weeks after planting (Figure 2). FS showed the highest dry matter yield (9.5 tons acre^{-1}) followed by PS (8.1 tons acre^{-1}), GS (5.5 tons acre^{-1}) and corn (3.2 tons acre^{-1}). Irrigation also showed statistical differences with irrigated plots having higher yields than non-irrigated plots. The overall means for irrigated and non-irrigated plots were 7.4 tons acre^{-1} and 5.8 tons acre^{-1}, respectively.

Results from dry matter collected at 18 weeks after planting showed statistical differences for different tillage systems and irrigation treatments as well as for the interaction between these two factors. Different crops showed significant difference in dry matter (Figure 2), where PS showed the highest yield (11.9 tons acre^{-1}) followed by FS (10.2 tons acre^{-1}), GS (5.9 tons acre^{-1}) and corn (4.0 tons acre^{-1}).

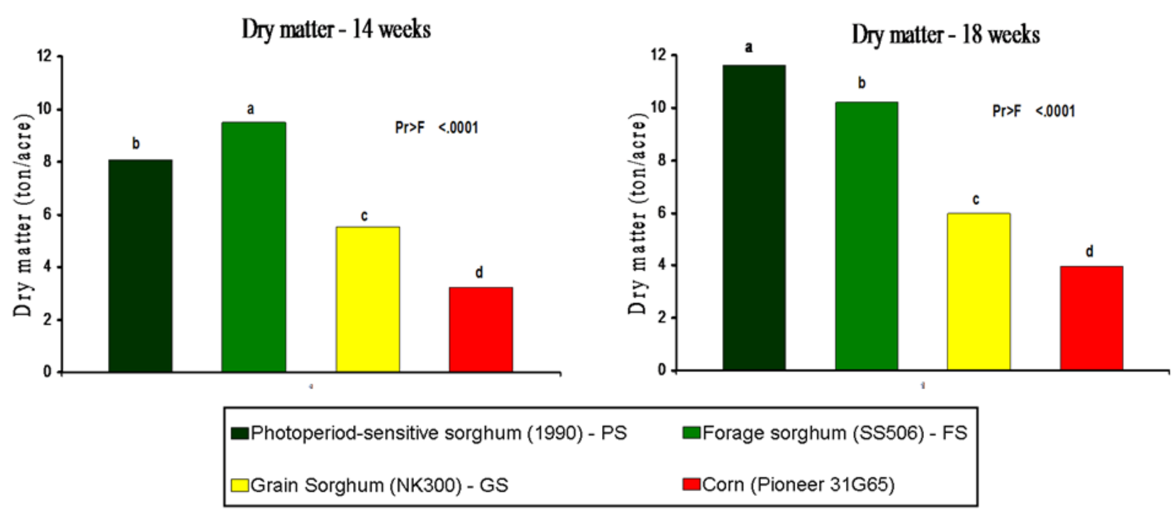

Figure 2: Dry matter yield at 14 (left) and 18 weeks (right) after planting.

Comparing the dry matter results for different tillage systems between the 14th and 18th week, the PS became more productive between 14 and 18 weeks after planting. Therefore, photosensitive sorghum has the highest biomass production potential during longer growing periods in US Southeast. Irrigated plots had higher yield than non-irrigated, 9.0 and 6.8 tons acre^{-1}, respectively.

Additionally, an interaction between tillage system and irrigation was found (Figure 3) and the results showed that all rainfed sorghums produced more biomass than irrigated corn. Therefore, sorghum showed higher drought resistance than corn. This statement was explained based on the different ability of sorghum and corn to extract water from soils. Corn absorbed water from top soil (0-18 in.) while sorghum absorbed water in deeper soil layers (18-53 in.), which had more available water for plants (Farre & Faci, 2006).

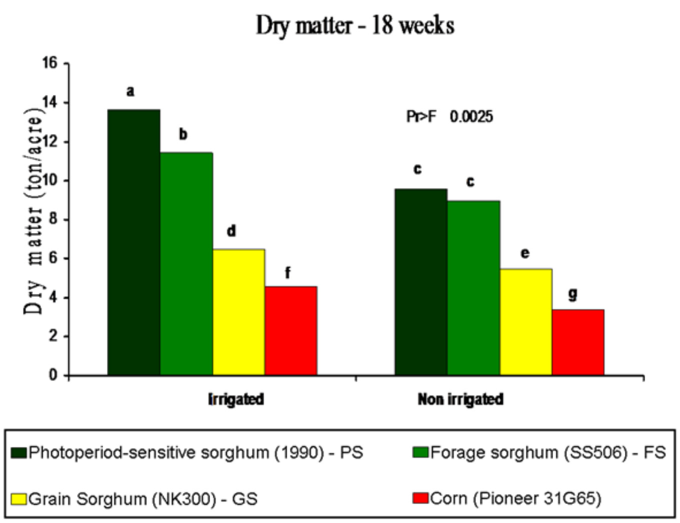

Figure 3: Dry matter yield for cultures x irrigation at 18 weeks after planting.

The dry matter collection at 24 weeks after planting was performed only in PS and FS plots, because the other cultures were mature and terminated at 18th week. For this reason, the total plot numbers were reduced in half (32 plots), which decreased the statistical power to detect significant differences (less replications, reduced degree of freedom) at 24 weeks after planting. Therefore, no differences were observed for any factor. However, PS showed numerically higher yields than FS, 13.4 and 10.70 tons acre^{-1}, respectively which was a difference of 2.7 tons. This was a greater difference than the advantage that PS showed at 18 weeks which was 1.7 tons.

The two different tillage treatments were not found to be different at any period time. Different results was reported by Cogle et al. (1997) which observed higher sorghum dry matter yields among three different tillage managements (zero-tillage, shallow tillage – 4 in. and deep tillage – 8 in.) applied on corn and sorghum fields. However, conservation tillage should be recommended in both cases because fuel, compaction, and erosion are all reduced using conservation technologies.

PLANT HEIGHT

The evaluated tillage systems showed different growth over time when analyzed in each irrigation x tillage treatment (Figure 4). In all scenarios, plant height followed the same trend as total biomass. Corn and FS showed higher growth until 9 weeks after planting. PS and FS overcame corn at 14th week. GS showed lower plant height values than corn during the entire season. Controversially, GS produced more dry matter than corn due to its ability to produce more leaves, which resulted in more dry matter accumulated than corn.

In irrigated treatments within any tillage, PS became statistical different from FS at 18 weeks after planting, but they were not different in non-irrigated treatments. However, water availability may have more affect in PS development than FS due to significantly greater biomass production when irrigation was provided.

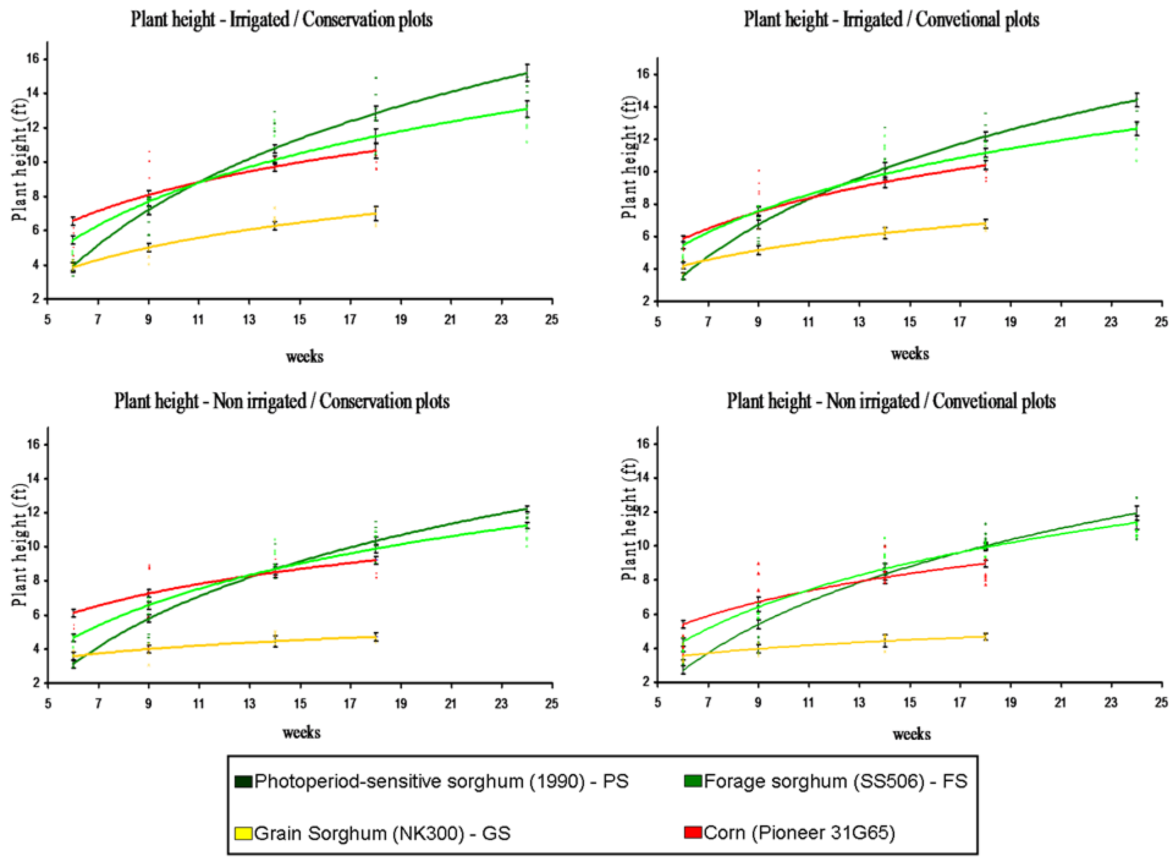

Figure 4: Plant height of cultures over time in each tillage x irrigation treatment.

CONCLUSIONS

In order to achieve the highest biomass yield for biofuels production, PS showed the greatest potential by yielding more than 13 tons per acre. At 14 weeks after planting, FS had the greatest biomass, but PS overcame the difference and exceeded FS during the later growing weeks of the season.

Irrigation increased biomass production in any period time for all tillage systems. However, PS, FS and GS showed higher yields in rainfed conditions than irrigated corn. Therefore, any sorghum, especially PS, should be recommended not only for higher biomass production, but also for reduced water use.

Different tillage systems did not affect biomass production. Therefore conservation tillage should be recommended because fuel, compaction, and erosion were all reduced using conservation technologies.

REFERENCES

Cogle, A. L., K.P.C. Rao, D.F. Yule, P.J. George, S.T. Srinivasan, G.D. Smith, and L. Jangawad. 1997. Soil management options for Alfisols in the semi-arid tropics: annual and perennial crop production. Soil and Tillage Res. 44:235–253.

Farre, I., and J.M. Faci. 2006. Comparative response of maize (*Zea mays L.*) and sorghum (*Sorghum bicolor L. Moench*) to deficit in a Mediterranean environment. Agricultural Water Management 83:35–43.

Habyarimana E., P. Bonardi, D. Laureti, V. Di Bari, S. Cosentino, and C. Lorenzoni. 2004. Multilocational evaluation of biomass sorghum hybrids under two stand densities and variable water supply in Italy. Industrial Crops and Products. 20:3–9.

Pioneer Hi-Bred International, Inc. 2009. Seed products & traits [on line]. Available at https://www.pioneer.com/growingpoint/product_info/catalog/TopProducts.jsp?prodLnCd=011&prodCd=31G65&GO=Search (verified 5 June 2009). Pioneer, Johnston, IA.

Sorghum Partners, Inc. 1990 Technical information [on line]. Available at https://www.sorghum-partners/pdfs/1990.pdf (verified 24 August 2008). Sorghum Partners, New deal, TX.

HIGH TUNNEL RASPBERRY PRODUCTION – VIRGINIA STATE UNIVERSITY'S EXPERIENCE

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ABSTRACT

Nationally, consumer demand for locally grown fresh fruits and vegetables is on the rise. This trend in combination with higher gas prices adding to the transportation cost to supply fresh produce over long distances has forced produce retailers, brokers and wholesalers to look for sources of regional supply. Clearly, this is an opportunity for local growers to capitalize on this trend and concentrate on growing crops with proven market demand.

In recent years the health benefits associated with many of the berry crops, in particular raspberries have caused a sharp increase in their market demand. According to a USDA publication, raspberries are ranked among the top ten food items with the highest level of Oxygen Radical Absorbance Capacity (ORAC), a unit used to measure the antioxidant capacity of foods. According to another USDA report, the consumption of fresh raspberries in the U.S. has tripled since the early 1990s to an estimated 0.33 pounds per person in 2005. The growing demand for raspberries and the recognition of their health benefits in an increasingly health conscious society identifies raspberries as a crop with considerable market potential.

As Virginia growers are looking for profitable farm enterprises to diversify their current production systems, crops such as raspberry appear as a prime production candidate for Virginia farmers. A high tunnel is an affordable structure that provides a micro climate for crops under production, allowing growers to expand their production season and improve fruit quality. Virginia State University has established a high tunnel raspberry project, testing several varieties and developing a sustainable production and marketing package to assist growers the possibility of growing this potential crop.

Preliminary results at VSU indicate considerable yield increase and season expansion when comparing high tunnel grown raspberries with that grown in the field. This allows growers to harvest fruit starting from mid-April and continue until Mid-November in Southern Virginia. Also due to the protection provided by high tunnel, the disease and insect incidences are less when compared raspberries grown in a high tunnel with that grown in the field. Research is underway to study the economic feasibility of high tunnel gown raspberries in Southern Virginia.

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WATER–STABLE AGGREGATES AND SOIL ORGANIC MATTER UNDER ITALIAN RYEGRASS AND TALL FESCUE ECOSYSTEMS IN WESTERN KENTUCKY

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SUMMARY

The objective of this study was to determine the effects of Italian ryegrass systems on water-stable aggregate and soil organic matter compared to tall fescue and tall fescue - legume mixture systems. The results show that growth of cool-season grasses and legumes caused significant differences in the amount of macro-aggregate, micro-aggregate, soil organic C, N and C/N ratio. In conclusion, introduction of Italian ryegrass in western Kentucky has shown to reduce soil aggregate stability, organic C and total N, compared to tall fescue and tall fescue mixture systems.

Keywords: Aggregation, Carbon, Nitrogen, Ryegrass, Tall fescue

INTRODUCTION

Most soils in western Kentucky have undergone moderate erosion and degradation as a result of historic tillage systems and seedbed preparation during cropping (Frye et al., 1982). Soil erosion removes the lighter particles from topsoil, such as organic matter, up to 12% (Murdock and Frye, 2003). Extreme losses of soil organic carbon occurred as high as 50% in the topsoil because of accelerated decomposition due to tillage practices and erosion (Frye et al., 1982). However, long-term forage systems have been shown to improve soil aggregation and organic matter (Franzluebbers et al., 2000). In addition, grasses can act as a cover crop and be easily accommodated into different crop rotations or pastures, without the use of extensive tillage (Franzluebbers and Stuedemann, 2008). A previous study in Bernheim Forest, Kentucky shows soil restoration using grass species improved particulate organic matter and aggregation by providing continuous roots and grass residues (Handayani et al., 2008). Forage ecosystems also provide low-cost feed, conserve soil and water resources, and capable of storing a large amount of soil organic C and total organic N (Franzluebbers and Stuedemann, 2005). Grassland soils are noted for their high levels of organic matter and high structural stability (van Veen and Paul, 1981).

Forage systems in Kentucky are commonly based on perennial and annual cool-season forages, such as tall fescue (*Festuca arundinacea* Schreb.) and Italian ryegrass (*Lolium multiflorum* Lam.), respectively (Lacefield et al., 2003a). These systems have an abundance of biomass in the spring and most falls but are not productive in mid to late summer. Tall fescue is deep-rooted, long-lived bunchgrass with short rhizomes (Ball et al., 2002). Common tall fescue management in Kentucky consists of tall fescue stands and tall fescue - legume mixture stands (i.e. tall fescue plus white clovers). Overall, tall fescue mixture stands perform better in terms of forage production, quality and reduce the fertilizer cost (Lacefield et al., 2003a). Italian ryegrass can

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grow more than three feet in height as the seed heads mature (Lacefield et al., 2003b). It has greater overall productivity than most other cool-season grasses during its growing period (Lacefield et al., 2003b). Tall fescue and Italian ryegrass are preferred due to their high adaptability under a wide range of soil and climatic conditions, and play an important role in soil conservation and carbon sequestration (Ball et al., 2002; Franzluebbers and Stuedemann, 2008; Lacefield and Evans, 2009). However, basic physical information on how forage species, especially annual and perennial grasses, affect on soil is limited. Such understanding is important for conserving soil and water resources, as well as improving the sustainability of forage-based enterprises.

Water-stable aggregate is a key to maintaining soil structure stability and is considered an effective means of controlling erosion (Angers, 1992; Cambardella and Elliot, 1992). Soil aggregation also influences gas exchange between the soil and atmosphere, soil water movement, plant root development, and microbial development (Jastrow, et al., 1998). It is usually determined by a wet sieving method (Kemper and Rosenau, 1984). Aggregates physically protect soil organic matter from microbial decomposition, resulting in reduced organic matter turnover rates and a steady release of plant available nutrients (Six et al., 1998). Soil aggregation has been conceptualized as a hierarchical system of primary particles forming micro-aggregates (<0.25 mm), which then become the foundation for formation of macro-aggregates (>0.25 mm) of varying sizes (Tisdall and Oades, 1982). Within stable macro-aggregates, micro-aggregates will develop the binding of complex organic matter, silt, and clay. The micro-aggregate is stable and provides a mechanism for long-term C storage.

Soil organic matter is the most important indicator for soil quality improvement because it regulates water movement and water holding capacity, provides nutrients for plants, and controls soil structural stability by affecting the quantity of macro- and micro-aggregates (Handayani et al., 2008). Variations in forage management that may influence soil aggregation and organic matter include grass species, forage composition, grazing pressure, and stand age (Blanco-Canqui et al., 2005).

Italian ryegrass provides the most productive forage component, because of its fast growth in most counties in western Kentucky (Henning, 2009) and considered the best traffic tolerance (Minner and Valverde, 2009). Commonly, Italian ryegrass is planted after harvesting corn during fall. Introducing legumes into tall fescue pasture can help improve forage quality and efficiency of forage growth available for livestock production, as well as reduce the N fertilizer needed (Strohmeier, 2003). Both forages are an important agricultural commodity in Kentucky, but little is known about the effect of forage species composition on soil structure and organic matter. Therefore, the objective of this study was to determine the effects of Italian ryegrass systems on water-stable aggregate and soil organic matter compared to tall fescue and tall fescue - legume mixture systems

MATERIALS AND METHODS

Sampling Procedure

Three adjacent fields were identified at four sites of moderately well drained soils in western Kentucky. Four sites were selected to give a reasonable coverage of our area of inference (western KY; Table 1). Each site included one field managed in tall fescue, one with tall fescue plus clover and one with Italian ryegrass stands. In the tall fescue mixture systems, tall fescue and white clover (*Trifolium repens* L.) contribute 60% and 40%, respectively. Each field has been in its current management for at least five years but no more than 6 years. Surface soils at all sites had silt loam texture (12-16% clay, 65-68% silt, and 17-20% sand), pH 5.85 - 6.43, and bulk density 1.10 - 1.15 g/cm^3 with slope of 0 to 8%.

Soil samples from each field were collected from depth intervals of 0 to 15 cm during Spring 2007. Within each field, five areas of 100 m^2 were selected for similarity and uniformity of topography, soil order, and soil textural class. Four subsamples were composited in each of the five selected areas per field. The composited soil samples were air dried at room temperature for seven days and gently crushed and sieved to pass through 2 mm. Visible organic matter was removed prior to analyses.

Soil and Data Analyses

Aggregate size distribution was determined using wet sieving with screen diameters of 2.00 mm, 0.25 mm and 0.053 mm. The range of micro-aggregates and macro-aggregates is between 0.25 to 0.053 mm and 2 to 0.25 mm, respectively. Soils were submersed in water on the largest screen for 5 minutes before sieving commenced. Soils were sieved under water by gently moving the sieve 3 cm vertically 50 times over period of 2 min through water contained in a shallow pan. Material collected from each sieve (0.25 – 2 mm, 0.053 – 0.25 mm, and < 0.053 mm) was dried at 60^{o}C until a constant weight was achieved, then weighed (Elliot and Cambardella, 1991). Sand corrections were determined for a subset of samples according to Denef et al. (2000). Organic C was determined by the loss of ignition method (LOI) (Lal et al., 2001). Dry combustion (Leco CHN Analyzer) was employed to determine total N. All soil analyses in the laboratory were conducted in three replications.

The effects of forage system on soil properties were analyzed by ANOVA. Mean separations were computed using Duncan’s multiple range test. Results were considered significantly different at the $p < 0.05$ level.

RESULTS AND DISCUSSION

Table 2 presents results on aggregate size distribution under three forage systems. The distribution of soil aggregates among the different size fractions was significantly influenced by forage system except for the amount of fractions < 0.053 mm. The amount of macro-aggregates (0.25 – 2 mm) decreased in the following order of; tall fescue = tall fescue plus clover > Italian ryegrass. The results in Table 2 indicate that 24% of the soil dry weight was present as macro-aggregates under Italian ryegrass, and 28% under tall fescue and tall fescue plus clover stand. The amount of micro-aggregates (< 0.25 mm) decreased in the following order of; Italian ryegrass > tall fescue = tall fescue plus clover. These results indicate that 28% of the soil dry weight was present as micro-aggregates under Italian ryegrass, 23% under tall fescue, and 24% under tall fescue plus clover stand. These results support the hypothesis that perennial grass with continuous input of organic matter from plant biomass without involving tillage would produce the highest level of macro-aggregates. On the other hand, annual grass, such as Italian ryegrass, decreases the amount of macro-aggregates due to corn cultivation each year. Haynes (1993) observed that 5-yr of C3 grass pasture could provide more soil organic matter and increase aggregate stability. Plant roots, fungal hyphae and excretion of microbial polysaccharides are major factors controlling macro-aggregate formation. Plant and microbial diversity and time are major components of micro-aggregate formation. As plant become less productive, micro-aggregate becomes dominant (Visser et al., 1983). In general, total aboveground production for the Italian ryegrass system (3-5 ton/ha/yr) were higher than tall fescue system (2-4 ton/ha/yr) (Lacefield et al., 2003a,b). In addition, Tufekcioglu et al (1999) reported that cool-season grass had significantly greater dead fine root biomass than any other grass type. However, annual pasture involving conventional tillage results in a substantial loss of soil organic matter and soil degradation by reducing aggregate stability (Milne and Haynes, 2004). The reduction of macro-aggregates in soils under cropped system has been clearly documented (Green et al., 2005; Tufeckcioglu et al., 1999). Long-term cropping decreased the length and mass of fine roots, and soil organic matter resulting in a reduction of macro-aggregates (Tisdall and Oades, 1980; Cambardella and Elliot, 1992).

Soil organic matter pools (C and N) were significantly affected by forage system (Table 3). The amount of C and N followed the order of; tall fescue plus clover > tall fescue > Italian ryegrass. The results in Table 2 indicate that perennial grass cultivation using tall fescue and tall fescue mixture stands increased 26% to 38% of C and 25% to 46% of N, respectively compared to annual or Italian ryegrass stand. These results were consistent with other reports (Li et al., 2007; Wright et al., 2004). Li et al. (2007) observed that annual pasture cultivation had substantially decreased total organic C and N at depths ranging from 0-30 cm compared with permanent pasture cultivation. In this study, continuous root productions from perennial grass of tall fescue and tall fescue mixture stands are able to maintain the level of organic C and N in the soil surface. On the other hand, conventional tillage was involved in Italian ryegrass system each year for corn production, thus it caused soil organic matter depletion. Lal (2002) concluded that conventional tillage can deplete soil organic matter by following processes: (1) accelerated mineralization, (2) leaching and translocation as dissolved or particulate organic matter and (3) accelerated erosion. Other studies have also shown that different grass species can cause differences in N accumulation in soil due to variations in plant morphology and biomass (Clements and Williams, 1967). Generally, the amount of lignin and carbohydrates in plant roots, and the C/N ratios, interact to control decomposition of root material in soil (Angers, 1992; Alvarez et al., 1998). Alvarez et al. (1998) found that soils under bermuda grass plus ryegrass had less N availability compared with soils under bermuda grass plus clover stands.

Higher C/N ratio was found in Italian ryegrass and tall fescue stands compared to tall fescue mixture stands. The results from C/N ratios support the hypothesis that clover provides additional N into the ecosystem, thus tall fescue mixture had the lowest C/N ratios. However, other studies showed that introduction of clover to pastures, compared with ryegrass, decreased soil organic C and N sequestration at high-grazing activity, but not at low-grazing activity (Wright et al., 2004). Alvarez et al. (1998) demonstrated that ryegrass had higher C/N ratios than clover stands which caused limited N availability.

CONCLUSIONS

Growth of cool-season annual and perennial grasses during a 5- and 6-yr period in a silt loam caused differences in the amount of macro-aggregate, micro-aggregate, soil organic C, N and C/N ratio. The amount of macro-aggregates increased in the following order for the different forage system; Italian ryegrass < tall fescue = tall fescue plus clover. The amount of micro-aggregates decreased in the following order for the different forage system; Italian ryegrass > tall fescue = tall fescue plus clover. Tall fescue mixture stand provides the highest soil organic C and N, but the lowest C/N ratio. In summary, introduction of Italian ryegrass in western Kentucky has shown to reduce soil aggregate stability and soil organic matter pools compared to tall fescue and tall fescue – legume mixture systems.

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REFERENCES

Alvarez, G., R. Chaussod, P.Loiseau, and R. Delphy. 1998. Soil indicators of C and N transformations under pure and mixed grass-clover swards. European Journal of Agronomy 9:157-172.

Angers, D.A. 1992. Changes in soil aggregation and organic carbon under corn and alfalfa. Soil Sci. Soc. Am. J. 56:1244:1249.

Ball, D.M., C.S. Hoveland, and G.D. Lacefield. 2002. Southern forages, 3rd Ed. Potash and Phosphate Inst. Found. Agron. Res., Nocross, GA.

Blanco-Canqui, H., R. Lal, and R. Lemus. 2005. Soil aggregate properties and organic carbon for switchgrass and traditional agricultural systems in the southeastern United States. Soil Sci. 12: 998-1012.

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

Clement, C.R., and T.E. Williams. 1967. Leys and soil organic matter. II. The accumulation of nitrogen in soils under different leys. J. Agric. Sci. 69:133-138.

Denef, K., J.Six, R.Merckx, and K. Paustian. 2002. Short term effects of biological and physical forces on aggregate formation in soils with differing clay mineralogy. Plant and Soil 246:185-200.

Elliot, E.T., and C.A. Cambardella. 1991. Physical separation of organic matter. Agric. Ecosyst. Environ. 34:407-419.

Franzluebbers, A.J., and J.A. Stuedemann. 2008. Early response of soil organic fractions to tillage and integrated crop-livestock production. Soil Sci. Soc. Am. J. 72:613-625.

Franzluebbers, A.J., and J.A. Stuedemann. 2005. Bermudagrass management in the Southern Piedmont USA. VII. Soil-profile organic carbon and total nitrogen. Soil Sci. Am. J. 69:1455-1462.

Franzluebbers, A.J., J.A. Stuedemann, H.H. Schomberg, and S.R. Wilkinson. 2000. Soil C and N pools under long-term pasture management in the Southern Piedmont USA. Soil Biol. Biochem. 32:469-478.

Frye, W.W., S.A. Ebelhar, L.W. Murdock, and R.L. Blevins. 1982. Soil erosion effects on properties and productivity of two Kentucky soils. Soil Sci. Soc. Am. J. 46:1051-1055.

Green, V.S., M.A. Cavigelli, T.H. Dao, and D.C. Flanagan. 2005. Soil physical and aggregate-associated C,N, and P distributions in organic and conventional cropping systems. Soil Science 10:822-831.

Handayani, I.P. M.S. Coyne, C.Barton, and S.Workman. 2008. Soil carbon pools and aggregation following land restoration: Bernheim Forest, Kentucky. Journal of Environmental Restoration and Monitoring. 4:11-28

Haynes, R.J. 1993. Effect of sample pretreatment on aggregate stability measured by wet sieving or turbidimetry on soils of different cropping histories. J. Soil Sci. 44:261-270.

Henning, J.C. Putting forages together for year round grazing. http://www.kfgc.org/PDF/kca_jch.PDF. Retrieved 6/10/2009

Jastrow, J.D., R.M. Miller, and J. Lussenhop. 1998. Contributions of interacting biological mechanisms to soil aggregate stabilization in restored prairie. Soil Biology and Biochemistry 30:905-916.

Kemper, W.D., and R.C. Rosenau. 1984. Soil cohesion as affected by time and water content. Soil Sci. Soc. Am J. 48:1001-1006.

Lacefield, G., and J.K. Evans. Tall fescue in Kentucky. http://www.ca.uky.edu/agc/pubs/agr/agr108/agr108.htm. Retrieved 5/21/2009

Lacefield, G.D., J.C. Henning, and T.D. Phillips. 2003a. Tall Fescue. University of Kentucky – College of Agriculture Cooperative Extension Service.

Lacefield, G.D., J.C. Henning, and T.D. Phillips. 2003b. Ryegrass. University of Kentucky – College of Agriculture Cooperative Extension Service.

Lal, R. 2002. Soil carbon dynamics in cropland and rangeland. Environ. Pollut. 116:353-362.

Lal, R., J.M. Kimble, R.F. Follet, and B.A. Stewart. 2001. Assessment methods for soil carbon. Advance in Soil Science. CRC Press, Boca Raton, FL.

Li, X., F. Li, R. Zed, Z. Zhan, and Bhunpinderpal-Singh. 2007. Soil physical properties and their relations to organic carbon pools as affected by land use in alpine pastureland. Geoderma doi:10.1016/j.geoderma.2007.01.006

Milne, R.M., and R.J. Haynes. 2004. Soil organic matter, microbial properties, and aggregate stability under annual and perennial pastures. Biol. Fertil. Soils 39:172-178.

Minner, D.D., and F.J. Valverde. Traffic tolerance of cool-season grass species and cultivars when established during spring and fall in the presence of traffic. http://www.hort.iastate.edu/turfgrass/pubs/turfrpt/2007/pdffiles/71-barenburg2006.pdf. Retrieved 6/12/09

Murdock, L.W., and W.W. Frye. AGR-102. Erosion-its effect on soil properties, productivity and profit. http://www.ca.uky.edu/agc/pubs/agr/agr102/agr102.htm. Retrieved 5/21/2009

Six. J., E.T. Elliot, K. Paustian, and J. Doran. 1998. Aggregation and soil organic matter accumulation in cultivated and native grassland soils. Soil Sci. Soc. Am. 62:1367-1377.

Strohmeier, K.D. 2003. Owen Co. forages consider the possibilities. University of Kentucky – College of Agriculture Cooperative Extension Service.

Tisdall, J.M., and J.M. Oades. 1982. Organic matter and water-stable aggregates in grassland soils. J. Soil Sci. 33:141-163.

Tisdall, J.M., and J.M. Oades. 1980. The management of ryegrass to stabilize aggregates of a red-brown earth. Aust. J. Soil Res. 18:415-422.

Tufekcioglu, A., J.W. Raich, T.M. Isenhart, and R.C. Schultz. 1999. Fine root dynamics, coarse root biomass, root distribution, and soil respiration in a multispecies riparian buffer in central Iowa, USA, Agrofor. Syst. 44:163-174.

van Veen, J.A., and E.A. Paul. 1981. Organic carbon dynamics in grassland soils. I. Background information and computer simulation. Can. J. Soil Sci. 61:185-201.

Visser, S., C.L. Griffiths, and D. Parkinson. 1983. Effects of surface mining on microbiology of a prairie site in Alberta, Canada. Canadian Journal of Soil Science 63:177-189.

Wright, A.L., F.M. Hons, and F.M. Rouquette Jr. 2004. Long-term management impacts on soil carbon and nitrogen dynamics og grazed bermudagrass pastures. Soil Biology and Biochemistry 36:1809-1816.

Table 1. General site description.

Site	Soil texture	Soil order	Slope (%)	Age (yr)
I	silt loam	Alfisols	0-5	5
2	silt loam	Alfisols	0-7	6
3	silt loam	Alfisols	0-8	6
4	silt loam	Alfisols	0-5	5

Table 2. Aggregate size distribution after wet sieving under three different forage systems. Values are expressed as percentages of dry weight of soil and on a sand-free basis in each size fraction.

Forage System	Size fraction (μm)		
	250-2000	53-250	<53
	% dry weight of soil		
Italian ryegrass	23.52a	27.82b	48.66a
Tall fescue	27.85b	22.56a	49.59a
Tall fescue + clover	28.82b	23.82a	47.36a

†Values within columns followed by the same letter are not significantly different ($p < 0.05$) according to Duncan's multiple-range test.

Table 3. Soil organic C, N and C/N ratio under three different forage systems.

Forage System	Soil Organic Matter		
	C	N	C/N
	g kg -1		
Italian ryegrass	1.86a	0.15a	12.40a
Tall fescue	2.51b	0.20b	12.55a
Tall fescue + clover	2.99b	0.28c	10.68b

†Values within columns followed by the same letter are not significantly different ($p < 0.05$) according to Duncan's multiple-range test.

TRAP CROPPING FOR MANAGEMENT OF HARLEQUIN BUG IN COLE CROPS

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INTRODUCTION

Harlequin bug (HB), *Murgantia histrionica* (Hahn) (Hemiptera: Pentatomidae), is a pest of cole crops (Brassicaceae). Both adults and nymphs are piercing-sucking feeders on leaves and stems. Feeding results in blotching of leaf tissue, which reduces the marketability of crops sold as greens, and as feeding continues, wilting and browning of leaves may occur eventually leading to the death of the plant.

There are several broad-spectrum insecticides that provide effective control of HB; however, in the interest of human and environmental safety, as well as integrated pest management, there has been a major shift toward the use of narrow-spectrum, reduced-risk insecticides in cole crops for control of the lepidopteran pests, which historically have been the primary pest concern in most regions. Most of these newer chemicals have little to no toxicity to other species, including HB.

There is potential for management of HB using a trap crop to divert pest feeding from the protected crop to a nearby preferred “trap crop.” A double perimeter row of mustard or rape surrounding a broccoli field has been found to reduce feeding of HB on broccoli; however, this management practice alone was not found to be effective for control under high pest densities. This method of companion planting has potential in both conventional integrated pest management as well as in organic vegetable systems. This can result in an elimination of chemical sprays targeted at this pest, or in a dramatic reduction in pesticide, as any necessary sprays would be applied to the trap crop alone. By identifying preferred host plant species/variety, the information gained by this project will aid managers in selecting appropriate trap crop species/variety as a companion planting to the crop needing protection.

CHOICE TESTS JUNE/JULY 2009

To determine what species/variety of plant are preferred by HB for habitation, feeding and/or oviposition, HB adults were offered the choice of six types of plants in lab and field choice tests: bean (a non-Brassicaceae to act as negative control), arugula (Brassicaceae: Eruca sativa) collard (*Brassica oleracea*), mustard (*B. juncea*), rape (*B. napus*), rapini (*B. rapa*).

For field cage choice tests, 30 field collected HB adults were isolated to each of five cages (4 x 4 x 2 m) containing six of each of the test species/varieties (10-12 weeks old), and plants were observed every 1-2 days for adults and egg masses. All adults and egg masses were removed and this procedure was repeated with 50 field collected adults per cage (plants were 12-14 weeks old).

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For lab choice tests, 30 field collected HB adults were released into growth chambers (T = 25^{o}C, Day length = 16D, 8N) with a leaf each of each of the test plants, and leaves were observed for choice four times over 24 hours.

Mustard is clearly preferred by HB adults in both lab and field tests. In the first round of the field cage test significantly more HB adults were observed on mustard than any other variety offered ($p < 0.0001$). In round two of the field cage tests significantly more HB adults were observed on mustard than any other plant variety and significantly more adults were observed on rapini than the other varieties ($p < 0.0001$). Nearly all the rapini plants reached maturity between round one and two of this trial and presence of flowering tissues is likely the reason for the increase in attraction of HB, although mustard was still more attractive. In lab choice tests, rape is shown to be equally attractive to HB adults as mustard.

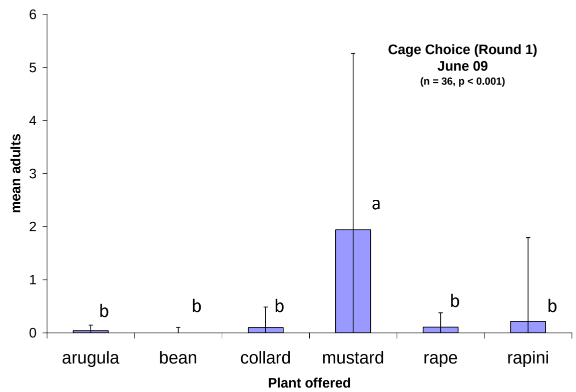
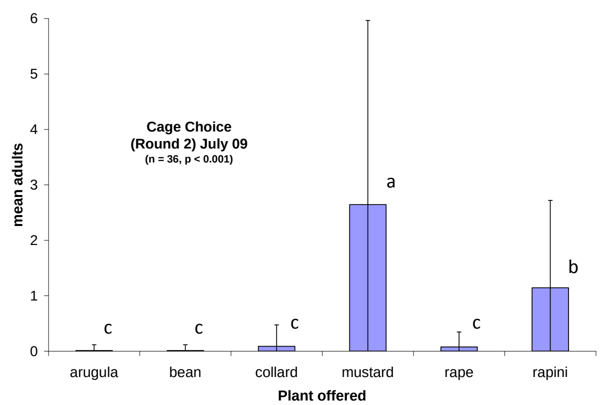


Figure 1: Mean HB adults observed on 10-12 week old plants in field cages (n = 36, $p < 0.001$).

Figure 2: Mean HB adults observed on 12-14 week old plants in field cages (n = 36, $p < 0.001$).



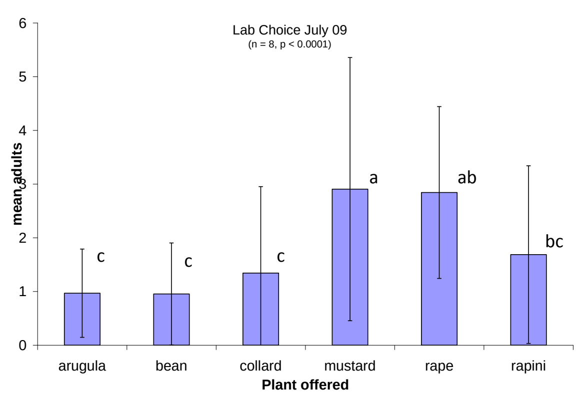


Figure 3: Mean adult HB observed plant leaves in lab choice test (n = 8, $p< 0.001$).

Future work: New assays will be conducted on host plant preference of HB in other varieties.
Roles of plant volatiles in host plant finding will be investigated.
Improvements on trap cropping system by augmenting with other IPM tactics will be investigated.

COVER CROPS AND NUTRIENT MANAGEMENT

CEREAL GRAIN COVER CROP PERFORMANCE IN VIRGINIA

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ABSTRACT

A Virginia study evaluating cover crop species at three plating dates with or without winter nitrogen application determined that rye and rye + hairy vetch yielded significantly more biomass than other species. Rye nitrogen uptake was also greater than other cereals. Early planted rye reduced total soil profile NO_3^- (0-36 in) by 13 lb ac^{-1}. Across species, early planting resulted in 19 lb ac^{-1} less soil profile NO_3^- in May than late planting. Averaged over cereal cover crops, N applied at GS 25 resulted in 1.0 ton ac^{-1} more biomass and 23 lb ac^{-1} more N uptake.

INTRODUCTION

Improved water quality in the Chesapeake Bay has been a long-term concern in Virginia and other Mid-Atlantic states. Today, the importance of water quality, and the role of agriculture in maintaining water quality, is apparent throughout the United States. The Chesapeake 2000 agreement, a strategic plan to maintain abundant, diverse populations of living resources, fed by healthy streams and rivers, sustain strong local and regional economies, and maintain quality of life in the region was adopted in June 2000 (Chesapeake Bay Program, 2000). Chesapeake 2000 calls for the development of locally supported watershed management plans in two-thirds of the Bay watershed. These goals make it imperative that growers utilize land and nutrient resources efficiently. Winter annual cover crops are an important tool for water quality protection because they can scavenge and utilize soil nutrients, especially nitrogen (N), which could otherwise be lost from the soil/plant system through leaching and runoff during winter months.

Beneficial effects of cover crops and crop rotation have been recognized for many years. As early as 3000 years ago, growers were using green manure cover crops to improve soil fertility. However, the steady increase of inorganic fertilizer use over the past 60 years and the development of more modernized farming techniques have resulted in less diversified cropping systems. Increasing environmental concerns associated with fertilizer lost from the agricultural system, soil erosion, and high production costs coupled with low commodity prices have led many growers to reexamine cover cropping as a method of increasing soil productivity.

Soil organic matter (SOM) content directly influences many biological, chemical, and physical properties that affect productivity. The greatest contributor to SOM is crop residue. Soil organic matter can hold up to 20 times its weight in water (Stevenson, 1982). This can significantly increase the amount of plant-available water, particularly in sandy soils. Even in high-rainfall regions, moisture is often a limiting factor in crop production, therefore, greater plant-available water, due to higher SOM content, can increase yield by improving the overall water use efficiency (crop yield per unit of water; WUE) of the crop.

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The crumbly, friable, well-aerated soil structure associated with good tilth is desirable due to improved drainage, reduced crusting and ponding, and ease of seedbed preparation for following crops. Crop rotation improves soil structure by reducing the impact of compaction by increasing aggregate stability. As early as 1967, researchers noted that aggregate stability increased from 67 to 76% when alfalfa was added to a corn-barley-sugarbeet rotation (Schumaker et al., 1967). More recently, similar results have been published documenting that aggregate stability is consistently higher under legume (alfalfa or red clover)-corn rotations compared with continuous corn (Raimbault and Vyn, 1991). Increased aggregate stability also reduces erosion by making the soil less vulnerable to the destructive forces of wind and rain.

Research cited by Peel (1998) found greater than 50% reduction in soil erosion when corn, barley, and hay were rotated compared with soil erosion from land in continuous corn. The decrease in soil loss when crop rotation and cover crops are employed is due to several factors. These factors include the dense canopy of the forage, reduced cultivation when the soil was in forage, the more extensive root system of the forage, and the increased amount of residue returned to the soil as a result of crop rotation. Reduced soil loss not only benefits crop production, but also decreases the potential for surface runoff of sediment containing nutrients and pesticide residues.

Therefore the objectives of this research were to: 1) Determine the winter cover crop species and planting date that provides the most vigorous winter soil cover, the greatest biomass return to the soil system, and the highest level of N uptake; 2) Determine the change in soil nitrate (NO_3^-) from the beginning to the end of cover crop season; 3) Evaluate cover crop effects on subsequent crop weed control; and 4) Educate producers and agricultural professionals on how to successfully implement cover crops to maximum environmental and economic advantage.

MATERIALS AND METHODS

1. Determine the winter cover crop species and planting date that provides the most vigorous winter soil cover, the greatest biomass return to the soil system, and the highest level of N uptake.

One experimental site was established annually on the Davis farm in the Coastal Plain of Virginia in a split plot design with two replications. Main plots were crop species or mix (Rye, Oats, Barley, and Triticale in 2005; and Rye, Oats, Barley, Crimson Clover, Vetch, and Rye+Vetch in 2006 and 2007) and planting date (approx. Oct. 1, Oct. 20, and Nov 10), sub plots were spring N rate (0, 25, 50 or 0 and 30 lb N ac^{-1} in 2005 and 2006-2007, respectively). Seeding was performed with a Great Plains no-till grain drill in plots that were 20 by 300 feet. Urea ammonium nitrate liquid (30% N) was the winter N source. Aboveground biomass was hand clipped from a 1.6 ft^{-2} area in each treatment at in mid-winter, prior to N application, and crop samples were dried in a forced air oven at 60°C for 48 hr dry matter yield determined dry matter yield. All aboveground biomass was again hand clipped from a 1.6 ft^{-2} area in each treatment just prior to killing the cover crop. Crop samples were again dried in a forced air oven at 60°C for 48 hr and then ground to pass a 2 mm screen using a Wiley (Thomas Scientific, Swedesboro, NJ) sample mill and total N determined by dry combustion (Leco Corp., St. Joseph, MI). Nitrogen uptake was determined as the product of dry matter yield and tissue N concentration.

2. Determine the change in soil nitrate (NO_3) over the cover crop season.

A composite sample to a depth of three feed in increments of 0-6, 6-12, 12-24, and 24-36 in was taken from the study site prior to cover crop planting each fall. At the time of cover crop termination, each plot was soil sampled by taking and compositing three cores to a depth of 3 feet in increments of 0-6, 6-12, 12-24, and 24-36 in. Samples were dried in a forced air oven at 60°C for 48 hr and then ground to pass a 2 mm screen using hand processing. Soil samples were extracted using 2M KCl (Bremner, 1965) and analyzed for NH_4-N and NO_3-N using automated flow injection analysis (Lachat Inst., Milwaukee, WI).

3. Evaluate cover crop effects on subsequent crop weed control.

Weed pressure was subjectively evaluated during early season growth of the following pumpkin crop. Photographs were taken for use as a teaching tool, especially as related to pumpkin shell quality.

RESULTS

Analysis of variance revealed a significant effect of crop species and planting date on biomass yield and nitrogen uptake in all three years (Table 1). There was a significant interaction of these factors for both yield and N uptake in 2007 caused by the vetch treatment where yield and N uptake increased with later planting. Application of spring N resulted in a significant increase in biomass yield across species in all instances and increased N uptake in 2005 and 2007 (Table 1). There was a significant interaction of crop and N rate for both yield and N uptake in 2007. This was due to the inclusion of legume and legume mix cover crops. Cereal cover crops alone did not exhibit this interaction.

Biomass

Over years, cereal cover crops planted early produced approximately 1.1 ton ac^{-1} more biomass than late plantings. Rye grew the most biomass, producing an average of 6.2, 5.5 and 3.4 ton ac^{-1} at the early, mid, and late plantings, respectively.

In 2005, rye produced more than twice the total biomass of any other species (Figure 1). Even late planted rye produced more than early planted triticale and barley. Oats produced the least biomass with average total production of 1.6 ton ac^{-1}. Rye and the rye+vetch mix produced the greatest biomass in 2006 (Figure 1) with both treatments producing over 5.4 ton ac^{-1} with early or mid planting. Early planted barley produced nearly 3.6 ton ac^{-1}, which was similar to 2005, however total biomass dropped dramatically with the mid and late planting date. Vetch alone, planted early, produced over 4.5 ton ac^{-1} indicating an exceptional ability to fix nitrogen for the following crop. In 2007, rye and rye+vetch again produced the greatest biomass with an average of 5.0 and 5.2 ton ac^{-1}, respectively. Barley and crimson clover biomass decreased approximately 40 % from the early to the late planting date (Figure 1). Early planted oats were severely damaged by deer grazing soon after emergence and this treatment was dropped. Early planted rye+vetch produced a total of 5.9 ton ac^{-1} while the average of all early planted cereals was 3.6 ton ac^{-1} and that of early planted legumes was 2.8 ton ac^{-1} (Figure 1).

Nitrogen Uptake

Over years, the highest levels of N uptake were observed in the vetch and rye+vetch treatments (247 and 197 lb ac^{-1}averaged over planting date). The average N uptake of early planted cereal crops was 84 lb ac^{-1} while that of early rye was 132 lb ac^{-1}. This same trend was evident for the late planting with the average over crops of 59 lb ac^{-1} and rye at 83 lb ac^{-1}.

Similar to the trend observed in 2005 biomass production, N uptake was highest for rye. None of the other cereal cover crop treatments took up over 89 lb N ac^{-1} but even late planted rye took up 99 lb ac^{-1} (Figure 1). In 2006, vetch and the combination of rye+vetch captured the most N with 220 and 136 lb N ac^{-1} taken up across planting dates, respectively (Figure 1). Average N uptake for early planted cereal cover crops was 92 lb ac^{-1} while that for rye planted early was 115 lb ac^{-1}. Early planted vetch resulted in over 297 lb ac^{-1} of N uptake by early May. In 2007, all planting dates of vetch alone or rye+vetch produced over 223 lb ac^{-1} N uptake (Figure 1). Average N uptake for early planted cereals was 109 lb N ac^{-1} while crimson clover uptake was 158 lb ac^{-1}.

Response to Spring N

While there was an overall interaction of N rate and crop species in 2007, this was due to the expected lack of N response in the legume treatments. Response of the cereal grain cover crops to spring N is presented in Table 2. In 2005, rates of 0, 25 and 50 lb ac^{-1} were applied at Zadoks GS 25, resulted in 1.3 ton ac^{-1} more production for the first increment and 0.2 ton ac^{-1} for the second increment. Total N uptake was increased by 29 lb ac^{-1} with the application of 25 lb N ac^{-1} as UAN fertilizer. This application likely increased the competitive ability of the crop and allowed it to scavenge even more N from the soil. The application of 50 lb N ac^{-1} increased N uptake by only 10 additional lb, so in future years, the winter N application was limited to 30 lb ac^{-1}. Over the 2006 and 2007 crop years, adding 30 lb N ac^{-1} resulted in an average increase of .65 ton ac^{-1} more biomass and 23 lb ac^{-1} more N uptake. This response indicates that low rates of N can be applied at GS25 to improve biomass production with little overall impact to soil NO_3 because of the high efficiency of uptake at this time.

Soil Nitrate Levels

Preplant soil nitrate levels decreased from 33 lb ac^{-1} in the top 12 in to 20 lb ac^{-1} by the third year of the study (Table 3). This was not the cumulative effect of these treatments over time; this study was moved to different fields in different years to match the crop rotation. However, it does represent the adoption of winter cereal cover crops on the entire farm and the effect cover crops can have in a fairly short time frame. Similarly, the sum of NH_4 and NO_3 below 3 ft decreased from 50 to 18 lb ac^{-1} by year three.

Early planted rye and oats (mid in 2007) had less soil NO_3 in the surface 3 inches in all three years (Figure 2). This effect was maintained throughout the profile in 2005, but not in other years. Early planted barley exhibited a similar effect of lower surface NO_3 in two years, but not in 2005. In this year, early barley growth was especially poor. In 2006 and 2007, soil NO_3 decreased with depth for all cover crops (Figure 2).

Carbon:Nitrogen Ratio of Rye and Rye+Vetch Cover Crops

In 2006, spring N application reduced the C:N ratio of rye but not vetch or the rye+vetch combination (Table 4). This observed difference probably does not have biological significance since the ratio is still above 50:1, indicating a net nitrogen sink in the short term. No differences in C:N ratio were observed due to N application in 2007, but did vary significantly among crops. Unlike 2006 where the rye+vetch treatment was in the range of 30:1, which was between vetch alone and rye alone, in 2007 the C:N ratio of the mixture was very similar to vetch alone (Table

4). The cover crop was terminated on approximately the same calendar date in both years but dry spring conditions in 2007 limited growth with the result of less mature rye. Vetch also made up a greater proportion of the total plant material in this season.

Cover Crop Effects on Pumpkins

Figures 3 and 4 demonstrate the impact of cereal cover crops and the resulting ground cover on a following pumpkin crop.

DISCUSSION

Among cereal cover crops, rye produced the greatest biomass in our studies. In fact, even late planted rye often outyielded the other cereals even when planted early. Results from these studies as well as others demonstrating this advantage led the Virginia Department of Conservation and Recreation (VADCR) to offer a $5 per acre payment incentive for growers who plant rye, in addition to the existing cost share program.
Our research plots moved to different fields on the farm each year to match the crop rotation. Despite this, we observed a decrease in soil NO3 both prior to planting and at termination of cover crops in years two and three. The use of cereal cover crops expanded greatly on the cooperating farm over the course of the study, as the producers gained experience and observed cover crop benefits. Ultimately producers, NRCS workers, crop advisors, and others now have up-to-date and accurate local information about the most effective cover crop species and management practices for the Coastal Plain of Virginia and the mid-Atlantic.

REFERENCES

Bremner, J.M. 1965. Inorganic forms of nitrogen. Agronomy 9:1179-237.

Chesapeake Bay Program. 2000. Chesapeake 2000: A Watershed Partnership Agreement. [Online]. Available at http://www.chesapeakebay.net/c2k.htm (verified 21 Oct. 2005)

Peel, M.D. 1998. Crop rotations for increased productivity. [Online]. Available at http://www.ext.nodak.edu/extpubs/plantsci/crops/eb48-1.htm#intro (verified 21 Oct. 2005).

Raimbault, B.A. and T.J. Vyn. 1991. Crop rotation and tillage effects on corn growth and soil structural stability. Agron. J. 83:979-985.

Schumaker, G.A., C.W. Robinson, W.D. Kemper, H.M. Golds, and M. Amemiya. 1967. Improved soil productivity in western Colorado with fertilizers and alfalfa. Technical Bulletin 91. pp.36-37. Colorado State University, Ft. Collins, CO.

Stevenson, F.J. 1982. Humus chemistry-genesis, composition reactions. John Wiley and Sons, Inc. New York, NY.

Table 1. Analysis of variance for cover crop yield and nitrogen uptake, 2005-2007.

		2005	
	df	Yield	N Uptake
		---------Pr>F---------	
crop	3	**	**
plant	2	**	**
crop*plant	6	ns	ns
Error A	11		
nrate	2	**	**
crop*nrate	6	ns	ns
plant*nrate	4	ns	ns
crop*plant*nrate	12	ns	ns
Error B	25		

		Yield		N Uptake	
	df	2006	2007	2006	2007
		----------------------Pr>F----------------------			
crop	5	**	**	**	**
plant	2	**	**	**	**
crop*plant	9	ns	*	ns	*
Error A	17				
nrate	1	*	**	ns	**
crop*nrate	5	ns	*	ns	**
plant*nrate	2	ns	ns	ns	ns
crop*plant*nrate	8	ns	ns	ns	ns
Error B	22				

Table 2. Cereal cover crop biomass and nitrogen uptake response to GS 25 spring nitrogen.

Year	Spring N Rate	Biomass Yield	N Uptake
	Lb ac^{-1}	Ton ac^{-1}	Lb ac^{-1}
2005	0	2.1	51
	25	3.4	80
	50	3.7	89
	LSD	0.7	17
2006	0	3.1	63
	30	3.9	85
	LSD	0.3	18
2007	0	2.2	76
	30	2.7	100
	LSD	0.2	12

Table 3. Preplant soil nitrate and ammonium nitrogen, 0-90 cm.

Year	Depth	NO_3-N	NH_4-N
	----in----	------lb ac^{-1}------	
2005	0-12	33.0	19.5
	12-24	29.4	18.2
	24-36	30.9	18.6
	LSD (0.05)	4.6	3.9
2006	0-6	25.9	13.3
	6-12	17.9	10.6
	12-24	17.9	12.2
	24-36	17.9	11.3
	LSD (0.05)	6.3	5.9
2007	0-6	19.4	2.9
	6-12	12.2	4.0
	12-24	14.7	2.4
	24-36	14.0	4.0
	LSD (0.05)	4.5	0.7

Table 4. Carbon to nitrogen ratio for rye, vetch, and rye+vetch.

		C:N Ratio	
2006	Crop	N Rate, lb ac^{-1}	
		0	30
	Rye	58	52
	Rye+Vetch	37	34
	Vetch	14	13
	LSD	3	
2007	Rye	31	38
	Rye+Vetch	12	15
	Vetch	10	11
	LSD	7	

Figure 1. Biomass yield (a) and nitrogen uptake (b) by species, 2005, biomass yield (c) and nitrogen uptake (d) by species, 2006, and biomass yield (e) and nitrogen uptake (f) by species, 2007, no spring nitrogen.

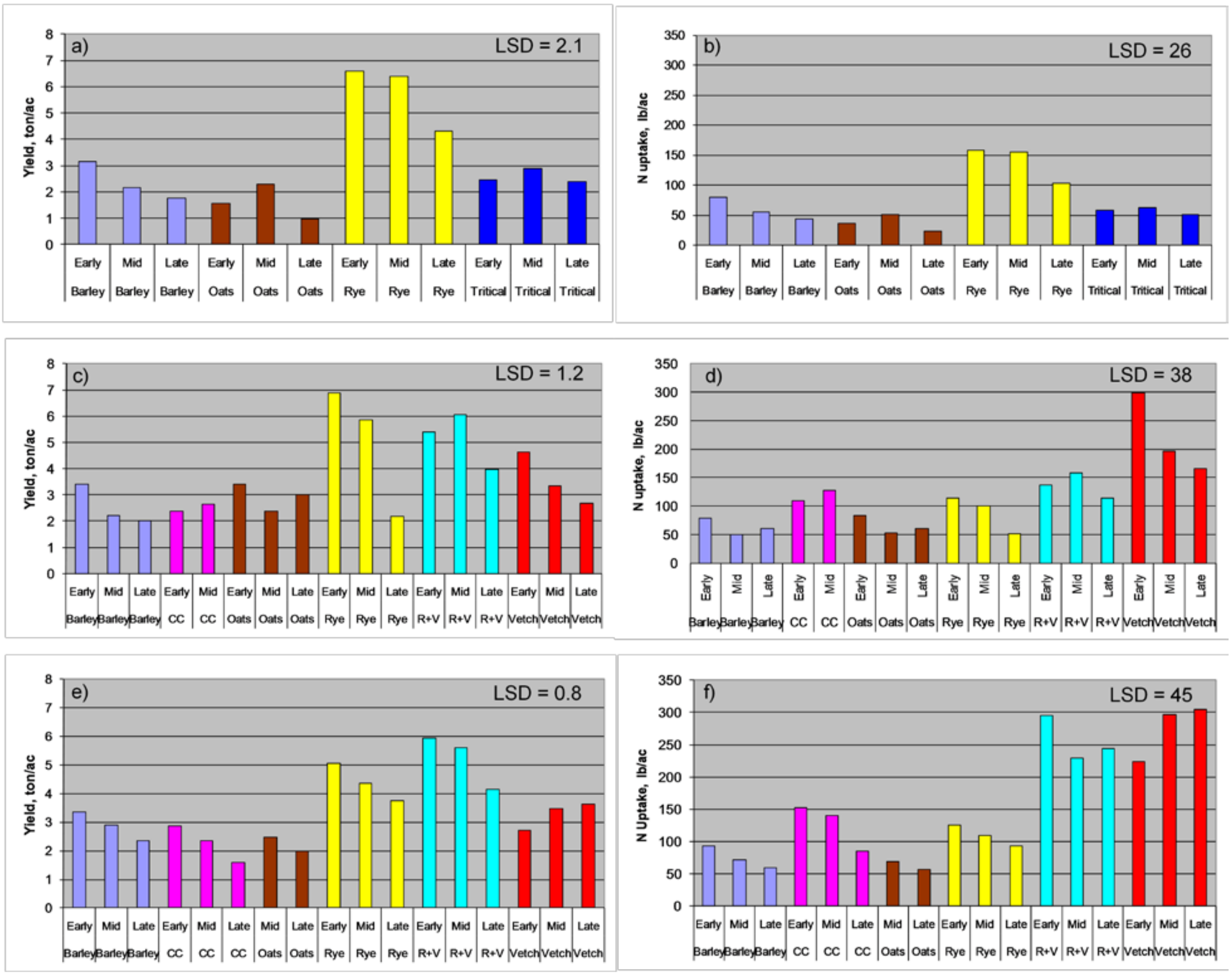

Figure 4. Soil nitrate concentration with depth for oat, barley, and rye cereal cover crops, a) 2005, b) 2006, and c) 2007.

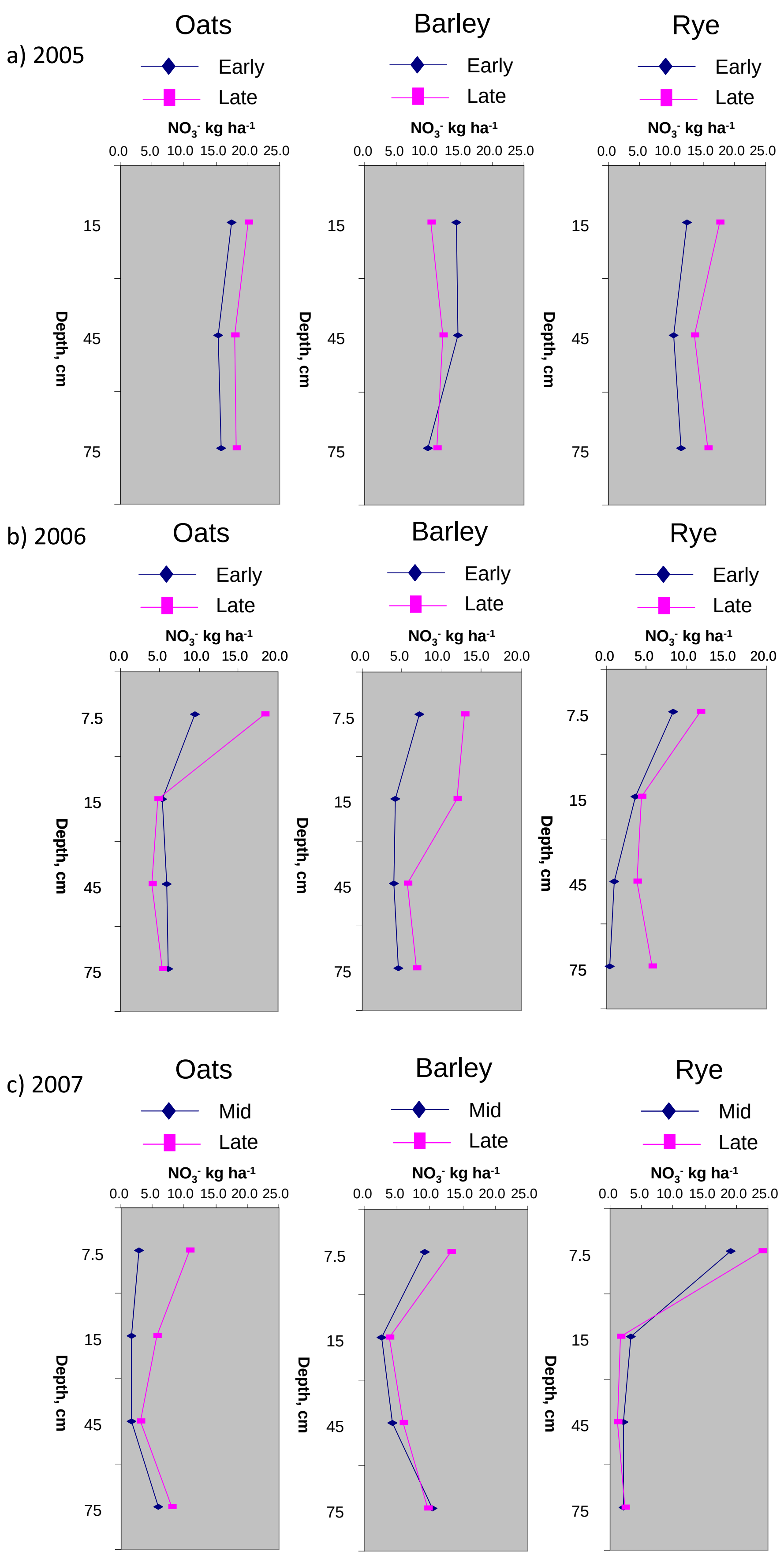

Figure 3. Ground cover present during mid-season growth of pumpkins following a) early planted rye; and b) late planted barley.

a)

b)

Figure 4. Pumpkin shell quality impacts of rye cover crop.

EVALUATING STOCKER CATTLE IN A SOUTHERN PIEDMONT CONSERVATION TILLAGE COTTON-COVER CROP SYSTEM TO INCREASE PRODUCTIVITY

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INTRODUCTION

Winter cover crops are often perceived as costly because there are no direct returns from selling the cover crop (Snapp et al., 2005). Additional negative concerns are expressed due to the potential for cover crop induced water stress early in the growth of the main cash crop. Cover crop conservation benefits have been documented for all major crops and growing regions of the US (Dabney, et al., 2001). Beyond the soil conservation benefits, cover crops have been shown to improve water availability by contributing to improvements in soil physical properties that increased water infiltration rate and reduce runoff (Touchton, et al., 1984; Bruce et al., 1995). Payments from government incentive programs, like the Conservation Security Program, can help offset the cost of cover crops (up to \$8 acre^{-1}) (Causarano et al., 2005). Another option for offsetting cover crop costs and increasing farm revenue is grazing of winter cover crops by cattle (*Bos taurus* L.). Grazing stocker cattle in a cotton-peanut rotation in south Alabama produced \$157 gross return and \$75 net return per acre from cattle (Siri-Prieto et al., 2003).

Grazing cover crops may reduce soil productivity due to hoof-induced soil compaction during the grazing period (Miller et al., 1997). Cotton yields were reduced an average of 14% in two out of three years on silt loam soil in North Alabama where cover crops were grazed (Mullins and Burmester, 1997). Soil compaction from grazing is influenced by a number of factors (soil texture, soil water content, grazing intensity, vegetation type and climate regime; Taboada and Lavado, 1988). Siri-Prieto et al. (2003) found that paratill or in-row subsoiling was required to alleviate grazing-induced compaction and maximize cotton and peanut yields in south Alabama.

In the Southern Piedmont, depth to the Bt layer influences rooting volume and water availability (Endale et al., 2006) and in turn can influence the degree of compaction from grazing. Depth to the Bt is spatially distributed with erosion class being a surrogate indicator but at a very rough scale. Other factors influencing soil response to cattle may also be spatially variable but need to be quantified before management strategies can be developed to reduce negative effects. By identifying spatially variable factors with GPS technology management zones can be delineated for prescription deep tillage. Performing deep tillage only on areas with a high probability of compaction would therefore reduce producer costs.

Our objectives were to evaluate the impact of cattle grazing winter annual small grains on (1) cotton production (2) forage available for grazing, and (3) soil compaction. We measured a number of spatially distributed soil and plant properties to identify those that might easily be used to identify management zones for ameliorating any negative effects from cattle.

MATERIALS AND METHODS

This study started in the fall of 2005 and will continue through 2009. Four fields at the USDA-ARS J. Phil Campbell, Sr., Natural Resource Conservation Center in Watkinsville, GA

In M.S. Reiter (ed.) A multidisciplinary approach to conservation. Proc. 31st Southern Conservation Agric. Systems Conf., Melfa, VA. 20-23 July 2009. Extension Publ. 2910-1417. Dep. Crop and Soil Environ. Sci., Eastern Shore Agric. Res. Ext. Cntr., Virginia Polytechnic Inst. and State Univ., Painter, VA. Available at: http://pubs.ext.vt.edu/2910/2910-1417/2910-1407.html.

(33° 59' N, 83° 27' W) historically in no-tillage and instrumented to determine management effects on sediment and nutrient losses from typical fields in the Southern Piedmont are used in the study. Three of the fields are 3.3 acres while the fourth is 6.9 acres.

Winter rye (*Secale cereale* L.) is planted with a no-till grain drill in early October as a cover crop on all fields. Poultry litter is applied in the fall to provide sufficient P for both rye and cotton (*Gossypium hirsutum* L.) and supplemental N is added as needed for cotton and rye. On two fields, rye is grazed with heifer cattle for 7 to 10 days starting in late-March. The other two fields are not grazed and the rye is killed with glyphosate the second week of April. Numbers of cattle are adjusted based on forage availability and estimated intake so that pastures are defoliated in less than 10 days. Cover crop biomass is determined prior to and after grazing and just prior to cotton planting. Cover crop residues are analyzed for carbon and N, P, K, Ca, Mg.

Soil type, EC data, depth to Bt, and soil penetrometer data collected in fall of 2006 were combined in a Geographic Information System (GIS) to develop plant sampling zones for the cotton growing season. The cumulative grazing effects on soil compaction will be determined by measuring soil penetration resistance at the same locations in the spring 2006 and 2009 following cotton planting. Geostatistical methods are being used to analyze soil, water, and plant data to determine landscape and grazing effects on cotton productivity.

Cotton is planted the first week of May with a no-till planter. Cotton plants are sampled at first bloom and mid-bloom for biomass, plant height, and nutrient status to determine grazing and landscape effects on growth and nutrient content. Winter grazing effects on plant water stress and soil water availability (0 to 30 cm) are determined from first bloom until cutout by measuring soil water content using TDR probes inserted vertically into the soil. Cotton is harvested in the fall after defoliation using a harvester equipped with a yield monitor and GPS to collect georeferenced yields. Cotton samples from five areas in each field are collected for determination of fiber length, strength, micronair, and uniformity using High Volume Instrument (HVI) classing.

RESULTS AND DISCUSSION

Grazing

In 2006, cereal rye (*Secale cereale* L.) herbage grew from approximately 1000 lbs/acre in late January to 8000 lbs/acre in mid April in the ungrazed plots. On the grazed plots, we began grazing with an herbage mass of approximately 4000 lbs/acre in mid to late March. The grazed plots were defoliated only once and the cattle consumed approximately 2600 lbs of dry matter per acre. In spring of 2007 herbage grew from approximately 1000 lbs/acre in February to 6000 lbs/acre in mid April in the ungrazed plots. On the grazed plots, we began grazing with a herbage mass of approximately 2200 lbs/acre in mid-March during a period of rapid growth. The mid-March grazing period was followed by a mid-April grazing and the animals consumed an estimated 2900 lbs of dry matter per acre during the grazing season. In spring of 2008, herbage grew from approximately 1000 lbs/acre in February to approximately 6000 lbs/acre in early April in the ungrazed plots. Grazing was initiated with only 1500 lbs/acre herbage mass. The watersheds were grazed twice and animals consumed approximately 2200 lbs of dry matter per acre of forage during the grazing season. Rye consumed in 2008 was about ½ this amount due to dry weather.

We estimate that 1.5 head/acre can be supported for a 75 day period between February 1st and April 15th if animal management and agronomic management are efficient and climate is adequate. Season to season variation will require careful and flexible management and alter rotational requirements. At $20 to $40 for an 800 lb round bale the 3000 lbs of forage would be worth $70 to $140/acre. The quality of grazed rye is higher than baled forage and should result in improved animal performance. In addition, grazed forage reduces labor, feeding losses and storage costs compared to hay. Adjusted to equivalents of feeding hay, yield/acre is closer to 4000 lbs/acre and the value of grazing the rye cover crop likely ranges from $100 to $200/acre.

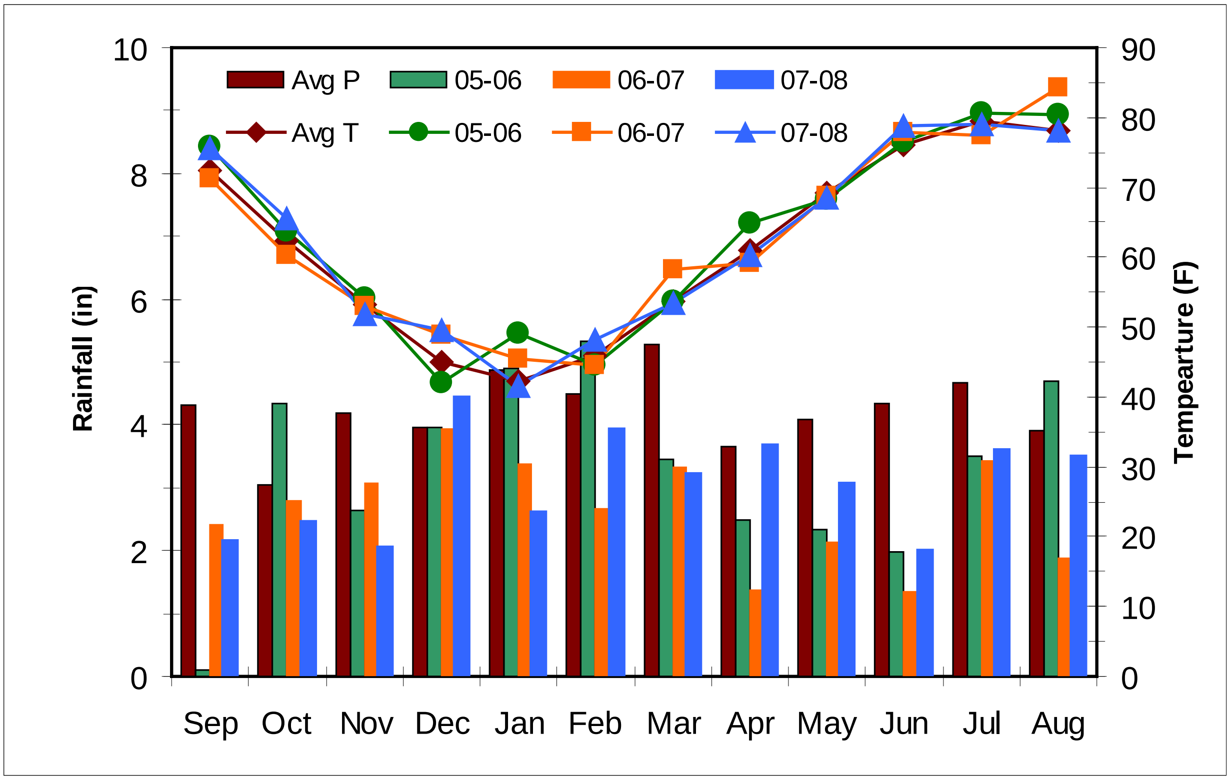
Cotton Yields

In 2006, cotton experienced 10 days of cool weather following planting on May 12th and 15th, which delayed germination and growth. Growing season rainfall was below historical averages but timely rains in late July and August were beneficial for cotton yields (Fig 1). Seed cotton yields ranged from 2140 lbs/ac to 2950 lbs/ac. No significant yield differences were detected between grazed and ungrazed fields (both treatments averaged approximately 2500 lbs/ac). After ginning, our yield per acre averaged 1008 lb lint/ac which was greater than the Georgia average of 765 lbs/ac or 1.6 bales/ac.

In 2007, rainfall was very low from planting to harvest. Rainfall in June (1.34 inches) and July (1.72 inches) was well below normal which reduced cotton growth and yield. Using our yield monitor equipped spindle picker, yields ranged from 200 to 300 lbs lint/acre and averaged 250 lbs/acre. About two weeks after using the spindle picker we picked the fields with a stripper unit and harvested another 140 lb lint/acre that was still in the field due to physiological hardlock. With the low yields there was no difference between grazed and ungrazed treatments.

In 2008, we had 12 inches of rain from planting to harvest. Rainfall in June was only 2 inches while July and August had 3.5 and 3.6 inches respectively. September rainfall was less than 1 inch. Our average yield was 794 lb lint / acre.

Fig 1. Temperature and Rainfall for the cover crop and cotton growing seasons Fall 2005 to Fall 2006 and the long-term averages at Watkinsville, GA.



CONCLUSIONS

Based on our grazing data, returns from grazing cover crops would be an economic benefit to cotton producers in the Southern Piedmont, especially in periods of poor crop production. In the first three years of the research, cereal rye provided sufficient forage to support approximately 1.5 animals/acre between February 1st and April 15th. Grazing did not influence yield in either year. Return on grazing was similar for both years while cotton returns were more variable. These results indicate grazing cover crops may be an important economic consideration for cotton producers in the Southern Piedmont because of the potential to increase revenues from grazing without reducing cotton yields and to minimize variations in total annual revenues. The research will continue in 2009.

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REFERENCES

Bruce, RR, GW Langdale, LT West, and WP Miller. 1995. Surface soil degradation and soil productivity restoration and maintenance. Soil Sci. Soc. Am. J. 59: 654-660.

Causarano HJ, AJ Franzluebbers, DW Reeves, JN Shaw and ML Norfleet. 2005. Potential for soil carbon sequestration in cotton production systems of the southeastern USA. Cotton Incorporated Report. http://msa.ars.usda.gov/al/auburn/nsdl/csr/docs/reeves/causarano/causarano05b.pdf

Dabney, SM, JA Delgado, and DW Reeves. 2001. Using winter cover crops to improve soil and water quality. Comm. Soil Sci. Plant Anal. 32: 1221–1250.

Endale, DM, DS Fisher, and HH Schomberg. 2006. Soil Water Regime in Space and Time in a Small Georgia Piedmont Catchment under Pasture. Soil Sci. Soc. Am. J. 70: 1-13.

Miller, MS, DW Reeves, BE Gamble, and R Rodriguez-Kabana. 1997. Soil compaction in cotton double-cropped with grazed and ungrazed winter covers. Proc. Beltwide Cotton Conf. Jan 6-10, 1997. New Orleans, LA. Vol. 1, pp. 647-648. National Cotton Council.

Mullins, GL, and CH Burmester. 1997. Starter fertilizer and the method and rate of potassium fertilizer effects on cotton grown on soils with and without winter grazing by cattle. Comm. Soil Sci. Plant Anal. 28: 739-746.

Siri-Prieto, G, DW Reeves, RL Raper, D Bransby, BE Gamble. 2003. Integrating winter annual grazing in a cotton-peanut rotation:forage and tillage system selection. Proc. Sod Based Cropping Systems Conf., Feb. 20-21, 2003. North Florida Research and Education Center-Quincy, University of Florida, Quincy FL.

Snapp SS, SM Swinton, R Labarta, D Mutch, JR Black, R Leep, J Nyiraneza, and K O'Neil. 2005. Evaluating Cover Crops for Benefits, Costs and Performance within Cropping System Niches. Agron. J. 97:322–332.

Taboada, MA, and RS Lavado. 1993. Influence of cattle trampling on soil porosity under alternate dry and ponded conditions. Soil Use and Management 9: 139-142.

Touchton, JT, and JW Johnson. 1982. Soybean tillage and planting method effects on yield of double-cropped wheat and soybeans. Agron. J. 74:57-59.

TOTAL SOIL PHOSPHORUS, ZINC AND COPPER CONCENTRATIONS AS AFFECTED BY LONG-TERM TILLAGE AND FERTILIZATION CHOICES IN CECIL SOIL

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ABSTRACT

Adoption of conservation tillage and use of animal waste as an alternative fertilizer source is increasing. The environmental consequences of these farm management choices need to be thoroughly evaluated. Poultry litter (PL) for example, while being an inexpensive and effective source of plant nutrients, could result in the buildup of phosphorus and heavy metals in soils with over application. Changes in total soil P, Zn and Cu in a Cecil soil (fine, kaolinitic, thermic Typic Kanhapludults) were assessed after 2, 5, 10 and 11 yrs of PL application under two tillage treatments, conventional tillage (CT) and no-till (NT) and two fertilizer sources, conventional fertilizer (CF) and PL in a cotton (*Gossypium hirsutum* L.) and corn (*Zea mays* L.) production experiment at the USDA-ARS, J. Phil Campbell, Sr. Natural Resource Conservation Center in Watkinsville, Georgia. At the end of 5 years of the cotton phase, under an annual PL application rate of 2 tons acre^{-1}, concentrations of total soil P, Zn, and Cu did not increase. In Yr 10 (end of the corn phase), soil P, Zn and Cu concentrations in the 0- to 6-in depth increased approximately 1.5 to 3 times to 846, 50 and 42 lb acre^{-1}, respectively, in NT, and 1116, 64, 54 lb acre^{-1}, respectively, in PL treatments. Total P and Cu also increased in the 6- to 12-in depth with concentrations being approximately 1/2 times those in the in the 0- to 6- in depth. The increase was due to a 2 to 4 times greater input of P, Zn and Cu from PL fertilizer to meet the corn N requirement. The PL effect continued one year after the last PL application. In Yr 11, total P, Zn and Cu concentrations were much greater in the 0- to 1-in depth for NT and in the 0- to 1- and 1- to 2-in depths for PL. Changes with depth exhibited both linear and non-linear patterns based on treatment effects. The relationship between extractable and total P and Zn changed at a threshold value beyond which extractable P and Zn increased at more than double the initial rate. These results highlight the need to reevaluate the practice of PL application based on crop N requirement.

Keywords: No-till, Conservation tillage, Poultry litter, Soil nutrients, Environmental risk

INTRODUCTION

Tillage and fertilizer source choices are important management variables with agronomic and environmental consequences in cropping systems. Adoption of conservation tillage and the use of animal waste as an alternative fertilizer source are increasing. Approximately 42% of U.S. cropland is in conservation tillage, of which approximately 24% is in no-till (CTIC, 2009). In the Southeast about 36% of all cropland is in no-till. The southern states of Alabama, Arkansas, Georgia, Mississippi and North Carolina account for over 60% of the 8.6 billion broilers ***(****Gallus*

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gallus domesticus) raised annually in the U.S, and consequently produce approximately 10 million tons of poultry litter (a mixture of bedding material and manure) (National Agricultural Statistics Service, 2007). Poultry litter provides a wide range of nutrients and organic matter (Moore et al., 1995) and is often an economical alternative to inorganic fertilizers.

The increased adoption of conservation tillage and use of animal waste as an alternative fertilizer source have raised environmental concerns related to soil and water resources, particularly from phosphorus (P). Manure application rates have historically been based on the nitrogen (N) requirement of crops and forages which has led to application of P greater than plant utilization (Kingery et al., 1994; Sharpley et al., 1993; Wood et al., 1996). Over time, this rate of application results in an accumulation of P and other elements in the soil (Kingery et al. 1994; Mitchell and Tu, 2006; Gascho and Hubbard, 2006; Adeli et al. 2007). In addition, high soil P decreases very slowly after P fertilization has stopped (Sharpley et al., 2003). State soil test results for the Southeast in 2000 indicated that, except for Alabama, 40 to 70% of the agriculture soil samples had high or very high soil test P levels (Sharpley et al., 2003). Schomberg et al. (2009) found that for a Cecil soil in the Southern Piedmont, Mehilich-1 extractable nutrients after a 10-yr PL application were predominantly in the 0- to 6-in. depth and that Mehilich-1 extractable P and Zn had increased more than 200%. Extractable nutrients represent only the acid soluble portion of P and metals in the soil. On the other hand, environmental risk assessments are generally based on total rather than extractable concentrations (Franklin et al. 2006; USEPA 1994, 1999). These reports suggest that the use of PL must be managed carefully to avoid negative environmental effects and the need for more research to quantify relationships between PL inputs and accumulation of nutrients in different tillage systems.

We evaluated the change in total P, Zn and Cu in the same Cecil soil used by Schomberg et al. (2009), a study of five years of cotton followed by five years of corn under combinations of tillage (conventional tillage and no-till) and fertilizer source (PL and conventional inorganic fertilizer). Our objectives were to quantify any buildup in the soil of these nutrients and to ascertain any definable relationships between extractable and total nutrients that might help identify environmental risks associated with long-term PL use.

MATERIALS AND METHODS

Experimental Site and Managements

The study was conducted from 1995 to 2005 at the USDA-ARS, J. Phil Campbell, Sr. Natural Resource Conservation Center, Watkinsville, GA (83^{o}24' W and 33^{o}54' N). The research facility is described in detail by Endale et al. (2002, 2008) and Schomberg et al. (2009). Briefly, the facility consists of 12 large (30 ft x 100 ft) tile-drained plots, located on nearly level (<2% slope) Cecil sandy loam soil. Cecil and closely related soils occupy greater than 50% the area of the approximately 42 million acres Southern Piedmont (Radcliffe and West, 2000). These soils are deep, well drained and moderately permeable. The pH decreases with depth. The clay subsurface (~ 10 in. from the surface where not eroded) is overlain by sandy clay loam to clay loam texture (Bruce et al., 1983). Long-term average daily air temperature in summer ranges from 75 to 80 ^{o}F at the site. Mean annual rainfall is 48.9 inches evenly distributed across months but with greatest amount occurring in March and the least in October. Short-term summer droughts are frequent in spring and summer.

Main plot treatments are conventional tillage (CT) and no-till (NT) while subplots treatments are conventional fertilizer (CF - either NH_4NO_3 or $(NH_4)_2SO_4$ for N) and PL. This arrangement results in a factorial combination of treatments: CT-CF, CT-PL, NT-CF, and NT-PL (Table 1). The experimental design is a randomized complete block with three replications of each treatment. The CT consisted of a 12-in deep chisel plowing, to break possible hard pans, followed by one to two diskings to an 8-in depth, and a subsequent disking to 3 in to smooth the seed bed. The only soil disturbance in NT occurs during planting with a four-row no-till planter equipped with fluted coulters to cut through surface residue, followed by double-disk openers to make a narrow slit for the seed, and press wheels to firmly cover the seed. No-till treatments were begun in the fall of 1991.

Cotton (cv. Stoneville 474) with a cereal rye (*Secale cereale* L.; cv. Hy Gainer) cover crop was grown from fall 1994 to fall 2000 (cotton phase). The cotton fertilization need of 60 lb N $acre^{-1}$ was provided as NH_4NO_3 in the CF treatment while in the PL treatment, starting in spring 1995 (Year zero), an equivalent amount of N was added by applying 2 tons PL $acre^{-1}$ (fresh weight basis) on the assumption that mineralization of N in PL was 50% during the main cropping season (Ritz and Merka, 2004). In both the CT and NT treatments, the cover crop was chemically killed two to three weeks before planting of cotton. Corn (cv. Pioneer 3223), again with cereal rye as the winter cover crop, was grown beginning in spring 2001. Nitrogen fertilization increased to 150 lb $acre^{-1}$ based on recommendations for corn and was applied as $(NH_4)_2SO_4$ in the CF treatment. The PL treatment received 5 ton PL $acre^{-1}$ in 2001, 2002, 2004 and 2005 providing an equivalent amount of plant available N. In 2003 the N application rate was doubled (to 300 lb N $acre^{-1}$ in CF and 10 ton PL $acre^{-1}$ in PL) to investigate hormone concentrations in soil, runoff and drainage from poultry litter use. The rye cover crop in the PL treatment was fertilized with 3.0, 1.8, and 1.8 ton PL $acre^{-1}$ during 2001, 2002 and 2003 and with $(NH_4)_2SO_4$ (60 lb N $acre^{-1}$) in 2004 and 2005 of the corn cropping phase in contrast to the use of commercial fertilizer during the entire cotton phase. Rye in the CF treatment was fertilized with $(NH_4)_2SO_4$ (60 lb N $acre^{-1}$) from 2001 through 2005. In CF treatments P and K fertilization rates were based on soil test where triple super phosphate and potash, respectively, were used as fertilizer sources. Corn and rye residues were shredded with a rotary mower in both the CT and NT treatments but were only incorporated in the CT treatment. No additional PL was added to these fields after the spring of 2005 (Yr-10) but conventional fertilizer continued to be used for fall and spring N fertilization as needed.

Soil Sampling and Analysis

In the fall of 1997 (Yr 2), 2000 (Yr 5) and 2005 (Yr 10), soil samples (0 to 12 in.) were collected with a tractor mounted hydraulic soil coring device from three locations in each plot. Soil cores (1-in diameter) were partitioned into 0- to 6-, and 6- to 12-in depths and the samples from each depth group from each plot were combined by plot. In addition, in December 2006 (Yr 11), we took 0- to 1, 1- to 2, and 2- to 6-in samples from each plot using the same procedure. All samples were dried at 55 to 60 °C for 3 to 5 d and kept at room temperature until analyzed. For analysis, soil samples were digested in concentrated HNO_3 in a CEM MDS-2100 microwave system (Matthews, NC). The resulting solution was analyzed using a TJA Model IRIS 1000 dual-view inductively coupled plasma emission spectrometer (ICP-ES) for total P (TP) and other metals (USEPA, 1986).

Table 1. Cumulative amounts of P, Zn, and Cu added to the experimental fields.

Year†	Treatment‡	P	Zn	Cu
			lb acre^{-1}	
1997 (Yr 2)	CT-PL	178.6	3.7	3.3
	CT-CF	66.1	0.0	0.0
	NT-PL	178.6	3.7	3.3
	NT-CF	66.1	0.0	0.0
2000 (Yr 5)	CT-PL	378.6	6.9	8.5
	CT-CF	132.2	0.0	0.0
	NT-PL	378.6	6.9	8.5
	NT-CF	132.2	0.0	0.0
2005/2006 (Yr 10/11)	CT-PL	1537.7	34.0	54.3
	CT-CF	219.7	0.0	0.0
	NT-PL	1537.7	34.0	54.3
	NT-CF	219.7	0.0	0.0

† Yr 2, 5, 10, 11 represent year since start of PL application in spring 1995

‡ CT, Conventional tillage; NT, no-till; PL, poultry litter; CF, commercial fertilizer.

Statistical Analysis

The MIXED procedure of SAS (Littell et al., 2000; SAS Inst. 2003) was used to analyze the data as a randomized complete block experiment with repeated measures. Tillage, fertilizer, year and their interactions were considered as fixed main effects while bock was considered a random effect. Means were estimated as least square means and contrast statements were used to compare means. Because plots of extractable P and Zn versus total P and Zn concentrations exhibited patterns of abrupt slope change, we used piecewise regression to estimate a break-point and regression parameters for the two line segments. Unless otherwise indicated, all significant differences are expressed at the level of $P \leq 0.05$.

RESULTS AND DISCUSSION

In the discussion, Yr 2, Yr 5, Yr 10 and Yr 11 refer to years after poultry litter application which began in spring 1995. For example the 1997 poultry litter application is also referred to as Yr 2. Depth and depth interactions with tillage or fertilizer source effects were generally significant including for the data collected in 2006 where we analyzed soils at finer depth increments in the top 6 in. Results are therefore presented by depth.

Total P

0- to 6-in Depth

During the cotton phase (Yr ≤ 5), mean total P concentrations were 426 to 620 lb acre^{-1} and there was no increase with either CF or PL (Fig. 1a-1). During the corn phase, total P in PL plots increased from near 600 to more than 1100 lb acre^{-1}, in part reflecting the increased P input from PL during the corn phase (from 63 to 261 lb acre^{-1} yr^{-1}). In CF plots total P was greater in Yr 10 (~600 lb acre^{-1}) than in Yr 5 (440 lb acre^{-1}) but not Yr 2 (510 lb acre^{-1}). Input of P from CF (as triple super phosphate based on soil test results) was approximately 20 lb acre^{-1} yr^{-1} during both the cotton and corn phases. Total soil P concentration remained essentially the same in Yr 11 (2006) one year after the last application of PL. Tillage and the tillage by year interaction effects were not significant (P>0.18) and the three way interaction with tillage, fertilizer, and year was not significant (P =0.1).

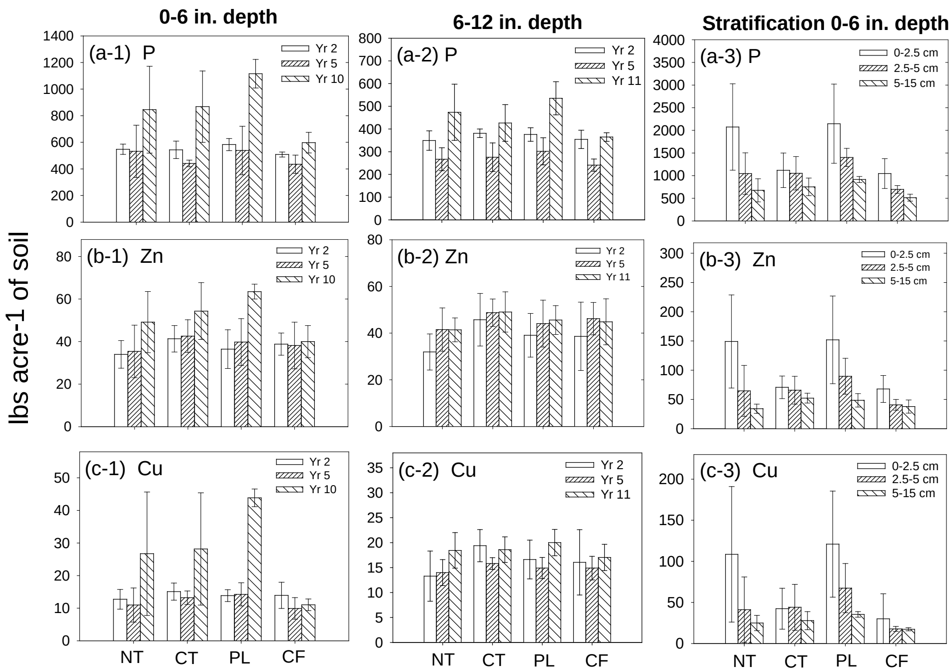


Fig. 1. Total P, Zn and Cu concentration in the 0- to 6-in depth for Yrs 2, 5 and 10, and in the 6- to 12-in depth for Yrs 2, 5 and 11, and in the 0- to 1-, 1- to 2-, and 2- to 6-in depths for Yr 11 by tillage (NT- No-till or CT- conventional tillage) or fertilizer (PL- poultry litter or CF- commercial fertilizer). Data are the average of 6 field triplicates. Error bars represent standard deviations.

6- to 12-in Depth

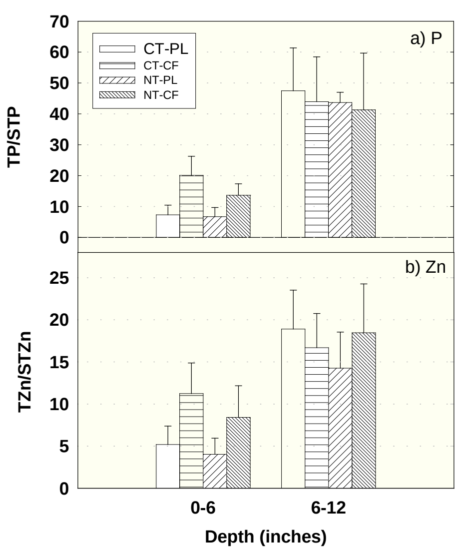
Soils collected in Yr 11 were used to compare concentrations in the 6- to 12-in subsurface soil (Fig. 1 a-2) (there were no soil samples for this depth in Yr 10). Year, fertilizer, and fertilizer by year interaction significantly influenced total P concentration (P<0.001). The interaction of tillage, tillage by fertilizer and tillage by fertilizer by year were not significant for total P (P

>0.17). Total P concentrations in the 6- to 12-in depth were essentially similar between CT-CF and NT-PL during the cotton phase (240 to 380 lb acre^{-1}) but by Yr 11 (2006) total P in the NT-PL soil was approximately 1.6 times greater than in the CT-CF soil with that for CT-CF showing no significant change from the cotton phase. In 1997 (Yr 2) total P was approximately 1.4 times greater in the 0- to 6-in than in the 6- to 12-in depth in both PL and CF treatments. By 2006 total P had increased to 2.2 and 1.7 times greater in the PL and CF treatments, respectively.

Stratification of P within the top 6 in. Soil Depth in Yr 11

As shown in Fig. 1 a-3, there were significant tillage by depth and fertilizer by depth interactions in total P distribution in the 0- to 1-, 1- to 2-, and 2- to 6-in depths of the Yr 11 soils. The tillage effect was limited to the 0- to 1-in depth, whereas that of fertilizer source was apparent in the 0- to 1-, 1- to 2- and 2- to 6-in depths. In the 0- to 1-in depth, total P was approximately 1.8 times greater in NT than in CT (2074 versus 1118 lb acre^{-1}), and approximately 2 times greater in PL than in CF treatments (2146 versus 1046 lb acre^{-1}). Total P in NT-PL was 3.6, 2.0 and 1.5 times greater compared to CT-CF, in the 0- to 1-, 1- to 2-, and 2- to 6-in depths, respectively.

When the total P data from all depths were pooled, a power relation best described change in total P concentration with depth in NT soils while both linear and exponential equations fit the CT data equally (data not shown). For fertilizer type, the distribution of P indicated slower or lesser movement from CF than from PL perhaps due to inorganic P in CF being more susceptible to immobilization by soil components and also due to greater organic P content and mobility with PL (He et al., 2009; Hunt et al., 2007).



Relationship between Total and Extractable P

The relationship between total versus extractable P was examined using total P data from this study and extractable P data reported in Schomberg et al. (2009) for these plots and time period of this study (Fig. 2a). Mean total P was approximately 7 times that of extractable P in the 0- to 6-in depths in the PL plots of either tillage treatment. The equivalent ratio was approximately 14 times that of extractable P in NT-CF and 20 times in CT-CF. The greater ratio for the CF plots indicates less extractable P than in PL. The ratio was much greater in the 6- to 12-in depth, but varied in a narrow range of 41 to 48 across the four treatments, again indicating less extractable P in the 6- to 12- than the 0- to 6-in depth.

Fig. 2. The ratio of total P to extractable P (a) and total Zn to extractable Zn (b) in conventional tillage (CT) and no-till (NT) fields with poultry litter (PL) or commercial fertilizer (CF) application. Data are the average of 3 field triplicates. Error bars represent standard deviations.

Plots of extractable P versus total P concentration showed patterns of abrupt slope change. We used piecewise regression to estimate a break-point and regression parameters for the two line segments (data not shown). The solution converged for all treatments except CF and CT-CF. Where piecewise regression estimated a break point, 86 to 97% of the variation in extractable soil P could be explained by variation in total P. The 95% confidence limit lines for the two-line model for P based on pooled data are shown in Fig. 3a. For data pooled across treatments, the break point for total P was approximately at 600 lb acre^{-1}. The slope after the break point was approximately 7 to 8 times that of the slope before the break point for PL associated with either CT or NT. While we cannot make definitive comparisons across treatments due to the non-convergence for CF and CT-CF, some general observations are: 1) a greater break point with PL compared to CF, 2) a smaller break points with NT compared to CT, and 3) a greater change in extractable P with PL than with CF.

The smaller break point for NT compared to CT probably reflects the greater stratification of nutrients in the NT treatment. Stratification could result in saturation of exchange sites in the surface soil and increase extractable P concentration at a lower total P concentration. In the NT plots the amount of P needed to saturate the available sorption sites is smaller because there is no soil mixing. Our results indicate that the available P fraction response to the cumulative amount applied may be confounded because once a saturation point is reached availability changes substantially.

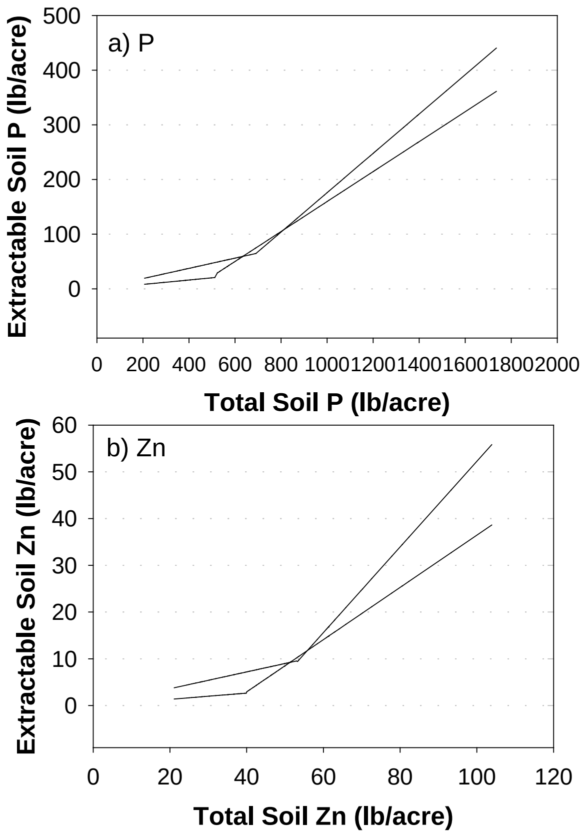


Fig. 3. 95 percent confidence limit lines for a two-line linear model for extractable soil P versus total P (a) and extractable soil Zn versus total Zn (b) based on data pooled across all treatments.

Total Zn

The three-way interaction for tillage, fertilizer and year significantly influenced the concentration of total Zn in the 0- to 6-in depth (P=0.04). No soil build up of Zn due to PL was observed during the cotton phase (Fig. 1 b-1). Total Zn concentration remained in the narrow range of 42 to 46 lb acre^{-1} in CT-CF for the 10-yr period while in the NT-PL it increased 1.4 times this amount by Yr 10 (62 versus 42 lb acre^{-1} for PL and CF treatments, respectively). Input of Zn increased from 1 lb acre^{-1} yr^{-1} during the cotton phase to 6 lb acre^{-1} yr^{-1} during the corn phase (Table 1). The long-term PL application effect remained a year after application of PL was stopped (2006). Changes in total Zn in the 6-12-in depth were much less than in the 0- to 6-in depth (Fig. 1 b-2). There were significant changes over time (P=0.01) but changes due to fertilizer or tillage (and their interactions) were too small to be significant. Total Zn concentrations in CT-CF and NT-PL were essentially similar in the 6- to 12-in depth.

Combinations of tillage and fertilizer influenced the distribution of total Zn in the top 6 in. soil in 2006 (P<0.007; Fig. 1 b-3). The tillage effect was most obvious in the 0- to 1-in depth while fertilizer source effects were obvious in the 0- to 1-, and 1- to 2-in depths. In the 0- to 1-in depth, total Zn was approximately 2 times more in NT and PL than in CT and CF, respectively.

Total Zn in NT-PL was approximately 4 and 2 times greater than in CT-CF in the 0- to 1-, and 1- to 2-in depths, respectively. Total Zn concentrations were similar between CT-CF and NT-PL in the 2- to 6-in depth.

As shown in Fig 2b, total Zn was up to 5 times greater than extractable Zn in the 0- to 6-in depths in PL soils, whereas in the CF plots it was 4 to 12 times greater. In the 6- to 12- in depth total Zn was approximately 14 to 19 times that of extractable Zn. Where piecewise regression (similar to total P) estimated a break point (between 40 and 44 lb acre^{-1}; Fig. 3), 73 to 91% of the variation in extractable Zn could be explained by variation in total Zn. Piecewise regression solutions could not be determined for CF, CT-CF and NT-CF. The slope of the second line segment is approximately 5 times greater than the slope of the line segment before the break point for PL associated with either CT or NT.

Total Cu

Tillage and fertilizer treatments influenced total Cu in the 0- to 6-in depth **(**Fig. 1 c-1). The fertilizer and year by fertilizer interaction effects were significant (P<0.0001), as was the tillage by fertilizer interaction (P=0.03). Total Cu concentration in 1997 and 2000 was less than total Cu concentration in 2005 and 2006 (P<0.0001). In CT and NT plots, total Cu concentration remained in the range 10 to 16 lb acre^{-1} during the cotton phase but rose to approximately 28 lb acre^{-1} at the end of Yr 10 (Fig. 1 c-1). Inputs of Cu from PL were approximately 1.5 lb acre^{-1} yr^{-1} and 10.3 lb acre^{-1} yr^{-1} during the cotton and corn phases, respectively. The absence of inputs of Cu in the CF treatment is reflected in the difference in total Cu concentration between the PL and CF treatments (44 lb acre^{-1} versus 12 lb acre^{-1}, respectively). The concentration of Cu was approximately 3.4 times greater in NT-PL than in CT-CF at Yr 10 and 11. In the 6- to 12-in depth the concentration of total Cu showed a significant response only to year (P=0.002). Tillage and fertilizer did not affect the concentration of total Cu at the 6- to 12-in depth (no significant interactions or main effects). At this depth, total Cu concentration was essentially similar between CT-CF and NT-PL through out the study (Fig. 1 c-2).

There was significant stratification of Cu in the 0- to 6-in depth in Yr 11. Combinations of fertilizer and tillage influenced differences by depth (P=0.05). Tillage differences were most apparent in the 0- to 1-in depth with total Cu concentration being approximately 2 times greater in the NT versus CT soils (Fig. 1 c-3). Fertilizer source effects were apparent in both the 0- to 1- and 1- to 2-in depths with PL having approximately 4 times more total Cu than CF in both depths. Compared to CT-CF, total Cu in NT-PL was approximately 8.5, 3.3 and 1.8 times more in the 0- to 1-, 1- to 2- and 2- to 6-in depths, respectively.

CONCLUSIONS

Application of 5 years of poultry litter at 2 tons acre^{-1} annually based on crop N requirement in a no-till and conventional tillage cotton-rye cover cropping system did not increase total soil P, Zn or Cu. While this is encouraging, the effect on even longer term application has not been established. A similar crop N requirement-based application of PL for corn (four years at 5 and one year at 10 tons acre^{-1} year^{-1}), however, lead to substantial increases within the 0- to 6-in soil depth potentially increasing environmental risks from these nutrients. These results support the need for P-based application of PL in vulnerable soils and calls for continued longer term research to determine critical threshold values under combinations of different tillage and fertilization sources across regions.

ACKNOWLEDGEMENTS

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REFERENCES

Adeli, A., K.R. Sistani, H. Tewolde, and D.E. Rowe. 2007. Broiler litter application effects on selected trace elements under conventional and no-till systems. Soil Science 172:349-365.

Bruce, R.R., J.H. Dane, V.L. Quisenberry, N.L. Powell, and A.W. Thomas. 1983. Physical characterization of soils in the southern region: Cecil. Southern Coop. Series Bull. No. 267. University of Georgia, Athens, GA.

CTIC, 2009. Amendment to 2007 national crop residue management survey. Conservation Technology Information Center, West Lafayette, IN.

Endale DM, Cabrera ML, Steiner JL, Radcliffe DE, Vencill WK, Schomberg HH, Lohr L (2002) Impact of conservation tillage and nutrient management on soil water and yield of cotton fertilized with poultry litter or ammonium nitrate in the Georgia Piedmont. Soil Tillage Res 66:55-86

Endale, D. M., Schomberg, H. H., Fisher, D. S., Jenkins, M. B., Sharpe, R. R., and Cabrera, M. L. 2008. No-till corn productivity in a southern United States Ultisol amended with poultry litter. *Agron. J.* 100**:** 1401-1408.

Franklin, RE, L. Duis, BR Smith. 2006. Mehlich extractable and total elemental concentrations in South Carolina Soils. Communications in Soil Science and Plant Analysis 37: 679-691.

Gascho, G.J. and R.K. Hubbard. 2006. Long-term impact of broiler litter on chemical properties of a Coastal Plain soil. Journal of Soil and Water Conservation 61:65-74.

He, Z., Tazisong, I. A., Senwo, Z. N., Honeycutt, C. W., and Zhang, D. 2009. Nitrogen and phosphorus accumulation in pasture soil from repeated poultry litter application. *Commun. Soil Sci. Plant Anal.* 40**:** 587-599.

Hunt, J. F., Ohno, T., He, Z., Honeycutt, C. W., and Dail, D. B. 2007. Inhibition of phosphorus sorption to goethite, gibbsite, and kaolin by fresh and decomposed organic matter. *Biol. Fertil. Soils.* 44**:** 277-288

Kingery, W. L., C.W. Wood, D.P. Delaney, J.C. Williams, and G.L. Mullins. 1994. Impact of long-term land application of broiler litter on environmentally related soil properties. J. Environ. Qual. 23:139-147.

Littell R.C., G.A. Milliken, W.W. Stroup, and R.D. Wolfinger. 2000. SAS System for Mixed Models. Second Edition. SAS Institute Cary, NC.

Mitchell, C.C. and S. Tu. 2006. Nutrient accumulation and movement from poultry litter. Soil Sci. Soc. Am. Journal, 70 (6), pp. 2146-2153.

Moore, P.A., T.C. Daniel, A.N. Sharpley, and C.W. Wood. 1995. Poultry manure management-Environmentally sound options. Journal of Soil and Water Conservation 50(4):321-327.

National Agricultural Statistics Service 2007. Poultry: Production and value 2006 summary. NASS, Washington, DC.

Radcliffe, D.E., and L.T. West. 2000. MLRA 136: Southern Piedmont. Southern Cooperative Series Bulletin #395. University of Georgia, Athens, GA.

Ritz, C.W., Merka, W.C. 2004. Maximizing poultry manure use through nutrient management planning. Bulletin 1245. Georgia Cooperative Extension Service, College of Agricultural and Environmental Sciences, Athens GA.

SAS Institute. 2003. SAS/STAT for Windows, version 9.1. SAS Inst., Cary, NC.

Schomberg, H. H., Endale, D. M., Jenkins, M., Sharpe, R. R., Fisher, D. S., Cabrera, M. L., and McCracken, D. V. 2009. Soil test nutrient changes induced by poultry litter under conventional tillage and no-tillage. *Soil Sci. Soc. Am. J.* 73**:** 154-163.

Sharpley, A.N., S.J. Smith, and W.R. Bain. 1993. Nitrogen and phosphorus fate from long-term poultry-liter applications to Oklahoma soils. Soil Sci. Soc. Am. J. 57:1131-1137.

Sharpley, A.N., T. Daniel, T. Sims, J. Lemunyon, R. Stevens, and R. Parry. 2003. Agricultural phosphorus and eutrophication. Second Edition. U.S. Department of Agriculture, Agricultural Research Service, ARS-149.

USEPA. 1994. The standards for the use or disposal of sewage sludge; 40, CFR, Part 503, amended February 25, 1994, FR 59: 9095. U.S. Environmental protection Agency. Washington, DC.

USEPA. 1999. Estimating risks from contaminants contained in agricultural fertilizers; draft, Office of Solid Waste and Center for Environmental Analysis. Washington, DC.

Wood, B.H., C.W. Wood, K.H. Yoo, K.H. Yoon, D.P. Delany. 1996. Nutrient accumulation and nitrate leaching under broiler litter amended corn fields. Commun. Soil Sci. Plant Anal. 27:15-17.

EVALUATION OF SOIL COMPACTION IN CORN GROWN UNDER DIFFERENT TILLAGE SYSTEMS AND SOIL ZONES

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SUMMARY

Determination of soil compaction under different soil zones and tillage systems can help to improve soil management. The objective of this study was to evaluate soil compaction under different soil textures, based on the soil electric conductivity (EC) measurements, and tillage systems in dryland corn (*Zea mays* L.). The research project was initiated with planting wheat (*Triticum aestivum* L.) cover crop at Clemson University, Edisto Research and Education Center near Blackville, SC in the fall of 2006. A commercially available soil electric conductivity (EC) measurement system (Veris Technologies 3100) was used to identify variations in soil texture across the fields prior to planting wheat cover crop and create soil zone maps using global positioning system (GPS) and geographical information system (GIS). Corn was planted across four different soil zones (based on soil EC measurements and ranging from 1 - sandy soils to 4 – clay soils) and under three tillage systems (no-till, conventional, and strip-till). Soil compaction was measured within corn rows using a CP40II cone penetrometer during corn vegetation. The results show that soil compaction can be influenced not only by tillage, but also soil texture. Generally, soil compaction varied from year to year creating different conditions for plant growth and development, and significant differences between soil zones were observed at some depths within the top 12 inches under conventional tillage and strip-till in 2007, and under no-till and strip-till in 2008.

INTRODUCTION

Greater understanding of spatial-variability due to soil texture, tillage systems, and nitrogen application on crop production under dryland conditions can help to obtain optimum yields. Tillage systems are among the many factors that affect soil productivity (Licht and Al-Kaisi, 2005). Tarkalson et al. (2006) noted that tillage systems and nutrient management influence soil chemical properties that can impact the long-term sustainability of dryland production systems. Also, previous research has shown that nitrogen (N) availability depends on seasonal changes in soil structure (Radke et al., 1985; Johnson and Lowery, 1985; Wagger, 1989; Ranells and Wagger, 1992). Nitrogen mineralization and availability may be reduced due to soil compaction (Hassink, 1995) and low temperature, as a result of reduced air flow in conservation tillage (Johnson and Lowery, 1985). However, frequent soil movement in conventional tillage (CT) may increase the N mineralization process (Grace et al., 1993). Azam et al. (1988) and Grace et al. (1993) noted that N fertilization not only increases ammonium N, but also N mineralization in the soil. The synchrony of N supply with crop demand is essential in order to ensure adequate nitrogen utilization and optimum yield in the economically sustainable crop production (Fageria and Baligar, 2005).

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A commercially available soil electrical conductivity (EC) measurement system (Veris Technologies 3100) helps to identify variations in soil texture across the field and create soil zone maps using global positioning system (GPS) and geographic information systems (GIS).

More in depth evaluation of soil compaction under different soil zones and tillage systems may help to improve soil management. Therefore, the objective of this study was to evaluate soil compaction under different soil textures, based on the soil electric conductivity (EC) measurements, and tillage systems in dryland corn.

METHODS AND MATERIALS

The study was initiated on Dothan loamy sand (fine loamy, kaolinitic, thermic Plinthic Kandiudult) at Clemson University, Edisto Research and Education Center near Blackville, SC in the fall of 2006. Prior to planting wheat cover crop in 2006, soil electrical conductivity (EC) measurement system (Veris Technologies 3100) was used to identify variations in soil texture across the field and create soil zone maps using global positioning system (GPS) and geographic information systems (GIS). Feed wheat planted in early December of 2006 and Pioneer 26R12 wheat planted on 21 November 2007 were killed on 26 February 2007 and 6 March 2008, respectively. Field was divided into 4 different soil zone areas based on the soil EC readings. Each soil zone area was split into three tillage systems (conventional, strip-till, and no-till). Due to high soil variability, each tillage system was split into four soil zones based on average soil EC for each plot. Great Plains Turbo Till was used in the no-till (NT) sections and worksaver following disk was used in the conventional (CV) sections of the study on 12 March 2007 and 17 March 2008.

Pioneer 31G65 corn was planted at aproximately 28,000 seeds/acre in CV and NT sections using a John Deere 7300 MaxEmerge II Vaccum planter on 13 March 2007 and strip-till (ST) sections were planted on 14 March 2007 using a Univerferth Ripper-Stripper (Unverferth Mtg. Co., Inc., Falida, OH) and John Deere 1700 MaxEmerge XP Vaccum planters. In 2008, the Univerferth Ripper-stripper implement was used in ST and Pioneer 31G65 corn was planted in all plots, at the same rate as 2007, using a John Deere 7300 MaxEmerge II Vaccum planter on 18 March 2008. Weed control was based on the South Carolina Extension recommendations.

Soil compaction was measured within corn rows using a CP40II cone penetrometer with a 0.2 sq. inch cone during corn vegetation on 13 and 24 June in 2007 and 2008, respectively.

The experimental design was a split-plot with four replications. Tillage systems were considered the main plots and soil zones were subplots. The PROC GLM (SAS, 1999) was used to compare soil zones under different tillage systems. The difference between soil zones was considered significant at $P \leq 0.05$.

RESULTS AND DISCUSSION

Soil compaction was influenced by soil zones under convetional tillage, no-till, and strip-till in 2007 and 2008 (Fig. 1 - 6). Under conventional tillage, significantly higher soil compaction was observed on soil zone 4 (clay soils) compared to soil zone 1 (sandy soils) at 5-8, 19 and 20 inch soil depth in 2007 (Fig. 1). In 2008, soil zone 4 had higher compaction at 13-19 inch soil depth compared to soil zone 1 (Fig. 2). There was no significant difference across soil zones at 1-4 and 9-18 inch soil depth in 2007, and 1-12, and 20 inch soil depth in 2008.

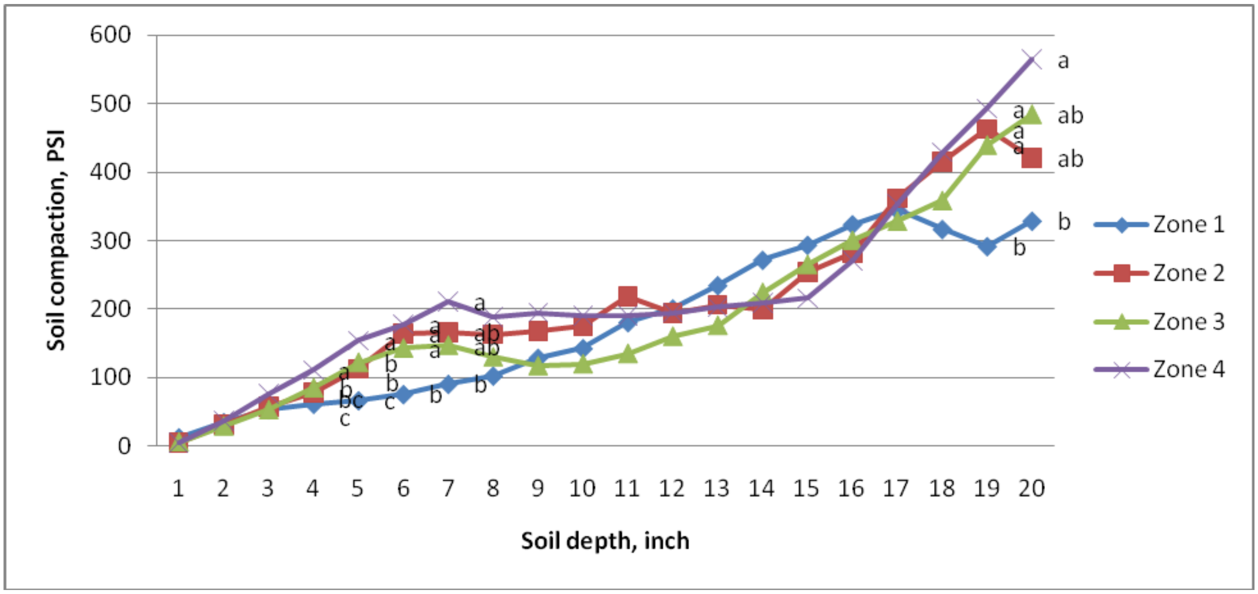

Fig. 1. Soil compaction across different soil zones (based on soil electric conductivity) under convetional tillage in 2007. Letter separation for each soil depth indicates significant difference at $P \leq 0.05$.

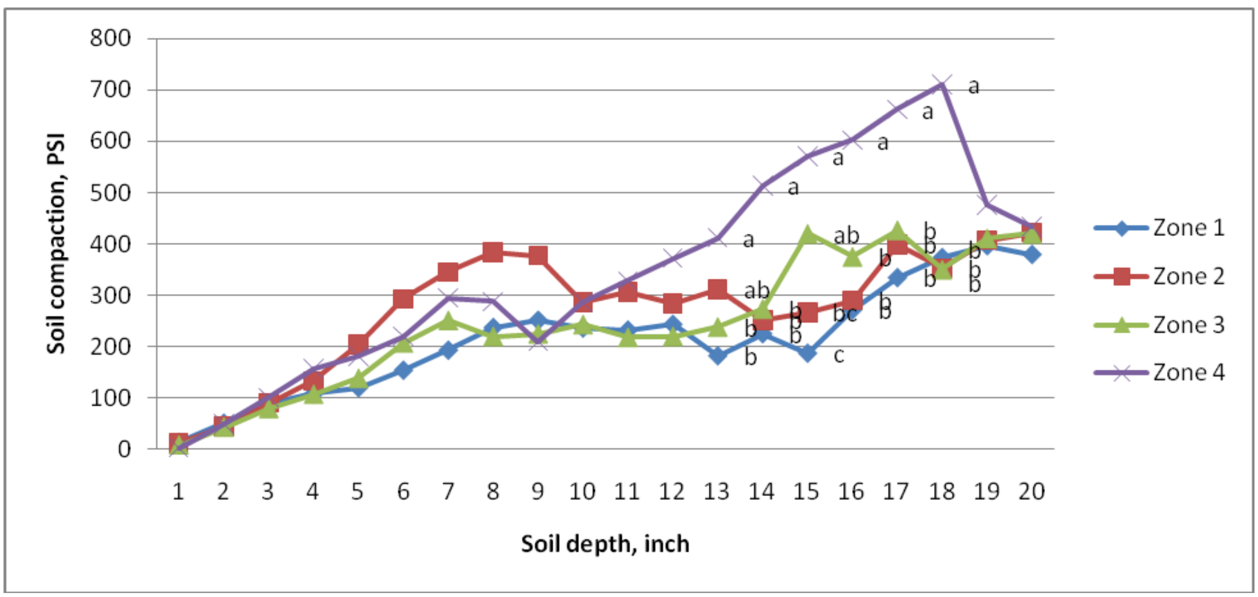

Fig. 2. Soil compaction across different soil zones (based on soil electric conductivity) under convetional tillage in 2008. Letter separation for each soil depth indicates significant difference at $P \leq 0.05$.

As for no-till, highest soil compaction was noted for soil zones 4 and 3 at 14-20 inch depth in 2007 (Fig. 3). For the same year, lowest soil compaction was observed for zone 2 at 15, 16, and 17 inch soil depth, and lowest for zone 1 at 18, 19, and 20 inch soil depth. In 2008, highest soil compaction was noted for zone 3 and 4 at 7 inch soil depth, and soil zone 2 at 8 inch depth (Fig. 4). For soil depth 17-20, significantly lower compaction was noted for zone 1 compared to other zones. For the same depths, there was no significant difference observed between zones 2, 3, and 4. Difference between zones was not significant at 1-13 inch soil depth in 2007 and 1-2, 5, and 9-16 inch soil depth in 2008.

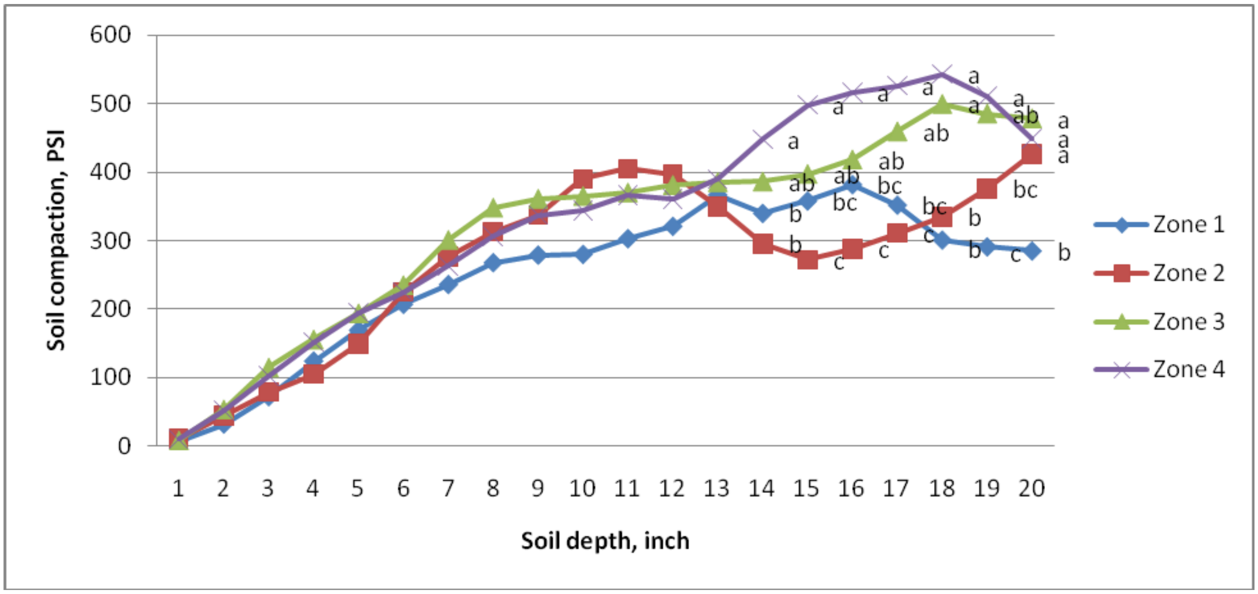

Fig. 3. Soil compaction across different soil zones (based on soil electric conductivity) under no-till in 2007. Letter separation for each soil depth indicates significant difference at $P \leq 0.05$.

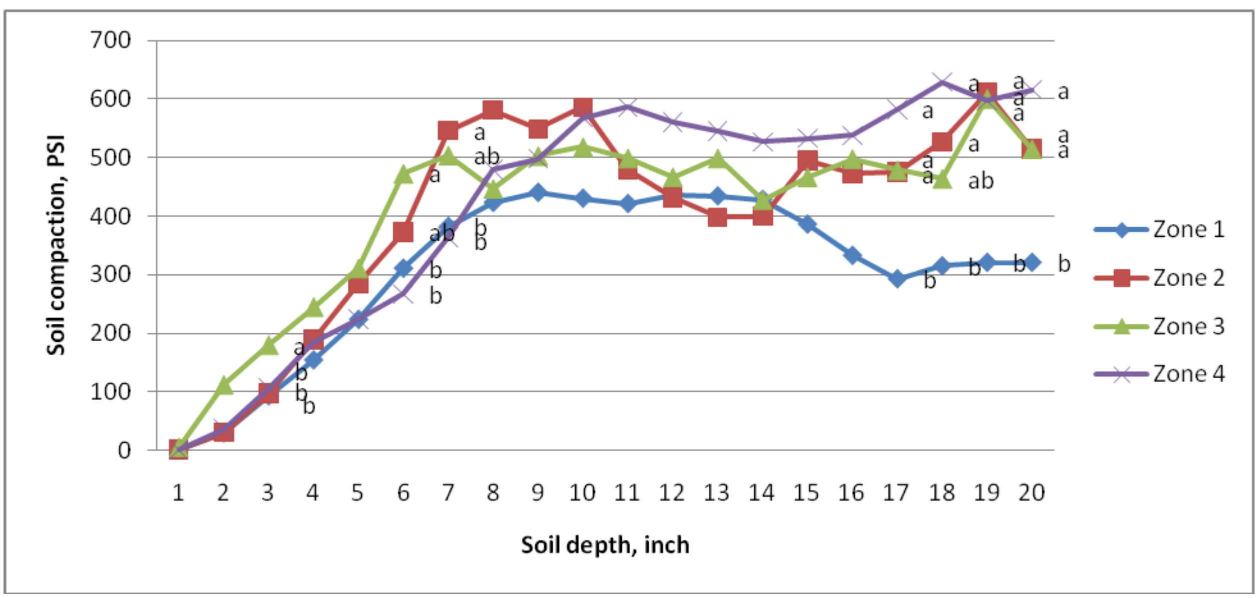

Fig. 4. Soil compaction across different soil zones (based on soil electric conductivity) under no-till in 2008. Letter separation for each soil depth indicates significant difference at $P \leq 0.05$.

Under strip-till, soil compaction was highest for soil zone 4 at 8-14 and 20 inch depth, and higher for zones 1, 3, and 4 than zone 2 at 15, 16, and 17 inch depth in 2007. In 2008, higher soil compaction was noted for zone 4 and 2 at 6-8 inch soil depth, and zone 4 and 3 at 17 inch depth. There was no significant difference between soil zones at 1-7 and 19 inch soil depth in 2007, and 1-4, 10-16, and 19-20 inch soil depth in 2008.

Generally, the differences for soil compaction close the soil surface were very small. However, compaction changed at lower soil depths with higher compaction usually observed for soil zone 4, which is characterized by highest soil EC values due to clay content.

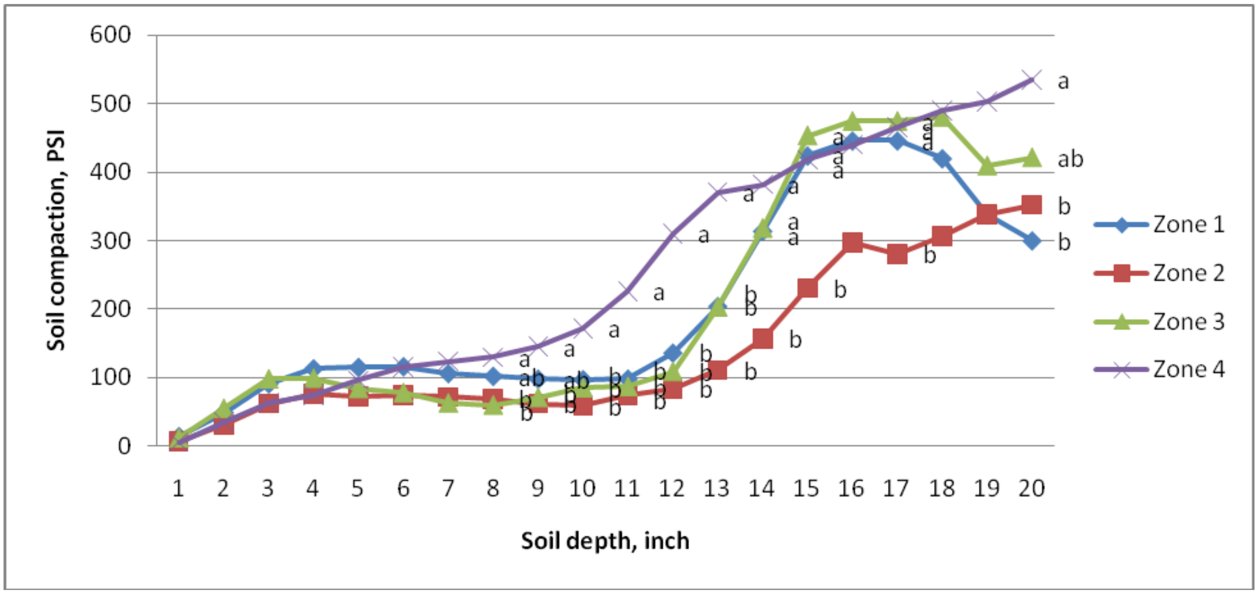

Fig. 5. Soil compaction across different soil zones (based on soil electric conductivity) under strip-till in 2007. Letter separation for each soil depth indicates significant difference at $P \leq 0.05$.

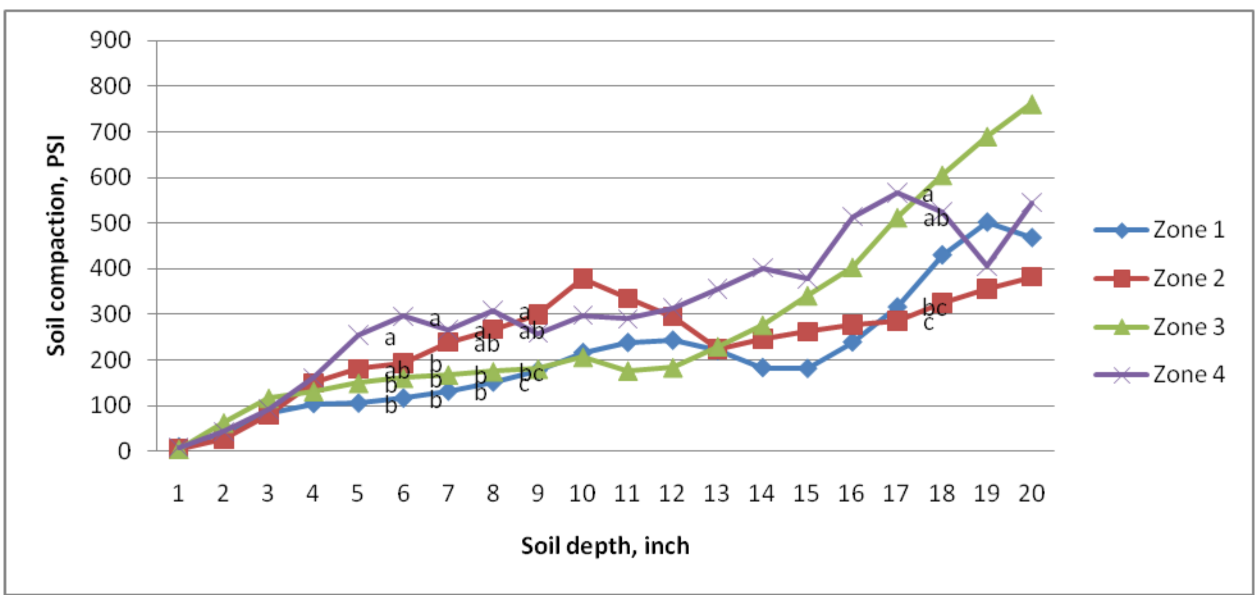

Fig. 6. Soil compaction across different soil zones (based on soil electric conductivity) under strip-till in 2008. Letter separation for each soil depth indicates significant difference at $P \leq 0.05$.

CONCLUSION

Soil EC can be successfully used to map fields for soil texture changes. Generally, higher EC indicate heavier soils and lower EC indicate sandier soils. The soil compaction results show that soil compaction varied from year to year creating different conditions for plant growth and development. Within the top 12 inches, significant differences between soil zones were observed at some depths under conventional tillage and strip till in 2007, and under no-till and strip-till in 2008.

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Technical Contribution No. 5682 of the Clemson University Experiment Station.

DISCLAIMER

Any opinions, findings, conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the USDA.

REFERENCES

Azam, F., R.L. Mulvaney, and F.J. Stevenson. 1988. Determination of in situ KN by the chloroform fumigation method and mineralization of biomass N under anaerobic condition. Plant and Soil. 111:87-93.

Fageria, N.K., and V.C. Baligar. 2005. Enhancing nitrogen use efficiency in crop plants. Adv. Agron. 88:97-185.

Grace, P.R., C. Macrae, and K. Myers. 1993. Temporal changes in microbial biomass and N mineralization under simulated field cultivation. Soil Biol. Biochem. 25:1745-1753.

Hassink, J. 1995. Density fraction of soil macroorganic matter and microbial biomass as predictors of C and N mineralization. Soil Biol. Biochem. 27: 1099-1108.

Johnson, M.D., and B. Lowery. 1985. Effect of 3 conservation tillage practices on soil temperature and thermal properties. Soil Sci. Soc. Am. J. 49:1547-1552.

Licht, M.A., and M. Al-Kaisi. 2005. Corn response, nitrogen uptake, and water use in strip-tillage compared with no-tillage and chisel plow. Agron. J. 97:705 - 710.

Radke, J.K., A.R. Dexter, and O.J. Devine. 1985. Tillage effects on soil temperature, soil water, and wheat growth in South Australia. Soil Sci. Soc. Am. J. 49:1542-1547.

Ranells, N.N., and M.G. Wagger. 1992. Nitrogen release from crimson clover in relation to plant growth stage and composition. Agron. J. 84:424-430.

SAS Inst. 1999. SAS user's guide. SAS Inst., Cary, NC.

Tarkalson, D.D., G.W. Hergert, and K.G. Cassman. 2006. Long-term effects of tillage on soil chemical properties and grain yields of a dryland winter wheat-sorghum/corn-fallow rotation in the Great Plains. Agron. J. 98:26-33.

Wagger, M.G. 1989. Time of desiccation effects on plant composition and subsequent nitrogen release from several winter annual cover crops. Agron. J. 81:236-241.

DEVELOPING AND IMPLEMENTING FERTILIZER BMPS FOR SIX MAJOR U.S. CROPPING SYSTEMS

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ABSTRACT

With support from a 3-year Conservation Innovation Grant from the USDA-Natural Resources Conservation Service, the International Plant Nutrition Institute and the Foundation for Agronomic Research designed a project to identify fertilizer best management practices (BMPs) for six major U.S. cropping systems. The intent was to help develop the BMP definition process in such a way that environmental objectives are met without sacrificing current or future production or profit potential and in full consideration of the newer technologies relevant to fertilizer use. A series of publications, decision support tools, and internet websites have been developed from this project. The concept of applying the right fertilizer at the "right rate, right time, and right place" is a guiding theme in this series. Details of this project and the publications and other products from it are available on the project website, http://www.farmresearch.com.

The following text highlights the specific cropping systems targeted in this project.

Applying the "Four Rights" for Cotton Production in the Midsouth and Southeast
Farmer interest in BMPs is associated with the increasing awareness that how we manage our soils and landscapes can have a large impact on the surrounding environment. As stewards of the land, farmers in the Midsouth and Southeast USA implemented soil conservation practices to improve their soil and water quality. Reductions in soil erosion and increased moisture conservation have led to higher crop yields and enhanced whole-farm economics.

Fertilizer Management Practices for Potato Production in the Pacific Northwest
Potatoes are grown in almost every state and province in North America. Some potatoes are grown for fresh consumption, while others are used for processing into fries, chips, or frozen products. Whatever the end use, the objective of every potato grower is to provide high quality potatoes that meet the market objectives at a price that is economically profitable and environmentally sustainable.

Fertilizing Irrigated Corn in the Great Plains
Irrigated corn production is an important component of agricultural systems in the central and southern Great Plains. Adequate and balanced nutrient inputs are critical to producing optimum yields that result in maximum profit. A 52-page color manual was designed and authored by industry, university, and government soil fertility experts to address fundamental irrigated corn fertility questions to this region. The content is especially timely considering the importance of fertilizer best management practices in managing the risk associated with today's market conditions.

In M.S. Reiter (ed.) A multidisciplinary approach to conservation. Proc. 31st Southern Conservation Agric. Systems Conf., Melfa, VA. 20-23 July 2009. Extension Publ. 2910-1417. Dep. Crop and Soil Environ. Sci., Eastern Shore Agric. Res. Ext. Cntr., Virginia Polytechnic Inst. and State Univ., Painter, VA. Available at: http://pubs.ext.vt.edu/2910/2910-1417/2910-1407.html.

Best Management for Fertilizers on Northeastern Dairy Farms
In the past 10 years, many dairy farms in the humid temperate zone of northeastern North America have implemented best management practices (BMPs) for manure and fertilizer to address concerns about nutrient buildup in soils and nutrient losses that can impact water and air quality. An Introductory Guide was developed, focused on fertilizer BMPs: applying the right source at the right rate, at the right time, and in the right place.

Fertilizer BMPs for Small Grains in the Northern Great Plains
As stewards of the land, northern Great Plains farmers have implemented soil conservation practices that exceed many other resource conservation activities in North America. The resulting reduction in wind and water erosion and moisture conservation have improved soils, and increased crop yields and whole-farm economics.

Fertilizing Corn and Soybean Systems in the Midwest
The dominant cropping system of the Midwest is the largest user of fertilizer and the one perhaps most often targeted for environmental issues. Project focus for this region was on nutrient management decision support tools that would aid farmers and their advisers in managing crop nutrients in this intensive management system to produce optimum yields with a minimum environmental footprint.

Fertilizer Nitrogen BMPs to Limit Losses that Contribute to Global Warming
The right fertilizer N management decisions in producing corn and other crops can help reduce the impact on greenhouse gas (GHG) emissions and global warming potential. These fertilizer best management practices (BMPs) can go a long way toward making the most of applied N, for economic benefit as well as environmental.

SOIL-AGGREGATE STABILITY AND LEAF WATER POTENTIAL UNDER CONSERVATION TILLAGE AND SOD-BASED CROP ROTATIONS IN A SEQUENCE OF DRY AND WET YEARS

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ABSTRACT

Perennial grass such as bahiagrass (*Paspalum notatum* Flugge) in rotations with cotton and peanuts under conservation tillage has shown positive impact on crop yields and economics. A long term experiment is in the 9th year at the University of Florida's North Florida Research and Education Center in Quincy to evaluate the impact of short-term perennials (2 yr bahiagrass) in a rotation scheme with peanut and cotton in conservation-till system. The experiment was a split-plot design with three replicates. Irrigation regime was the main plot and cropping system was subplot. Under irrigated conditions, peanut in sod-based system had significantly higher yields than the conventional peanut, but cotton yield response to cropping system depended on years; under non-irrigated conditions, both cotton and peanut in the sod-based cropping system had higher yields. Therefore, especially under non-irrigated condition, sod-based cropping system mitigated water deficit stress effect on crops and improved crop yield and water use efficiency compared to the conventional cropping system.

INTRODUCTION

The classical concepts of crop rotations are related to the technology of soil cultivation, pests control and water/nutrient supply. Advances in plant genetics and agronomic engineering, as well as the relatively cheap energy sources have resulted in a shift to specialization and concentration that appears to impair soil resilience, nutrients cycling, and agricultural stability (Gates, 2003; Franzluebbers, 2007). Some challenges to an economically viable and sustainable farming system are infertile soils, crop protection, low soil organic matter, and low soil water holding capacity. It is estimated that up to 80 per cent of the farming in the Southeastern US Coastal Plains is high input management (irrigation, fertilizers, and pesticides) of peanut-cotton rotation. Thus, there is still a need for estimating a balance that has to be maintained between agricultural production and environmental protection. A series of studies begun in 1999 at the University of Florida's North Florida Research and Education Center (NFREC) in Quincy, aiming to address these challenges by integration of perennial grasses into conservation-till rotation system of peanut and cotton (Katsvairo et al., 2007; Wright et al., 2007). Many aspects of the system have been and are being studied. Integrating perennial grasses, such as bahiagrass (*Paspalum notatum* Flugge) into the system has shown positive impacts on crop yield and economics. Short-term (2 yr) perennials in the rotation adds significantly to the soil organic carbon and nitrogen pools as well as helps diminish nematodes and other pests normally found with annual row crops (Tsigbey et al, 2009). Rearrangement of soil-inherited and external-stimulated processes often occurs in soils but the effect of different loading rate of conservation-till system with short-term (2 yr) bahiagrass on soil aggregates and leaf water potential (LWP) is

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rarely discussed. In this paper we address the impact of different row-crop to sod-grass sequences on soil aggregation and cotton LWP under conventional and sod-based rotation in a dry-wet-year sequence.

MATERIALS AND METHODS

A crop-rotation experiment was established to study two cropping systems (sod-based vs. conventional) under two irrigation regimes (irrigated vs. non-irrigated) and conservation tillage on a Dothan sandy loam at the University of Florida's North Florida Research and Education Center in Quincy, FL. The sod-based system is a 4-yr rotation with bahia-bahia-peanut-cotton, while the conventional system is a 3-yr rotation with peanut-cotton-cotton. In both systems a winter oat cover crop is following the summer crops. The irrigated plots are irrigated with a lateral-moving irrigation system when needed, whereas the non-irrigated plots have never received any irrigation since the experiment started in 2000. During 2000–2006 period the irrigation was applied based on Florida cotton production guidelines. In 2007 and 2008 the irrigation was applied when lowest LWP was about -15 bars during squaring and fruiting (Zhao and Oosterhuis, 1997).

Three weeks prior to cotton planting, oat cover crop was killed with Roundup and plot rows were strip-tilled using a Brown Ro-till implement. Cotton cultivar ‘DP 555 BG/RR’ was used for this study. All plantings were made in early May using a Monosem pneumatic planter with a row spacing of 3 feet and about 4.5 seeds per foot row. Nitrogen (25 lbs. N acre^{-1}), P (50 lbs. P acre^{-1}), and K (75 lbs. K acre^{-1}) from a combination fertilizer (5-10-15) were band applied adjacent to each row at planting. Cotton was sidedressed with additional N of 60 lbs. acre^{-1} (ammonia nitrate) at first square stage. Seedcotton was mechanically harvested from four middle rows in each plot two weeks after defoliation for determination of seedcotton yield. Two seedcotton subsamples (2 lbs each) in each plot were ginned to determine turnout (lint %). Lint yield was estimated based on seedcotton yield and lint %.

Peanut (cv. ‘Georgia Green’ or ‘AP-3’) was planted at 8 seeds per foot row in mid May. Peanuts were dug in mid September to early October. When peanut reached maturity stage, the four middle rows in each plot were mechanically dug and inverted prior to harvest. Pod samples were placed in a forced-air dryer at 113°F for 72 hours to ensure for a constant weight. Pod yield were determined.

During the 2007-2008 growing season, LWP of uppermost fully expanded leaves was measured with a plant water status console (Soil Moisture Inc., CA); the same procedure was also used for the oat winter-cover crop.

In the early spring of 2009 soil-aggregate separation was made from 0 to 20-cm depths with a 5-cm increment in a range (0-100%) of sod-based crop rotations; five aggregate-size ranges (2, 2-1, 1-0.5, 0.5-0.25, and 0.25-0.053 mm) were obtained by sieving.

The experiment was a set up as a completely randomized design with 3 replications. Irrigation was the main plot and crop rotation was the sub-plot. Plots received irrigation water according to standard extension recommendations for production in Florida. Weed and other crop management practices were done based on the Florida Cooperative Extension Services recommendations. All data were evaluated with the MIXED procedure in SAS (SAS, 2002).

RESULTS

Precipitation and irrigation during the experimental years

Cumulative yearly and seasonal precipitation during both major-summer (May-October) and cover-winter (November-April) growing seasons are presented in Table2/Fig. 1. The annual mean precipitation for the 2002 and 2003 (51.3 and 51.5 inches respectively) was close to the 30-yr average of 50.1 inch; for May-October growing season these two years were close to the 30-inch normal with precipitation of 25.5 and 35.5 inches, respectively. The 2004 and 2005 growing seasons were wet with up to 7 inches more precipitation from the long-term average of 30.0 inches, while the 2006 and 2007 growing seasons were dry (26.6 and 21.5 inches respectively. This wide range of hydrological years during the experiment allows us to analyze conservation tillage and rotational system responses to irrigation. The amount of irrigation for the 2002-2008 growing seasons for the study ranged from 4.2 to 7.6 inches (Table 1).

Table 1

Accumulated precipitation and amount of irrigation in the 2002 to 2007 growing seasons from April to October at Quincy, FL

Year	2002	2003	2004	2005	2006	2007	2008
	-- (inch) --						
Precipitation	25.5	35.5	36.9	31.8	26.6.2	21.5	32.6
Irrigation	7.4	4.4	5.0	7.5	7.6	5.2	4.2
Year type	Normal	Normal	Wet	Wet	Dry	Dry	Wet

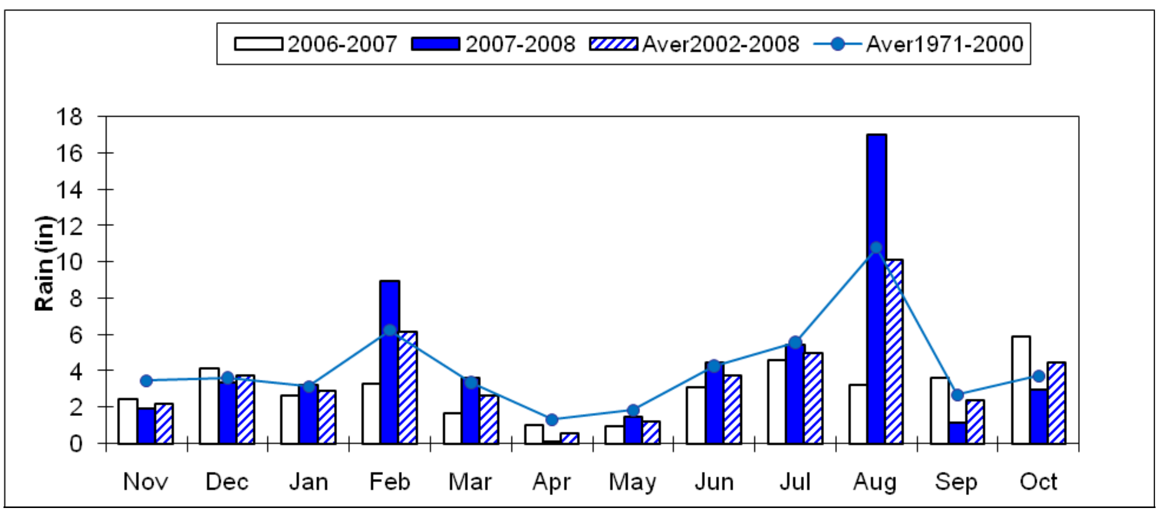


Figure 1

Monthly climatic water balance of the sod-based trial in Quincy, FL

Table 2
Precipitation (inch) during the 2006-2007 and 2007-2008 hydrological years in a comparison with short (6-yr) and long (30-yr) averages for Quincy, FL

Hydrological year	May-October	November-April	Year-total
2006-2007	21.54	15.27	36.81
2007-2008	32.64	21.34	53.98
Average 2002-2008	27.09	18.31	45.40
Average 1971-2000	28.92	21.20	50.12

Soil aggregates
Perennial sod has an effect on soil aggregation, but the proportion of the sod in a crop rotation may affect the quantification of aggregate size distribution. The mean weight diameter (MWD) of the aggregates was calculated and correlated with the soil properties; the smaller the aggregate, the higher was the aggregate stability. The aggregate-size status differed between crop-rotation systems as well as between the top two depths (0-5 and 5-10 cm) within a system; no significant differences were observed below 6-in depth. In spite of conservation tillage the permanent sod and the rotations without sod decreased in aggregate stability compared with the sod-based rotations (Fig. 2).

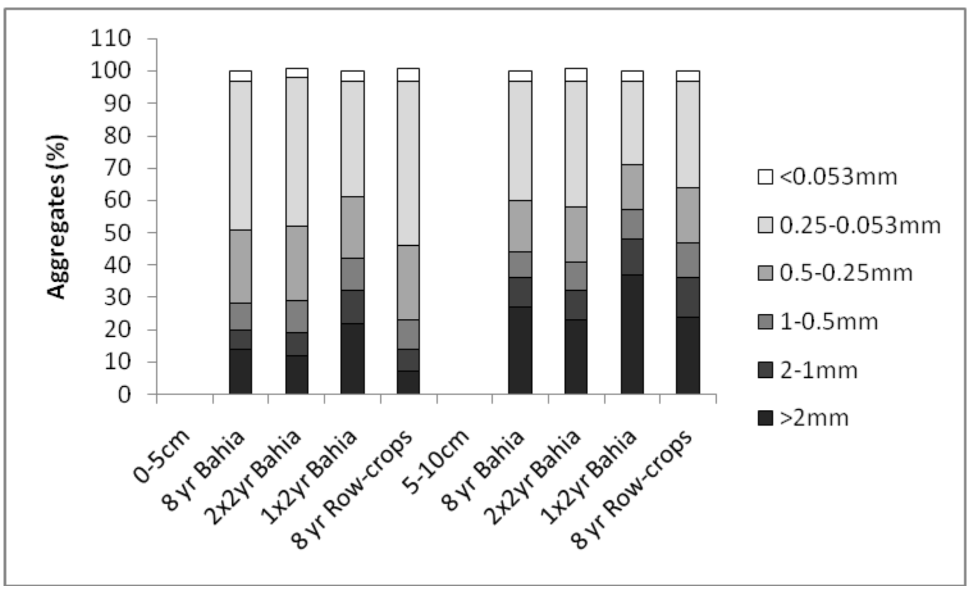


Figure 2
Particle-size distribution in the top 2 soil layers of the sod-based trial in Quincy, FL

Leaf water potential
In general, both peanut and cotton grown in the sod-based cropping system had greater LWP than plants grown in the conventional system, especially under non-irrigated conditions. During the 2007 growing season, the mean LWP values of sod-based and conventional peanuts were -4.9 and -8.3 bars, respectively, under irrigated conditions and -8.3 and -16.2 bars, respectively,

under non-irrigated conditions. Similarly, LWP of sod-based and conventional cotton were -14.1 and -14.6 bars, respectively, under irrigated conditions and -15.9 and -17.5 bars, respectively, under non-irrigated conditions (Data not shown). Integrating cover crops into rotations have also shown to benefit soil quality and productivity. In the 8-yr crop-rotation study the leaf water potential (LWP) was measured during both summer 2008 and winter 2008-2009 to assess plant response of both major and cover crops to moisture stress. According to the measurements sod-based cotton had -13.8 bars mean LWP while conventional (1st and 2nd year) crops with the -15.4 and 15.2 bars were also in the range of well-watered plants (Fig. 3).

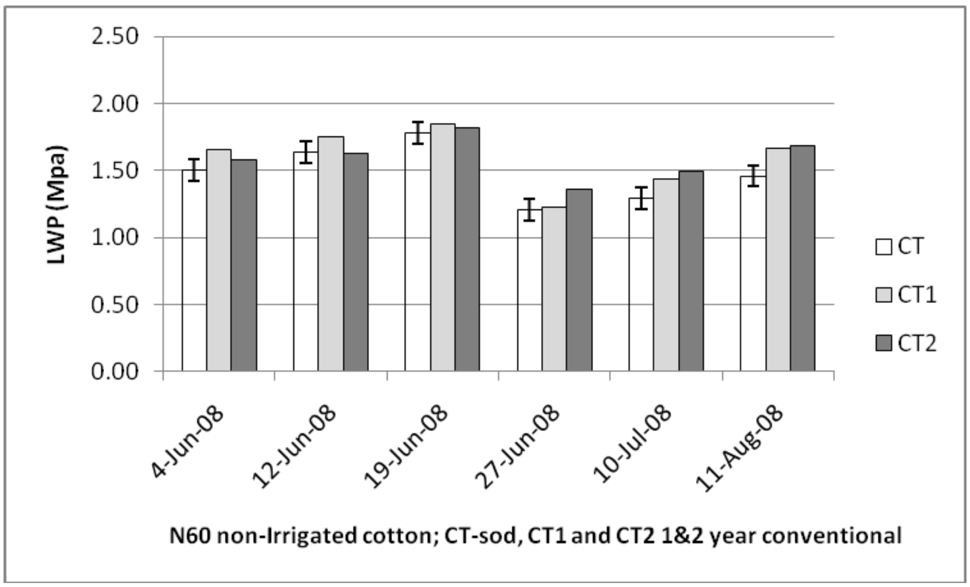
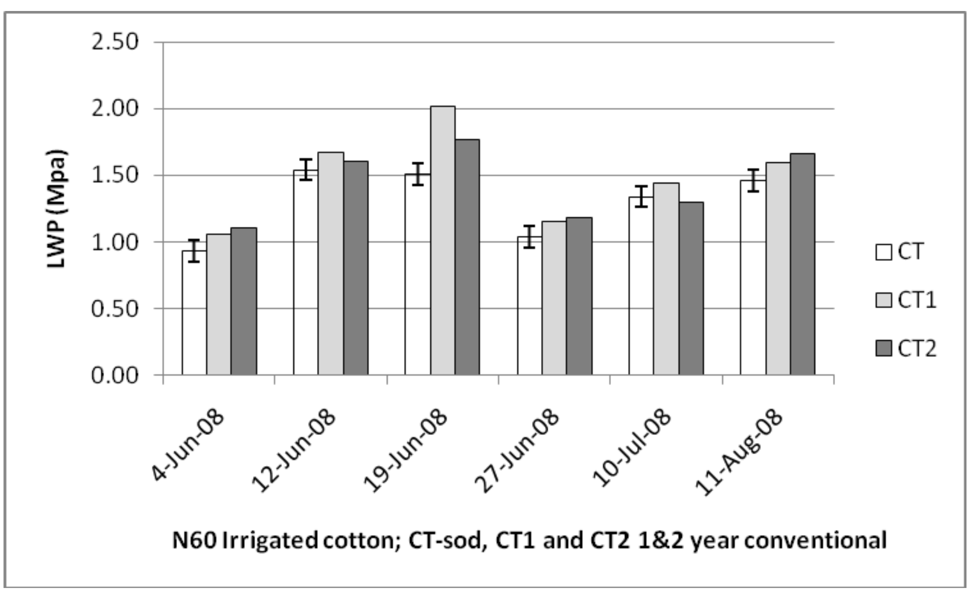


Figure 3. Dinamic of cotton-LWP during 2008 groing season



Similar tendency was observed for the following oat-cover crop; -14.7 bars LWP was detected after 2nd year cotton vs. -10.2 bars after sod-based cotton and -11.3 bars for the oats following 1st year cotton (Fig. 4). The same trends for lower LWP in sod-based systems were seen in both major (peanut) and cover (oat) crops.

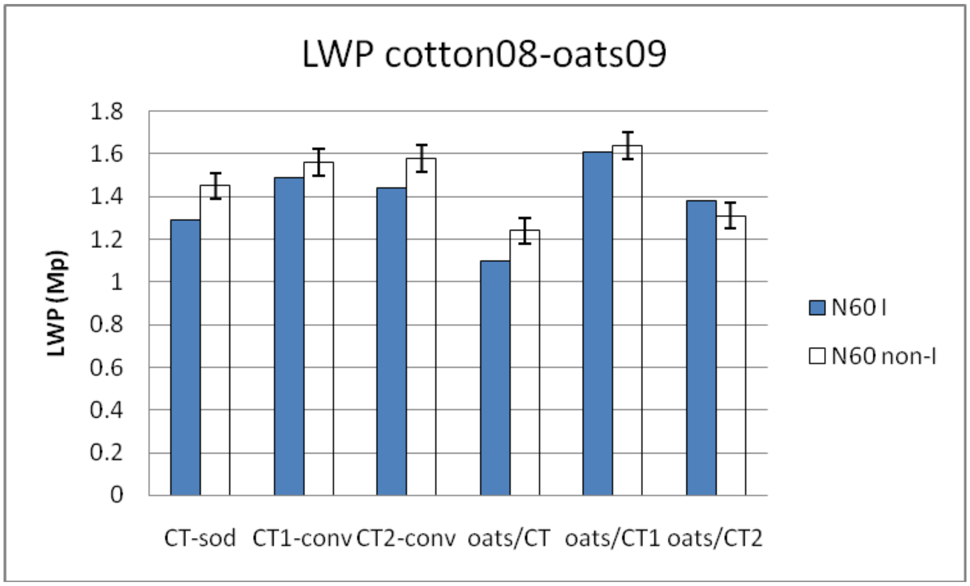
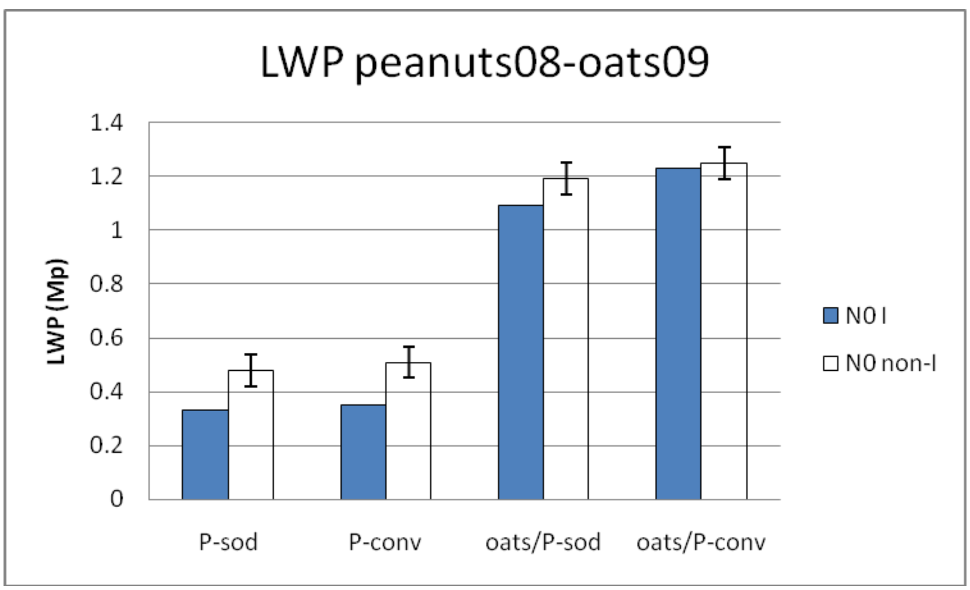


Figure 4
LWP means of both major summer and cover winter crops



CONCLUSION

The results of this study indicated that irrigation in both sod-based and conventional cropping systems with winter oat cover crop and a wide range of precipitation/irrigation water did not improve either peanut or cotton yields in normal years in the southeast USA. However, the row crops in the sod-based system are responding better to water stress in both dry and wet years. Even in dry years, there is potential to reduce irrigation, conserve regional water, and improve crop water and nutrients use efficiency. Compared to conventional system, sod-based peanut-cotton rotation can improve soil quality and crop growth resulting in higher crop yields, water-nutrients use efficiency and overall profitability.

ACKNOWLEDGEMENT

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REFERENCES

Franzluebbers, A.J. 2007. Integrated crop–livestock systems in the southeastern USA. Agron. J. 99:361-372.

Gates, R.N. 2003. Integration of perennial forages and grazing in a sod based crop rotation. P 7-14 *In* F. M. Rhoads (ed.) Proc. Sod Based Cropping Syst. Conf., Quincy, FL. 20-21 Feb. Univ. of Florida, NFREC Quincy, FL

Katsvairo, T. W., Wright, D. L., Marois, J. J., Hartzog, D. L., and Rich, J. R. 2007. Performance of peanut and cotton in a bahiagrass cropping system. Agronomy Journal 99:1245-1251.

SAS Institute. 2002. The SAS system for Windows. Version 9.00. SAS Inst., Cary, NC

Tsigbey, F. K., J. R. Rich, J. J. Marois, and D. L. Wright. 2009. Effect of bahiagrass on nematode populations in the field and their behavior under greenhouse and laboratory conditions. Nematropica In Press

Wright, D.L., Marois, J.J., and Katsvario, T. W. 2007. Bahiagrass impacts on cotton in a peanut/cotton rotation. Proceedings of Beltwide Cotton Production Research Conference. National Cotton Council of America. Pp. 1770-1774.

Zhao, D., and D.M. Oosterhuis. 1997. Physiological responses of growth chamber-grown cotton plants to the plant growth regulator PGR-IV under water-deficit stress. Environ. Exp. Bot. 38:7-14.

UREA-AMMONIUM NITRATE (UAN) SOLUTION PLACEMENT IN NO-TILLAGE CORN PRODUCTION

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ABSTRACT

Urea N fertilizers are subject to potentially high losses of N from volatilization in no-tillage systems. Common sidedress applications in corn production apply surface bands of urea-ammonium nitrate (UAN). This application method increases the probability for N-loss as volatilized ammonia. Subsurface banding (injection) of UAN greatly decreases the possibility of N-loss by directly placing UAN into the mineral soil. These field studies will be conducted for 3 years on multiple sites throughout the state of Virginia to compare the efficiency of surface banding and injection of UAN at sidedress in no-tillage corn production. Sites for the first year of the experiment were in the coastal plain and ridge and valley regions of Virginia. Nitrogen rates were 30, 60, 90, 120, and 150 lb N ac^{-1} for small plot studies as well as the producer N rate for the site, and -15%, and -30% of the producer rate for large plot or strip trials. The results for corn grain yield from the first year of the study showed that, there was no significant difference between surface banding and injection of UAN. Similar grain yield for the two methods of application at the ridge and valley sites were to be expected due to significant rainfall events shortly after sidedress applications. Precipitation data were not available at the coastal plain sites, but the absence in yield differences may also be due to rain events shortly after application. Precipitation data for many of the sites in the next two years of the study will be maintained for more accurate explanations of results.

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WEED SUPPRESSION OF A BICULTURE COVER CROPPING SYSTEM IN FRESH MARKET TOMATOES

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INTRODUCTION

Fabacaceae (legume) and Brassicaceae are two families of cover crops that are often recommended in a sustainable production system because of their unique properties and benefits on the soil. The use of allelopathic legume cover crops is of great interest because of their ability to fix nitrogen (Hill et al 2006). Several studies have shown the allelopathic potential of legume cover crops (Njoujio & Mennan 2005; Teasdale 1996; Hutchinson & McGiffen 2000). One such group of legume cover crops that have shown strong allelopathic capabilities is the vetches (Njouajio & Mennan 2005, White et al 1989; Hill et al 2006). Vetches, which include hairy vetch, purple vetch, and lana vetch, perform well over a wide range of soils, can fix over 100 pounds of nitrogen per acre and release about half of it to the following cash crop (Schonbeck & Morse 2006). They also make soil phosphorus more available and provide habitats for beneficial insects.

Cover crops in the *brassica* family, which include daikon, oilseed, and fodder radishes, are often chosen as cover crops because they are deep rooted crops that can help open subsoil hardpan (Schonbeck & Morse 2006). This characteristic is especially important in areas where traditional tillage has left a layer of hard soil just under the disturbed soil area. Other advantages include conservation of soluble nitrogen and rapid canopy closure to help prevent weed seed germination (Schonbeck & Morse 2006). These cover crops are also known to have strongly allelopathic root exudates, which can leave behind a weed-free seedbed after winterkill.

Planting a *brassica* and legume cover crop as a biculture could be very beneficial. In areas where traditional agricultural practices, such as mold-board plowing, have left a hardpan under the soil, the *brassica* cover crop could help break-up this layer. Incorporating a legume cover crop, that will help fix nitrogen, could prove to be very beneficial, especially in areas where the soil contains very low organic matter. Weed suppression could also be increased by incorporating the two families, instead of planting a monoculture cover crop system. However, it is important to understand how these crops will not only affect one another, but the cash crops that would follow behind this system. If increased weed suppression occurred from the biculture system, it is possible cash crops could be negatively affected, as well. Field studies are necessary to examine this system before it can be recommended to growers. Therefore, the objectives of this study were to determine: 1. compatibility of a *brassica* and legume cover crop

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in a biculture production system, 2. weed suppression when *brassica* and legume cover crops are planted as a mono-and biculture, and 3. effects on a cash crop when *brassica* and legume cover crops are planted as a mono- and biculture.

MATERIALS AND METHODS

For this study, oilseed radish (*Raphanus sativus*) and purple vetch (*Vicia atropurpurea*) were chosen because both have similar planting dates and should be winterkilled when temperatures drop below 20° F. Field design was a randomized complete block design with four replications. Individual plots measured 15 feet by 6 feet and consisted of four treatments: 1. Bare-ground control, 2. Purple vetch monoculture, 3. Oilseed radish monoculture, and 4. Purple vetch/oilseed radish biculture. Two locations were chosen for this study, one at the Tidewater Agricultural Research and Extension Center in Suffolk, VA and one in Dinwiddie County, VA. Plots were planted in Dinwiddie on 13 August 2007 and in Suffolk on 11 September 2007. Prior to planting, soil samples were taken from each treatment plot and evaluated for basic soil nutrient levels and percent organic matter. The cover crop seed was planted at the recommended rated with an Earthway® "EV-N-SPRED" broadcast seed spreader. After broadcasting, the seed were incorporated into the top two inches of the soil with a hard garden rake. Approximately two weeks after planting, data were collected from each plot based on percent ground coverage of the cover crops and weed coverage. Ground coverage percentages were subjected to ANOVA and the means were separated using Fisher's Protected LSD test.

The following spring, the treatments were incorporated into the soil with a garden tiller and soil samples were again taken from each plot. Approximately two weeks after cultivation, 'Crista' tomatoes were transplanted into the treatment plots and maintained according the Virginia Vegetable Production Recommendations Guide (Kuhar et al 2008). Weed data were taken on a weekly basis for approximately eight weeks. A 20- by 20- inch quadrat was placed randomly within the plot and the numbers of weeds were counted within the quadrat. Two quadrat samples were taken per treatment each week. Weed data were placed into one of the following categories: 1. < 2 inches, 2. 2-4 inches, and 3. ≥ 5 inches. Weed counts were totaled and subjected to ANOVA and the means were separated using Fisher's Protected LSD test. Weed data were also analyzed to determine if weed suppression properties of the cover crops diminished over time.

Yield data was also collected in late summer of 2008 from the transplanted tomatoes. Data were collected for total number of plants that survived to harvest, total fruit weight, and marketable fruit weight. These data were subjected to ANOVA and the means were separated using Fisher's Protected LSD test.

RESULTS AND DISCUSSION

When purple vetch was planted in a monoculture, percent coverage totaled 32.50%, which is significantly higher than 11.88% coverage when planted in the biculture system with oilseed radish (Figure 1). Subsequently, percent coverage of oilseed radish in a monoculture compared to the biculture with purple vetch was not significantly different, totaling 78.13% and 75.00%, respectively (Figure 2).

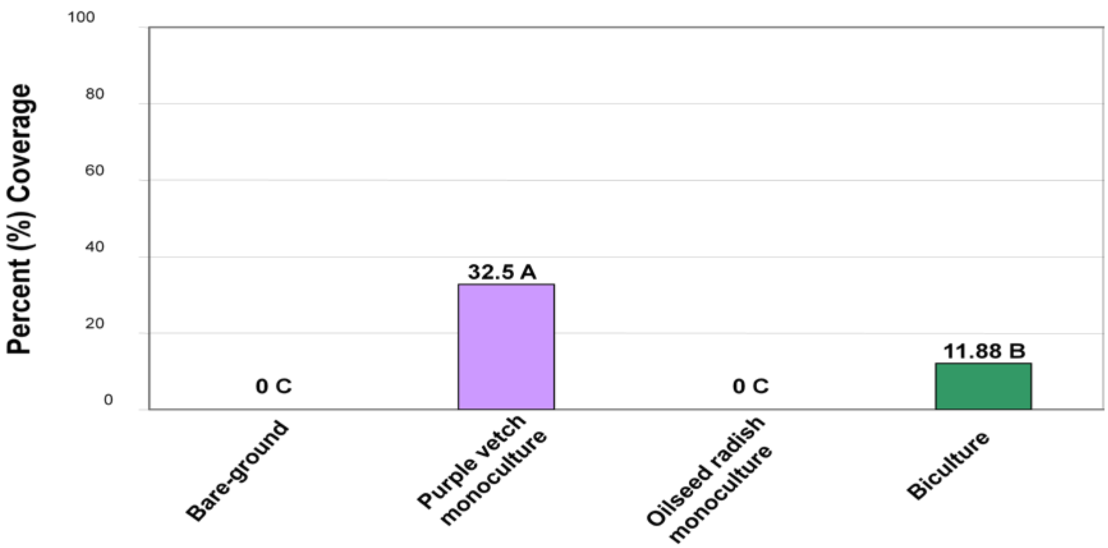


Figure 1. Percent coverage of purple vetch. Treatments with the same letter are not significantly different (α=0.05).

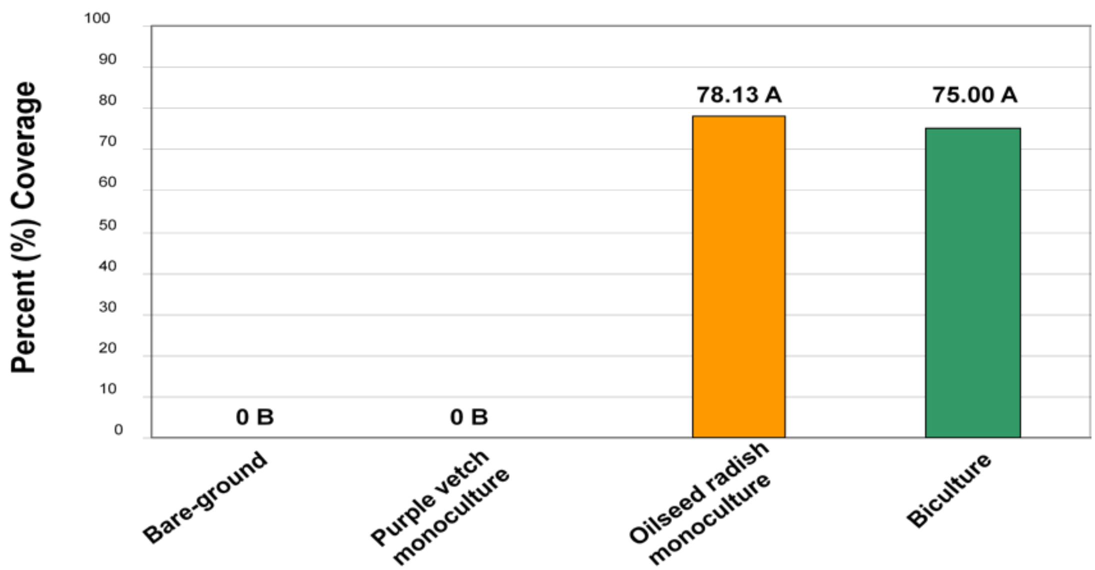
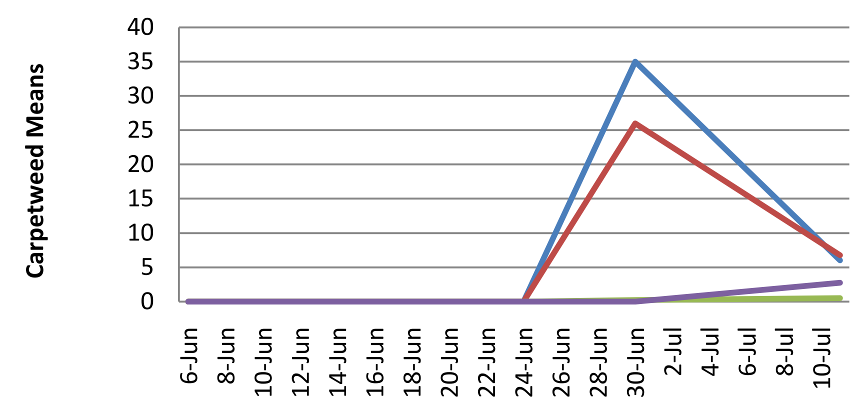


Figure 2. Percent coverage of oilseed radish. Treatments with the same letter are not significantly different (α=0.05).

In 2008, there were significant differences in total weed counts when individual species of weeds were compared from the Suffolk location, however, there were no significant differences in total weed counts for individual species of weeds from the Dinwiddie location (Figure 2). In Suffolk, there were three predominant species of weeds present: carpetweed (*Mollugo verticillata*), yellow nutsedge (*Cyperus esculentus*), and a variety of grass species. Carpetweed counts between the untreated control (41.00) and the vetch monoculture (32.75) were not significantly different from one another. Likewise, carpetweed counts in the oilseed radish monoculture (0.75) and the biculture (2.75) were not significantly different. However, when carpetweed counts for the untreated control and the purple vetch monoculture were compared to weed totals in the oilseed radish monoculture and the biculture, the treatments that contained oilseed radish had significantly lower carpetweed counts. Significant differences in total weed counts did not occur with any of the other predominate weed species at the Suffolk location.

At the Suffolk location, carpetweed counts were significantly higher approximately one month after the initial counts in both the untreated control and the purple vetch monoculture (Figure 3). There were no significant differences in weed numbers at different days in the oilseed radish monoculture and the biculture, suggesting carpetweed suppression up to eight weeks after incorporation of the cover crop. There were no other significant differences in weed counts over time at the Suffolk location. As with total weed counts, there were no significant differences in weed species as a function of time at the Dinwiddie location.



	6-Jun	24-Jun	30-Jun	11-Jul
Bare-ground	0	0	35	6
Purple vetch monoculture	0	0	26	6.75
Oilseed radish monoculture	0	0	0.25	0.5
Biculture	0	0	0	2.75

Figure 3. Carpetweed means over time at the Suffolk location ($p<0.0001$).

There were no significant differences in yield data from either location.

CONCLUSIONS

Early results from this study suggest that a biculture production system involving a brassica (oilseed radish) and a legume (purple vetch) cover crop may not be a viable system for Southeast Virginia. Purple vetch coverage was significantly lower when planted in a biculture system with oilseed radish versus a purple vetch monoculture. However, this situation only occurred at one of the two locations used in this study, so it is difficult to say for certainty if this would occur each time these two cover crops were planted together or if there were other factors contributing to these differences. Likewise, differences in weed counts only occurred at the Suffolk location, and then only with carpetweed. Carpetweed also showed significant differences as a function of time. Total carpetweed counts steadily increased in both the bare-ground control and the purple vetch monoculture, but remained significantly lower in the oilseed radish up to eight weeks after incorporation of the cover crop into the soil. While it is possible that carpetweed totals were significantly lower in treatments containing oilseed radish because of allelopathy, it may actually be a result of shading. The Suffolk location experienced very warm temperatures in early spring, which caused the oilseed radish to bolt and ultimately seed out before the cover crop was incorporated into the soil. High numbers of “volunteer” oilseed radish germinated in all treatment plots that contained this cover crop. Early in its development, carpetweed is a very low growing weed and may have been shaded by the oilseed radish plants and was therefore unable to grow as well in the treatment plots that did not have an oilseed radish problem.

There does not appear to be any negative effects on tomato growth and yield as a result of allelopathy from either of the two cover crops. However, as with weed counts and ground coverage percentages from these treatments, further data needs to be collected.

REFERENCES

Hill, E.C., M. Ngouajio, and M.G. Nair. 2006. Differential response of weeds and vegetable crops to aqueous extracts of hairy vetch and cowpea. HortScience 41(3):695-700.

Hutchinson, C.M., and M.E. McGiffen, Jr. 2000. Cowpea cover crop mulch for weed control in desert pepper production. HortScience 35:196-198.

Kuhar, T.P., J.H. Freeman, S. Rideout, R. A. Straw, C. Waldenmaier, and H.P. Wilson, 2008. Virginia Commercial Vegetable Production Recommendations (456-420). Virginia Cooperative Extension.

Ngouajio, M. and H. Mennan. 2005. Weed populations and pickling cucumber (*Cucumis sativus*) yield under summer and winter cover crop systems. Crop Protection 24:521-526.

Schonbeck, M. and R. Morse. 2006. Cover crops for all seasons—Expanding the cover crop tool box for organic vegetable producers. Available at www.vabf.org/infosheets/3-06.pdf (verified 07 July 2009) Virginia Association of Biological Farmers, Lexington, VA.

Teasdale, J.R. 1996. Contribution of cover crops to weed management in sustainable agriculture systems. J. Prod. Agr. 9:475-479.

White, R.H., A.D Worsham, and U. Blum. 1989. Allelopathic potential of legume debris and aqueous extracts. Weed Sci. 37:674-679.

IMPACT OF DIFFERENT COVER CROP RESIDUES AND SHANK TYPES ON NO-TILL TOMATO YIELD

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SUMMARY

A three year experiment with no-till tomatoes was conducted in Cullman, AL to determine the impact of plastic mulch (control), rye and crimson clover cover crops, and different subsoiler shanks on no–till tomato yield. In 2006 and 2008, plastic cover provided higher yield compared with rye and crimson clover in all shank treatments. In 2007, higher yield was produced following rye compared with plastic mulch and crimson clover. Across years, tomato yield after crimson clover was lower compared with rye and plastic. Percent of marketable fruit yield to total yield exceeded 80% in all treatments including the plastic control.

INTRODUCTION

Cover crops have become a vital part of no-till systems for row crops in the southern US; however, no-till systems using cover crops for vegetable production has not been widely adopted. Only 12% of the Alabama vegetable production area is under no-till production (CTIC, 2004). A limitating factor is the lack of equipment (rollers/crimpers) needed to manage tall cover crops such as cereal winter rye (*Secale cereale, L.)* and winter crimson clover (*Trifolium incarnatum* L.) in flat or ridge vegetable production systems. In addition, the tradition of plowing/disking soil in vegetable production is strong in this region. However, there is interest in Alabama to utilize cover crops in no-till vegetable systems to reduce cost and protect soil resources while increasing or maintaining yields. Cover crop use can improve soil physical properties, increase soil organic carbon, conserve soil water, reduce surface runoff, and recycle nutrients (Hubbell and Sartain, 1980; Reeves, 1994; Mansoer et al., 1997).
Cereal rye is the main cover crop widely used in Alabama and produces between 3 to 11 tons/ac of biomass which provides benefits such as alleopathic weed suppression and a mulch effect due to enhanced residue cover (Barnes and Putnam, 1983). Another widely used cover crop is the legume crimson clover which can be utilized in a mixture or alone to fix atmospheric nitrogen. To realize benefits of cover crops, they must be managed appropriately to avoid cash crop planting problems. To generate maximum biomass, these covers must be terminated at the appropriate growth stage. A common method to terminate cover crops is the use of herbicides since spraying is relatively fast and effective. However, since rye is very tall and lodges in multiple directions, planting efficiency of a cash crop can be reduced due to frequent delays required to clean accumulated cover residues from planting units.
Flattening and crimping cover crops by mechanical rollers in the direction parallel to planting of a cash crop is widely used in South America (especially in Brazil) to successfully terminate cover crops without herbicides (Derpsch et al., 1991). Because of potential environmental and monetary benefits (no use of herbicides), this technology is now receiving increased interest in North America. Ashford and Reeves (2003) indicated that when rolling was conducted at the

In M.S. Reiter (ed.) A multidisciplinary approach to conservation. Proc. 31st Southern Conservation Agric. Systems Conf., Melfa, VA. 20-23 July 2009. Extension Publ. 2910-1417. Dep. Crop and Soil Environ. Sci., Eastern Shore Agric. Res. Ext. Cntr., Virginia Polytechnic Inst. and State Univ., Painter, VA. Available at: http://pubs.ext.vt.edu/2910/2910-1417/2910-1407.html.

appropriate plant growth stage (i.e. soft dough), the roller was equally effective (as chemical herbicides) at terminating cover crops (94%). They concluded that rye mortality above 90% was sufficient to begin cash crop planting due to accelerated cover crop senescence.
Conventional tomato production typically includes deep tillage and bedded plastic mulch to minimize weed populations. Conventional tillage increases soil erosion and nutrient loss, reduces organic carbon, and increases soil strength (Blough et al., 1990; Mahboubi et al., 1993). Plastic mulch is expensive and could cause environmental problems if not removed from the field after harvest. According to Teasdale and Abdul-Baki (1995), tomatoes grown under plastic mulch increased soil temperature which caused tomatoes to produce fruit early in the season. In contrast, tomatoes grown under hairy vetch mulch systems showed that fruit production was more uniform throughout the season (Abdul-Baki et al., 1996). Therefore, no-till tomato production with cover crops might be a good alternative to protect the soil and the environment while decreasing tomato production costs.
The objective of this study was to evaluate the effects of two different cover crops (rye and crimson clover) and two shank types on tomato (*Lycopersicon esculentum* L.) yield.

MATERIALS AND METHODS

The experiment was conducted during the 2006-2008 growing seasons at the Northern Alabama Horticultural Research Station in Cullman, Alabama. The study was initiated in the fall of 2005 by planting two cover crops: winter Rye (Secale cereale, L.) and winter crimson clover *(Trifolium incarnatum* L.). Each fall cover crops were drilled with a no-till drill in rows 7 inches apart in plots 16 ft wide and 20 ft long. Rye was seeded at a rate of 90 lb/ac, whereas clover was seeded at 25 lb/ac. Nitrogen was applied at a rate of 60 lb/ac on rye plots in early spring each year. The experiment was established on a Hartsells fine sandy loam soil (Fine-loamy, siliceous, sub-active, thermic Typic Hapludults). The experimental design was a randomized complete block with four treatment replications. Treatments included two cover crops (winter rye and crimson clover). For each cover crop treatment three subsoil shank treatments were used: no shank, slim shank and wide shank. These treatments were compared to control plots (no cover crops) using plastic mulch, a typical tomato production system in Alabama. Each plot was 20 ft long and 8 ft wide and had a single row of tomatoes in the middle of the plot with 15 inch spacing between plants. To determine winter cover crop biomass, plants were clipped at the ground from two randomly selected 2.7 ft^2 sections per each plot immediately before termination. Plant samples were dried at 149 F for 72 hours and weighed. The winter cover crops were terminated each spring with a mechanical roller crimper prior to a supplemental chemical application of glyphosate at a rate of 1.0 a.i. lb/ac at the end of April approximately 3 weeks before transplanting tomatoes. The roller/crimper used in this experiment was 8 ft wide and consisted of a round drum with equally spaced blunt straight steel bars around the drum’s circumference and across the drum’s length (Fig. 1). The function of the bars was to crimp or crush the cover crop stems without cutting them. The rolling process produced a uniform residue cover on the soil surface.

Figure 1. Rolling cover crops using a 8 ft straight bar roller/crimper with ¼ inch thick crimping bars

Tomato cultivar ‘Florida 47’ seedlings were transplanted on May 15 in 2006, May 02 in 2007, and on May 01 in 2008. Seedlings were planted into both residue covers using a modified RJ No-till transplanter (RJ Equipment*, Blenhiem, Ontario; Fig. 2).

Figure 2. Planting tomato seedlings into rolled rye residue cover using a modified RJ No-till transplanter from RJ Equipment Company, Blenhiem, Ontario

To alleviate the soil compacted layer, the transplanter was modified by adding a sub-frame between the toolbar (with a mounted plastic tank for water/startup fertilizer) and the parallel linkage of the transplanter. The sub-frame was able to accommodate both commercially available shanks (subsoilers) and custom made shanks. Subsoiler shanks were able to penetrate the heavy residue and disrupt a naturally occurring consolidated compacted soil layer to a depth of 12-16 inches which is common at the experimental site in Cullman (Fig. 3). Additionally, in 2007, two driving wheels were utilized (one wheel on each side of the tomato row) instead of the original single wheel at the center of the row to improve stability and help minimize re-compaction of the soil opening created by the shank.

Figure 3. Side view of the RJ transplanter showing the sub-frame with the subsoiler shank and two powered wheels

A day after transplanting tomatoes, 13 temperature sensors were placed below the soil surface on selected plots at the plot center to collect soil temperatures (using 13 HOBO Water Temp pro Model H20-001 data loggers) for different covers during the growing season. Tomatoes were hand harvested four times at mature-green to pink color stages from 14 plants in each plot. Fruit number and fruit weight for total (cull included) extra large, large, medium and small sizes from each plot were recorded. Data was analyzed by analysis of variance and treatment means were separated using the Fisher's protected Least Significant Differences (LSD) test at the 10 % probability level. Where interactions between treatments and years occurred, data was presented separately and when interactions were not present, data was combined.

RESULTS AND DISCUSSION

Cover crops height and biomass

Rye and crimson clover plant heights are shown in Table 1. There were interactions between years and covers (P=0.0001), thus the heights for each year were analyzed separately. Average rye and crimson clover heights during three growing seasons were 65.5 inches and 21 inches, respectively. Rye heights were different each year whereas clover heights were similar. For rye, the lowest height was 58.7 inches in 2007 and the highest (71.6 inches) in 2008. The differences in rye height were reflected in biomass produced each year. In 2007, rye produced the lowest biomass (5528 lb/ac) and in 2008 the biomass was the highest (8630 lbs/ac). In 2007, there was no significant difference (P=0.6450) in rye and clover biomass (4949 lbs/ac). Lower rye biomass in 2007 might be related to soil moisture deficit after fall rye planting in 2006. Similar to rye, in 2008 crimson clover also produced the highest biomass (6297 lbs/ac).

Soil temperature for different covers

Over three years, maximum temperature for rye was significantly lower compared to clover and plastic (P=0.021; Table 2). Maximum temperature under rye was 93.3^{o} F compared to clover (97.9^{o} F) and plastic (100.5^{o} F). In 2006, no difference in minimum temperature was found between covers, whereas in 2007 minimum temperature under plastic was at least 2 degrees higher (68.2^{o} F) compared to rye and clover. In 2008, minimum temperature for rye was higher compared to plastic and clover. Since maximum temperature under clover during three years was higher than rye, it appears that higher temperature and lower clover biomass production lead to incomplete soil cover, resulting in more weed pressure that affected tomato yield.

Total tomato yield

There was a significant interaction between treatments and years (P = 0.0027) for total tomato yield, thus statistical analysis was done separately for each year. In 2006, averaged across treatments, total tomato yield was significantly lower compared to 2007 and 2008. In 2006, total tomato yield under plastic mulch was higher compared to no shank and wide shank treatments in rye and clover residue covers, even though there was no significant difference between plastic control and slim shank treatments after rye and clover covers (Fig. 4).

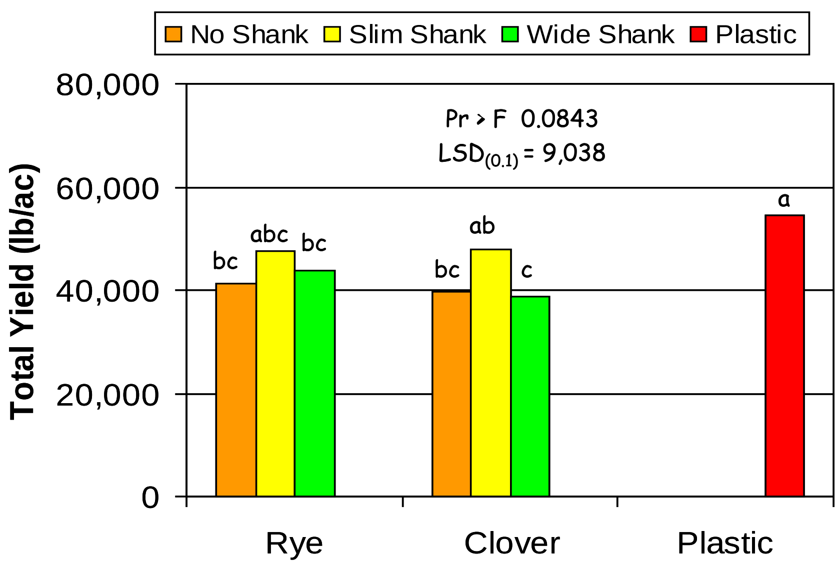

Figure 4. Total tomato yield in 2006 growing season

In 2007, the highest tomato yield was obtained for rye cover with no shank and with wide shank treatments. The lowest yield was calculated for plastic and crimson clover cover with no shank on the transplanter (Fig. 5).

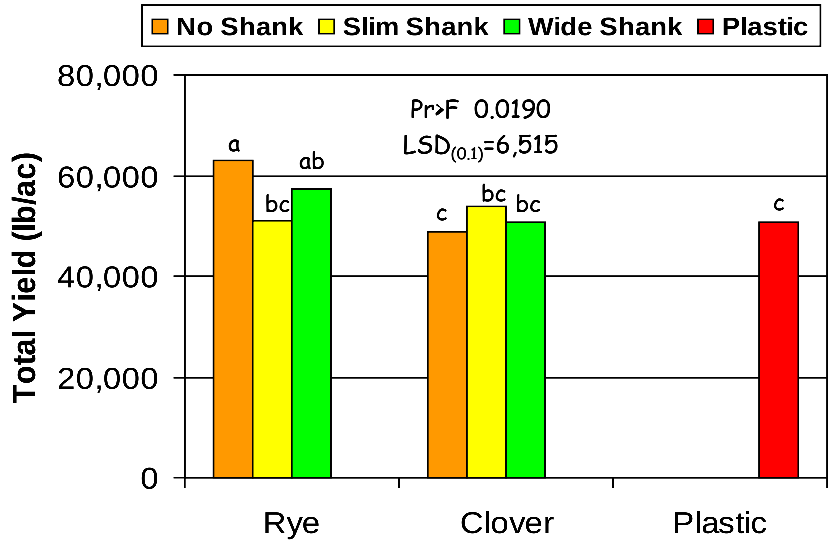

Figure 5. Total tomato yield in 2007 growing season

In 2008, significantly higher total tomato yield was reported for plastic mulch cover compared to rye cover crop and crimson clover residues. Tomatoes planted into rye residue produced significantly higher total yield compared to crimson clover cover. Shank treatments did not have any significant effects on yield in 2008 (Fig. 6).

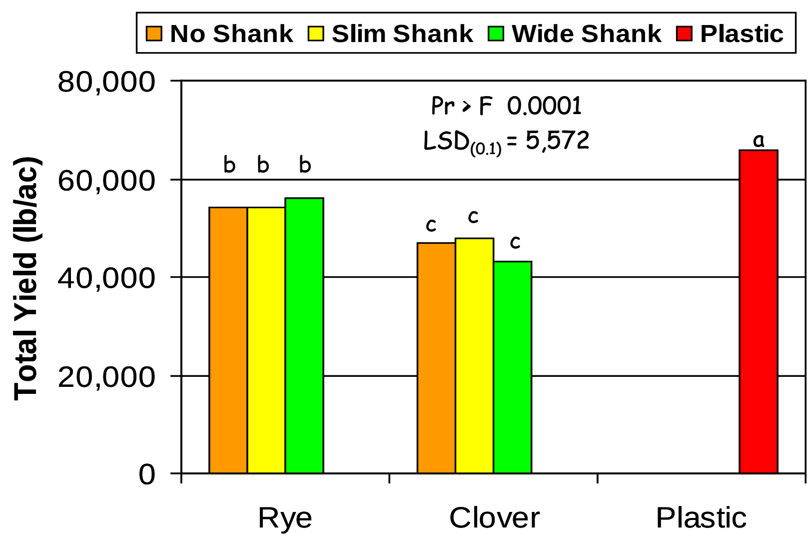

Figure 6. Total tomato yield in 2008 growing season

Marketable tomato yield

In 2006, there were no significant differences between both cover crop residue (with three shank treatments) and plastic mulch control (Pr>F 0.1637). Average marketable yield during 2006 growing season was 36,205 lbs/ac.

In 2007, the highest marketable yield was calculated for rye with no shank treatment (51,226 lbs/ac) in comparison with rye (slim and wide shanks), crimson clover (all shank treatments) and plastic mulch control (Fig. 7)

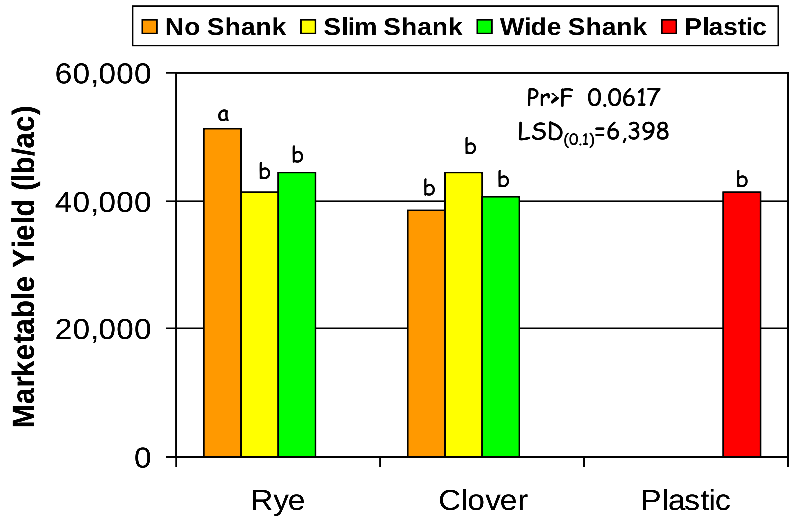

Figure 7. Marketable tomato yield in 2007 growing season.

In 2008, significantly higher marketable tomato yield was found for plastic mulch control (54,821 lbs/ac) compared to rye and crimson clover covers with all shank treatments. Comparing two residue covers and the shank treatments, rye residue cover with slim and wide shanks produced significantly higher yield than crimson clover with all three shank treatments (Fig. 8).

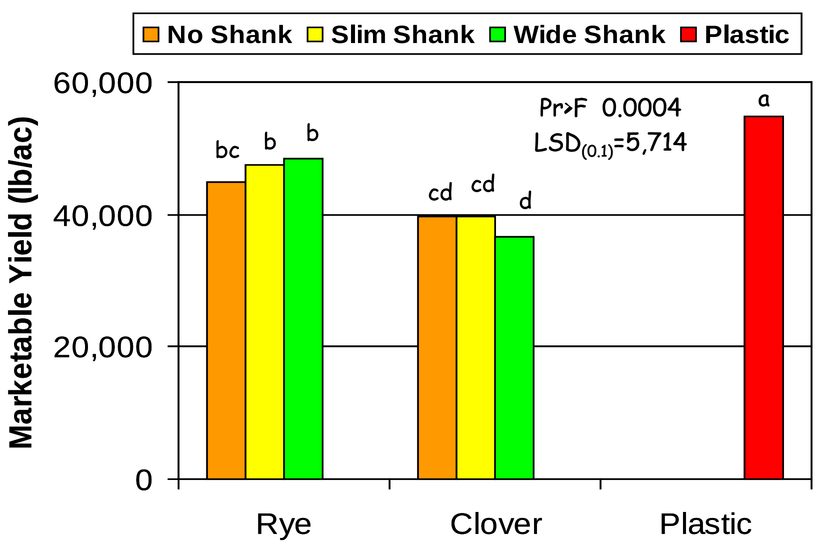

Figure 8. Marketable tomato yield in 2008 growing season.

Percentage of marketable tomato vs total yield

Comparing three growing seasons, significantly higher percentage (84.6%) of marketable tomato to total yield was recorded in 2008, compared to 2006 (80.7%) and 2007 (80.3%).

Overall, during 2006 - 2008 no differences were detected between all treatments (cover crops, shanks and plastic mulch control) indicating that plastic mulch did not improve percentage of marketable fruit.

Number fruit per plant

No significant difference in number of fruit per plant averaged over all treatments was found during the three growing seasons. Average number of fruit per plant was 24.8, 23.2 and 24.8, in 2006, 2007, and 2008, respectively.

During these growing seasons, the highest number of fruit was produced with plastic mulch (26.4), rye with no shank (24.9), and rye with wide shank (25.1). The lowest fruit number per plant was recorded for crimson clover with no shank (21.1) and with wide shank (21.5). In 2006 and 2007, no significant difference in number fruit per plant was found between cover crops, shanks and control plastic mulch. In contrast, in 2008, the highest number of fruit was found with the plastic mulch (30) and the lowest with the clover cover (21) (Fig. 9). The lower yield and number of fruit per plant following crimson clover (2006 - 2008), may have been due to high weed competition since clover biomass production was low and incompletely covered the soil compared to the higher residue producing rye system (except in 2007).

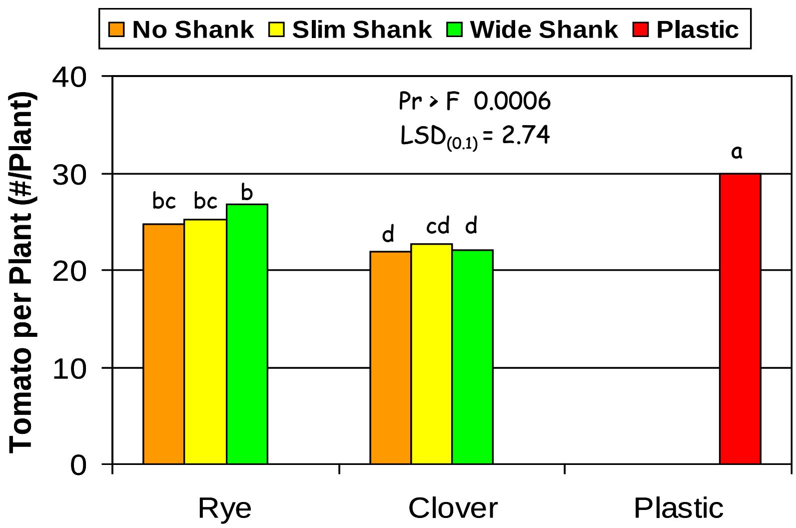

Figure 9. Treatment effect on number tomato fruit per plant in 2008 growing season

CONCLUSION

In two of three growing seasons (2006 and 2008), tomatoes planted into plastic mulch cover produced higher total yield and number of fruit per plant. In 2007, when a severe drought occurred, tomatoes planted into rye residue (without shank) produced significantly higher total and marketable yield in comparison to the plastic mulch control and clover indicating that the rye cover crop was better for conserving soil water for tomato use. Cover crops and shank treatments did not affect percentage of marketable tomato yield compared to total tomato yield. Economical analysis should be performed to determine whether cover crops or plastic provided higher net returns. In addition, soil strength and soil moisture and soil temperature must be included in future studies to better understand why crimson clover generally produced lower yields.

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Disclaimer

*The use of trade names or company names does not imply endorsement by the USDA-Agricultural Research Service.

REFERENCES

Abdul-Baki. A.A., J.R. Teasdale, R. Korcak, D.J. Chitwood, and R.N. Huettel. 1996. Fresh-market tomato production in a low-input alternative system using cover crop mulch. HortScience 31:65-69.

Ashford, D. L. and D. W. Reeves. 2003. Use of a mechanical roller crimper as an alternative kill method for cover crop. American Journal of Alternative Agriculture 18(1): 37-45.

Barnes, J.P. and A.R. Putnam. 1983. rRye residues contribute weed suppression in no-tillage cropping systems. Journal of Chemical Ecology 9:1045-1057.

Blough, R. F., A. R. Jarrett, J. M. Hamlett, and M. D. Shaw. 1990. Runoff and erosion water from silt, conventional, and chisel tillage under simulated rainfall. Transactions of ASAE 33(5):1557–1562.

CTIC. 2004. Conservation tillage trends 1990-2004. National Crop Residue Management Survey. West Lafayette, Ind.: Conservation Technology Information Center.

Derpsch, R., C. H. Roth, N. Sidiras, and U. Köpke. 1991. Controle da erosão no Paraná, Brazil: Sistemas de cobertura do solo, plantio directo e prepare conservacionista do solo. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Eschborn, SP 245, Germany.

Hubbell, D.H. and J.B. Sartain. 1980. Legumes - a possible alternative to fertilizer nitrogen. Fla. Coop. Ext. Serv. Circular SL-9.

Mahboubi, A.A., R. Lal, and N.R. Faussey. 1993. Twenty-eight years of tillage effects on two soils in Ohio. Soil Science Society of America Journal 57:506–512.

Mansoer, Z. D. W. Reeves, and C.W. Wood. 1997. Suitability of sunn hemp as an alternative late-summer legume cover crop. Soil Science Society of America Journal 61:246-253.

Reeves, D.W. 1994. Cover crops and rotations. P 125-172. In J.L. Hatfield and B.A. Stewart (ed.) Advances in soil science: Crops residue management. Lewis Publ., Boca Raton, FL.

Teasdale, J.R.and A.A. Abdul-Baki. 1995. Soil temperature and tomato growth associated with black polythene and hairy vetch mulches. Journal of American Society Horticultural Science 120:848-853.

Table 1. Height and dry biomass of rye and Crimson clover cover crops for 2006 through 2008

Year	Height (inch)		Pr > F	Biomass (lbs/ac)		Pr > F
	Rye	Clover		Rye	Clover	
2006	65.1	21.8	<0.0001	7132	4072	0.0461
2007	58.7	20.1	<0.0001	5528	4949	0.6450
2008	71.6	21.1	<0.0001	8630	6297	0.0961

Table 2. Maximum and minimum soil temperature (^{o} F) for different covers during 2006 through 2008 growing seasons.* Values of the means within columns having the same letters are not significantly different at the 10% level.

Year	2006		2007		2008		Average Max temp
Temp (^{o} F)	Max	Min	Max	Min	Max	Min	
Rye	86.8	65.0	109.0	65.2b*	88.0	56.1a	93.3b
Clover	93.2	64.2	116.9	66.2b	93.1	54.6b	97.9a
Plastic	97.0	65.0	115.4	68.2a	92.7	54.7b	100.5a
LSD	N/A	NS	N/A	1.71	N/A	0.75	3.06

SUSTAINABLE NITROGEN FERTILIZATION STRATEGIES FOR NO-TILLAGE WHEAT

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SUMMARY

No-tillage wheat production has gained significant acreage across Virginia over the last 10 years. The recent high cost of nitrogen (N) fertilizer has prompted producers to look for additional ways to increase efficiencies in fertilizer management. The use of N injection equipment is currently being evaluated in no-tillage corn production and may also be useful to no-tillage wheat fertilization. This study has shown that further work is warranted with wheat to determine if N injection can lower the overall N application rates while still maintaining high wheat yields.

INTRODUCTION

Wheat is an important crop to Virginia producers as we annually produce 230,000 acres valued in excess of $71.5 million (USDA-NASS, 2008). A recent study indicated that worldwide N fertilizer efficiency in cereal crops averages 33%; meaning that 67% of applied fertilizer is not taken up by the small grain plants (Raun and Johnson, 1999). Nitrogen losses commonly occur by leaching, volatilization when using urea containing fertilizers, and assimilation by competing microbes in the soil system (Havlin et. al., 1999; Westfall et. al., 1996). Nitrogen losses from volatilization are aggravated in conservation tillage systems where large amounts of crop residue remain on the soil surface. Assuming the average Virginia winter wheat producer applies 120 pounds of N per acre in their Spring applications, Raun and Johnson's (1999) estimates mean that nearly 18.5 million pounds or $9.2 million of N fertilizer is lost to the environment per year in Virginia alone ($300/ton for 30% liquid urea-ammonium nitrate = $0.50 per pound of N; Crop Production Services, personal communication, June 2009). Exorbitant losses waste natural resources, pollute sensitive waterways, add to greenhouse gas emissions, and cause a decrease in fertilizer use efficiency that reduces farmers' profit margins.

Virginia small grain producers have higher fertilizer use efficiency than the world average, but technology exists to further increase our farmers' N efficiency. For instance, a recent study in Kansas indicated that different N placement methods on winter wheat increased plant N uptake (Kelly and Sweeney, 2007). In the Kansas study, broadcast N applications had the lowest N uptake (52 lbs N/acre); which is the standard fertilization practice in Virginia. Banding N increased uptake by 10% (57 lbs N/acre) while subsurface banding increased N uptake by nearly 30% (67 lbs N/acre). Reducing average spring wheat applications by 30% would save Virginia producers over $4.1 million and reduce N losses via environmental factors by 8.3 million pounds, annually. On-farm research trials with corn in Virginia have indicated that N rates may be cut 10-15% by injecting UAN solution two inches into the soil under the residue compared to surface dribble applications (Davis and Lewis, 2008). Kansas' climate and soil conditions vary

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significantly from Virginia's climate and soil; however, we expect to see greater efficiency increases in Virginia than observed in Kansas since we have a greater chance of N being lost via volatilization and leaching in our high rainfall, warm, and sandy soil growing conditions (Hayden and Michaels, 2008).

MATERIALS AND METHODS

No-tillage wheat was planted following corn at two locations in Virginia. A sandy loam at the Virginia Tech Eastern Shore AREC (data not presented) and a loam soil in the Coastal Plains region of Virginia in Prince George County were selected. Different N application treatments were applied using an N applicator capable of applying surface and subsurface treatments. Treatments included surface-broadcast, surface-banded (15 and 30 inch bands), and subsurface-banded applications (15 and 30 inch bands) of urea-ammonium nitrate fertilizer (30% N) at four different N rates (40, 80, 120, and 160 lbs N/acre). Three no-fertilizer controls were included. Two of the no-fertilizer controls had the subsurface applicator ran across the plots (at 15 and 30 inch spacing) to test for plant damage from the no-tillage coulters. Nitrogen treatments were made in the spring with 50% of the N applied at Zadoks' growth stage 25 and the remaining N applied at Zadoks' growth stage 30. All other production practices were made according to Virginia Cooperative Extension recommendations for no-tillage wheat (Thomason et. al., 2004). Wheat samples from 7 square feet were taken from each plot and analyzed for aerial dry matter production and N concentration at early heading (data not presented). From this data, plant N uptake and N fertilizer efficiency will be calculated. A plot combine was used to harvest wheat plots and yield calculated after correcting harvest weights for moisture. Economic analysis will be conducted to predict farmer profit increases due to increased yields and reduced fertilizer rate recommendations that result from increased N fertilizer efficiency.

RESULTS AND DISCUSSION

The data presented represent the 2009 results from the Brandon Plantation site in Prince George County, VA. The 2009 season produced average wheat yields for the region. Wheat yields ranged from 43.8 bu/A to 75.6 bu/A. There was not a significant interaction between N rates and fertilizer application method on grain yields therefore the data was averaged across N rates or application method to determine main factor values.

All N rates significantly increased grain yields over the no N control plots (Table 1) when averaged across application method. Grain yields did not plateau or decline as expected at high N rates, but linearly increased up to the 160 lb/acre N rate yielding 67.3 bu/A. The 0 to 120 lb/A N rates were not significantly different in grain test weight but the 160 lb/A had the lowest test weight at 59.7 lbs/bushel. None of the test weight values were low enough to cause a discount at market. There was a significant difference in moisture concentrations (11.4 to 11.9%); however, there is no practical importance as no discount would be incurred at market. Increasing N rates did have a significant impact on lodging percentage. The 0, 40, 80, and 120 lb N/A rates were not significantly different from each other in lodging percentage ranging from 18 to 29 percent. The 160 lb N/A rate had a 43% lodging rate. This would significantly affect the harvest speed in a commercial farming operation. The lodging rate of the control plot at 18% would also be unacceptable to wheat farmers. It should be noted that deer damage is suspected to have caused some lodging in the plots. Deer scat was observed in several plots on top of lodged wheat. The test plot was also the last standing wheat in this particular field so it was attractive to deer. Wheat biomass also linearly increased with increasing N rates and ranged from 7015 lbs/A to 8489 lbs/A.

Nitrogen application methods significantly impacted grain yields (Table 2) when averaged across N rates. The lowest yielding plot was the 15 inch injected treatment at 53.8 bu/A. The highest yielding treatment was the 15 inch surface band application at 70 bu/A. The broadcast, 30 inch surface band, and 30 inch injected were not significantly different in yield at 62.3, 62.4, and 62.5 bu/A, respectively. We suspect that the 15 inch injected treatment was damaged by driving over the plots 2 times with the tractor to create the 15 inch spacing with a 30 inch spacing applicator. The 15 inch surface band did not receive any tractor damage at GS 30 since it was applied with a CO2 backpack sprayer. There was a significant difference in grain test weight with the 15 inch injection being highest at 60.8 lbs/bu with other treatments being similar (60 to 60.2 lbs/bu). There was a difference in moisture with the injected treatments having higher water concentrations (11.9 and 12%) compared to the broadcast and surface band treatments (11.4 to 11.6%). However, all moisture concentrations were acceptable for marketing wheat with no discount. It is likely the damage caused by injection caused late tillers to predominate therefore they were not as dry at harvest. Lodging percentage was the highest with the broadcast treatment at 42% of the plot. The 15 and 30 inch surface band treatments were similar at 31% and 28%, respectively. The 15 and 30 inch injected treatments had the lowest lodging levels at 14% and 17%, respectively. The lowest biomass levels were obtained with the 15 inch injected treatment at 7256 lbs/A. The broadcast, 15 inch surface band, and 30 inch surface band treatments were not significantly different in biomass yield. The 30 inch injected treatment yielded 7865 lbs biomass per acre but was not different from the highest and lowest yielding plots. It was evident at early headed that the 30 inch injected treatment had the most variability in growth within the plot. The N bands were readily visible with pale green plants at the center between each band.

CONCLUSION

Grain yield data suggest that spring N rates from 80-120 lbs per acre are adequate for good wheat yields. This is the range currently recommended by Virginia Cooperative Extension guidelines based on tiller counts and plant tissue sampling. The idea of banding N deserves more study in Virginia. The 15 inch surface band produced high yields and had less lodging than broadcast treatments. Banding wheat N holds promise as a method to gain more yield with the same N inputs currently used. The 15 inch surface band would require slight modifications to our current application equipment compared to obtaining a fertilizer injection applicator. This study will be repeated in 2010 to further explore N banding potential.

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REFERENCES

Davis, P. and M. Lewis. 2008. 2008 Virginia On-Farm Corn Test Plots. Publ. 2812-1025. Virginia Coop. Ext., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA.

Havlin, J.L., J.D. Beaton, S.L. Tisdale, and W.L. Nelson. 1999. Soil fertility and fertilizers: An introduction to nutrient management. Prentice Hall, Upper Saddle River, NJ.

Hayden, B.P. and P.J. Michaels. 2008. Virginia's climate. Available at http://climate.virginia.edu/description.htm (verified 15 June 2009). Univ. of Virginia Climatology Office, Charlottesville.

Kelly, K.W. and D.W. Sweeney. 2007. Placement of pre-plant liquid nitrogen and phosphorus fertilizer and nitrogen rate affects no-till wheat following different summer crops. Agron. J. 99:1009-1017.

Raun, W.R. and G.V. Johnson. 1999. Improving nitrogen use efficiency for cereal production. Agron. J. 91:357-363.

Thomason, W.E., M.M. Alley, E.L. Stromberg, E.S. Hagood, and A. Herbert. 2004. No-tillage small grain production in Virginia. Publ. 424-005. Virginia Coop. Ext., Virginia Polytechnic Inst. and State Univ., Blacksburg.

USDA-NASS. 2008. Virginia agricultural statistics. Available at http://www.nass.usda.gov/Statistics_by_State/Virginia/index.asp (verified 15 June 2009). USDA-National Agric. Statistics Serv., Washington, D.C.

Westfall, D.G., J.L. Havlin, G.W. Heregert, and W.R. Raun. 1996. Nitrogen management in dryland cropping systems. J. Prod. Agric. 9:192-199.

Table 1. Nitrogen (N) rate main effect on grain yield, test weight, moisture, lodging, and above ground biomass on a loam soil in Prince George County, VA. All means are averaged over N application method.

N Rate	Yield	Test Weight	Moisture	Lodging	Biomass
	---bu/A---	---lbs/bu---	--------------%	--------------	---lbs/A---
0	56.0	60.3	11.9	18	7015
40	61.0	60.7	11.8	20	7715
80	62.1	60.2	11.6	29	8333
120	64.5	60.3	11.8	23	8499
160	67.3	59.7	11.4	43	8489
$LSD_{0.10}$	3.8	0.5	0.2	12	670

Table 2. Nitrogen application method main effect on grain yield, test weight, moisture, lodging, and above ground biomass on a loam soil in Prince George County, VA. All means are averaged over N rate.

Application Method	Yield	Test Weight	Moisture	Lodging	Biomass
	---bu/A---	---lbs/bu---	------------%	------------	---lbs/A---
No Nitrogen Control	56.0	60.3	11.9	18	7015
Broadcast	62.3	60.1	11.4	42	8373
15 inch Surface Band	70.0	60.8	11.6	31	8335
15 inch Injected Band	53.8	60.2	12.0	14	7256
30 inch Surface Band	62.4	60.0	11.6	28	8222
30 inch Injected Band	62.5	60.1	11.9	17	7865
$LSD_{0.10}$	3.8	0.5	0.2	12	670

EFFECTIVE SETBACKS FOR CONTROLLING NUTRIENT RUNOFF LOSSES FROM LAND-APPLIED POULTRY LITTER

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SUMMARY

Field trials were conducted to determine the effective setback widths for controlling nutrient runoff losses from poultry litter-fertilized cropland under different management practices. Nitrogen and phosphorus losses in runoff water at varied setback widths of Delaware corn plots (45 m × 15 m) that received poultry litter at 9.6 Mg ha^{-1} on the up-gradient 15 m were quantified. The results reveal that 15-m setbacks achieved nutrient reduction equivalent to 30-m setbacks attained when soil incorporation or cover crop planting was practiced. When both practices were employed, 5-m setbacks achieved the equivalent nutrient reduction.

INTRODUCTION

The Delaware poultry industry generates approximately 290,000 Mg of litter waste annually, of which the majority is applied to nearby agricultural land as organic fertilizers (Montgomery, 2004). Nutrient losses via surface runoff from poultry litter following land application have resulted in significant water quality issues. According to the State of Delaware 2002 Watershed Assessment Report, 94% of the rivers/streams and 68% of the ponds/lakes in the state are impaired by nonpoint-source phosphorus (P) and nitrogen (N) mainly from historic over-application of organic fertilizers to croplands (DNREC, 2005).

Overland flow is the major pathway for nutrient export from manure-fertilized agricultural systems (Sharpley et al., 1999). Buffer strips or setbacks have been demonstrated effective in reducing nutrient runoff losses through physical interception (suspended particles) and biochemical fixation (soluble N and P) (Muscutt et al., 1993; Sharpley et al., 1994). The ability of a buffer zone in trapping nutrients is related to its width. It is evident that wider setbacks or buffer strips will achieve greater water-purification effects (Wilson, 1967). As a consequence, less land will be available for manure disposal if setbacks are excessively wide. To protect water resources while ensuring manure disposal and cropping land areas, the minimal width of application setbacks that provide necessary pollutant-trapping effects has to be determined.

The federal Clean Water Act requires a minimum 30-m (100-foot) setback between the manure application area and down-gradient surface waters; alternative conservation practices or field specific conditions have to provide pollutant reductions equivalent to or better than the reductions that would be achieved by the 100-foot setback (EPA, 2003). However, the proposed Delaware Concentrated Animal Feeding Operation (CAFO) regulations state that a 15-m setback is required if the manure is incorporated into soil within 2 d of application or a winter cover crop is planted. The setback can be reduced to 5 m if both soil incorporation and cover crop planting are employed. It is unclear whether these proposed alternative practices will provide nutrient-trapping effects equivalent to or better than that would be achieved by 30-m setbacks. This study was to determine under soil incorporation and/or cover crop planting conditions the minimal

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width of setbacks that generate nutrient-trapping results equivalent to that would be achieved by 30-m setbacks.

MATERIALS AND METHODS

Field trial

Eight plots each 15 m × 45 m were prepared on typical Delaware agricultural land with 2 ~ 3% slope gradients (Fig. 1), with the long side lying along the slope gradient. The soil was Sassafras sandy loam (fine-loamy, siliceous, semiactive, mesic Typic Hapludults). Selected physical and chemistry properties of the soil are given in Table 1. Four treatments were randomly assigned in duplicates to the plots: (1) Surface Application. Poultry litter was simply surface broadcast to the up-gradient 15 m; (2) Soil Incorporation. Poultry litter was incorporated into soil by disc plowing immediately following broadcasting; (3) Cover Crop. Cover crops were planted in the late fall and killed by herbicide prior to spring fertilization; and (4) Cover Crop + Soil Incorporation. Cover crops were planted on the plots through the winter time and killed by herbicide prior to spring fertilization. Poultry litter was soil incorporated following broadcasting.

Soybean was grown in the previous season. In late October, 2006, rye (*Secale cereale*) was planted on four randomly selected plots as winter cover crops. On April 10, 2007, the herbicide "Roundup" was applied to kill the rye. On May 2, 2007, poultry litter obtained from a local broiler farm was broadcast at 9.6 Mg ha^{-1} over the up-gradient 15 m of the plots. Nutrient contents of the poultry litter are listed in Table 2. The down-gradient 30 m was used as setback, receiving no poultry litter. For the treatments requiring soil incorporation, the applied litter was incorporated into the top 15 cm soil by tillage using a disc plow immediately after litter application; the setback area was also mechanically turned. Corn seeds were then drill-planted at 17 cm interval in 70 cm-spacing rows perpendicular to the field slope into all the plots, including the 30 m setback areas.

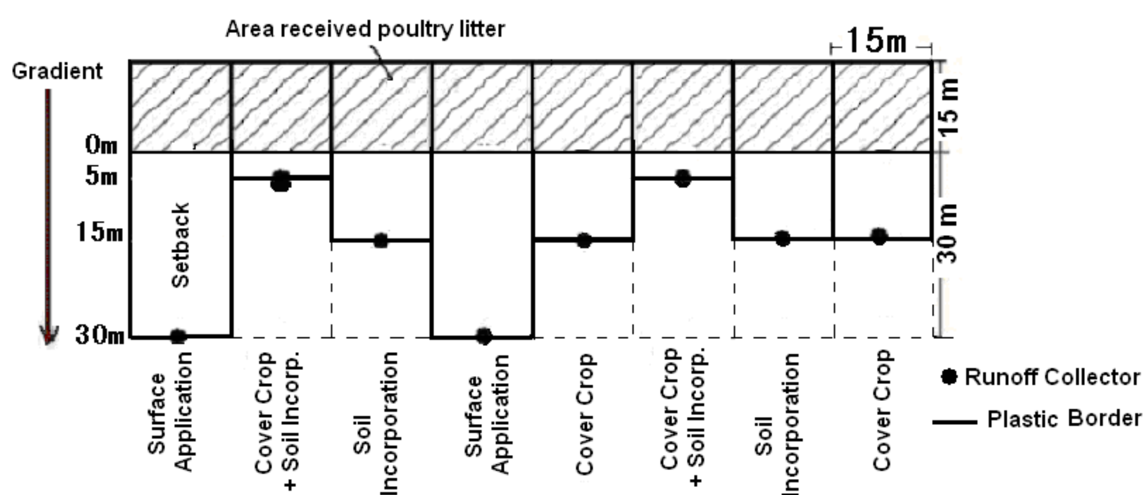

Fig.1. Layout of experimental plots showing treatments, poultry litter-fertilized area, runoff collector position, and plot isolation border.

Plastic tanks (0.47 m^3 or 124 gallon) were buried under the ground of the setbacks to collect runoff water. For the treatments Surface Application, Soil Incorporation, Cover Crop, and Cover Crop + Soil Incorporation, the collection tanks were installed at 30 m, 15 m, 15 m and 5 m down-gradient from the litter fertilized areas, respectively, as indicated by black dots in Fig 1. All plots were hydrologically isolated by 10 cm polyethylene plates buried in soils to a depth of 5 cm. Runoff water was directed to the collection tanks through open holes in the tank covers.

Runoff sample collection and analysis

Runoff water samples were collected monthly or after severe rainfall events. Water was withdrawn out of the collection tanks using a hand pump and the volume was measured. A subsample of approximately 1,000 mL was obtained from each runoff collector and stored at 4ºC prior to chemical analysis.

To measure total phosphorus (TP) and total nitrogen (TN) concentrations of runoff water, 20 mL of the bulk solution were drawn from each sample immediately after up-and-down mixing and digested with sulfuric acid and potassium persulfate in a 50-mL glass tube at 121°C for 60 min ((Jeffries et al., 1979). The digest was passed through a 0.22 μm filter and measured for TP and TN using the phosphomolybdate blue methods (Murphy and Riley, 1962) and a Shimadzu TOC/TN analyzer (Shimadzu, Tokoyo, Japan), respectively.

Another aliquot (~ 50 mL) of the bulk solution was centrifuged and passed through a 0.45 μm glass fiber filter to remove any particulates. The filtrate was analyzed for total dissolved P (TDP) after acid digestion, total dissolved N (TDN) using a TOC/TN analyzer, and dissolved inorganic P (DIP, PO_4^{3-}-P), and dissolved inorganic N (DIN, NH_4^+-N + NO_3^--N) using ion chromatography techniques (Metrohm IC 790, Metrohm Ltd., Herisau, Switzerland).

Data analysis

The runoff rate of test plots was calculated following the equation below:

$$R = V \times 10^{-3} \times 43.55 \qquad [1]$$

where R is the runoff rate (m^3 ha^{-1}), V is the volume (L) of water received in the runoff collectors, 10^{-3} is the coefficient to convert L into m^3, and 43.55 is the coefficient to extrapolate the test plot area from 225 m^2 to 1 hectare.

Nutrient runoff losses from individual plots during the whole growing season were estimated by summing up the nutrient runoff losses in each sampling interval:

$$Loss_d = \Sigma\, Loss_{d,i} = \Sigma\, (C_{d,i}R_{d,i}) \qquad [2]$$

where $Loss_d$ is the cumulative runoff losses of P and N (g ha^{-1}), $Loss_{d,i}$ is the nutrient loss rate at the d^{th} collector in the i^{th} rain event (g ha^{-1}), d is the serial number of the runoff collector, i is the i^{th} sampling event, $C_{d,i}$ is the nutrient concentration in the runoff water collected at the d^{th} collector during the i^{th} sampling interval (mg L^{-1}), $R_{d,i}$ is the runoff rate at the d^{th} collector in the i^{th} rain event (m^3 ha^{-1}).

Student's t-test was performed to evaluate differences in cumulative runoff losses of TP, TDP, TN, TDN, DIP and DIN between differently treated plots. Nutrient runoff losses from the surface application plots with a 30-m setback were treated as the reference level and compared with other treatments. Level of significance was set at $\alpha = 0.05$.

RESULTS AND DISCUSSION

Nutrient contents of poultry litter

The applied poultry litter contained 40.4 g kg^{-1} of TN and 15.1 g kg^{-1} of TP, of which 57.2% and 17.2%, respectively, were water soluble. Of the water soluble nutrients, inorganic P (73%)

was the dominant P form while organic N (59.5%) and NH_4-N (40.3%) were the major N forms. Nitrate-N (NO_3-N) only accounted for 0.2% of the water soluble N.

Fertilization rates for corn production in the area are recommended at 150 kg N ha^{-1} and 30 kg P ha^{-1} (Layon, 1999; Chratochvil; 2009). Through the poultry litter 387.8 kg N ha^{-1} and 145.0 kg P ha^{-1} were applied (Table 2). Nevertheless, merely 29.0% of the N and 25.2% of the P in the poultry litter were plant-available during the first growing season (Guo et al., 2009). Therefore, the applied poultry litter provided 112.5 kg N ha^{-1} and 36.5 kg P ha^{-1} utilizable by the corn crops, basically meeting the nutrient requirements.

Runoff rates

Surface runoff occurs when rainfall intensity exceeds soil infiltration rate. Soils in the test plots exhibited an average infiltration rate of 263.03 mm hr^{-1} (160 – 480 mm hr^{-1}). As such, surface runoff occurred predominantly in the summer and early fall when thunderstorms brought high density rains. The initial runoff samples were collected on May 31, 2007, right after a heavy rain event. Collection of runoff water continued until December 28, 2007. As given in Table 3, runoff rates of the test plots during sampling intervals ranged from 0.43 to 1.43 m^3 ha^{-1}, varying with dates and influenced unclearly by the management practices.

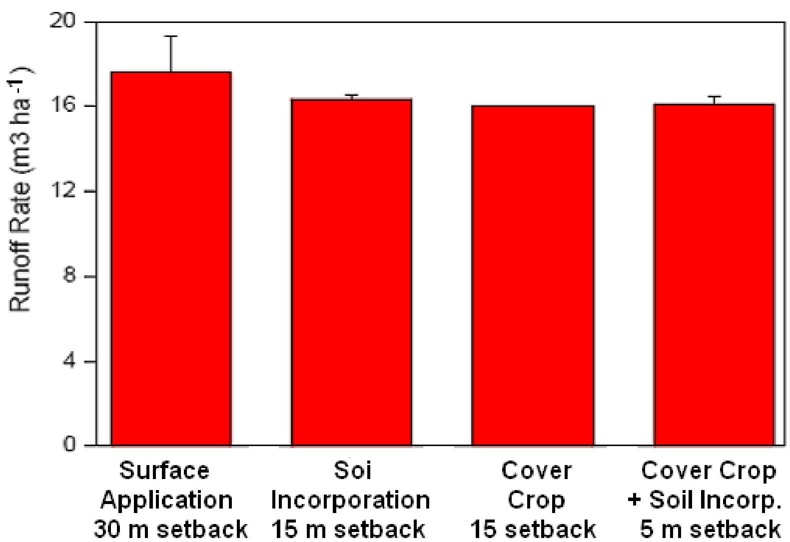

Fig. 2. Cumulative runoff rates (m^3 ha^{-1}) of differently managed plots

The bulk runoff rates of the plots through the whole growing season are presented in Fig. 2. From May to December, the cumulative runoff occurring at the experimental site was averagely 16.45 m^3 ha^{-1}. No significant differences were detected among the differently managed plots.

Concentrations of nutrients in runoff water

Concentrations of TP in runoff water from the poultry litter-fertilized plots ranged from 0.09 to 7.56 mg L^{-1}, with an average of 1.48 mg L^{-1} (Fig. 3-TP). For the first batch samples collected on May 31, Surface Application showed the highest concentration (0.77 mg L^{-1}) while the Soil Incorporation had the lowest (0.16 mg L^{-1}) (Fig. 3-TP). Peak TP concentrations occurred in runoff collected on August 27: Soil Incorporation was the highest (7.56 mg L^{-1}) and Surface Application was 4.62 mg L^{-1} (Fig. 3-TP). The peak concentration concurred with the highest rainfall amount and intensity during that period. Noticeable soil water erosion occurred and carried soil particles, organic debris, and poultry litter to the runoff collection tanks, forming a layer of soil on the tank bottom. The eroded soil contained high content of P (Table 1) and elevated the TP levels in runoff water.

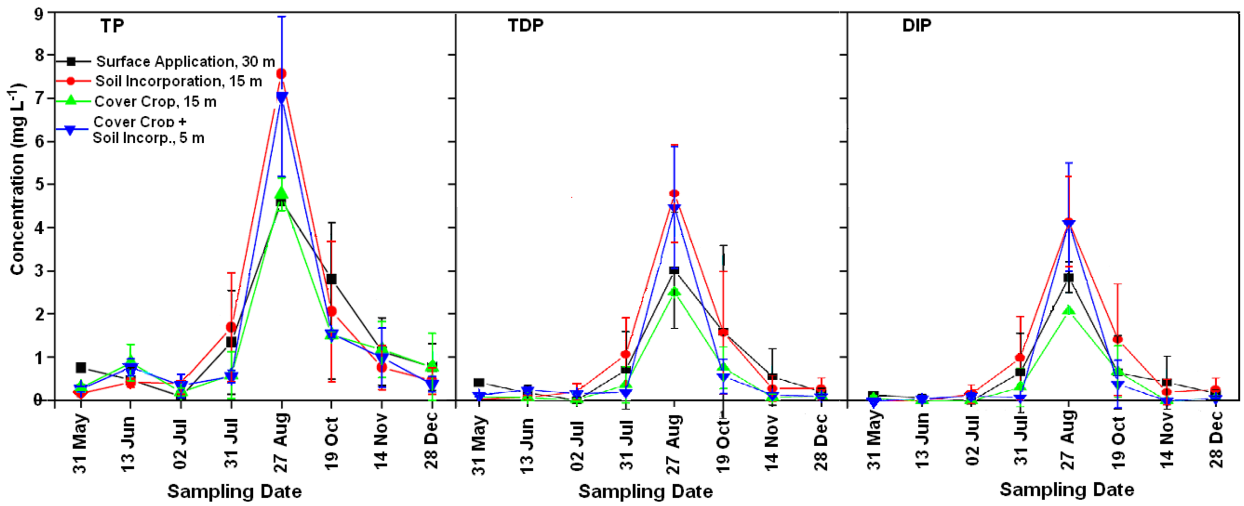

Fig. 3. Concentrations of total phosphorus (TP), total dissolved phosphorus (TDP), and dissolved inorganic phosphorus in runoff water from differently managed plots.

The major fraction of TP in runoff was dissolved P. The concentration of runoff TDP fluctuated between 0.00 and 4.9 mg L^{-1}, with an average of 1.0 mg L^{-1} (Fig. 3-TDP). The predominance of TDP in runoff TP was also discovered by Pionke et al. (1999), who used historical data of watershed storm flows to determine seasonal differences in nutrient transport. Although surface application of animal manure may cause accumulation of P at the soil surface and result in increased P runoff, especially for dissolved P (Sharpley and Smith, 1994), soil incorporation by mechanical plowing may give rise to accelerated soil water erosion, causing deteriorated nutrient runoff losses. In runoff samples collected on August 27, the lowest (2.59 mg L^{-1}) and the highest (4.94 mg L^{-1}) TDP concentrations were observed for the Cover Crop and Soil Incorporation treatments, respectively (Fig. 3-TDP). At the end of the experiments, TDP in runoff water from the manure-fertilized plots decreased to less than 0.3 mg L^{-1}.

The TDP consisted of DIP and DOP (dissolved organic P). In the first three batches of runoff water DOP was the major form of TDP, but in later runoff, DIP became predominant. The concentration of DIP in runoff ranged from 0.0 to 4.3 mg L^{-1}, averaging at 0.84 mg L^{-1} (Fig. 3-DIP). Runoff from the treatments Soil Incorporation, Surface Application, Cover Crop, and Cover Crop + Soil Incorporation had average DIP of 0.92, 0.64, 0.41, and 0.62 mg L^{-1}, respectively. In a cultivated watershed with poultry litter application at 9 Mg ha^{-1}, Harmel et al. (2004) reported annual mean and maximum DIP concentrations of 0.52 and 2.15 mg L^{-1} respectively.

Total nitrogen (TN) in the runoff water demonstrated a much higher concentration than TP. The TN concentration ranged from 1.1 and 232.4 mg L^{-1} and averaged at 24.7 mg L^{-1} (Fig. 4-TN). It increased initially with time and reached the peak on August 27. In the first batches of samples, the Surface Application treatment demonstrated the highest TN (4.51 mg L^{-1}) while the Cover Crop + Soil Incorporation exhibited the lowest (1.12 mg L^{-1}). Overall, the average concentration of TN in runoff from the differently treated plots followed the order: Cover Crop (40.5 mg L^{-1}) > Soil Incorporation (24.1 mg L^{-1}) > Surface Application (20.1 mg L^{-1}) > Cover Crop + Soil incorporation (14.2 mg L^{-1}).

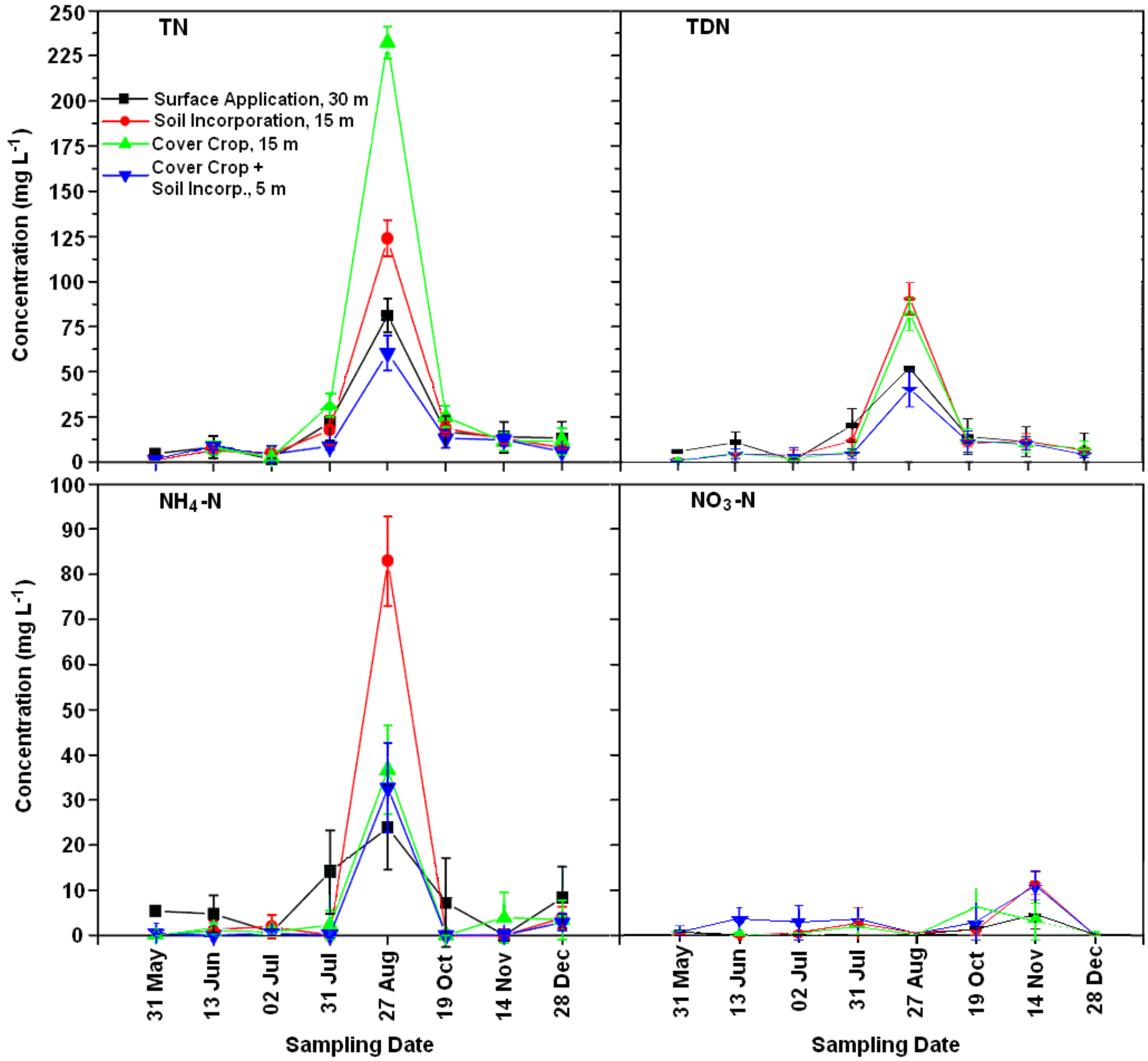

Fig. 4. Concentrations of total nitrogen (TN), total dissolved nitrogen (TDN), dissolved ammonium-N (NH_4-N), and dissolved nitrate-N (NO_3-N) in runoff water from differently managed plots.

The TN was in both dissolved and particulate forms. Concentrations of TDN in the runoff ranged from 0.6 to 90.3 mg L^{-1}, with an average of 14.6 mg L^{-1} (Fig. 4-TDN). Similar to TN, TDN also peaked out its concentration on August 27. Of the TDN, NH_4-N was the dominant form (Fig. 4-NH_4-N). Concentrations of NH_4-N fluctuated between 0.0 and 82.9 mgL^{-1} (average 7.5 mg L^{-1}). The initial runoff from the Surface Application plots had an NH_4-N at 5.4 mg L^{-1}, 92.4% of the TDN; while the other treatments during the same period had NH_4-N less than 0.5

mg L^{-1} (Fig. 4-NH_4-N), demonstrating the effect of management practices. Concentrations of NO_3-N in runoff water were rather low, in the range of 0.0 to 3.8 mg L^{-1} (average 0.5 mg L^{-1}; Fig. 4-NO_3-N). Nitrate was a product from microbial nitrification of ammonium (Pierson et al., 2001). Evidently, only a small portion of NH_4^+ in runoff was oxidized to NO_3^-.

Nutrient mass runoff losses

Losses of P and N nutrients in runoff water from the differently managed plots during the experimental period were computed using Eq. 2 and 3. As illustrated in Fig. 5, losses of TP from the treatments Surface Application, Soil Incorporation, Cover Crop, and Cover Crop + Soil Incorporation were estimated at 22.6, 23.5, 18.3, and 17.9 g ha^{-1}, respectively. Of the lost TP, TDP accounted for 12.3, 12.8, 7.2, and 6.6 g ha^{-1}, respectively; and DIP, 9.2, 9.6, 4.8, and 4.2 g ha^{-1}, respectively. In terms of TP, TDP, and DIP runoff losses, no significant differences (t test p-value >0.05) were observed between these different treatments, suggesting reduced setback widths in combination with soil incorporation and/or cover crop planting did provide nutrient reductions equivalent to that achieved by a 30 m setback in litter surface application.

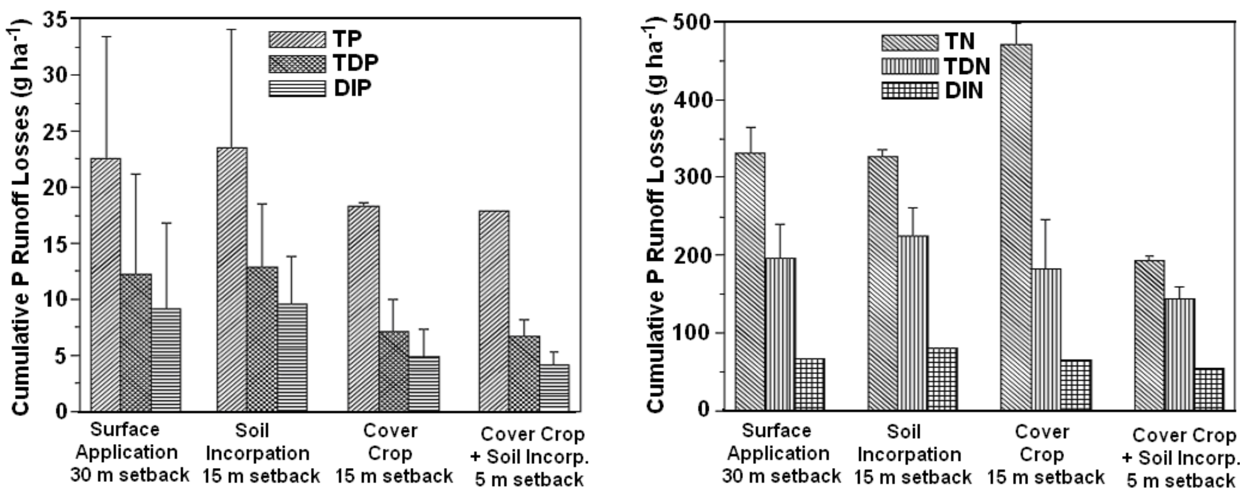

Fig. 5. Cumulative runoff losses of phosphorus (Left) and nitrogen (Right) from differently managed plots

Cumulative losses of TN via runoff from Surface Application, Soil Incorporation, Cover Crop, and Soil Incorporation + Cover Crop were 331.7, 327.0, 471.6, and 192.6 g ha^{-1}, respectively. In addition to particulate N, dissolved N (TDN) was another form of N lost in runoff water: the TDN losses for the treatments were 196.7, 225.4, 181.8, and 143.7 g ha^{-1}, respectively. Of the lost TDN, DIN was dominant. Losses of DIN were 166.1, 200.9, 161.0, and 134.6 g ha^{-1}, respectively, for these differently managed plots (Fig. 5).

Runoff losses of TN from the Soil Incorporation plots (327.0 g h^{-1}) were close to those from the Surface Application (331.7 g ha^{-1}), although the former had setbacks (15 m) shorter than the later (30 m), indicating the effectiveness of soil incorporation on reducing N runoff losses from land-applied animal manure. The Cover Crop treatment demonstrated significantly higher runoff losses in TN (t test P-value < 0.025) than Surface Application, while slightly lower in TDN and DIN (Fig. 5). By reducing rainfall erosivity and increasing water infiltration, cover crop residues decreased the transport capacity of runoff water and encouraged sediment deposition (Ross et al., 2002). When both soil incorporation and cover crop planting are employed, the effect on nutrient runoff reduction can be augmented. Cumulative losses of TDN in the Cover Crop + Soil Incorporation treatment were significantly lower than that in the Surface Application (P-value < 0.05, Fig. 5).

Effective setback width for controlling nutrient runoff losses

To determine the effective setback width under specific management practices for reducing nutrient runoff losses, cumulative runoff losses of different forms of N and P nutrients from the treatments Soil Incorporation, Cover Crop, and Cover Crop + Soil Incorporation were compared with those from Surface Application with a 30-m setback. Statistical analyses indicate that no significant differences existed except for TN (Table 4), in which from Cover Crop + Soil Incorporation with a 5-m setback were significantly lower (t test p-value < 0.0025) while from Cover Crop with a 15-m setback were significantly higher (t test p-value <0.025).

Indeed, if appropriately employed, soil incorporation and winter cover crop could effectively reduce nutrient runoff losses and thus, decreases the width of effective setbacks required for poultry litter application. In combination, cover crop and soil incorporation provided better nutrient reductions than the management practices alone and could further reduce the effective setback width.

CONCLUSIONS

Installation of setbacks between animal manure-fertilized areas and adjacent, down-gradient open water bodies is an effective approach for controlling non-point source water pollution by nutrients. This one-year field study conducted in Central Delaware demonstrates that when poultry litter was surface broadcast at 9.6 Mg ha^{-1} to a non-till corn field with sandy loam soil, a 30 m setback controlled the nutrient runoff losses at 22.5 g P ha^{-1} and 325 g N ha^{-1}. Soil incorporation and/or cover crop had mixed effects on nutrient concentrations in runoff water but helped reduce overall nutrient runoff losses. When winter cover crop was planted or the poultry litter was incorporated into soil immediately following application, a 15-m setback provided equivalent nutrient reductions. As both cover crop planting and soil incorporation were simultaneously implemented, a 5-m setback achieved comparable nutrient reductions. The results suggest that to effectively control nutrient runoff losses from land-applied poultry litter, the 30 m setback required by the federal Clean Water Act may be reduced to 15 m if cover crop or soil incorporation is practiced; the setback may be further reduced to 5 m if bother cover crop and soil incorporation are practiced.

REFERENCES

Chratochvil, D.R. 2009. Nitrogen management for agronomic crops: yesterday, today, and tomorrow. University of Maryland Cooperative Extension, College Park, MD. Available at: http://www.inlandbays.org/cib_pm/pdfs/uploads/1445Kratochvil.pdf (verified 6 June 2009).

DNREC. 2005. State of Delaware 2004 Combined Watershed Assessment Report (305(b)) and Determination for the Clean Water Act Section 303 (d) List of Water Needing TMDLs. Delaware Department of Natural Resources and Environmental Control: Dover, DE.

EPA, 2003. Best management practices for land application of manure, litter, and process wastewater. 40CFR412.4. US Environmental Protection Agency: Washington D.C.

Guo, M., M. Labreveux, and W. Song. Nutrient release from bisulfate-amended phytase-diet poultry litter under simulated weathering conditions. Waste Manag. 29:2151–2159.

Harmel, R.D., H.A. Torbert, B.E. Haggard, R. Haney, and M. Dozier. 2004. Water quality impacts of converting to a poultry litter fertilization strategy. J. Environ. Qual. 33: 2229-2242.

Jeffries, D.S., Diken, F.P., Jones, D.E., 1979. Performance of the autoclave digestion method for total phosphorus analysis. Water Res. 13:275–279.

Lanyon, L.E. 1999. Nutrient management: regional issues affecting the bay. In A.N. Sharpley (ed.) Agriculture and Phosphorus Management: the Chesapeake Bay. p. 145-157. CRC Press, Boca Raton, FL.

Montgomery, J. 2004. Perdue recycling plant shows promise. The News Journal. 9/14/2004. Delawareonline.com: Wilmington, DE.

Murphy, J. and J.P. Riley, 1962. A modified single solution method for the determination of phosphate in natural waters. Anal. Chim. Acta. 27: 31–36.

Muscutt, A.D., G.L. Harris, S.W. Bailey, and D.B. Davies. 1993. Buffer zones to improve water quality: A review of their potential use in UK agriculture. Agric. Ecosyst. Environ. 45:54–77.

Pionke, H.B., W.J. Gburek, R.R. Schnabel, A.N. Sharpley, and G.F. Elwinger. 1999. Seasonal flow, nutrient concentrations and loading patterns in stream flow draining an agricultural hill-land watershed. J. Hydrol. 200:62–73.

Ross, C.W., Hogarth, W.L., Ghadiri, H., Parlange, J.Y., Okom, A., 2002. Overland flow to and through a segment of uniform resistance. J. Hydro. 255:134–150.

Sharpley, A.N. and S.J. Smith. 1994. Wheat tillage and water quality in the Southern Plains. Soil Tillage Res. 30:33–48.

Sharpley, A.N., S.C. Chapra, R. Wedepohl, J.T. Sims, T.C. Daniel, and K.R. Reddy. 1994. Managing agricultural phosphorus for protection of surface waters: Issues and options. J. Environ. Qual. 23:437– 451.

Sharpley, A.N., T. Daniel, T. Sims, J. Lemunyon, R. Stevens, and R. Parry. 1999. Agriculture phosphorus and eutrophication. ARS-149, USDA, Washington, D.C.

Wilson, L. G. 1967. Sediment removal from flood water by grass filtration. Transactions of the American Society of Agricultural Engineers 10:35–37.

Table 1. Selected physical and chemical properties of soil at the experimental site.

Parameter	Value
Particle size composition	sand 500 g kg^{-1}, silt 480 g kg^{-1}, clay 20 g kg^{-1}
pH*	5.9 ± 0.02
EC* (dS m^{-1})	0.33 ±0.00
Organic carbon content (g kg^{-1})	13.5 ±0.27
CEC ($mmol_c$ kg^{-1})	146 ±0. 3
Total N (mg kg^{-1})	108.7 ±1.48
Mehlich-III P (mg kg^{-1})	85.4 ±0.11
Water soluble nutrients	
PO_4-P (mg kg^{-1})	8.4 ±3.2
NO_3 -N (mg kg^{-1})	0.2 ±0.04
NH_4-N (mg kg^{-1})	5.8 ±0.80

* Measured in 1:1 soil/water paste.

Table 2. Nutrient contents of poultry litter applied to field plots.

Parameter	Value
pH	6.0
Moisture content	35.12 %
Electronic conductivity	13.8 dS m^{-1}
Total N	40.4 g kg^{-1}
Total P	15.1 g kg^{-1}
Organic C	377g kg^{-1}
Water soluble nutrients	
Dissolved organic C	94.3 g kg^{-1}
Dissolved N	23.1 g kg^{-1}
Dissolved P	2.6 g kg^{-1}
Dissolved inorganic P	1.9 g kg^{-1}
NH_4^+-N	9.3 g kg^{-1}
NO_3^--N	0.053 g kg^{-1}

Table 3. Average runoff rates ($m^3\ ha^{-1}$, mean ± stdev) of differently managed plots*.

Runoff rate $m^3\ ha^{-1}$	Surface Application 30 m setback	Soil Incorporation 15 m setback	Cover Crop 15 m setback	Cover Crop + Soil Incorp. 5 m setback
31 May	0.65 ± 0.04	0.52 ± 0.13	0.52 ± 0.02	0.43 ± 0.03
13 Jun.	0.50 ± 0.05	0.59 ± 0.16	0.70 ± 0.25	0.74 ± 0.04
02 Jul.	1.10 ± 0.08	1.12 ±.06	1.18 ± 0.16	1.16 ± 0.33
31 Jul.	0.70 ± 0.10	0.45 ± 0.14	0.71 ± 0.13	0.60 ± 0.08
27 Aug.	0.53 ± 0.06	0.51 ± 0.07	0.52 ± 0.03	0.44 ± 0.09
19 Oct.	1.36 ± 0.09	1.43± 0.05	1.32 ± 0.13	1.32 ± 0.04
14 Nov.	1.08 ± 0.14	0.93 ± 0.06	0.82 ± 0.02	1.04 ± 0.06
28 Dec.	1.13 ± 0.12	0.98 ± 0.09	0.67 ± 0.08	0.74 ± 0.06

Table 4. Significance of treatment differences in nutrient reductions as indicated by P-values in Student's t tests.

Surf. application vs.	P-value					
	TP	TDP	DIP	TN	TDN	DIN
Soil Incorporation	>0.40	>0.40	>0.40	>0.40	<0.10	<0.10
Cover Crop	>0.40	>0.25	>0.25	<0.025	>0.25	>0.40
Cover Crop + Soil Incorporation	>0.25	>0.25	>0.25	<0.0025	<0.05	>0.10

DEVELOPING TECHNOLOGY FOR SUBSURFACE APPLICATION OF POULTRY LITTER IN NO-TILL SYSTEMS

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ABSTRACT

Poultry litter provides a rich source of crop nutrients, but applying litter on the soil surface can lead to water-quality degradation, odor problems, and significant nutrient losses. Because surface-applied litter is completely exposed to the atmosphere, rainfall runoff can transport phosphorus and other nutrients into streams, lakes, estuaries, and bays; and much of the ammonia nitrogen volatilizes into the atmosphere before it can enter the soil. For tilled cropping systems, incorporating manure into the soil has proven to be a successful technique for decreasing nutrient losses and odors, but existing farm implements have not been capable of applying dry poultry litter under the surface of no-till systems. Our goal is to develop management options that allow no-till producers to decrease nutrient losses from poultry litter, thus protecting air and water quality while increasing soil productivity. We established field plots to test the hypothesis that nutrient losses could be decreased by using a knifing technique to apply dry poultry litter beneath the surface of perennial grassland. Results showed that subsurface litter application decreased nutrient losses in runoff more than 90% compared to those from surface-applied litter, and prevented the volatilization of ammonia-N. In fact, nutrient losses from subsurface litter were statistically as low as those from plots receiving no litter. Furthermore, subsurface-applied litter produced greater yields than surface-applied litter, possibly by retaining more N in the soil. However, subsurface litter application will not become a practical management option for no-till producers until the technique is fully mechanized. We initially tested single-shank and four-shank prototypes that successfully placed dry poultry litter under the surface of rocky perennial pasture and other no-till systems, but these prototypes have limited capacity and litter distribution capabilities. Therefore, we have constructed a larger (eight shank) tractor-drawn prototype that can transport five tons of dry untreated litter directly from the poultry house and rapidly apply it under the surface of no-till fields at the desired rate. Initial field testing indicates the eight-shank prototype decreases nutrient losses by more than 90% compared to surface-applied litter.

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IRRIGATION MANAGENMENT OF FRESH MARKET TOMATO ON SANDY LOAM SOILS IN THE MID-ATLANTIC

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SUMMARY

Fresh market tomatoes are an intensively grown vegetable crop on the Eastern Shore of Virginia. With so many acres (ac) dedicated to tomato production in close proximity to the Chesapeake Bay and tributaries, nutrient leaching and runoff are of high concern. Irrigation management can reduce nutrient leaching and increase fertilizer use efficiency. Tomato nitrogen sufficiency status measurements were performed to determine fertilizer needs and included petiole sap nitrate tests and infrared camera tests at fruit set. Results indicated that 1.0 evapotranspiration (ET) irrigation calculations were comparable to tensiometer triggered irrigation treatments and were superior to under or over-irrigated treatments with respect to crop nitrogen status. The infrared camera tests need more refinement in vegetable crops before they will prove beneficial to farmers for predicting nitrogen status midseason.

INTRODUCTION

Tomatoes (*Solanum lycopersicum*) are an intensively grown vegetable crop on the Eastern Shore of Virginia. In 2008, 4,700 ac of commercial fresh market tomatoes were harvested in Virginia, with an estimated value of 51 million dollars (USDA-National Agricultural Statistics Service, 2009). The United States harvested a total of 105,250 ac of fresh market tomatoes with Virginia ranked third after California and Florida (37,000 ac and 31,500 ac, respectively) (USDA-National Agricultural Statistics Service, 2009). In regards to value of production, Virginia ranked fourth behind Florida, California, and Ohio (622, 387, and 61 million dollars, respectively) (USDA-National Agricultural Statistics Service, 2009). With so many acres dedicated to tomatoes grown in close proximity to the Chesapeake Bay and tributaries, irrigation efficiency, nutrient efficiency, nutrient leaching and runoff are of high concern.

According to the Chesapeake Bay Program (2009), the Chesapeake Bay watershed is the largest estuary in the United States, covering over 64,000 square miles, with the shoreline stretching over 11,000 miles long. The watershed encompasses parts of Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, and the District of Columbia. Over 100,000 tributaries flow through the watershed and eventually into the Chesapeake Bay that supports more than 3,600 species of plants, fish and animals (Chesapeake Bay Program, 2009).

Nutrient pollution from rural and urban areas has caused water quality problems in the environmentally sensitive Chesapeake Bay (Chesapeake Bay Program, 2009). Nutrient loading has caused excessive algae growth, or eutrophication, in the Chesapeake Bay and caused many water quality problems. Nitrogen is one of the main nutrients of concern since nitrogen is often

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the limiting nutrient in saltwater ecosystems. Many efforts and programs have been put in place to protect the watershed from nutrient loading stressors. However, further efforts are needed to reduce nutrient loading to improve water quality in the Chesapeake Bay.

The soils on the Eastern Shore of Virginia are predominantly sandy loams (~65% sand) that are predisposed to leaching nutrients with excessive irrigation or rainfall. Possible nutrient inflows from over-fertilization and over-irrigation have caused the Chesapeake Bay Foundation to place Virginia's Chesapeake Bay coastal waters in the 75 to 100 percentile range for agricultural nutrient loading (Wolf, 2008). Outcry from the general public resulted in a petition for non-point source pollution regulation of large agricultural operations on the Eastern Shore of Virginia. Large tomato operators utilizing plastic mulch and drip irrigation production systems were the main target of a December 2008 petition submitted to the State Water Control Board of the Virginia Department of Environmental Quality with the degradation of water quality from nutrient and sediment inflows being the major complaint (Terry, 2008).

Water availability often correlates with N availability since soluble nitrogen fertilizer moves readily throughout the soil profile with the irrigation wetting front; therefore, over irrigation can move fertilizer below the effective root zone. Infrared camera and petiole nitrate sap concentrations at fruit set can be used to test for nitrogen availability. By testing the plant during the growing season, problems related to nitrogen can be diagnosed and resolved. Hochmuth, (1994a, 1994b), states that field tomatoes with two-inch diameter fruit should have a fresh petiole sap concentration of 400 to 600 ppm nitrate-N. Petiole sap tests are a quick and fairly inexpensive way to monitor nitrate concentrations in plants to help achieve optimal fertilization (Hochmuth, 1994b). Similarly, normalized difference vegetation index (NDVI) readings can give an instant indication of nitrogen status in many crops, although no algorithms are established for tomato production in Virginia (Raun et. al., 2002; Phillips et. al., 2004). The NDVI readings can depict in-season N status of plants and correlate well with plant biomass, plant petiole nitrate concentration, and yield (Osborne, 2007).

Government agencies are pushing for regulations to reduce nutrient loading into the Chesapeake Bay and tributaries by reducing nutrient and sediment loading in runoff. However, there is little current scientific data showing the amount of nitrogen and irrigation that should be applied to plastic mulch tomatoes in the Mid-Atlantic. This study will investigate irrigation volumes to find greatest water use efficiency to decrease economic losses by reducing fertilizer and irrigation waste. This project will prove a starting point for implementation of best management practices (BMPs) for local farmers and will provide guidance to decrease agricultural nonpoint source pollution, reduce fertilizer and water waste, and protect the tributaries and the Chesapeake Bay.

MATERIAL AND METHODS

This study was established in Spring 2003 on a Bojac sandy loam (coarse-loamy, mixed, semiactive, thermic Typic Hapludults) at the Virginia Tech Eastern Shore Agricultural Research and Extension Center in Painter, Virginia (37.59°N 75.77°W). Bojac sandy loam has 61.4% sand, 27.8% silt, and 10.8% clay in the Ap horizon (Sukkariyah, et. al 2007). The soil was conventionally tilled, and 8 inch raised beds were constructed on 6 foot centers and covered with plastic mulch. Nitrogen was incorporated into the beds at a rate of 86 lb N/ac. Tomato seedlings were transplanted on May 20, 2009 into 40 foot plots.

The amount of irrigation necessary for optimal tomato fruit production was based on estimations from a combination of assumptions and equations based on previous research. Calculated ET was the water amount expected to be removed via evaporation and transpiration and is the calculated "optimal" irrigation value used for water replacement. The optimal calculated ET value was considered 1.0. Irrigation treatments are comprised of "optimal" ET at 1.0 and multiplied by 0.5, 1.0, 1.5, and 2.0 coefficients to develop a crop irrigation response curve.

Calculating ET

Tomato's evapotranspiration coefficient (ET_c) was calculated by multiplying crop coefficient (K_c) by a reference ET (ET_o) using $ET_c = K_c*ET_o$. The ET_o was determined using the Hargreaves equation = $ET_o = 0.0023(T_{mean} + 17.8)(T_{max} - T_{min})^{0.5} R_a$; where T is temperature (ºC) and R_a is extraterrestrial solar radiation (mm/day) found in Table 2.6 in Allen and coworkers (1998). Temperature values were taken from the 1971-2000 monthly climate summaries for Painter, Virginia from the Southeast Regional Climate Center (2007). Extraterrestrial solar radiation can be found in Table 2.6 of Allen and coworkers (1998) and is based on the site's latitude. Table 1 shows monthly calculations for ET_o.

To calculate ET_c for different stages over the growing season, K_c was interpolated from Figure 7 in Doorenbos and Pruitt (1977). Figure 1 shows the crop coefficient curve of tomatoes with an estimated value of 0.6 for K_c in the initial crop growth stage ($K_{c\ ini}$). From Figure 1, the K_c value during the crop development stage was estimated to be 0.8. Allen and coworkers (1998) report K_c for the mid-season stage ($K_{c\ mid}$) and K_c for the late-season stage ($K_{c\ end}$) are 1.15 and 0.70-0.90, respectively. Any K_c reductions due to the use of plastic mulch were taken into consideration when calculating ET_c. Tables 2, 3, and 4 show calculated (ET_c) values during initial, crop development, and mid-season stages using the reduced K_c values for plastic mulch systems. Evapotranspiration is reported in millimeters per day.

Calculating Irrigation

The proper amount of daily irrigation for a crop is the amount of daily ET taking place minus any daily precipitation. To simplify the irrigation regime, long-term average precipitation data was used from the Southeast Regional Climate Center (2009) instead of monitoring daily precipitation and changing irrigation amounts daily. A 1971-2000 Monthly Climate Summary for Painter, VA provided average monthly total precipitation and was thusly subtracted from ET_c to determine irrigation for different tomato growth stages. The resulting value was our 1.0 ET treatment in the study.

Irrigation Treatments

Four irrigation treatments were initiated based on ET calculations. Irrigation treatments were set using automatic timers (Hunter Smart Valve Controller, San Marcos, CA, 92069) to irrigate twice a day, 7 days a week, to deliver 0.5, 1.0, 1.5 and 2.0 calculated ET values. A fifth treatment was triggered automatically with a wired tensiometer (Model RA, Irrometer, Riverside, CA). Irrigation for the tensiometer treatment will initiate after the 12 inch depth tensiometer reading raises above 40 kilopascal (kPa) and will run until the 12 inch depth reading falls below the 40 kPa value (Kuhar et. al., 2009). Irrigation was provided through trickle irrigation tubing with a flow rate of 0.45 gallons per 100 feet per minute at 10 psi. All other production practices, with the exception of N management, will be conducted according to Kuhar and coworkers (2009).

Fertilizer Treatments

A total of 172 lb nitrogen/ac was applied using a 50-50% split between at-planting and fertigation (Kuhar et al., 2009). At-planting treatments were applied using ammonium nitrate (34%N, 34-0-0) and incorporated using a rotary tiller prior to laying plastic mulch. Liquid urea-ammonium nitrate (32%N; 32-0-0) was used to apply fertigation treatments. Nitrogen rates increased as the growing season progressed to match plant N uptake. Fertigation took place on Monday and Thursday during the afternoon irrigation cycle. Fertigation N was applied at 0.5, 0.7, 1.0, 1.5, 2.2, and 2.5 lb N/day for time periods 0-14, 15-28, 29-42, 43-56, 57-77, and 78-98 days after planting, respectively. All treatments will receive the same amount of N during planting and bi-weekly fertigation.

Fruit Set Nitrate Status Tests

Petiole sap nitrate tests and infrared camera tests were performed when fruit was two inches in diameter (July 13-14, 2009). Petioles were collected from 6 plants per plot from the upper most fully expanded leaf. The sap of all six petioles was combined and nitrate concentrations were found using a Cardy meter (Spectrum Technologies, Plainfield, Illinois 60585). An infrared camera (Greenseeker, NTech Industries, Ukiah, CA 95482) was used to determine NDVI readings.

Statistics

The overall experimental design was a randomized complete block design that has treatments replicated four times, giving a total plot combination of 20 plots. Statistical analysis was conducted in SAS using PROC GLM and PROC REG. Fisher's Least Significant Difference values were established at alpha = 0.10. A Regression correlation was used to relate petiole nitrate concentrations to NDVI readings.

RESULTS AND DISCUSSION

Petiole nitrate-N concentrations at fruit set were significant when comparing different irrigation treatments (Table 5). For petiole nitrate concentrations, 1.0 ET, 1.5 ET, and tensiometer treatments had statistically similar petiole nitrate-N concentrations (792, 648, and 696 ppm nitrate-N, respectively; Table 5). Of these treatments, 1.0 ET treatments had higher petiole nitrate concentrations than 0.5 ET treatments (792 vs. 501 ppm, respectively; Table 5). Although all petiole readings were above the lower threshold suggested by Hochmuth (1994a, 1994b) of 400 ppm nitrate-N, higher concentrations indicate more plentiful supply of nitrogen to tomatoes at fruit set. We speculate that the 0.5 ET treatment did not solubilize nitrogen fertilizer in the soil or did not have adequate water assimilation for nutrient uptake. Inversely, the 2.0 ET treatment had lower concentrations than the 1.0 ET treatment since excessive irrigation likely leached nitrogen below the effective tomato root zone (521 vs. 792 ppm, respectively). Increased water use efficiency should minimize nitrate-N leaching; therefore, nutrients should be more plant available (Zotarelli et. al, 2009). Zotarelli and coworkers (2009) found that excessive leaching in sandy soils reduced crop N uptake as demonstrated by petiole nitrate concentrations in this tomato study.

The NDVI readings at fruit set were not significantly different and averaged 0.899. More research needs to be conducted to established NDVI readings for tomatoes during the growing season.

When plotting petiole nitrate-N concentrations versus NDVI values, a significant inverted quadratic correlation was established ($NDVI = 1.04 – 0.0005N + 4×10^{-7}N^2$; $R^2 = 0.247$; Fig. 2). We do not fully understand the reasoning behind the aforementioned correlation; however, we suspect that plants with higher fruit loads had lighter NDVI readings. The lowest NDVI readings were between 400 and 800 ppm nitrate-N; which is similar to the optimal range at fruit set established by Hochmuth (1994a, 1994b). Therefore, we speculate that lower petiole nitrate concentrations had lower fruit loads and higher petiole nitrate concentrations experiences excessive vegetative growth.

CONCLUSION

Irrigation amounts impact petiole nitrate-N concentrations. Excessive irrigation leaches nutrients and causes lower petiole nitrate-N concentrations while too little irrigation also reduces nitrogen uptake. By calculating and irrigating at1.0 ET or using a tensiometer, optimal amounts of irrigation and nutrients are provided to the plant. More work with NDVI measurements and resulting correlations needs to be conducted in the Mid-Atlantic with vegetable crops.

ACKNOWLEDGMENTS

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REFERENCES

Allen, R.G., L.S. Pereira, D. Raes, and M. Smith. 1998. Crop evapotranspiration. Guidelines for Computing Crop Water Requirements. Irrigation and Drainage Paper No. 56. FAO. Rome.

Chesapeake Bay Program. 2009. About the bay [Online]. Available at: http://www.chesapeakebay.net/ (accessed 20 Oct. 2009; verified 21 Oct. 2009). Chesapeake Bay Progr. Annapolis, MD.

Doorenbos, J., and W.O. Pruitt. 1977. Crop water requirements. Irrigation and Drainage Paper No. 24. FAO. Rome.

Hochmuth, G., 1994a. Plant petiole sap-testing for vegetable crops. CIR1144. Univ. Florida IFAS Extension, Gainesville.

Hochmuth, G., 1994b. Efficiency ranges for nitrate-nitrogen and potassium for vegetable petiole sap quick tests. HortTechnology 4:218-222.

Kuhar, T.P., H.B. Doughty, J.H. Freeman, R.A. Straw, C. Waldenmaier, S. Rideout, M. Reiter, H.P. Wilson, and T.E. Hines. 2009. Commercial vegetable production recommendations - Virginia. Publ. 456-420. Virginia Coop. Extension, Blacksburg.

Osborne, S.L., 2007. Determining nitrogen nutrition and yield of canola through existing remote sensing technology. Agric. J. 2(2):180-184.

Phillips, S.B., D.A. Keahey, J.G. Warren, and G.L. Mullins. 2004. Estimating winter wheat tiller density using spectral reflectance sensors for early-spring, variable-rate nitrogen applications. Agron. J. 95:591-600.

Raun, W.R., J.B. Solie, G.V. Johnson, M.L. Stone, R.W. Mullen, K.W. Freeman, W.E. Thomason, and E.V. Lukina. 2002. Improving nitrogen use efficiency in cereal grain production with optical sensing and variable rate application. Agron. J. 94:815-820.

Southeast Regional Climate Center. 2007. Weather data [Online]. Available at: http://www.sercc.com/ (accessed 20 Oct. 2009; verified 21 Oct. 2009). Univ. North Carolina at Chapel Hill, Chapel Hill, NC.

Sukkariyah, B., G. Evanylo, L. Zelazny. 2007. Distribution of copper, zinc, and phosphorus in coastal plain soils receiving repeated liquid biosolids applications. J. Environ. Qual. 36:1618-1626.

Terry, P. 2008. Prevention of degradation of water quality on the Eastern Shore as a result of large scale agricultural operations [Online]. Available at: http://townhall.virginia.gov/L/ViewPetition.cfm?petitionid=68 (accessed 8 July 2009; verified 8 July 2009). State Water Control Board, Virginia Dep. Environ. Quality, Richmond.

USDA-National Agricultural Statistics Service. 2009. U.S. & All states data - tomatoes [Online]. Available at: http://www.nass.usda.gov/QuickStats/PullData_US.jsp (accessed 12 August 2009; verified 20 November 2009). USDA-Natl. Agric. Statistics Serv., Washington, D.C.

Wolf, J. 2008. Delivered nitrogen: Loads per agricultural acres within the Chesapeake Bay Watershed [Online]. Available at: http://www.chesapeakebay.net/maps.aspx?menuitem=19556 (accessed 15 Oct. 2008; verified 15 Oct. 2008). The Chesapeake Bay Foundation, Annapolis, MD.

Zotarelli, L., M.D. Dukes, J.M. Scholberg, R. Munoz-Carpena, and J. Icerman. 2009. Tomato nitrogen accumulation and fertilizer use efficiency on a sandy soil, as affected by nitrogen rate and irrigation scheduling. Agric. Water Management 96:1247-1258.

TABLES AND FIGURES

Table 1. Calculated reference evapotranspiration (ETo) values used in the Hargreaves equation for the fresh market plastic mulch tomato irrigation efficiency study for Painter, Virginia

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Average Max (°C)	8.3	9.9	14.1	19.0	23.8	27.9	30.4	29.4	26.5	21.1	14.6	10.9
Average Min (°C)	-1.1	-0.2	3.3	7.7	12.8	17.6	20.4	19.5	16.1	10.2	4.6	1.4
Avg (°C)	3.6	4.9	8.7	13.3	18.3	22.8	25.4	24.5	21.3	15.6	9.6	6.1
R_a†	16.2	21.5	28.1	35.2	39.9	41.8	40.8	37.0	30.7	23.6	17.5	14.8
ET_o (mm/day)	2.45	3.57	5.63	8.49	11.00	12.54	12.82	11.34	8.90	5.97	3.49	2.51

†Extraterrestrial solar radiation (Ra) based on 38°N latitude, Painter, VA = 37.5°.

Table 2. Calculated specific crop evapotranspiration (Et_c) for initial growth stage using a reduced K_c value for plastic mulch tomato production systems on sandy loam soils.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
ET_o (mm/day)	2.45	3.57	5.63	8.49	11.00	12.54	12.82	11.34	8.90	5.97	3.49	2.51
$K_{c\ ini}$	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
0.65 $K_{c\ ini}$	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
$ET_{c\ ini}$ (mm/day) using 0.65 K_c	0.95	1.39	2.19	3.31	4.29	4.89	5.00	4.42	3.47	2.33	1.36	0.98

Table 3. Calculated specific crop evapotranspiration (Et_c) for crop development (CD) growth stage using reduced K_c value for plastic mulch tomato production systems on sandy loam soils.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
ET_o (mm/day)	2.45	3.57	5.63	8.49	11.00	12.54	12.82	11.34	8.90	5.97	3.49	2.51
$K_{c\ CD}$	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
0.65 $K_{c\ CD}$	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
$Et_{c\ CD}$ (mm/day) using 0.65 K_c	1.27	1.86	2.93	4.41	5.72	6.52	6.66	5.90	4.63	3.11	1.81	1.31

Table 4. Calculated specific crop evapotranspiration (Et_c) for mid-season (mid) growth stage using reduced K_c values for plastic mulch tomato production systems on sandy loam soils.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
ET_o (mm/day)	2.45	3.57	5.63	8.49	11.00	12.54	12.82	11.34	8.90	5.97	3.49	2.51
$K_{c\ CD}$	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
0.69 $K_{c\ CD}$	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
$Et_{c\ CD}$ (mm/day) using 0.69 K_c	1.77	2.59	4.08	6.15	7.97	9.09	9.29	8.22	6.45	4.33	2.53	1.82

Table 5. Mean petiole sap nitrate-N concentrations and normalized difference vegetative index (NDVI) measurements for irrigation treatments based on evapotranspiration (ET) on a sandy loam soil.

Treatment	Nitrate-N	NDVI
	----------ppm----------	
0.5 ET	501 c†	0.926 a
1.0 ET	792 a	0.911 a
1.5 ET	648 abc	0.859 a
2.0 ET	521 bc	0.893 a
Tensiometer	696 ab	0.908 a
$LSD_{0.10}$	191	NS‡

†Means followed by the same letter are not statistically different at $p = 0.10$.
‡Not significantly different ($p = 0.221$).

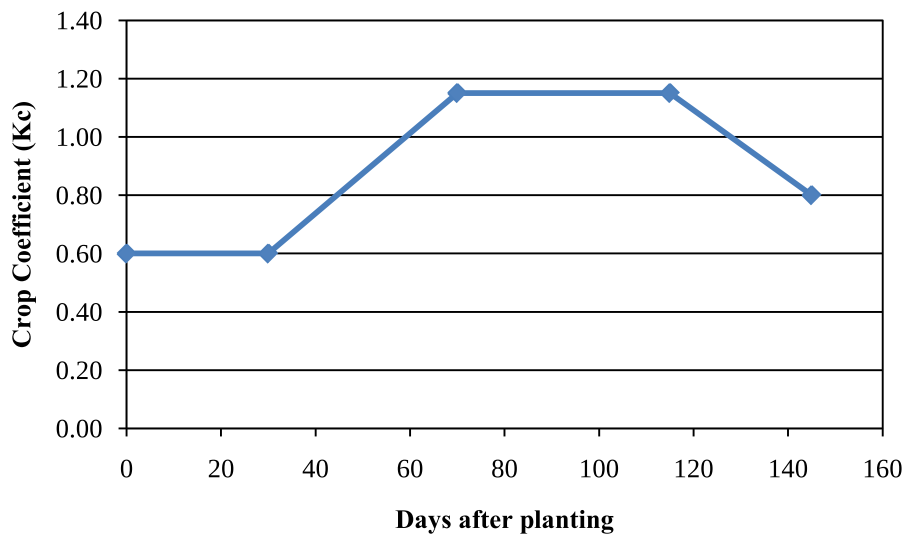

Figure 1. Crop coefficient (K_c) curve for tomatoes over the growing season.

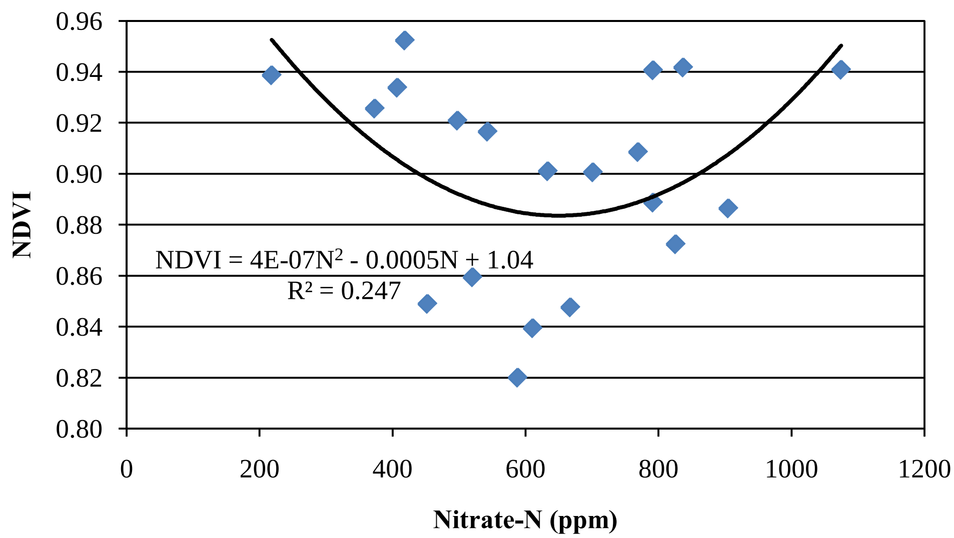

Figure 2. Petiole nitrate-N concentrations versus normalized difference vegetative index (NDVI) readings in response to irrigation regimes.

APPENDICES

APPENDIX A

PAST CONFERENCES, CHAIRMEN, AND CITATIONS OF PROCEEDINGS

Year	Location	Program Chairman or Co-Charimen	Proceedings
1978	Griffin, GA	J.T. Touchton Agronomy Department University of Georgia 1103 Experiment St. Griffin, GA 30223-1797	Touchton, J.T., and D.G. Cummins (eds.). 1978. Proc. First Annual Southeastern No-Till Systems Conference. Experiment Georgia 29 November 1978. Georgia Exp. Sta. Special Pub. No. 5 Univ. of Georgia, Agri. Exp. Stn., Experiment, GA.
1979	Lexington, KY	Shirley Phillips Agronomy Department University of Kentucky Lexington, KY 40546	No Proceedings Published
1980	Gainesville, FL	R.N. Gallagher PO Box 110730 Agronomy Department University of Florida Gainesville, FL 32611	Gallaher, R.N. (ed.). 1980. Proc. 3rd Annual No-Tillage Systems Conference. Williston, Florida 19 June 1980. Inst. Food & Agri. Sci., Univ. of Florida, Gainesville, FL.
1981	Raleigh, NC	A.D. Worshum, W.M. Lewis & G.C. Naderman Crop Science Department NC State Univ. Raleigh, NC 27650	Lewis, W.M. (ed.). 1981. No-Till Crop Production in North Carolina – Corn, Soybean, Sorghum, and Forages. North Carolina Agri. Extension Service AG-273, Raleigh, NC
1982	Florence, SC	J.H. Palmer Agronomy Department Clemson University Clemson, SC 29634	Palmer, J.H. and E.C. Murdock (eds.). 1982. Proc. 5th Annual Southeastern No-Till Systems Conference. Florence, SC 15 July 1982. Agronomy and Soils Extension Series No. 4. Clemson Univ. Clemson, SC
1983	Milan, TN	E.L. Ashburn & T. McCutchen University of Tennessee West TN Agric. Exp. Stn. Jackson, TN	Jared, J., F. Tompkins, and R. Miles (eds.). 1983. Proc. 6th Annual Southeastern No-Till Systems Conference, Milan, TN 21 July 1983. Univ. of Tennessee Inst. of Agri., Knoxville, TN
1984	Headland, AL	J.T. Touchton Agronomy Department Auburn University Auburn, AL 38301	Touchton, J.T. and R.E. Stevenson (eds.). 1984. Proc. 7th Annual Southeast No-Tillage Systems Conference. Headland, AL 10 July 1984. Alabama Agri. Exp. Stn., Auburn Univ., Auburn, AL
1985	Griffin, GA	W.L. Hargrove Agronomy Department University of Georgia 1109 Experiment Station Griffin, GA 30223-1797	W.L., F.C. Boswell, and G.W. Langdale (eds.). 1985. Proc. 1985 Southern Region No-Till Conference. Griffin, GA. 16-17 July 1985. Georgia Agri. Exp Sta., Univ. of Georgia, Athens, GA

In M.S. Reiter (ed.) A multidisciplinary approach to conservation. Proc. 31st Southern Conservation Agric. Systems Conf., Melfa, VA. 20-23 July 2009. Extension Publ. 2910-1417. Dep. Crop and Soil Environ. Sci., Eastern Shore Agric. Res. Ext. Cntr., Virginia Polytechnic Inst. and State Univ., Painter, VA. Available at: http://pubs.ext.vt.edu/2910/2910-1417/2910-1407.html.

1986	Lexington, KY	R.E. Phillips & K.L. Wells Agronomy Department University of Kentucky Lexington, KY 40546	Phillips, R.E. (ed.). Proc. Southern Region No-Till Conference. Lexington, KY 18 June 1986. Kentucky Agri. Exp. Stn., Southern Region Series Bulletin 319. Univ. of Kentucky, Lexington, KY
1987	College Station, TX	T.J. Gerik & B.L. Harris Blackland Research Center Temple, TX 76501	Gerik, T.J. and B.L. Harris. (eds.). 1987. Proc. Southern Region No-Tillage Conference. College Station, TX 1-2 July 1987. Texas Agri. Exp. Stn. MP-1634, Texas A&M Univ. System. College Station, TX
1988	Tupelo, MS	N.W. Buehring & J. E. Harrison Mississippi State University NE Mississippi Branch Station Verona, MS 38879	Hairston, J.E. (ed.). 1988. Proc. 1988 Southern Conservation Tillage Conference. Tupelo, MS 10-12 August 1988. Mississippi Agri. and Forestry Exp. Stn., Special Bulletin 88-1. Mississippi State Univ., Mississippi State, MS
1989	Tallahassee, FL	D.L. Wright and I.D. Teare University Of Florida N. Florida Res., & Educ. Ctr. Rt. 3 Box 4370 Quincy, FL 32351	Teare, I.D. (ed.). 1989. Proc. 1989 Southern Conservation Tillage Conference. Tallahassee, FL 12-13 July 1989. Inst. of Food and Agri. Sci. Special Bulletin 89-1. Univ. of Florida, Gainesville, FL
1990	Raleigh, NC	M.G. Wagger NC State University Raleigh, NC 27650	Mueller, J.P. and M.G. Wagger (eds.). 1990. Proc. 1990 Southern Region Conservation Tillage Conference. Raleigh, NC 1990. NCSU Special Bulletin 90-1. North Carolina State Univ., Raleigh, NC
1991	North Little Rock, AR	S.L. Chapman & T.C. Keisling University of Arkansas Soil Testing & Res. Lab. P.O. Drawer 767 Marianna, AR 72360	Keisling, T.C. (ed.). 1991. Proc. 1991 Southern Conservation Tillage Conference. North Little Rock, AR 18-20 June 1991. Arkansas Agri. Exp. Sta. Special Report 148, Univ. of Arkansas, Fayetteville, AR
1992	Jackson, TN	J.F. Bradley & M.D. Mullen University Of Tennessee P.O. Box 1071 Knoxville, TN 37901	Mullen, M.D. and B.N Duck (eds.). 1992. Proc. 1992 Southern Conservation Tillage Conference. Jackson and Milan, TN 21-23 July 1992. Tennessee Agri. Exp. Sta. Special Publication 92-01. Univ. of Tennessee, Knoxville, TN
1993	Monroe, LA	P.K. Bollich Louisiana State University Louisiana Agric. Exp. Stn. P.O. Box 1429 Crowley, LA 70527-4129	Bollich, P.K. (ed). 1993. Proc. 1993 Southern Conservation Tillage Conference for Sustainable Agriculture. Monroe, LA 15-17 June 1993. Louisiana Agri. Exp. Stn. Ms. No. 93-86-7122. Louisiana State Univ., Baton Rouge, LA

1994	Columbia, SC	W.J. Busscher & P.J. Bauer USDA – ARS Coastal Plains Res. Ctr. Florence, SC 29501-1241	Bauer, P.J., and W.J. Busscher (eds.). 1994. Proc. 1994 Southern Conservation Tillage Conference for Sustainable Agriculture. Columbia, SC 7-9 June 1994. USDA-ARS Coastal Plains Soil, Water, and Plant Research, Florence, SC
1995	Jackson, MS	N.W. Buehring & W.L. Kingery Mississippi State University NE Mississippi Branch Station Verona, MS 38879	Kingery, W.L. and N. Buehring (eds.). 1995. Proc. 1995 Southern Conservation Tillage Conference for Sustainable Agriculture. Jackson, MS 26-28 June 1995. Mississippi Agr. and Forestry Exp. Stn. Special Bulletin 88-7., Mississippi State Univ., Mississippi State, MS
1996	Jackson, TN	P. Denton, J.H. Hodges, III, & D. Tyler University of Tennessee Plant & Soil Sci. Dept.	Denton, P., N. Eash, J. Hodges, III, and D. Tyler (eds.). 1996. Proc. 19th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Jackson and Milan, TN 23-25 July 1996. Univ. of Tennessee Agri. Exp. Stn. Special Public. 96-07. Univ. of Tennessee, Knoxville, TN
1997	Gainesville, FL	R.N. Gallagher & D.L. Wright PO Box 110730 Agronomy Department University of Florida Gainesville, FL 32611	Gallaher, R.N., and R. McSorley. 1997. Proc. 20th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Gainesville, FL 24-26 June 1997. IFAS Coop. Extn. Service, Special Series SS-AGR-60, Univ. of Florida, Gainesville, FL
1998	North Little Rock, AR	S.L. Chapman & T.C. Keisling University of Arkansas P.O. Box 391 Little Rock, AR 72203	Keisling, T.C. (ed.). 1998. Proc. 21st Annual Southern Conservation Tillage Conference for Sustainable Agriculture. North Little Rock, AR 15-17 July 1998. Arkansas Agri. Exp. Stn. Special Report 186, Univ. of Arkansas, Fayetteville, AR
1999	Tifton, GA	J.E. Hook University Of Georgia-NESPAL Coastal Plain Exp. Sta. P.O. Box 748 Tifton, GA 31793-0748	Hook, J.E. (ed.). 1999. Proc. 22nd Annual Southern Conservation Tilage Conference for Sustainable Agriculture, Tifton, GA 6-8 July 1999. Georgia Agri. Exp. Sta. Special Pub. 95. Univ. of Georgia, Athens, GA
2000	Monroe, LA	P.K. Bollich Rice Research Station Louisiana Agric. Exp. Stn. LSU AgCenter P.O. Box 1429 Crowley, LA 70527-4129	Bollich, P.K. (ed). Proc. 23rd Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Monroe, LA 19-21 June 2000. Louisiana Agri. Exp. Sta., LSU Agri. Center Manuscript No. 00-86-0205, Louisiana State Univ. Crowley, LA 70527-1429

2001	Oklahoma City, OK	J.H. Stiegler Plant & Soil Sci. Department Oklahoma State University Stillwater, OK 74078	Stiegler, J.H. 2001 (ed.). Proc. 24th Annual Southern Conservation Tillage Conference for Sustainable Agriculture, Oklahoma City, OK 9-11 July. Oklahoma Agri. Exp. Sta. Misc. Pub. MP-151. Oklahoma State Univ. Sillwater, OK
2002	Auburn, AL	D.W. Reeves, R.L. Raper & K.V. Iversen USDA-ARS NSDL 411 S. Donahue Dr. Auburn, AL 36832	E. van Santen (ed.) 2002. Making Conservation Tillage Conventional: Building a Future on 25 Years of Research. Proc. of 25th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Auburn, AL 24-26 June 2002. Special Report No. 1. Alabama Agric. Expt. Stn. and Auburn University, AL 36849. USA
2003	No Meeting	No Meeting	No Proceedings Published
2004	Raleigh, NC	D.L. Jordan, B. Brock & M.G. Wagger NC State University Raleigh, NC 27650	D.L. Jordan and D.F. Caldwell (eds.) Proceedings of the 26th Southern Conservation Tillage Conference for Sustainable Agriculture. June 8-9, 2004, Raleigh, North Carolina. North Carolina Agricultural Research Service Technical Bulletin No. TB-321
2005	Florence, SC	P.J. Bauer USDA – ARS Coastal Plains Res. Ctr. Florence, SC 29501-1241	W. Busscher, J. Frederick, and S. Robinson (eds.) Proc. Southern Conservation Tillage Systems Conf., 27, Florence, S. Carolina. June 27–29, 2005, Clemson Univ. Pee Dee Res. Educ. Ctr., Florence, SC
2006	Bushland, TX	R.L. Baumhardt Conservation and Production Research Laboratory P.O. Drawer 10 (2300 Experiment Station Rd - Ship) Bushland, TX 79012-0010	R.C. Schwartz, R.L. Baumhardt, and J.M. Bell (eds.) Proc. 28th Southern Conservation Tillage Systems Conf., Amarillo, Texas. June 26-28, 2006, USDA–ARS Conservation and Production Research Laboratory, Report No. 06-1, Bushland, TX
2007	Quincy, FL	D.L. Wright 155 Research Rd. Quincy, FL 32351-5677	D.L. Wright, J.J. Marois, and K. Scanlon (eds.) Proc. 29th Southern Conservation Agricultural Systems Conf., Quincy, Florida. June 25-27, 2007
2008	Tifton, GA	G.L. Hawkins, H.H. Schomberg, A. Smith NRCC 1420 EXPERIMENT STATION ROAD WATKINSVILLE, GA 30677	D.M. Endale (ed.) Proc. 30th Southern Conserv. Agric. Syst. Conf. and 8th Ann. Georgia Conserv. Prod. Syst. Trng. Conf., Tifton, Georgia, July 29-31, 2008

2009	Melfa, VA	M.S. Reiter Virginia Tech Eastern Shore Agricultural Research and Extension Center 33446 Research Drive Painter, VA 23420	M.S. Reiter (ed.) A multidisciplinary approach to conservation. Proc. 31st Southern Conservation Agric. Systems Conf., Melfa, VA. 20-23 July 2009. Extension Publ. 2910-1417. Dep. Crop and Soil Environ. Sci., Eastern Shore Agric. Res. Ext. Cntr., Virginia Polytechnic Inst. and State Univ., Painter, VA. Available at: http://pubs.ext.vt.edu/2910/2910-1417/2910-1407.html

APPENDIX B

SOUTHERN CONSERVATION AGRICULTURAL SYSTEMS CONFERENCE AWARD RECIPIENTS

Year	Recipient	Affiliation
1998	Dr. Raymond Gallaher	University of Florida, Gainesville, FL
1999	Dr. George Langdale	USDA – ARS, Watkinsville, GA
2000	Dr. Stan Chapman	University of Arkansas
	Dr. Don Howard	University of Arkansas
2001	Dr. Normie Buehring	Mississippi State University
	Dr. Terry Keisling	University of Arkansas
2002	Dr. Jim Stiegler	Oklahoma State University
	Dr. Joe Johnson	Mississippi State University
2003	No Awards Given	No Awards Given
2004	Dr. Joe Touchton	Auburn University, AL
	Dr. D. Wayne Reeves	USDA-ARS, Watkinsville, GA
2005	Dr. David Wright	University of Florida
2006	Dr. Pat Bollich	Louisiana State University
	Dr. Don Tyler	University of Tennessee
2007	Dr. Randy Raper	USDA-ARS, Auburn, AL
2008	Kirk Iversen	Auburn University, AL
2009	No Awards Given	No Awards Given

APPENDIX C

Agenda

31st Southern Conservation Agricultural Systems Conference
July 20-23, 2009

Monday, July 20

4:00 – 6:00pm **Poster set-up and registration,** *Atrium*
Workforce Development Center, Eastern Shore Community College
29300 Lankford Highway
Melfa, Virginia 23410
Telephone: 757-787-5900

6:00pm **SERA-IEG Group 20 Steering Committee (By invitation only) (For minutes from the meeting, see Appendix D).**
Island House Restaurant
17 Atlantic Avenue
Wachapreague, Virginia 23480
Telephone: 757-787-4242

Tuesday, July 21

7:30 – 8:15am **Registration,** *Atrium*
A bus will leave the Holiday Inn Express at 7:20am and the Best Western at 7:30am. You are also welcome to drive yourself.
Workforce Development Center, Eastern Shore Community College
29300 Lankford Highway
Melfa, Virginia 23410
Telephone: 757-787-5900

8:15 – 8:30am **Welcome to Virginia and Conference Information,** *Great Hall*
Mark Reiter, Conference Chairman, Virginia Tech Eastern Shore AREC
Henry Wilson, Director, Virginia Tech Eastern Shore AREC
Loke Kok, Interim Dean, Virginia Tech College of Agriculture and Life Sciences

8:30am – 12:00pm **Plenary Session: Multi-disciplinary problems and solutions with conservation agricultural systems,** *Great Hall*
Moderator: Bill Shockley, Northampton County, Virginia Cooperative Extension

8:30 History of Agriculture on the Eastern Shore of Virginia.
Bill Shockley, Northampton County, Virginia Cooperative Extension
8:50 Insect pest concerns in reduced tillage crops.
Tom Kuhar, Entomologist, Virginia Tech Eastern Shore AREC
9:10 Conservation tillage in vegetable crops.
Josh Freeman, Horticulturalist, Virginia Tech Eastern Shore AREC
9:30 Effect of soil conservation on plant diseases.
Steve Rideout, Pathologist, Virginia Tech Eastern Shore AREC
9:50 Tillage practices, weed management, and herbicide resistance.
Henry Wilson, Weed Scientist, Virginia Tech Eastern Shore AREC

10:10 **Break around posters**. Refreshments catered by Kate's Cupboard.

In M.S. Reiter (ed.) A multidisciplinary approach to conservation. Proc. 31st Southern Conservation Agric. Systems Conf., Melfa, VA. 20-23 July 2009. Extension Publ. 2910-1417. Dep. Crop and Soil Environ. Sci., Eastern Shore Agric. Res. Ext. Cntr., Virginia Polytechnic Inst. and State Univ., Painter, VA. Available at: http://pubs.ext.vt.edu/2910/2910-1417/2910-1407.html.

10:30 Sustainability of shellfish aquaculture on the Eastern Shore of Virginia
Michael Pierson, CEO, Cherrystone Aqua Farms

11:20 Implementing best management practices in tomatoes.
Jane Corson-Lassiter, Former District Manager, Eastern Shore Soil and Water Conservation District

11:40 Helping farmers achieve sustainability through Farm Bill programs
Tina Jerome, District Conservationist, NRCS

12:00 – 1:00pm **Lunch catered by Exmore Diner**

1:00 – 2:00pm Concurrent Sessions

Conservation Agricultural Systems, *Room 170*
Moderator: Grace Hite, Halifax County, Virginia Cooperative Extension

1:00 *Sustainable Wind Energy for Farmers* – George Stricker, Project Manager, Accomack Wind Energy Project
1:15 *Can the Soil Conditioning Index Predict Soil Organic Carbon Sequestration with Conservation Agricultural Systems in the South?* – Alan Franzluebbers, USDA-ARS JPCNRCC
1:30 *Extension Agent Perspective on Using Goats and Sheep on Brush and Grass Control in Virginia* – Michael Lachance, Virginia Cooperative Extension
1:45 *The Influence of Cattle Grazing Alone and with Goats on Forage Biomass, Botanical Composition and Browse Species on Reclaimed Coal-mine Pastures* – Ozzie Abaye, Virginia Tech Powell River Project Research and Education Center

Cover Crops and Nutrient Management, *Great Hall*
Moderator: Scott Reiter, Prince George County, Virginia Cooperative Extension

1:00 *Winter Annual Cover Crops: Species and Timing of Planting* – Paul Davis, New Kent County, Virginia Cooperative Extension
1:15 *Corn Nitrogen Rates Following Winter Annual Cover Crops* – Paul Davis, New Kent County, Virginia Cooperative Extension
1:30 *Cereal Grain Cover Crop Performance in Virginia* – Wade Thomason, Virginia Tech Dept. Crop and Soil Environmental Sciences
1:45 *Evaluating Stocker Cattle in a Southern Piedmont Conservation Tillage Cotton-Cover Crop System to Increase Productivity* – Harry Schomberg, USDA-ARS, JPCNRCC

2:00 – 3:00pm Break with Poster Presentations (All authors present)

Conservation Agricultural Systems, *Atrium*

P01 *Improving Crop Productivity Using Raised Beds in Northeast Oklahoma*. – Jason Warren, Department of Plant and Soil Sciences, Oklahoma State University
P02 *Teff: What Do We Know and What Do We Need to Know?* – Katie Hurder, Virginia Tech Kentland Farm, Blacksburg, VA
P03 *Effects of Three Tillage Systems on Wheat Yield and Double Crop Soybean Yield.* – Cyndi Estienne, Greensville and Southampton County, Virginia Cooperative Extension
P04 *Transitioning to Organic Grain Production: Can Conservation Tillage Practices Be Effective?* – Alan Meijer, Department of Soil Science, North Carolina State University

Cover Crops and Nutrient Management, *Atrium*

P05 *Total Soil Phosphorus, Zinc and Copper Concentrations as Affected by Long-term Tillage and Fertilization Choices in a Cecil Soil*. – Dinku Endale, USDA-ARS, JPCS-NRCC

P06 *Evaluation of Soil Compaction in Corn Grown Under Different Tillage Systems and Soil Zones.* – Pawel Wiatrak, Dept. of Entomology, Soils and Plant Sci., Clemson University

P07 *Developing and Implementing Fertilizer BMPs for Six Major U.S. Cropping Systems.* – Steve Phillips, International Plant Nutrition Institute

P08 *Soil-aggregate Stability and Leaf Water Potential under Conservation Tillage and Sod-based Crop Rotations in a Sequence of Dry and Wet Years.* – Gueorgui Anguelov, UF-IFAS-NFREC

P09 *Urea-Ammonium Nitrate (UAN) Solution Placement in No-Tillage Corn Production*. – Tim Woodward, Dept. of Crop and Soil Environmental Sciences, Virginia Tech

P10 *Can the Soil Conditioning Index Predict Soil Organic Carbon Sequestration with Conservation Agricultural Systems in the South?* – Alan Franzluebbers, USDA-ARS JPCNRCC

3:00 – 4:30pm Concurrent Sessions (continued)

Conservation Agricultural Systems, *Room 170*

3:00 *Evaluating Soil Compaction in an Annual Winter Grazing/Vegetable Production Rotation in North-Central Alabama* – Eric Schwab, USDA-ARS-NSDL

3:15 *The Role of Longleaf Pine in the Conservation Framework of the Southeast United States* – Neil Clark, Tidewater AREC, Virginia Cooperative Extension

3:30 *Impact of Sod-Based Rotation on Peanut Diseases Using Conservation Technology* – Jim Marois, UF-IFAS, NFREC Quincy, FL

3:45 *Effect of Conservation Systems and Irrigation on Potential Bioenergy Crops* – Alexandre Rocateli, Auburn University, Agronomy and Soils Department

4:00 *High Tunnel Raspberry Production – Virginia State University's Experience* – A. Reza Rafie, Virginia State University

4:15 *Teaching Sustainable Systems to High School Students: Practical Hands-On Approaches*. – Rich Wilfong, Northampton County, Virginia High School

Cover Crops and Nutrient Management, *Great Hall*

3:00 *Weed Suppression of a Bioculture Cover Cropping System in Fresh Market Tomatoes* – Janet Spencer, Southeast District, Virginia Cooperative Extension

3:15 *Impact of Different Cover Crop Residues and Shank Types on No-till Tomato Yield* – Corey Kichler, USDA-ARS-NSDL

3:30 *Sustainable Nitrogen Fertilization Strategies for No-tillage Wheat* – Scott Reiter, Prince George County, Virginia Cooperative Extension

3:45 *Effective Setbacks for Controlling Nutrient Runoff Losses From Land-applied Poultry Litter* – Mingxin Guo, Delaware State University

4:00 *Developing Technology for Subsurface Application of Poultry Litter in No-till Systems* – Dan Pote, USDA-ARS, DBSFRC

4:35pm Bus leaves for Holiday Inn Express and Best Western Eastern Shore Inn

We will have 1 bus shuttling people between the hotels and the Eastern Shore AREC for dinner. You are also welcome to drive yourself.
6:00 – First bus run leaves Holiday Inn Express for Eastern Shore AREC.
6:05 – First bus run leaves Best Western Eastern Shore Inn for Eastern Shore AREC.
6:35 – Second bus run leaves Holiday Inn Express for Eastern Shore AREC.
6:40 – Second bus run leaves Best Western Eastern Shore Inn for Eastern Shore AREC.

6:30 – 9:00pm **Crab and BBQ Feast**
Virginia Tech Eastern Shore Agricultural Research and Extension Center
33446 Research Drive
Painter, VA 23420
Telephone: 757-414-0724

8:30pm First bus run for return to hotel.
9:00pm Second bus run for return to hotel.

Wednesday, July 22 (For Details, See Appendix E).

7:30am **Registration**
Holiday Inn Express lobby

7:45am Leave Eastern Shore Best Western Inn to begin tour
8:00am Leave Holiday Inn Express to begin tour

9:00am **Chesapeake Bay Bridge Tunnel**

10:45am **Yaros Potato Farms**

11:30am **Pacific Tomato Company**

12:30pm **Lunch catered by Eastville Inn**

1:45pm **Cherrystone Aqua-Farms**

3:00pm **C&E Farms**

4:00pm **Scenic Drive**

Thursday, July 23 (For Details, See Appendix F).

9:00 – 11:30am **Eastern Shore Agricultural Research and Extension Center Summer Field Day**
33446 Research Drive
Painter, VA 23420
Telephone: 757-414-0724

11:45am **Sponsored lunch** catered by Little Italy Restaurant.

4:00pm **1st Annual Methyl Bromide Alternative Field Day**
Eastern Shore Agricultural Research and Extension Center
33446 Research Drive
Painter, VA 23420
Telephone: 757-414-0724

6:00pm **Sponsored dinner** catered by August Boys.

APPENDIX D

SOUTHERN EXTENSION AND RESEARCH ACTIVITIES-INFORMATION EXCHANGE GROUP-20
31ST SOUTHERN CONSERVATION AGRICULTURAL SYSTEMS CONFERENCE STEERING COMMITTEE MEETING MINUTES

Tuesday July 20, 2009; 6:00 PM
Island House Restaurant, Wachapreague, VA

Presiding: Mark Reiter, Chairman
Notes: Sara Reiter

Attending:

- Mark Reiter (Virginia Tech)
- Dan Pote (ARS-Boonville, AR)
- Kirk Iversen (Auburn University)
- Alan Franzluebbers (ARS-Watkinsville, GA)
- Harry Schomberg (ARS-Watkinsville, GA)
- Joy Schomberg (Southern SARE)
- Jonathan Pote (Mississippi State)
- Alan Meijer (NC State)
- Richard Roseberg (Oregon State)
- Pawel Wiatrak (Clemson University)
- John Aigner (Virginia Tech)
- Cathy Fleming (Virginia Tech)
- Mandy Phillips (Eastern Shore Community College)
- Sara Reiter (Virginia Tech)
- Chad Kellam (Virginia Eastern Shore Clam Farmer)
- Annette Kellam (Virginia Tech)

1. Read notes from 2008 minutes in Tifton, GA and approved (M. Reiter)
    a. Schomberg and J. Pote motioned and seconded, respectively.
2. Awards report (Schomberg)
    a. Service Award – The purpose of this award is to reward a person's commitment to the SCASC and enhancements of the program. Award was not given in 2009 due to a lack of nominees. Only one nominee was generated.
    b. Champion Award – This is a new award developed over the last 3 years for persons raising awareness of the conservation systems program on a broad/national level. This would have been the 1st year to give it out. No nominees were received. No award was given in 2009.
    c. Current awards committee: Raper, Behring, Busher, Matocha, Schomberg, and Whitman. Contact a committee member if you are willing to serve.
3. Conservation Tillage Production Guide (Iversen and Schomberg)
    a. Kirk Iversen, Randy Raper, and Jason Bergtold are the leads for the project.

In M.S. Reiter (ed.) A multidisciplinary approach to conservation. Proc. 31st Southern Conservation Agric. Systems Conf., Melfa, VA. 20-23 July 2009. Extension Publ. 2910-1417. Dep. Crop and Soil Environ. Sci., Eastern Shore Agric. Res. Ext. Cntr., Virginia Polytechnic Inst. and State Univ., Painter, VA. Available at: http://pubs.ext.vt.edu/2910/2910-1417/2910-1407.html.

b. The aim of the project is for farmers and professionals to have a one-stop source for recommendations in conservation agricultural systems.
c. Chapter authors are currently submitting their work.
d. The hope is for the publication to be available July 2010. Will be published by the Sustainable Ag Network.
e. Fundraising is being done to help bring down the cost of the books. You can also pre-order to help defray costs. We need about $15,000 more to meet the fundraising goals of $30,000.
f. Free copies will be available via pdf format on the website.
g. *Getting Started* was written a couple years ago. Some of the chapters will be rewritten using material from the Conservation Tillage Production Guide and will also be available online.

4. Renewal of SERA-IEG-20 application: Nobody was present to give a report. However, M. Reiter noted that one panel has approved the packet and another panel is currently reviewing the application.
5. Overview of 2009 SCASC (M. Reiter)
    a. Thank you to Butch Nottingham and Bill Shockley for their help with the conference planning (Field Tour and Crab Steam).
    b. Attendance is down from 2008, but we are not in conjunct with another conference like 2008. Should conjunct events be pursued during future conferences?
        i. 27 oral presentations
        ii. 10 poster presentations
    c. Registrants so far: 32 Virginia Tech Extension Agents/Specialists/Graduate Students/Staff, 23 University Researchers/ARS, 11 governmental agencies other than ARS or University, 14 farmers, and 5 agribusiness. We hope to have significant registrations at the door from local producers.
6. Location of future meetings (M. Reiter)
    a. Reiter stated that more time is needed for planning meetings. Agreeing to host a meeting in March of the same year is not enough time to established relationships with sponsors and the University at the host institution. Schomberg agreed and stated that traditionally the meeting locations were planned for two years (in 2009 we should be picking the 2011 location, not the 2010).
    b. Expanding the focus of the meeting was helpful, especially for the Virginia location. Maybe we should have the meeting in a state that has not had the meeting in several years since there is no “preconceived connotation” about the scope of the meeting = more diverse group.
    c. Maybe we should expand to the Midwest, etc.
    d. Regardless, we need to have a location designated within 30 to 60 days (by the end of September).
    e. From the 2008 steering committee agenda, it was noted that Alabama may host the 2010 meetings.
        i. Iversen from Auburn University stated that they do not think they will be able to host the meeting in 2010. Maybe in a future year.
        ii. Iversen also stated that USDA-ARS-NSDL in Auburn, AL is going through reorganization, and do not want to commit to a date at this time.

f. Previous minutes (from 2007) state that Texas A&M would host the meetings in 2010 or 2011. However, John Matocha may be retired and we do not know if they are still interested in being a host since no representative from Texas was present.
g. Possible location in Milan, TN to coincide with the No-Till field day rotation. We believe this is in 2010. Schomberg agreed to call Don Tyler to inquire about interest.
    i. Iversen – Let's talk to Don Tyler first. He may be close to retirement and will lose his chance until 2012 if they deny the 2010 opportunity.
    ii. John Pote – Maybe Mississippi in the future. He will check for interest upon his return.
    iii. Arkansas was nominated for a future host. Randy Raper has moved to that location and Arkansas has not hosted for several years.
h. Karen Scanlon from the CTIC wants to be involved in hosting the conference in future years.
    i. Is on a fee basis.
    ii. Hosts the website, collects registration, sends notices, and handles papers.
    iii. Does an excellent job as demonstrated by past conference events.

7. Clarification on the chairman's role was discussed. M. Reiter will be chairman of SERA-IEG 20 until the 2010 conference since he hosted the conference in 2009.
8. SERA-IEG 20 needs a better database system for conference hosts to pass information on from year to year. This is the best way to spread information regarding the conference, call for papers, etc. The SERA site can send email announcements to their lists; however, many of the past conference participants are not on this list.
    a. Iversen agreed to help maintain a list of conference attendees.
    b. M. Reiter suggested that the list be updated every year with the current year's presenters, sponsors, and attendees.
9. No further business was discussed and the meeting was adjourned at 9:00 pm.

APPENDIX E

Field Tour Schedule

31st Southern Conservation Agricultural Systems Conference
July 22, 2009

7:45 am – Leave Eastern Shore Best Western Inn

8:00 am – Leave Holiday Inn Express

9:00 am - Chesapeake Bay Bridge Tunnel
Opened in 1964 - A tour of the facility demonstrates why the Chesapeake Bay Bridge Tunnel was selected as one of the Seven Structural Engineering Wonders of America for the 20th Century. Length from toll plaza to toll plaza is 20 miles through waters 25 to 100 feet deep and overpasses 4 manmade islands 5.25 acres in size with two tunnels 1 mile in length each. Internet Address: http://www.cbbt.com/

10:45 am - Yaros Potato Farms
John and Jack Yaros are one of the best father-son operations on the Coast. Their Cardinal brand of potatoes is sought after in every market in the East. Hands on management and family involvement are two reasons why this family business is so successful. They offer round whites, yukons, and russets in almost any size and type of package. They are one of the true pioneers in russet potato production in Virginia

11:30 am - Pacific Tomato Company
Pacific Tomato Company has a state of the art grape tomato operation. They grow hundreds of acres of grape tomatoes, both organic and conventional, as well as organic round tomatoes. Internet Address: http://www.sunripe.sunripeproduce.com/index.php?pr=Home

12:30 pm – Lunch – Eastville Inn

1:45 pm – Cherrystone Aqua-Farms
Cherrystone Aqua-Farms is a division of Ballard Fish and Oyster, Incorporated; which has been in the shellfish business since 1895. Cherrystone Aqua-Farms is the largest hard clam aquaculture operation in the Country. They co-operate with a number of local growers to supply markets throughout the country with both clams and oysters that are raised in the salty waters of the Chesapeake Bay and tributaries. http://www.littleneck.com/index.php

3:00 pm – C&E Farms
A fine family-run operation that has become one of the largest snap bean operations in the East. Quality is the watchword as brothers Mark and Bob harvest, process, and ship five to ten thousand bushels of beans daily during their June -October season. Hydro-cooled green and wax varieties are available the entire season.

4:00 pm – Scenic Drive
At Birdsnest, VA, we head east to Northampton County Route 600, also known as Seaside Road. Seaside Road parallels Virginia Highway 13 from the tip of the DELMARVA Peninsula north to the Virginia state line. Along the ride North to Exmore, VA we see significant acreage of plasticulture raised round tomatoes, cotton, corn, soybeans, and more…

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SCHEDULE OF EVENTS

9:00 am *Welcome and Introductory Remarks* – Henry Wilson

STOP 1 – *Field crop disease update* – Steve Rideout & Christine Waldenmaier

STOP 2 – *New findings concerning bean leaf beetle and bean pod mottle virus on the Eastern Shore* – Meredith Cassell, Tom Kuhar, Sue Tolin, & Pete Schultz

STOP 3 – *Snap bean disease management* – Leigh Ann Harrison, Steve Rideout, & Christine Waldenmaier

STOP 4 – *Update on new insecticides for vegetable crops* – Tom Kuhar & Helene Doughty

STOP 5 – *Potato disease update* – Steve Rideout & Christine Waldenmaier

STOP 6 – *Potato variety trials and cultural management research* – Josh Freeman, Ursula Deitch

STOP 7 – *Herbicide research in field corn* – Henry Wilson & Tommy Hines.

STOP 8 – *Vegetable soybean & lima bean research update* – Josh Freeman & Luther Carson

STOP 9 – *Thrips sampling and management in Virginia* – Heather Andrews, Tom Kuhar, Helene Doughty, Pete Schultz, Ames Herbert, & Sean Malone

STOP 10 – *Methyl bromide alternatives research and bacterial wilt resistance in tomato* – Josh Freeman, Steve Rideout & Adam Wimer

STOP 11 – *Soil fertility and management in vegetable and agronomic crops* – Mark Reiter & John Aigner

STOP 12 – *Irrigation and nitrogen management in tomatoes* – Cathy Fleming, Mark Reiter, & Josh Freeman

STOP 13 – *Harlequin bug host plant preference and potential for trap cropping in brassica crops* – Anna Wallingford, Tom Kuhar, & Pete Schultz

STOP 14 – *Subsurface application of poultry litter in no-till systems* – Dan Pote, Tom Way, Mark Reiter, & Philip Moore

STOP 15 – *Ticks of the Eastern Shore and tick safety* – Ellen Stromdahl & Tom Kuhar

11:30 am *Return to head house*

11:45 am *Closing comments and acknowledgements. Sponsored lunch catered by Little Italy* – Henry Wilson.

Virginia Polytechnic Institute and State University
Eastern Shore Agricultural Research and Extension Center

APPENDIX F

2009 Annual Eastern Shore AREC Research Field Day

EASTERN SHORE AGRICULTURAL RESEARCH AND EXTENSION CENTER
33446 Research Drive
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APPENDIX G

THIRTY-FIRST SOUTHERN CONSERVATION AGRICULTURAL SYSTEMS CONFERENCE: FULL PAPER GUIDELINES

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SUMMARY

The summary should be 100 words or less. This summary will be included along with authors and locations in a handout at the conference. Longer summaries will be truncated if needed.

INTRODUCTION

The 31st Southern Conservation Agricultural Systems Conference (SCASC) will be held on Virginia's Eastern Shore in Melfa, Virginia from July 20 to July 23, 2009. The Eastern Shore of Virginia is the epicenter for Mid-Atlantic fiber, grain and vegetable production along with the ever important aquaculture industry. We are situated between the Atlantic Ocean and the environmentally sensitive Chesapeake Bay. Due to the unique mixes of industry and environment; papers are invited to be included in the annual proceedings that encompass all disciplines related to conservation agricultural systems. The theme for 2009 is "A multidisciplinary approach to conservation." More information for the conference can be found at: http://www.cpe.vt.edu/scasc/index.html (SCASC, 2009b).

MATERIALS AND METHODS

Please format your paper as specified below. Failure to do so may result in your submission being excluded from the proceedings. For any questions, please contact Mark Reiter at mreiter@vt.edu or 757-414-0724 × 16.

- **Page size:** 8.5 by 11 inches.
- **Margins:** 1 inch on all sides.
- **Font:** Times New Roman, size 12.
- **Line spacing:** Single
- **Page numbering:** No page numbering or headings. These will be added during editing.
- **Units of measure:** English units (SI units may be added in parenthesis behind English units if desired, but not required).
- **Length:** Not to exceed 10 pages, including references, figures, and tables.
- **Title:** Should be centered at the top of the pages in boldface type and capital letters, followed by a blank line. Names of the authors should be centered directly below the title. On the next line, include the author's affiliation and location. On the next line, include the presenter's email address. Place an asterisk by the presenter's name and email address. For multiple authors and affiliation, use superscripts for identification.

In M.S. Reiter (ed.) A multidisciplinary approach to conservation. Proc. 31st Southern Conservation Agric. Systems Conf., Melfa, VA. 20-23 July 2009. Extension Publ. 2910-1417. Dep. Crop and Soil Environ. Sci., Eastern Shore Agric. Res. Ext. Cntr., Virginia Polytechnic Inst. and State Univ., Painter, VA. Available at: http://pubs.ext.vt.edu/2910/2910-1417/2910-1407.html.

- **Content:** Include Summary, Introduction, Materials and Methods, Results and Discussion, Conclusion, and References sections. Center these headings in boldface type and capital letters.
- **References:** Use the accepted style of the American Society of Agronomy (ASA), Crop Science Society of America (CSSA), and the Soil Science Society of America (SSSA) (ASA-CSSA-SSSA, 2004). Use author-year citation system in body of text in parenthesis. Place references in order by last name. Include all authors, year, complete title, publication, volume, and page numbers. For books, cite all authors, year, complete title, page numbers, editors, book title, and publisher. Use style manual approved abbreviations. Reference examples can be found at: https://www.soils.org/sites/default/files/Chapt01W_1.pdf (ASA-CSSA-SSSA, 2004).
- **Tables:** Number tables consecutively. Table guidelines should follow those defined in the ASA-CSSA-SSSA Style Manual. Examples can be found at: https://www.soils.org/sites/default/files/Chapt05W.pdf (ASA-CSSA-SSSA, 2004).
- **Figures:** Include figures within the body of the paper or at the end following tables. Figures may be in color or black and white.
- **File:** Save document in Microsoft Word Format. File name should be presenter's full name (John_Doe.doc or John_Doe.docx).
- **Submission:** Submit via email to Mark Reiter (mreiter@vt.edu).
- **Deadline:** June 15, 2009.

RESULTS AND DISCUSSION

All proceeding papers will be available online following the conference. Papers will be posted at: http://www.ag.auburn.edu/auxiliary/nsdl/scasc/proceedings.html (SCASC, 2009a).

CONCLUSION

Attendees from the 31st SCASC will benefit by seeing multidisciplinary concerns and approaches to conservation systems in grain and vegetable crops on the agronomically productive and ecologically unique Eastern Shore of Virginia.

REFERENCES

ASA-CSSA-SSSA. 2004. Publications handbook and style manual. Available at: https://www.soils.org/publications/style (verified 1 May 2009). ASA, CSSA, and SSSA, Madison, WI.

Southern Conservation Agricultural Systems Conference. 2009a. Proceedings. Available at: http://www.ag.auburn.edu/auxiliary/nsdl/scasc/proceedings.html (verified 1 May 2009). Ala. Coop. Ext. System, Auburn, AL.

Southern Conservation Agricultural Systems Conference. 2009b. Southern conservation agricultural systems conference. Available at: www.cpe.vt.edu/scasc (verified 1 May 2009). Virginia Tech Eastern Shore Agric. Res. Ext. Cent., Painter, VA.

TABLES AND FIGURES

Place any tables at the end of the document. Include any figures following the tables that you did not include within the body of the document.

Appendix H

EVALUATION FORM SUMMARY
31st SOUTHERN CONSERVATON AGRICULTURAL SYSTEMS CONFERNCE
42 RESPONSES

1. Academic/Research (15), Extension Agent (11), Farmer (8), Governmental Agency (12)

2. Rate Location

Excellent (39), Good (3)

3. Recommend rural locations such as the ES?

Yes (41), No (0)

4. Costs?

Reasonable (39), Unreasonable (1)

5. Time of year

April – June (8), June-July (1), July – Sept (35), Oct – Dec. (1)

6. Overall structure of program

Excellent (31), Good (11)

7. Recommend the program

Yes (41), No (0)

8. Would you recommend holding the conference in conjunction with other conferences?

- No. This is too good.
- Other conservation ag. Groups?
- Yes, it would be ok but depends on which one. However, most folks cannot be gone that long.
- Depends, maybe a field day.
- Don't know – but whatever makes sense.
- No preference. Depends on total length of conference.
- Where producers are invited.
- No, maybe?
- Occasionally, farmer organizations, maybe some environmental organizations.
- Probably not – too much information
- Any in-service training
- No, Field Day
- Yes, if broadly applicable and not conflicting in interest.

9. What do you consider to be the best feature of this conference?

- Cherrystone, Tomato Farm, Chesapeake B ay Tunnel, Potato Picking
- Small group, focus on local conditions, tour

- Mixed ag, much of it new to this conference. Glad to finally get to VA.
- Location
- A lot of different people with different expertise and different program areas.
- Killer picnic – the Best! A little tired from the day of sightseeing but very informative. You couldn't have done better.
- Party! Beer!
- Bus tour of farms
- Educational farm/field visits of various types of agriculture
- The research presented was applied.
- Tour and bbq
- The tours
- Field trip
- Variety of stops on the tour.
- Farm tours and crab feast/social hour
- The tours to farms to speak and interact with growers in their environment.
- 2 day format
- Seeing everything first-hand during the field trips
- Focused on conservation systems.
- Tour, speakers on problems with no till
- Tour was excellent – lived here my whole life and still learned so much about the area.
- Location, organization, staff. Great food.
- Location, facilities, easy to get to events. Food was very good. Host very accommodating, hotel reasonable.
- Field trips. On hand observations.
- Ag tour
- Wide variety of information
- Touring local farming operations and good food.
- Tour
- The crabs ☺ Delish! The cherrystone aquatic farm and tour of the CBBT
- Field tours were awesome.
- Great diversity of production systems. Wonderful food (mmm… crabs)! Good size.
- Field Day, dinner. Really enjoyable.
- Getting to see all the different types of agriculture. And the crab fest.
- Farm visits
- Farm tours
- Showcase of Eastern Shore agriculture
- Field trips.
- Reasonable schedule (not too long, too busy). Field tours.
- The tour.
- Local field/industry tours
- Organization, tour and qualities of presentations

10. Did you learn something during the conference that you will take back with you?

- Yes: 13

- Sometimes
- Yes, especially tomato growing and cover crop c vetch application.
- Where do I start – good speakers – good day trip
- Get Extension involved in conference arrangements.
- Some ideas about research.
- Cover crop in no-till
- Yes. Better staking of tomatoes, cover crops to try this winter.
- Yes – rotational aspects of conservation tillage
- Benefits of setbacks, filter areas.
- I don't really feel that I learned anything new.
- I learned many things but unfortunately don't have a farm yet.
- Yes – I learned a lot!
- Yes, always question the rationale for conventional system and consider alternatives.
- Other types of agriculture other than grain or livestock production in Virginia
- No?
- Yes – also much greater appreciation for other ag industries/production/Eastern Shore
- Yes, vegetable production systems.
- Mainly from the other attendees whose expertise could be helpful to my business.
- Picked up some cover crop ideas for international application
- Better appreciation for the CBBT

11. How do you prefer to receive announcements pertaining to the conference?

- Mail (8), Email (31), Website (8). Email notice with reference to website

12. Do you have suggestions for improvement and/or changes?

- Very good as is.
- More on conservation tillage.
- More advanced notification.
- None. Very satisfied.
- No – everything came together nicely.
- Social mixture at start for new people.
- Shorter speeches at beginning of conference.
- Well-organized/food great
- Great as is! Good job Mark!
- Possibly more research base and info, on farm demonstrations, maybe incorporate talks by producers implementing conservation practices.
- No – everything was great!
- Better selection of speakers, presentations
- Fewer presentations of higher merit.
- None, it was truly <u>Excellent</u> well planned and executed.
- No. Excellent presentation.
- Allow time for farmers to speak with us in a quiet location or make sure the host can/will address questions.

- More organized at the farm tour. Discount for farmers through partnerships with other groups.
- No chicken salad!!
- In tour, focus on one aspect of conservation at each stop.
- Excellent. Will attend again.
- Outstanding JOB. Encourage more (geographical) participants. Such a good conference

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