Why Mix Cattle and Crops?

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Introduction

The Southern Piedmont region of Georgia is composed of a mixed agricultural land use of row cropping, small grains, pasture-based cattle production, and confined poultry production. Significant opportunities are available to Georgia landowners to reap the ecological and economical benefits from rotation and integration of these operations on the same farm. Historical land use patterns over the past century in Georgia indicate a cattle inventory between 1 and 2 million head and currently low corn acreage at <1 million acres compared to >4 million acres prior to World War II. However, the recent rise in corn grain price due to the demand for corn to produce ethanol has driven a much greater need to supply corn from other regions of the country, including the Piedmont region of Georgia.

Although there is a perception that cattle grazing crop-residue stubble or cover crops will compact soil in Piedmont soils of Georgia, it is the condition and management of the surface soil that dictates whether animal trampling will compact soil and cause environmental deterioration and agronomic loss. For example, with grazing of Coastal bermudagrass, the impact of animal traffic on soil compaction was insignificant due to the accumulation of an organic matter-enriched surface soil layer (Franzluebbers et al., 2001). Establishment of perennial pasture on eroded soils in the Piedmont region may be one of the most effective strategies to improve soil organic matter (Franzluebbers, 2007a). In addition, conservation tillage in combination with pasture-crop rotation has been shown to significantly reduce soil erosion and improve water quality from agricultural runoff (Garcia-Prechac et al., 2004). Initial data from this proposed conservation tillage/pasture-crop rotation experiment have been collected and are validating many of the hypotheses focused on balancing agronomic production and environmental quality (Franzluebbers and Stuedemann, 2006, 2007). However, multiple-year data are needed to adequately quantify the agronomic, soil quality, and economic impacts of conservation-tillage systems in rotations of crops and pastures (Russelle et al., 2007).

Hypotheses for this research are:

1. Rotation of crops with pastures will yield agronomic and environmental benefits
2. Conservation tillage will preserve rotation benefits for an extended period of time
3. Cover crops can be grazed by cattle and increase farm profitability
4. Rotation with legume cover crops can reduce purchased N fertilizer requirement, while providing a high quality forage component

Since conservation-tillage systems operate most effectively with high-biomass producing cover crops, utilization of these cover crops as forage for cattle could increase the economic benefit to an integrated farming system. Economic information gathered from a diversity of sources throughout the USA suggests that integration of crops and livestock could be more profitable than either operation by itself (Katsvairo et al., 2006). The effect of cattle grazing cover crops on farming-system production and economics in the southeastern USA has not been adequately investigated, but this information could greatly improve recommendations and decisions for optimizing agricultural land use for profitability and environmental quality.

The objectives of this experiment were to quantify (1) cash/feed grain and stover production, (2) changes in soil quality, and (3) economic returns of crop/grazing systems in response to tillage, cover crop management, and source of N inputs. Specifically, we wanted to answer the following:

1. What are the effects of cattle grazing on subsequent cash/feed grain performance and soil quality?
2. How does cash/feed grain respond to no tillage under high surface soil organic matter conditions?
3. Can legume cover crops realistically provide adequate N to a subsequent cash/feed grain crop, particularly when grazed as forage by cattle?
4. How long will the benefits of rotating crops with pasture persist under no tillage compared with disk tillage?

Materials and Methods

The experimental site was located at the research station of the USDA–Agricultural Research Service in Watkinsville GA on a set of 18 plots (1.7-acre each, ~30 acres total) on Cecil sandy loam with 2 to 6% slope. The experiment evaluated tall fescue treatments from 1981 to 2001, during which time organic C of the surface 4" of soil more than doubled. In May 2002, the experimental paddocks were converted to either sorghum/rye or wheat/pearl millet cropping systems and managed with either disk or no tillage with four replications of these four main treatments. Paddocks were subdivided to exclude grazing from 1/3 of the area and allow grazing of the cover crop on the remainder. In 2005, corn replaced sorghum. In 2006, all cropping systems were converted to a rye / corn – wheat / soybean cropping system. During the summer, half of the plots were planted to corn and half planted to soybean. A new treatment, N management, was also introduced in 2006 to evaluate (1) typical inorganic N fertilizer input and (2) low inorganic N fertilizer input supplemented by legume cover crops as a source of biologic N fixation. Management details during the first 3 ½ years were reported in Franzluebbers and Stuedemann (2007).

Round-Up-Ready corn hybrid was planted in April and fertilized with split application at planting and at 12-15" height. Treatments evaluated were:

1. Grass cover crop mowed and disked into soil prior to corn fertilized with typical inorganic N input (DT – ungrazed – typical inorganic N)
2. Grass cover crop grazed by cow/calf pairs and soil disked prior to corn with typical inorganic N input (DT – grazed – typical inorganic N)
3. Grass cover crop rolled and corn no-till planted with typical inorganic N input (NT – ungrazed – typical inorganic N)
4. Grass over crop grazed by cow/calf pairs and corn no-till planted with typical inorganic N input (NT – grazed – typical inorganic N)
5. Legume + grass cover crop mowed and disked into soil prior to corn fertilized with low inorganic N input + biological N (DT – ungrazed –inorganic+biological N)
6. Legume + grass cover crop grazed by cow/calf pairs and soil disked prior to corn with low inorganic N input + biological N (DT – grazed –inorganic+biological N)
7. Legume + grass cover crop rolled and corn no-till planted with low inorganic N input + biological N (NT – ungrazed –inorganic+biological N)
8. Legume + grass cover crop grazed by cow/calf pairs and corn no-till planted with low inorganic N input + biological N (NT – grazed –inorganic+biological N)

Grass cover crop was ryegrass (Bulldog Grazer, 60 lb acre^{-1}) / rye (Wrens Abruzzi, 60 lb acre^{-1}) and legume + grass cover crop was clover (15 lb acre^{-1} of 38.5% Dixie Reseeding crimson clover, 38.5% Dalkeith subterranean clover, and 23% Bigbee berseem clover) / rye (Wrens Abruzzi, 30 lb acre^{-1}). Corn (Pioneer 31 G65, 32000 seed acre^{-1}) was harvested in autumn and cover crops or wheat (Coker 9663, 130 lb acre^{-1}) established soon thereafter. Following wheat harvest in early June, soybean (Roundup-Ready S76-L9, 45 lb acre^{-1}) was planted for bean production during the remainder of the summer. Fertilizer was applied as 46-23-26 lb N-P_2O_5-K_2O acre^{-1} at planting to all corn treatments and an additional 45-0-0 lb N-P_2O_5-K_2O acre^{-1} at sidedress to the corn treatment with typical inorganic N input. No sidedress N was applied to corn with legume N input. Fertilizer was applied as 46-0-0 lb N-P_2O_5-K_2O acre^{-1} to all wheat plots, as well as to ryegrass / rye cover crop.

This study also evaluated changes in soil organic matter, water infiltration, and soil compaction in response to tillage management, cover-crop management, and source of N inputs. Description of methods and the responses were reported in Franzluebbers and Stuedemann (2006; 2007b; 2008a, b).

Results and Discussion

During the first 4 years of research, net return over variable costs from grain only systems averaged \$11.33 acre^{-1} (Table 1). By including cover crops and grazing cattle into the production system, variable costs increased 32 $\pm$ 7%, but net return over variable costs increased considerably to an average of \$122.20 acre^{-1} (Table 1). Investing in cattle and cover crops improved economic return by an average of more than \$100 acre^{-1} during the first 4 years of evaluation.

Grazing of cover crops had both positive and negative effects on crop responses. When rye was grazed as a winter cover crop, summer grain yield and stover production were reduced compared to ungrazed rye under no tillage (Table 2). However, there was no effect of grazing of rye cover crop when the tillage system was disk tillage. Wheat grain yield was unaffected whether pearl millet cover crop was grazed or not, either under disk tillage or under no tillage. Wheat stover production was greater when pearl millet cover crops were grazed than not grazed under both tillage systems. Cattle gain was greater under no tillage than under disk tillage under both winter and summer cropping systems. Allowing cattle to graze cover crops appears to make good economic sense and is causing slight variations in agronomic response up to this point in this research.

Table 1. Economic analysis of four production scenarios evaluated across a 4-year period from 2002 to 2005 (Franzluebbers and Stuedemann, 2007).

Item	Sorghum (corn) / rye		Wheat / pearl millet	
	DT	NT	DT	NT
	--------------- \$ acre^{-1} ---------------			
Grain only system				
Variable cost	115.30	115.17	93.90	101.23
Crop value	122.13	153.13	100.17	95.50
Net return over variable cost	6.83	37.96	6.27	-5.73
Grain + cattle system				
Variable cost	160.00	159.16	118.58	127.67
Crop value	131.75	117.50	103.25	97.83
Calf gain value	117.57	159.66	154.31	172.35
Net return over variable cost	89.32	118.00	138.98	142.51

Analysis excludes labor cost, as well as grazing time and gain of cows. Assumed values of \$2.50 bu^{-1} grain and \$0.75 lb^{-1} calf gain. DT is disk tillage and NT is no tillage.

Soil organic C and N contents following termination of pasture declined with disk tillage, but remained stable and similar to continuation of perennial pasture when crops were managed with no tillage (Fig. 1). More active fractions of organic matter followed similar trends as those of total organic C and N. These data suggest that longer term evaluation of these cropping systems will be needed to define a new steady-state level in soil organic matter. Allowing cattle to graze winter and summer cover crops has not led to any consistent negative effects on soil organic C and N fractions, and therefore, can be recommended as a viable conservation approach to intensify agricultural land use, especially when practiced in combination with no tillage. To preserve high surface-soil organic C and N fractions and total plow-layer contents, no-tillage cropping following termination of perennial pasture is highly recommended.

Table 2. Crop yields and animal production from four production systems across a 4-year period from 2002 to 2005 (Franzluebbers and Stuedemann, 2007).

Cover crop	Sorghum (corn) / rye		Wheat / pearl millet	
	DT	NT	DT	NT
Grain crop yield (bu acre^{-1})				
Ungrazed	49	61	40	38
Grazed	53	47	41	39
Stover yield of grain crop (ton acre^{-1})				
Ungrazed	1.9	3.3	0.5	0.6
Grazed	1.8	2.5	0.6	0.7
Cover crop yield (ton acre^{-1})				
Ungrazed	2.7	3.1	3.4	4.5
Grazed	0.1	0.2	0.2	0.4
Cattle gain on cover crop (lb acre^{-1})				
Grazed	182	312	247	289

DT is disk tillage and NT is no tillage.

Conclusions

Preservation of high surface-soil organic matter with no-tillage management following termination of perennial pasture was a critical condition that allowed cattle grazing of cover crops to (1) improve soil microbial biomass C, (2) have little negative effect on surface soil compaction (i.e., bulk density), and (3) limited the degeneration of the soil pore network that influences water infiltration (results presented in Franzluebbers and Stuedemann, 2006). Grazing cover crops with cattle had (1) a positive effect on wheat stover production irrespective of tillage system, (2) no effect on winter grain and summer grain and stover production under disk tillage, and (3) a negative effect on summer grain and stover production under no tillage. Both rye and pearl millet cover crops provided an abundant and high quality diet for cattle for 26 to 77 days each season. Calf performance on cover crops was 4.7 $\pm$ 0.4 lb head^{-1} day^{-1} under no tillage, which was an average of 11% greater than under disk tillage (Franzluebbers and Stuedemann, 2007). These data indicate that integrated crop–livestock

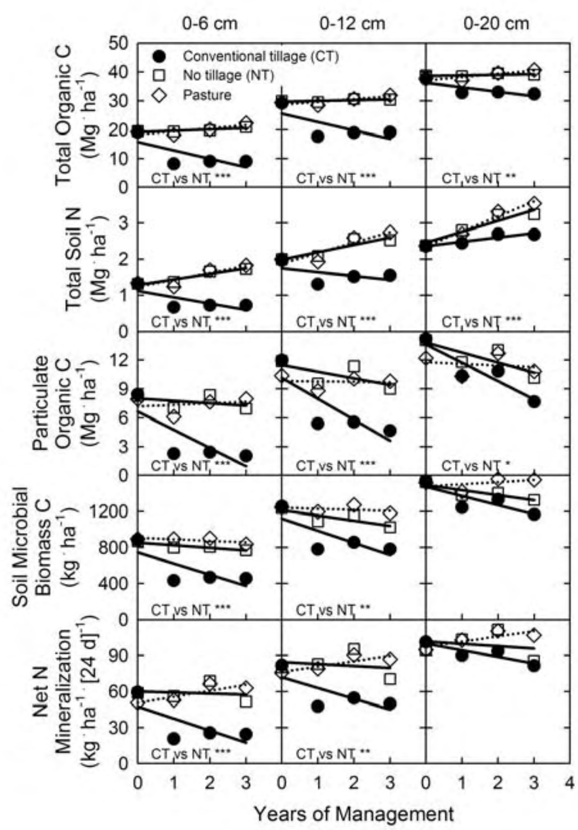

Fig. 1. Temporal change in total, particulate, microbial biomass, and mineralizable C and N fractions as affected by disk- and no-tillage management at three different depth intervals (Franzluebbers and Stuedemann, 2008a).

production may not necessarily suppress crop yields, but could even enhance yields and net economic return, especially if managed with conservation tillage. Despite current social challenges with integrated crop–livestock production systems, significant agronomic and economic benefits could be expected with their adoption.

Acknowledgements

We gratefully acknowledge the excellent technical contributions of Steve Knapp, Dwight Seman, Kim Lyness, Josh Cown, Carson Pruitt, Eric Elsner, and Robert Martin. Financial support was provided in part by the USDA–National Research Initiative Competitive Grants Program (Agr. No. 2001-35107-11126) and the Georgia Agricultural Commodity Commission for Corn. Continuation of this project has been possible with additional funding provided by the GRACEnet Cross-Location Research Project.

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