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JPC Research Note 11

Response of Corn to Organic Matter Quantity and Distribution in Soil

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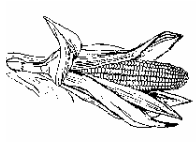
Investigator



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Working Hypotheses

1. Rotation of crops with pastures will yield agronomic and environmental benefits
2. Conservation tillage will preserve rotation benefits for extended period of time
3. Cover crops can be grazed by cattle and increase farm profitability

Objectives

1. Quantify the agronomic response of corn to tillage and cover crop management
2. Determine soil quality changes following cropping of previous land in pasture
3. Estimate economics of corn production in response to tillage and cover crop management

Methods

This report describes the first year of a cropping system modification to an existing experiment at the USDA–ARS experiment station in Watkinsville GA. Four treatments were replicated four times in a split-plot design. Individual plots were either 1.01 acre (grazed) or 0.46 acre (ungrazed). Treatments evaluated in 2005 were:

1. Rye cover crop mowed and disked into soil prior to corn (DT – ungrazed)
2. Rye cover crop grazed by cow/calf pairs and soil disked prior to corn (DT – grazed)
3. Rye cover crop rolled and corn no-till planted (NT – ungrazed)
4. Rye cover crop grazed by cow/calf pairs and corn no-till planted (NT – grazed)

'Wrens Abruzzi' rye was the cover crop planted in November 2004 in all treatments. Cropping system prior to 2005 was grain sorghum with a rye cover crop from 2002 to 2004. Tillage and cover crop management during this previous period was the same as in 2005. Land was previously in grazed tall fescue from 1982 to early 2002.

Roundup-Ready Pioneer 31N26 corn was planted at 29,000 seeds acre^{-1} on 11 April in NT plots and on 21 April in DT plots. Rye was grazed by Angus cow/calf pairs from 10 March to 5 April. Ungrazed rye was mechanically rolled or mowed on 6 April. Roundup was sprayed onto NT plots at 1.5 quart acre^{-1} on 12 April. Fertilizer (260 lb acre^{-1} of 18-9-18) was broadcasted on 15 April in NT plots and 18 April in DT plots. Soil in DT plots was disked 3 times with a heavy harrow and 2 times with a smoothing harrow from 18-19 April. All plots were sprayed with Roundup at 0.7 quart acre^{-1} on 19 May. Fertilizer (290 lb acre^{-1} of 34-0-0) was broadcasted on all plots on 24 May. Corn grain yield by hand harvest was from a 20-foot row length in each plot on 14 September. Corn grain was harvested by combine from 26 September to 3 October. Corn stalks were grazed by bred Angus cows from 13 October to 27 October.

Results

How did corn respond to tillage system?

Corn grain yield harvested with a combine was not statistically different between tillage systems, when averaged across cover crop management scenarios (average of 132 bu acre^{-1}; Table 1). There was a trend for greater corn grain yield under NT than under DT when rye cover crop was left ungrazed.

Table 1. Combine-harvested corn grain yield during 2005 as affected by tillage system in two cover-crop management systems.

Cover Crop Management	Tillage System: Disk	Tillage System: No till	Pr > t
	-------- bu acre^{-1}	--------	
Ungrazed	115	153	0.17
Grazed	133	119	0.36
Average	124	136	0.43

When corn was harvested by hand, grain yield was higher (average of 172 bu acre^{-1}; Table 2) than when the whole plot was harvested by combine. This suggested significant grain loss during combine harvest, which was evident with the emergence of seedlings following Tropical Storm Tammy in early October. The relatively small size of plots with surrounding fences also made it difficult to culture the entire plot, such that significant border reductions occurred with the combine-harvested yield estimate.

Table 2. Hand-harvested corn yield components during 2005 as affected by tillage system in two cover-crop management systems.

Cover Crop Management	Tillage System: Disk	Tillage System: No till	Pr > t
Grain yield (bu acre^{-1})			
Ungrazed	**160**	**203**	**0.03**
Grazed	173	153	0.30
Average	166	178	0.43
Stover yield (ton acre^{-1})			
Ungrazed	3.2	4.8	0.17
Grazed	3.3	3.2	0.91
Average	3.3	4.0	0.28
Ear weight (lb ear^{-1})			
Ungrazed	0.41	0.43	0.47
Grazed	0.40	0.34	0.16
Average	0.41	0.39	0.47

Grain yield was not different between tillage systems when previous cover crop was grazed, but *grain yield was greater under NT than under DT when cover crop was ungrazed*. This corroborated the similar trend that occurred in combine-harvested yield. At least during the 4th year following termination of pasture, no-tillage management was able to preserve a potential pasture-rotation benefit, although only with sufficient surface mulch provided by the cover crop.

Corn stover yield was not affected by tillage system, but there was a trend for higher yield under NT than under DT, when cover crop was ungrazed. Ear weight was not affected by tillage system, but there was a trend for reduced ear weight with NT and grazed cover.

How did corn respond to cover crop management?

Corn grain and stover yields were not statistically affected by cover crop management (Table 3). When the cover crop was grazed, ear weight was reduced compared with ungrazed cover-crop condition. Average number of ears per stalk was 0.98 and number of stalks per foot of row was 1.44, both of which were not different between grazed and ungrazed cover-crop management systems. The lower ear weight under grazed cover crop than unharvested cover crop suggests that a minor nutrient or water limitation may have occurred during development.

Table 3. Corn yield components during 2005 as affected by cover crop management, averaged across two tillage systems.

Tillage System	Cover Crop Management: Ungrazed	Cover Crop Management: Grazed	Pr > t
Combine-harvested grain yield (bu acre^{-1})			
	134	126	0.53
Hand-harvested grain yield (bu acre^{-1})			
	181	163	0.21
Stover yield (ton acre^{-1})			
	4.0	3.3	0.29
Ear weight (lb ear^{-1})			
	0.42	**0.37**	**0.05**

What were the animal gains with grazing?

When rye cover crop was grazed by cow/calf pairs in spring prior to corn planting, there were few statistically significant differences between tillage systems, but there was a consistent trend of better performance and total production under NT than under DT (Table 4). This was consistent with the amount of ungrazed rye forage produced at maturity. Calf performance was good, but the early and short duration of grazing limited cow gain.

Table 4. Cattle responses to tillage system on rye cover crop grazed from 10 March to 5 April 2005 prior to corn.

Response	Tillage System		Pr > t
	Disk	No till	
Grazing days [(head · days) acre^{-1}]			
	51	53	0.54
Calf daily gain (lb head^{-1} day^{-1})			
	2.1	2.5	0.21
Cow gain (lb acre^{-1})			
	-47	16	0.21
Calf gain (lb acre^{-1})			
	121	144	0.14
Cow/calf pair gain (lb acre^{-1})			
	74	160	0.13
Ungrazed rye production (ton acre^{-1})			
	1.9	2.4	0.37

Following harvest of corn, stalks were grazed by dry, bred cows for two weeks. Stocking rate was set high (4.4 head acre^{-1}), resulting in a total of 62 grazing days acre^{-1}. There was no difference in cattle gain between tillage systems, in which cows maintained weight during this period at 1153 $\pm$ 42 lb head^{-1}. At a daily intake rate of 2% of body weight, cows would have consumed 0.71 tons of corn stover acre^{-1} during this short grazing period (or ~20% of stover produced).

How has soil changed with tillage and grazing?

Soil samples following corn growth in 2005 are scheduled to be collected this winter. Soil collected in December 2004, as part of our intended long-term evaluation, suggested a significant change in distribution of soil organic C (Figure 1). The surface 2.5" of soil had greater soil organic C with no tillage than with disk tillage, while the opposite occurred at the 5-12" depth.

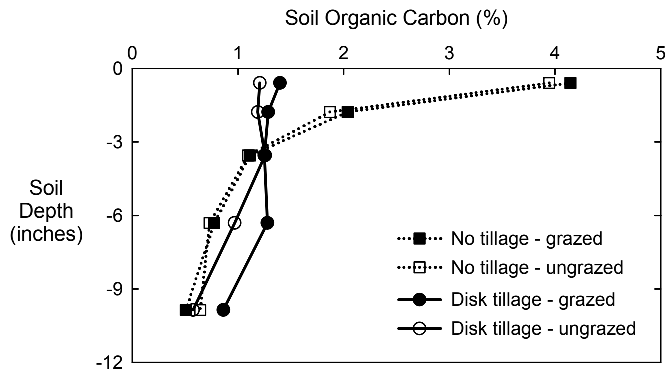

Figure 1. Distribution of soil organic carbon with depth as affected by tillage and cover crop management in November 2004.

When summed from surface residue to a depth of 12", the stock of organic C was 26.8 ton acre^{-1} with no tillage, which was 21% greater than with disk tillage (22.1 ton acre^{-1}). The stock of organic C was not statistically different between grazed and ungrazed cover crop management.

Soil moisture was not affected by tillage system (Table 5). Strength in the surface foot of soil was not different between tillage systems when cover crop was ungrazed, but was greater under NT than under DT when cover crop was grazed, suggesting that cattle may have contributed to compaction. Further work is needed to assess how grazing animals in different tillage systems might affect soil compaction.

Table 5. Soil moisture and soil strength in response to tillage and cover crop management in 2005.

Time Period/ Cover Crop Management	Tillage System		Pr > t
	Disk	No till	
Soil moisture on 6 April (%)			
Ungrazed	16.5	19.0	0.42
Grazed	20.4	20.8	0.80
Soil moisture on 24 October (%)			
Ungrazed	13.7	15.7	0.25
Grazed	14.5	15.0	0.59
Soil strength on 6 April (psi)			
Ungrazed	3469	4540	0.26
Grazed	**3861**	**4313**	**0.04**
Soil strength on 24 October (psi)			
Ungrazed	4600	4841	0.42
Grazed	4721	5746	0.15

Will it pay to integrate cattle with corn cropping?

The relatively narrow margin of return with corn cropping suggests that adding a complementary enterprise would be beneficial. Of course, there is risk associated with the unknown, but research to document the tangible factors of an agricultural enterprise can help individual producers make better decisions to tackle the less tangible factors, such as time availability, skill, personal goals, etc. The first year of this system analysis suggests that adding grazing cattle to a corn cropping system could return $90 to $130 more per acre of land. These first-year results indicate that integrating cattle with corn cropping could be profitable.

Table 6. Preliminary economic analysis of four production scenarios evaluated in 2005.

Response	Disk Tillage		No Tillage	
	Ungrazed	Grazed	Ungrazed	Grazed
	--------------- $ acre^{-1} ---------------			
Variable inputs	164	234	175	245
Fixed inputs	100	100	100	100
Crop output	288	333	383	298
Animal output	0	158	0	244
Return	24	157	108	197

Note: Outputs are from one year only. Variable and fixed inputs from 2003 Georgia enterprise budget for corn and assuming $70/acre of input cost for cattle. Outputs are from actual corn and cattle production, assuming $2.50/bu corn, $1/lb live-weight gain, and $120/ton of corn stover consumed.

Summary and Outlook

The objectives of this experiment were to:

1. Quantify the agronomic response of corn to tillage and cover crop management
2. Determine soil quality changes following cropping of previous land in pasture
3. Estimate economics of corn production in response to tillage and cover crop management

Data collected during the first year of corn in this experiment suggest that corn can be effectively grown with no tillage and integrated with cattle grazing.

Agronomically, corn performed better without cattle grazing, although the negative response of cattle on corn production was minor, and dependent upon tillage system. No tillage was superior to disk tillage with regards to corn, as well as cover crop production, and subsequent cattle gain when grazing the cover crop.

Environmentally, grazing caused some deterioration of soil properties, but not to a level that greatly affected crop production. No-tillage crop production was able to preserve the high level of surface soil organic matter that is necessary to control erosion and improve nutrient cycling.

Economically, cattle grazing rye cover and corn stover added significant value ($90-130 acre^{-1}) to the farming system without harming crop production. No tillage was able to add $40-60 acre^{-1} to net return.

These initially positive results will require another year or two of data to be able to make firm conclusions about how corn can be managed with alternatives to increase agronomic performance, preserve environmental quality, and improve farm profitability. This project complements other sustainable agriculture research being conducted at the Watkinsville ARS laboratory.