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Shallow Incorporation of Manure Minimizes Soil Disturbance and Conserves Nitrogen

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Introduction

Environmental concerns associated with surface application of manure and conventional tillage programs, as well as rising costs of both nitrogen (N) fertilizer and fuel, have led many New York dairies to employ the use of reduced tillage as a way to incorporate spring-applied manure for corn production. In 2008 and 2009, eight New York State dairy farms participated in a two- year on-farm trial to test the hypothesis that shallow incorporation (aeration) of spring-applied manure is an effective reduced tillage option for minimizing soil disturbance, conserving N, and maintaining yields equivalent to those obtained with chisel incorporation of manure. Funding for this project was provided by the New York Farm Viability Institute (NYFVI) and the Northern New York Agricultural Development Program (NNYADP).

Methods

The eight fields selected for this trial varied from first- to third-year corn after alfalfa/grass and varied in manure histories. All trials were conducted using a randomized complete block design (4 replications) with three treatments (surface application of manure (control), shallow incorporation of manure, and chisel incorporation of manure) in four replications, except one trial that was conducted in three replications. Corn was planted with no more than 30 lbs/acre of N starter fertilizer in addition to spring-applied manure application (5,500 – 12,000 gal/acre). Plot sizes varied depending on farmer equipment and ranged from 12 to 20 rows wide and 300 to700 ft long, with the inner 6 to 10 rows harvested for yield measurements. Soil samples, residue measurements and compaction readings were taken before manure was applied. Incorporation took place within one hour of manure application, and a second residue reading was done to compare the surface residue remaining for each treatment method. All sites were sampled three more times for soil fertility and soil moisture (at planting, sidedress time and harvest). Stand density was measured at sidedress time. At harvest time, soil compaction was measured one last time, and yield and forage quality samples were taken.

Surface Residue Coverage

Chisel incorporation of manure resulted in 13–74% reduction in surface residue (average reduction of 44%) for fields with an initial residue coverage of 20% or greater. For the same fields, aerator incorporation (15 degree angle) reduced surface residue by 9-53% (average

31%). Aeration conserved on average 30% more surface residue. Post-application residue levels exceeding 30% were obtained when the aerator was used to incorporate manure for first-year corn after sod (Site E, 2008), corn silage after corn grain (Site F, 2009), and if a cover crop was used (Site H, 2009). This indicates a potential for soil conservation with aerator incorporation if used following corn grain harvest or rotation into corn from sod or cover crops (Figure 1).

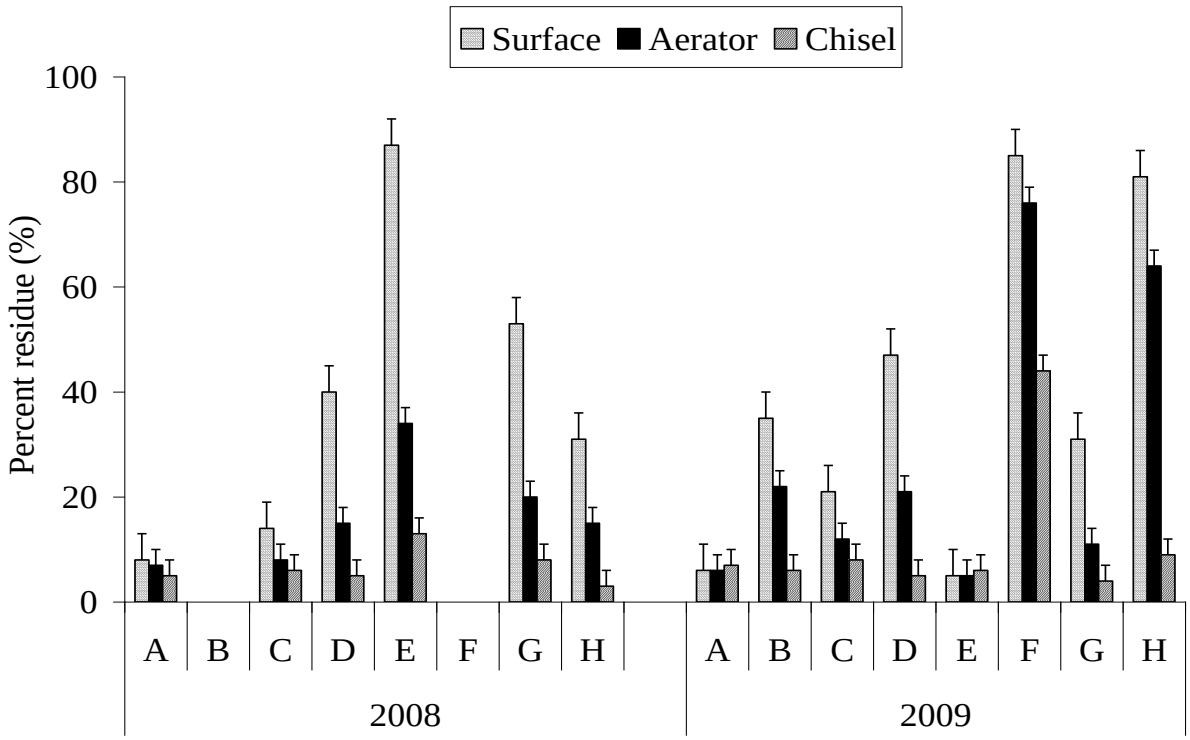

Figure 1. Percent surface residue coverage for 2008 and 2009 at eight locations as affected by manure application method (surface application without incorporation versus direct incorporation using an aerator or chisel plow).

Compaction

There was no measurable compaction at the start of the growing season, and compaction observed in the deeper soil layers due to harvest activities in 2008 (results not shown) did not carry over into the 2009 growing season, suggesting the freeze and thaw cycles over the winter alleviated the compaction caused during harvest of the corn in 2008. Studies on compacted fields need to be done to see if aeration can be as effective in reducing compaction as chisel plowing.

Yield, Forage Quality and Nitrogen Conservation

The two years showed very different growing conditions. The 2009 season was cold and wet, while growing conditions were considerably better at most locations in 2008. During the 2008 season, surface application of manure resulted in an average yield (across all silage sites) of 18.9 tons/acre, versus 20.0 tons/acre with aerator incorporation and 19.8 tons/acre with chisel

incorporation, indicating a yield benefit from incorporation of approximately 1 ton/acre (Table 1). When three sites with excess N (crude protein levels exceeding 7% and late season corn stalk nitrate levels exceeding 5000 ppm) were excluded from the comparison, the yield difference between surface application and incorporation was 2 tons/acre. Despite the weather-related lower yields in 2009, a similar trend was seen that year across all silage sites, in which surface application without incorporation resulted in an average yield of 16.9 tons/acre versus 18.0 and 17.9 tons/acre for chisel and aerator incorporation, respectively. The 2009 results also suggested no differences between chisel and aerator incorporation of manure, and a yield increase of 1 ton/acre increase with incorporation.

Table 1. Corn silage yield (ton/acre), crude protein (%), and milk production estimates (lbs/ton) at eight locations in 2008 and 2009 as affected by manure application method (surface application without incorporation versus direct incorporation using an aerator or chisel plow).

2008									
Site	Yield			Crude Protein			Milk Estimate		
	ton/acre			%			lbs/ton		
	Surface	Aerator	Chisel	Surface	Aerator	Chisel	Surface	Aerator	Chisel
A	17.4 b	19.4 a	19.4 a	5.9 a	6.4 a	6.4 a	3,441 a	3,439 a	3,426 a
B	20.5 a	22.1 a	22.7 a	6.2 a	6.7 a	6.6 a	3,653 a	3,725 a	3,598 a
C	20.7 a	21.1 a	20.1 a	7.1 a	7.3 a	7.3 a	3,309 a	3,346 a	3,396 a
D	12.7 b	14.9 a	15.2 a	6.3 a	6.7 a	6.8 a	3,270 a	3,322 a	3,301 a
E	27.6 a	27.1 a	27.1 a	7.2 a	7.1 a	7.2 a	3,567 a	3,538 a	3,541 a
F	.	.	.	.	.	.	.	.	.
G	11.8 a	13.5 a	12.9 a	6.0 a	5.9 a	6.1 a	3,624 a	3,643 a	3,615 a
H	21.2 a	21.6 a	21.7 a	7.4 a	7.4 a	7.7 a	3,581 a	3,600 a	3,614 a
Mean	18.9 b	20.0 a	19.8 a	6.6 b	6.8 ab	6.9 a	3,493 a	3,514 a	3,501 a
2009									
Site	Yield			Crude Protein			Milk Estimate		
	ton/acre			%			lbs/ton		
	Surface	Aerator	Chisel	Surface	Aerator	Chisel	Surface	Aerator	Chisel
A	18.7 a	18.6 a	18.6 a	6.9 a	7.6 a	7.3 a	3,636 a	3,631 a	3,664 a
B	11.3 a	13.3 a	12.7 a	5.9 a	5.6 a	5.8 a	3,634 a	3,620 a	3,599 a
C	19.8 a	20.7 a	20.0 a	8.0 a	8.1 a	7.8 a	3,675 a	3,642 b	3,649 ab
D	11.7 a	13.5 a	14.2 a	7.4 b	8.1 a	8.3 a	3,137 a	3,070 a	3,033 a
E	24.9 a	25.7 a	26.8 a	6.9 a	7.0 a	7.1 a	3,309 a	3,276 a	3,303 a
F	17.1 a	19.0 a	18.2 a	7.0 a	7.0 a	6.9 a	3,357 a	3,353 a	3,398 a
G	8.5 a	9.7 a	9.3 a	6.3 a	6.4 a	6.5 a	3,495 a	3,476 a	3,555 a
H	22.8 a	23.9 a	24.6 a	7.1 a	7.1 a	7.3 a	3,635 a	3,596 a	3,598 a
Mean	16.9 b	17.9 a	18.0 a	6.9 a	7.1 a	7.1 a	3,485 a	3,457 a	3,478 a

*Average values with different letters (a,b,c) are statistically different (a = 0.05).

There were no significant differences in soil nitrate levels (0-8 inches) between the aerator and chisel incorporation treatments for 62 of the 64 sampling times in 2008 and 2009 combined. Only one location (Site H) showed higher soil nitrate levels at planting with chisel

incorporation than with aerator incorporation in both years. Chisel incorporation of manure resulted in significantly higher PSNT (0-12 inches) nitrate levels than for aerator incorporation at one location in 2008, and another location in 2009 (14 of the 16 sampling times). At these two locations, the aerator incorporation resulted in values no different from the PSNT results of surface-applied manure. Forage quality (milk per ton) for both years showed no significant differences between the two incorporation treatments.

These results show that shallow mixing of spring-applied manure conserves soil N and has benefits for surface residue conservation, and will increase yield over surface application without incorporation, similar to what has been obtained with chisel plowing, on sites where N is limiting corn production.

Conclusion

Shallow incorporation of manure resulted in greater surface residue conservation compared to chisel incorporation with no measurable impact on soil compaction. Manure N conservation was similar for both incorporation treatments and increased yield by 1-2 tons/acre on sites where N was limiting corn yield. The additional N from manure incorporation did not increase corn yields where soil N supply was already sufficient. Shallow incorporation of manure is a suitable alternative to chisel incorporation in reduced tillage systems for conserving N and maintaining surface residue cover.

For Further Information

Questions about this project? Contact: Quirine M. Ketterings at 607-255-3061 or qmk2@cornell.edu, and/or visit the Nutrient Management Spear Program website (http://nmsp.cals.cornell.edu/).