What's Cropping Up?

A NEWSLETTER FOR NEW YORK FIELD CROPS & SOILS

VOLUME 19, NUMBER 2, MARCH- APRIL, 2008

Agronomics and Economics of Zone Tillage Depth for Corn Silage Production

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Large-scale dairies are increasingly common in western NY where rolling topography and highly erodible land (HEL) dominate. Currently, more than 600 dairy farms in NY are classified as confined animal feeding operations or CAFOs. Many large dairy operations in western NY abandoned conventional tillage in 2004 because the NY CAFO planning process, which utilizes the Revised Universal Soil Loss Equation 2 (RUSLE2), permitted only one year of corn silage under conventional tillage followed by 5 years of perennial forage on HEL to meet tolerable (T) soil erosion losses. Many large-scale dairy operations adopted zone tillage because NY CAFO plans permitted a continuance of the 4-year corn silage-perennial forage rotation on their HEL topography with zone tillage. Most adopted zone tillage at a 14-in depth (Rawson method); despite previous research in the early 1990s on three dairy farms in Otsego Co., NY that indicated that corn grain yielded the same at 9 and 13-in chisel tillage depths. The volatile nature of diesel fuel costs prompted us to examine what is the optimum zone tillage depth for corn silage production in the first year and in the 3rd and 4th years following perennial forage in a 4-yr corn silage-perennial forage rotation.

A farmer-researcher partnership was formed to conduct field-scale studies at Table Rock Farm, a ~1000-cow operation that grows about 650 acres of corn silage, in Castile, NY. A field-scale study was established in two 10 acre fields with predominant soil types of Erie-Langford channery silt loams in 2007 and 2008. Employees on the dairy farm performed all field operations, including manure applications, tillage practices, planting, herbicide spraying, and harvesting. Zone tillage was performed in late April of both years when soil conditions had dried because of limited precipitation in the previous 2 weeks. A 20 ft wide zone builder subsoiler (Model 130, Unververth, Kalida, OH) with 8 shanks spaced 30-in apart with a 20 ft wide Aerway (Model, AWS-C-Flex single roller) attached to the zone builder was used in this study. The zone builder, which tilled strips about 8 in wide, was set at 0-in (with the use of the Aerway), and at 7 and 14 in (with the use of the Aerway) for the three zone tillage depth treatments.

A partial budget approach was used to estimate the expected change in annual profit in an average future year for the dairy farm to determine the optimum depth of zone tillage. We analyzed only variable costs because the dairy farm had already purchased a zone builder. No other equipment changes in relation to tillage practices will be made until a future decision on whether to replace the existing zone builder. Variable costs included labor ($15/hr), fuel ($3.15/gallon), and lube, repair, and maintenance costs of equipment where

Table 1. Surface residue percent, plant densities, and dry matter (DM) accumulation of corn at the eight leaf stage (V8) under three zone tillage depths, averaged across the 2006 and 2007 growing seasons on a dairy farm near Warsaw, NY.

Depth	Residue	Plant densities	DM accumulation
--in--	----%----	----plants/ac---	-----g m^{-2}----
0	34.5	28990	334
18	33.7	29000	356
36	33.6	29959	365
		Contrasts	
0 vs. 7	NS	NS	NS
7 vs. 14	NS	NS	NS

Crop Management

Table 2. Silage yield (adjusted to 35% dry matter (DM), DM content, and N uptake of corn at harvest under three zone tillage depths, averaged across the 2006 and 2007 growing seasons on a dairy farm in Castile, NY.

Depth	DM yield	DM content	N uptake
--in--	----tons/ac^{-1}----	----%----	----lbs/ac----
0	23.8	36.7	195
7	25.3	36.6	210
14	25.1	36.9	210
		Contrasts	
0 vs. 7	*	NS	*
7 vs. 14	NS	NS	NS

appropriate (ASAE, 2000). A 360 hp articulated tractor was used for all tillage treatments in the study with time estimates of 0.09 hours/acre for the 0-in (Aerway attached) depth, 0.13 hours/acre for the 7-in depth, and 0.17 hours/acre for the 14-in depth (ASAE, 2000). All other management inputs in this study were similar across zone tillage depths so the only other variable costs were associated with harvesting and hauling and silo filling for different corn silage yields. Expected changes in income were generated from average corn silage yields for each zone tillage depth in this study and the average corn silage price ($35/ton) in New York for 2008. All dollar values for income and cost items are expressed in real terms as 2008 dollars. The expected changes in profit reflected differences in total net income (increases or decreases) and differences in costs (increases and decreases) for the dairy farm in this study for a future average year.

Tillage depth results did not differ for 1st year, 3rd, and 4th year corn or in 2007 or 2008 so the data have been averaged across rotations and years. Tillage depth did not affect surface residue, final plant densities, and DM accumulation of corn at the V12 stage (Table 1). Tillage depth, however affected silage yield with a 6% yield increase for the 7-in compared with the 0-in depth (Table 2). Zone tillage beyond the 7–in depth, however, did not provide additional silage yield increases. This is consistent with previous research in NY on three dairy farms with silt loam soils that indicated that corn grain yielded the same at a 9 compared with a 13-in chisel tillage depth.

Tillage depth did not affect corn DM content at harvest with DM contents averaging about 36.5% for all tillage depths (Table 2). The 7-in zone tillage depth had greater N uptake compared with the 0-in depth but had similar N uptake when compared with the 14-in depth (Table 2). The greater DM yield between the 7 and 0-in zone tillage depths mostly contributed to the greater N uptake because crude protein contents did not differ among zone tillage depth treatments (Table 3). Tillage depth also did not affect any other corn silage quality characteristics measured in this study (Table 3).

Partial budget analyses, based on variable costs and corn silage values in 2008, indicate that a reduction from a 14 to 7-in zone tillage depth on the dairy farm where the study was conducted would increase profit by about $12/acre (Table 4). The increase in profit would be realized in part because of decreased time and draught on the tractor during the tillage operation, which would reduce labor ($0.60/ acre), tractor fuel ($2.38/acre), and repairs and maintenance for the tractor, zone builder and Aerway ($1.22/acre). Also, there would be an increased return with the ~ 0.25 ton/acre higher silage yield ($8.90/acre); partially offset by the increase in harvesting costs ($1.04/acre). If silage yields are considered similar between

Table 3. Crude protein (CP), starch, 30 hour neutral detergent fiber (NDF), and in vitro true digestibility (IVTD) of corn at harvest under three zone tillage depths, averaged across the 2006 and 2007 growing seasons on a dairy farm in Castile, NY.

Depth	CP	Starch	NDF	IVTD
--in--	---- % ---	---- % ---	---%---	---- %----
0	7.3	30.7	45.1	81.9
7	7.4	30.5	45.0	82.0
14	7.5	31.0	45.1	82.3
			Contrasts	
0 vs. 7	NS	NS	NS	NS
7 vs. 14	NS	NS	NS	NS

Table 4. Partial budget analyses for a dairy farm that grows 650 acres of corn silage in Castile, NY, based on additional corn silage yield and mean corn silage price ($35/acre) in NY for 2008 and added variable (operating) costs at 2008 dollars for zone tillage (ZT) depths (with attached Aerway implement) of 0 vs. 7 in and 7 vs. 14-cm depths.

	ZT depth		ZT depth	
Partial budget	7 in	14 in	0 in	7 in
	-------$/acre ----------		---------$/acre-------------	
Income change	8.90			53.39
Variable costs change				
Labor	0.60		0.60	
Fuel	2.38		2.38	
Repairs & maintenance	1.22		3.37	
Harvest		1.04	6.64	
Depreciation-zone builder			1.14	
Expected profit change	12.06			39.27

7 and 14-in depths, the expected profit would be about $4/acre because of the savings in variable costs. Of course, the expected profit would change annually as diesel fuel costs and corn silage values change.

Partial budget analyses indicate that the use of the Aerway without the zone builder at a 7-in depth would not be profitable on this dairy farm in the near future (Table 4). The decrease in time and draught on the tractor as well as wear on the zone builder at the 0-in depth would contribute to decreased variable costs ($7.49/acre). Decreased variable costs, however, would be offset with a loss in crop value ($53.39/acre) because of higher silage yield at the 7-in depth, resulting in a loss of profit of about -$39/acre after adjusting for $6.64/acre lower harvesting costs. A loss of profit of this magnitude across 650 acres of corn silage indicates that the dairy farmer will probably purchase a new zone builder when a decision must be made on replacement of the existing zone builder.

Conclusion

Despite significant potential for soil compaction in a 4-yr corn silage –perennial forage rotation on dairy farms, the results from this study indicate that an intermediate zone tillage depth of 7-in was optimum on a dairy farm in western NY with silt loam soils with thick fragipans at the 16 to 20 in depth. We recommend that dairy producers on these soils experiment with reducing their zone tillage depth from 14 to 7 in to reduce labor, fuel, and repair and maintenance costs because silage yields remained similar in this study. We recommend that dairy producers on these soils do not eliminate zone tillage, despite savings in labor, fuel, and repair and maintenance costs, because of reductions in silage yield and N uptake of corn.