

Soil Management Research Report

Penn State University
Department of Crop and Soil Sciences
116 ASI Bldg. University Park, PA 16802

Report No. 03-03

Compaction Management in No-till, 2003

Principal Investigator: Sjoerd Duiker

Location: Dairy Farm Operations, Airport field, State College, PA

Collaborators: Brian Macaffee, Ron Hoover, Jennifer Moeny, and Melanie Lobadio

Research Objectives: 1) To determine the effects of soil compaction in no-till, 2) To determine the benefits of flotation tires versus truck tires, and 3) To determine the effects of shallow and deep in-row tillage to alleviate soil compaction.

Background: The site of the experiment has been in no-till for more than ten years.

Study Description: This study was established in 2002, with 9 treatments. A description of each compaction treatment can be found in Table 1. The plots are 250 ft long by 30 ft wide with 4 reps for each treatment, for a total of 36 plots.

Table 1. Compaction Treatments at No-till Compaction experiment at Dairy Farm Operations in 2003

Treatment Description	Further Details
1. No compaction control	-
2. No compaction, strip tilled in fall 2001 only	Strip tilled with Unferverth Zone Builder to a depth of 17 in
3. No compaction, strip tilled in spring	Strip tilled annually with Unferverth Zone Builder to a depth of 17 in
4. Compacted annually with loaded 30 ton manure truck, with truck tires	Compact whole field once (i.e. tracks on every inch) in fall and spring, when soil is moist
5. Compacted only in 2002 with loaded 30 ton manure truck with truck tires	Same as 4, except only compacted in 2002
6. Compacted as 4, strip tilled pre traffic	Strip tilled with Unferverth Zone Builder to a depth of 17 in, then compacted as 4
7. Compacted as 4, but strip tilled post traffic	Compacted as 4, then strip tilled with Unferverth Zone Builder to a depth of 17 in
8. Compacted as 4, zone tilled in spring post traffic	Compacted as 4, then zone tilled with Unferverth zone-till cart (3 coulters per row) to a depth of 4 in
9. Compacted annually with loaded 30 ton manure truck, with flotation tires	Same as 4, except using flotation tires

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Figure 1. Photos of equipment and soil.



Unverferth Zone Builder



Zone Till Equipment



Truck with Flotation Tires



Truck with Truck Tires



Flotation Tire Tracks



Truck Tire Tracks after Strip-Till

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Results:

Residue: The residue cover in 2003 showed significant differences among treatments. The no-till treatment showed the greatest residue cover at 48%. Zone-till reduced crop residue cover 15% to 33%, and strip-till reduced residue cover another 11% to 21%. The residue cover that remained was enough to categorize it as conservation tillage (>30% residue) with zone-till, but not with strip-till (see Table 2). The zone-builder set up we used had two coulters behind and besides each shank (Fig. 1) which created too much soil and residue disturbance to meet conservation tillage standards.

Table 2. Residue as affected by tillage treatment, Dairy Farm Operations, 2003.

Treatment Description	Residue (% cover)
No-till	48
Zone-till	33
Strip-Till	21
<i>LSD ($\alpha=0.05$)</i>	9.2

Plant population: Plant population was reduced due to truck-tire compaction (treatment 4) more in 2002 compared to 2003, possibly due to the drier conditions in 2002 (Table 3). When the soil was strip-tilled first, and then compacted with truck tires the results were no better (see Table 3). Strip-till after compaction, however, alleviated the reduction in plant population. We noticed also that soil that has been strip-tilled exhibits much more rutting when compacted than a no-till soil that has not been strip-tilled (Fig. 1). The irregularity in the field contributes to less precise seed placement. Zone-till and flotation tires helped to reduce the plant population reduction due to compaction somewhat in 2002, but not as much as post compaction strip-till. In 2003 there was no significant plant population improvement due to these treatments.

Table 3. Corn Population (rounded to nearest hundred) as affected by Compaction Treatment at No-till Compaction experiment at PSU Dairy Farm Operations in 2003.

Treatment	Population	
	2002	2003
	Plants/A	
1. No compaction control	18,000	22,200
2. No compaction, strip tilled in fall 2001 only	17,000	22,900
3. No compaction, strip tilled in spring	18,500	22,800
4. Compacted annually with loaded 30 ton manure truck, with truck tires	12,800	21,300
5. Compacted as for, but only in 2002	13,300	23,200
6. Compacted as 4, strip tilled pre traffic	13,700	20,300
7. Compacted as 4, but strip tilled post traffic	15,600	24,400
8. Compacted as 4, zone tilled in spring post traffic	14,800	22,000
9. Compacted annually with loaded 30 ton manure truck, with flotation tires	15,500	22,100
<i>LSD ($\alpha=0.05$)</i>	2,052	2,230

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Penetration resistance: Root penetration has been shown to be optimal if penetration resistance is approximately 100 psi. At 200 psi, roots start to experience detrimental resistance, whereas at 300 psi root penetration is minimal. Because penetration resistance is lowest in wet soils, measurements are taken when the soil is at field capacity (24 hours after soaking rain). This represents a best-case scenario, because penetration resistance will only increase with additional soil drying. The measurements were taken in the row in the spring of 2003.

Penetration resistance was significantly increased due to compaction with truck tires to a depth of 4 inches only compared to control (Fig. 2). This suggests that despite the high axle load, compaction did not penetrate into the subsoil. Zone-tillage significantly decreased penetration resistance to a depth of approximately 4 inches, and post-compaction strip-till reduced penetration resistance to the depth of tillage (17").

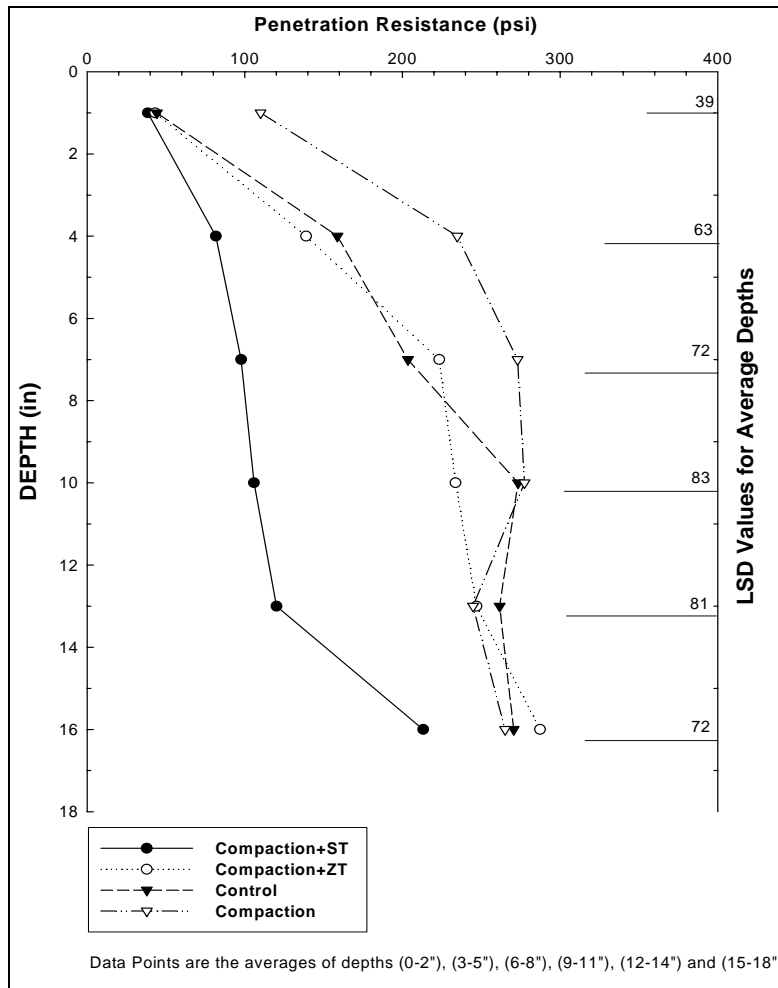


Figure 2. Penetration resistance as affected by three compaction treatments (2003).

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Yields: Annual compaction with truck tires reduced yields 31 bushels in 2002, and 18 bushels in 2003. The year 2002 was dry, whereas 2003 was a wet year. The results suggest higher yield losses can be expected when the crop experiences drought stress in the summer. Flotation tires helped to cut the yield loss roughly in half in both years. Benefits of flotation tires are therefore greatest if the crop experiences drought stress. Strip-till to alleviate compaction was quite effective, although yields were still depressed in 2002 compared to no-till without compaction. In 2003 strip-till after compaction completely eliminated the yield loss due to compaction. Shallow zone-till after compaction was somewhat effective in 2002, but did not increase yields compared to doing no tillage after compaction in 2003. Traffic after strip-tillage completely destroyed the yield gain obtained by the strip-till operation.

**Table 4. 2003 Corn Grain yield as affected by Compaction Treatment at No-till
Compaction experiment at Dairy Farm Operations**

Treatment	Yield*	
	2002	2003
	(bu/A)	
1. No compaction control	114	131
2. No compaction, strip tilled in fall 2001 only	104	119
3. No compaction, strip tilled in spring	116	140
4. Compacted annually with loaded 30 ton manure truck, with truck tires	83	113
5. Compacted as for, but only in 2002	73	122
6. Compacted as 4, strip tilled pre traffic	83	109
7. Compacted as 4, but strip tilled post traffic	106	132
8. Compacted as 4, zone tilled in spring post traffic	96	109
9. Compacted annually with loaded 30 ton manure truck, with flotation tires	96	119
<i>LSD ($\alpha=0.05$)</i>	22.3	18.5

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Conclusions: The results show that compaction can have significant negative effects for soil properties and crop yield in continuous no-tillage systems. We did observe, however, that penetration resistance was not significantly increased below 4 inches depth with 10 ton axle load. This suggests that subsoil compaction may be less of a threat in long-term no-till. An alternative explanation may be that the subsoil was already compacted due to heavy field traffic preceding the experiment. Yield reductions due to annual compaction of the whole field surface ranged from 15-25% in the two years of this study. Using flotation tires instead of truck tires to avoid compaction reduced the yield loss by approximately 50%. In-row strip-till to a depth of 17” improved soil physical properties and eliminated much of the yield loss due to compaction. However, traffic after strip-tillage completely destroyed all its benefits. Zone-till to a depth of 4” was somewhat effective to alleviate the yield reduction in one year, but not in the other year. It appears zone-till is not aggressive enough to reduce the effects of compaction. Although strip-tillage was effective to alleviate compaction, it reduced residue cover below 30%, which is unacceptable for erosion control. In addition, we know every tillage operation does damage to soil structure. Strip-till should therefore be used only occasionally, when substantial compaction was caused that merits a remedial treatment. We suspect that if a farmer monitors soil moisture conditions for traffic, and uses flotation tires in continuous no-tillage, subsoiling operations will only be marginally economical.

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