Soil Compaction Effects of Single and Tandem Tire Floater Spreaders

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Introduction

The impact of a soil compaction caused by tire traffic across fields is a frequent topic of farmers. This occurs in both wet and dry years with the assumption that a visible wheel track in the growing crop is an indicator of yield loss.

Soil compaction can have both good and bad effects on plant growth. A moderate amount of compaction in the seed row promotes good seed-soil contact, fast germination and prevents excessive drying out around the seed. However, when compaction exceeds an optimum level, root growth may decrease. From the standpoint of crop growth, the effect of soil compaction on water movement and storage may be more serious than the effect of increased soil strength on root growth

Wheel tracks in a growing field crop are often visually apparent, but quantification of their effects has produced variable results. In Iowa, studies of corn and soybean responses to compaction observed an average yield decrease of 13% due to tractor tire tracks. An Ohio study also found that corn and soybeans were adversely affected by soil compacted by tractors with high axle loads. A North Dakota study found no significant difference in small grain yields when comparing the yield in 4-WD tractor tracks, the yield in tracks left by a belted track type tractor and the yield in areas outside the wheel tracks.

A survey of farm cooperators in the North Dakota study also indicate that many believed that yield losses due to tractor tracks can be quite large. Most believed that there is a strong interaction between soil type and moisture content (at the time of tillage) in determining the degree of wheel tracking that may occur in a particular year.

Objective

- The objective of this study was:
- Determine the soil compaction of a single tire and a tandem tire configuration (one tire following the other in the same track) on floater spreaders.

Method

A test to determine the compaction of soil with floaters was conducted on summer fallow in August 1995 southeast of Moorhead, Minnesota. The predominant soil type in this field was a Wyndmere fine sandy loam. No tillage was done immediately before the test. The only tillage done was a few weeks before and had been rained upon since the tillage operation. The soil surface was dry and in good condition for field traffic. The moisture content of the soil was measured down to an 18 inch depth,

Floaters compared in this trial were:

- Terragator 1903-3 wheel design
- Loral 3310-4 wheel design

Both units contained the "Soilection" variable rate applicator. The 3 tires on the Terragator were VA 73 x 44.00 -32 NHS Terra Tire. The Loral floater was equipped with 2-48 x 31.00 - 20 NHS Terra Tire on the front and 2-66 x 43.00-25 NHS Terra Tire on the rear. All tires on both vehicles were operated at 27 psi. The tires on the Terragator produced a track width when loaded of 45.5 in. for each tire and the Loral produced a track width of 43.4 in. On the Loral the front tires (33.7 in. wide) run in line with the rears and produced a separate track only when turning. The tire arrangement for both applicators is shown in Figure 1. The overall out to out dimension for the tires on both vehicles was 11 feet. Both vehicles were weighed when empty and were filled as equally as possible with fertilizer and reweighed. The individual axle weights for both vehicles is shown in Table 1.

Table 1. Floater Weight

	Weights (lbs)					
	Empty			Loaded		
	Front	Rear	Total	Front	Rear	Total
Terragator	10,720	23,080	33,800	11,080	33,340	49,420
Loral	9,520	17,320	26,840	10,360	31,920	42,280

Both applicators were operated in alternating passes through the field at approximately 15 mph.

Soil bulk density samples were replicated 6 times to a depth of 18 inches. Soil cores were segmented into 3 inch lengths and dried for bulk density determinations. Cone penetrometer readings were taken to a depth of 24 inches. A digitizing pad with computer program was used to read and interpret the graphs.

Results and Discussion

Some individuals have the perception that wheel traffic across a field with one single pass of a tire is less detrimental from the standpoint of soil compaction than two tandem tires running in the same track. The majority of packing of the soil occurs during the first pass across the field. Very little packing occurs in subsequent passes. This occurs whether operating on wet or dry soils. Less total soil area is packed with 2 tires in tandem as compared to a 3-wheel type vehicle as shown in Figure 1.

The results found in these tests confirm that with dry to moist soil conditions, no additional packing of the soil occurs with a second tire running in the same wheel track. It takes more than two passes in the same wheel track to show a significant increase in soil density or penetrometer readings

Forces on the soil surface are directly related to tire pressure. The higher the tire pressure, the greater the pressure exerted on the soil. This is shown in figures 2, 3 and 4. Actual forces on the soil surface usually are 1 to 3 psi greater than tire pressure. This is caused by tire stiffness and lugs on the tire. Reducing tire pressure is one way to reduce force on the soil surface, but care must be used to be sure the load carrying capacity of the tire is not exceeded at lower pressures. Increasing tire size or using tandem tires (one tire in line with the other) is a way to increase load carrying capacity at lower tire pressures. The Loral floater should be run at 38 PSI and the Terragator should operate above 40 PSI but is a higher pressure than what the charts indicate.

If compaction from a tire occurs, the majority of it is being caused by the first pass of a tire and little compaction is caused by the second tire. Packing of soil to a particular depth is related to the tire pressure, and the load carried on the tire. This is shown in Figure 2. As axle load and tire size increases, compaction near the soil surface covers a larger area, even though the degree of compaction doesn't change. Therefore, contact pressure determines topsoil compaction and axle load determines compaction depth. The effect of soil moisture on the depth of compaction is shown in Figure 3. This indicates wet soils are capable of carrying fewer loads than dry soil. The use of large flotation tires may support machinery and allow field operations when soil is too wet to work without causing damage. Figure 4 shows the pressure distribution in the soil with tires of varying size and inflation pressures as compared to 2 tires carrying the same load at a lower pressure. Force exerted on the soil surface as well as depth of compaction is less at lower pressures.

Soil bulk density readings, penetrometer values and soil moisture content is the usual accepted way to show an increase in soil compaction due to wheel traffic. An increase in bulk density indicates more soil mass per unit area with less space for air in the soil. Typically a Wyndmere fine sandy loam soil has a low shrink to swell potential and contains 5 to 15% clay in the top 10 inches. Bulk density usually ranges from 1.3 to 1.6 gm/cm.' in the top 7 inches and slightly higher in the 7-23 inch profile.

Soil moisture was measured by weighing a soil sample, oven drying and reweighing the sample. When soil is dry, the load carrying capacity of the soil is high and the increase in bulk density usually occurs in the top few inches of the soil profile. Under wet conditions soil compaction can occur to a much greater depth, sometimes down to 24 inches or more.

Soil bulk density samples taken in the tracks and check areas are plotted in Figure 5. It was found that all test samples taken in the tracks at all depths are not significantly different. No difference in soil density is shown. This indicates that if soil compaction is occurring, the 3 wheeled Terragator is packing a strip I I feet wide as it makes a trip across a field. It should be noted that the rear tires overlapped the edges of the front tire slightly. The Loral floater is packing 2 strips of 43.3 inches wide for a total width of 7 1/4 feet. The Loral is packing 3 3/4 feet less soil than the Terragator with each pass through the field.

Soil penetrometer values are an indication of soil firmness and Figure 6 shows the force required to push a specific size cone into the soil. Several of the readings outside the wheel track were higher than in the wheel tracks for both applicators. This was probably caused by tractor traffic while doing tillage operations earlier in the season. This indicates that the floaters were not causing compaction of the soil especially in the top 15 inches of the soil surface. Soil moisture is shown in Figure 7. The moisture contents for all trials range from 9% near the soil surface to over 15% at the 9 inch depth. All trials are not statistically different at a particular soil depth.

A trial to compare the soil density, penetrometer and soil moisture values is shown in Figures 8, 9 and 10. No significant differences were found.

Conclusion

The total area "compacted" by tires on tandem wheel applicators (Loral) is about 7 1/4 feet wide as compared to the 3 wheel design which packs a strip I I feet wide. If compaction with 3 and 4 wheel flotation fertilizer applicators does occur (causing crop damage), the 3 wheel design is less desirable. From the trials completed, no difference was found in soil compaction caused by tire traffic from a single pass or from tandem tires.

References

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Soehne, W., 1958. Fundamentals of Pressure Distribution and Soil Compaction Under Tractor Tires. Agricultural Engineering, May 1958. American Society of Agricultural Engineering, St. Joseph, Michigan.

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Figure 1. Tire Track Configuration for Two Floater Applicators

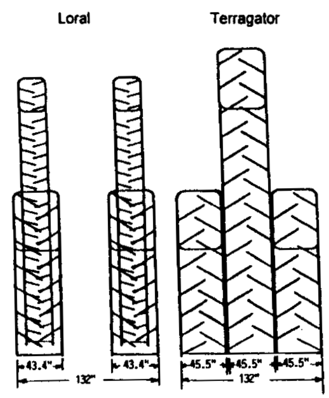

Figure 2. Effect of Axle Load on Compaction Depth

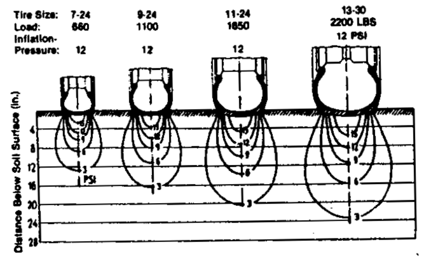

Figure 3. Effect of Soil Moisture on the Depth of Compaction

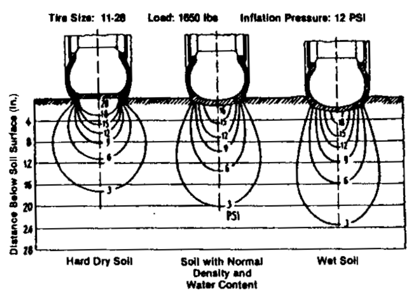

Figure 4. Effect of Equal Load, Varying Tire Pressure and Varying Tire Size on Compaction

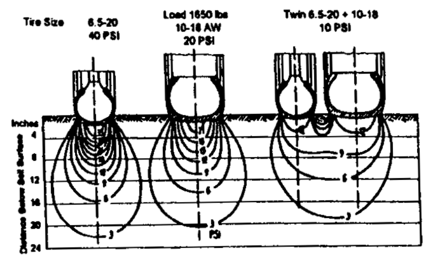

Figure 5. Soil Bulk Density Values In and Outside Floater Tire Tracks

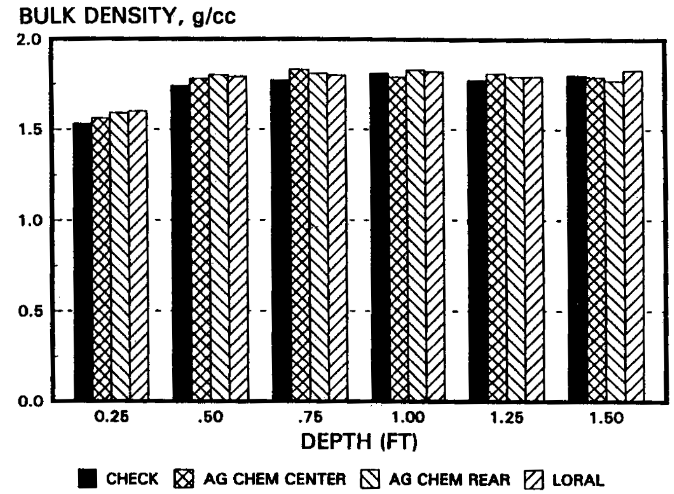

Figure 6. Soil Penetrometer Readings In and Outside Floater Tire Tracks

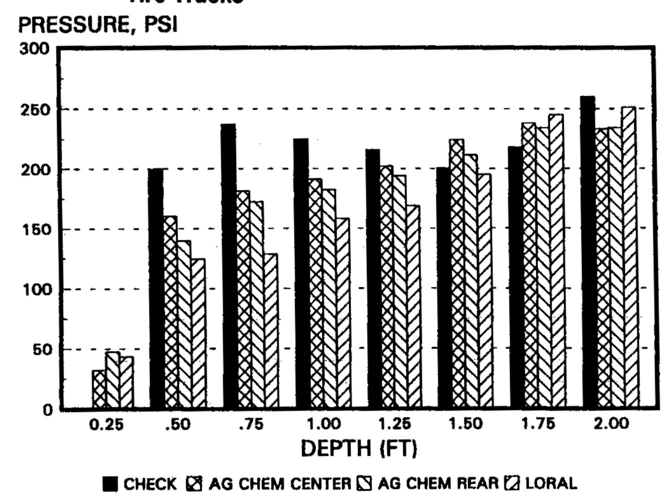

Figure 7. Soil Moisture Values In and Outside Floater Tire Tracks

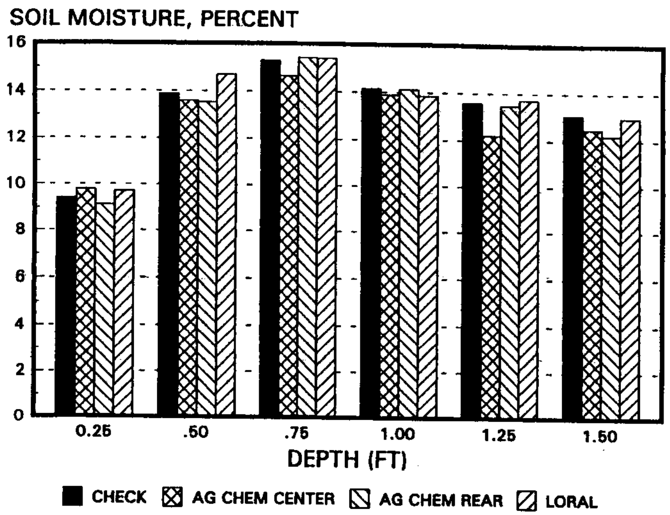

Figure 8. Soil Density In the Loral Front And Rear Tracks

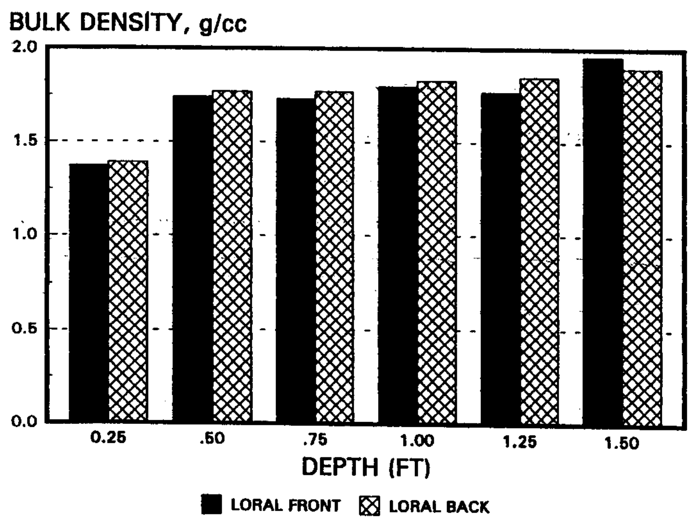

Figure 9. Penetrometer Values For the Loral Front and Rear Tracks

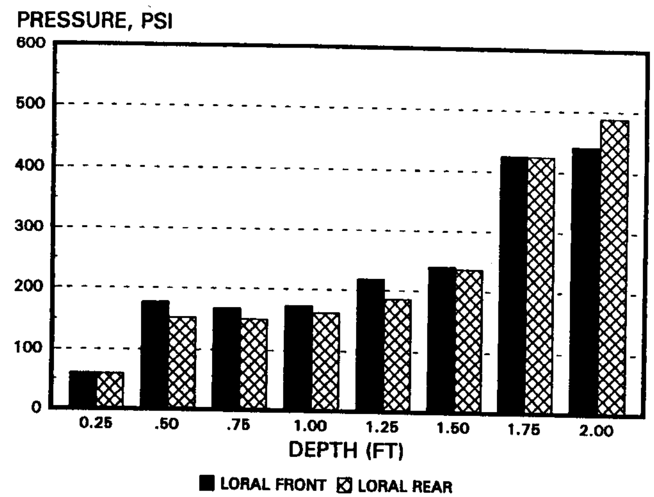

Figure 10. Soil Moisture Measured In the Loral Front and Rear Tracks

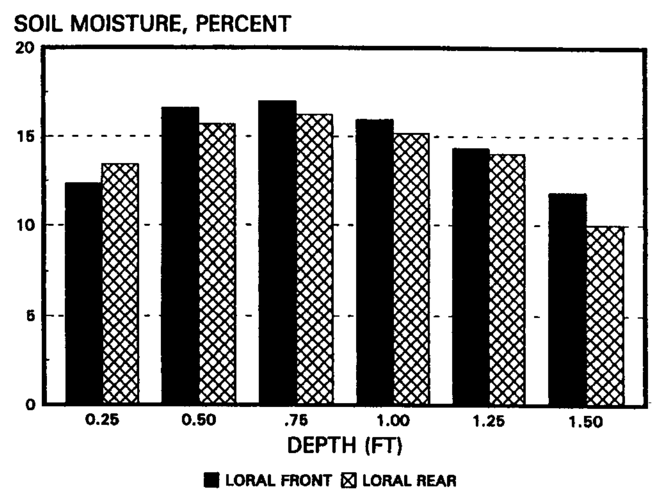

Table 2. Soil Bulk Density Values Plotted in Figure 5.
gm/cc

Soil Depth (Ft)	CHECK	AG CHEM CENTER	AG CHEM REAR	LORAL
0.25	1.53	1.56	1.59	1.60
0.50	1.74	1.78	1.80	1.79
0.75	1.77	1.83	1.81	1.80
1.00	1.81	1.79	1.83	1.82
1.25	1.77	1.81	1.79	1.79
1.50	1.80	1.79	1.77	1.83

Table 3. Soil Penetrometer Readings Plotted in Figure 6.
PSI

Soil Depth (Ft)	CHECK	AG CHEM CENTER	AG CHEM REAR	LORAL
0.25	0	32	47	43
0.50	200	160	139	124
0.75	237	181	172	128
1.00	225	191	182	158
1.25	216	202	194	169
1.50	200	224	211	195
1.75	218	238	234	245
2.00	260	233	234	251

Table 4. Soil Moisture Values Plotted in Figure 7.
Percent

Soil Depth (Ft)	CHECK	AG CHEM CENTER	AG CHEM REAR	LORAL
0.25	9.38	9.76	9.10	9.69
0.50	13.85	13.58	13.51	14.67
0.75	15.26	14.63	15.40	15.37
1.00	14.13	13.88	14.10	13.84
1.25	13.58	12.19	13.48	13.71
1.50	13.06	12.47	12.19	12.96

Table 5. Soil Bulk Density Values Plotted in Figure 8.
gm/cc

Soil Depth (Ft)	LORAL FRONT	LORAL BACK
0.25	1.37	1.39
0.50	1.74	1.77
0.75	1.73	1.77
1.00	1.80	1.83
1.25	1.77	1.85
1.50	1.96	1.90

Table 6. Soil Penetrometer Readings Plotted in Figure 9.
PSI

Soil Depth (Ft)	LORAL FRONT	LORAL REAR
0.25	59	58
0.50	177	152
0.75	168	150
1.00	173	162
1.25	217	185
1.50	239	235
1.75	425	424
2.00	441	488

Table 7. Soil Moisture Values Plotted in Figure 10.
Percent

Soil Depth (Ft)	LORAL FRONT	LORAL REAR
0.25	12.32	13.44
0.50	16.55	15.66
0.75	16.96	16.20
1.00	15.92	15.15
1.25	14.33	14.02
1.50	11.81	9.99