SOIL COMPACTION AND CROP GROWTH

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Soil compaction by heavy machinery, ill-timed cultivations or natural soil processes increases soil density. This decreases the volume of large pores and increases the proportion of fine pores. Physically, compacted soils have decreased soil aeration and porosity. Severe compaction impedes root growth. In wet weather slight compaction adversely affects plant growth by causing anaerobic conditions to develop. Both conditions reduce the availability of nutrients to plants.

With larger farm machinery, concern over soil compaction has increased. Apparently heavier farm machinery and tractors have contributed to the formation of a compacted surface layer in soils. The use of wider or multiple tires on an axle may not increase the pressure per unit of soil surface but allows for field operations to be performed under weather and soil moisture conditions too wet to maintain good soil structure. This is particularly true with row corps, such as sugarbeets and potatoes, where several cultivations are considered necessary for seedbed preparation and weed control.

During harvest, axle loads comparable to load restrictions on hard surfaced roads are common for combines and trucks. Often, the fields are wet and marginal for harvest equipment traffic. Frequently, harvest equipment tracts are apparent in subsequent crops.

In the evaluation of crop response as affected by machinery operations, the influence on soil physical factors such as moisture, temperature, aeration and root growth impedance need to be considered. Soil compaction can alter all of these factors to bring about changes in plant growth rates during some part of their growth cycle. In turn, changes in the physical factors can influence the chemical and biological processes involved in the growth process.

Some compact conditions are created in the soil-forming process. An increase in soil bulk density is normally found with increasing depth. The overburden weight tends to compact the lower horizons. Such increases are also associated with increasing clay content in the subsoil horizons. The bulk density usually increases when cultivation causes a loss in organic matter from a soil.

Soil bulk density samples of a Fargo clay in the Red River Valley, cultivated for over 100 years and an adjacent noncultivated native sod are presented in Table 1. Bulk density increases with depth in each profile. Cultivation has increased the bulk density, particularly at the plow layer. Samples from the wheel track of a partially loaded truck during sugarbeet harvest in the cultivated location show bulk density increases, particularly in the plow layer.

Table 1. Soil density measurements of Fargo clay under native sod and cultivation.

Depth	Native sod	Cultivated sugarbeet field: Beet row	Cultivated sugarbeet field: Truck track
cm		g/cm³	
7.5	0.8	0.9	1.4
15.0	1.0	1.2	1.3
22.5	1.2	1.3	1.4
30.0	1.3	1.4	1.4
37.5	1.3	1.3	1.4
45.0	1.3	1.3	1.5
52.5	1.2	1.3	1.4
60.0	1.3	1.4	1.4

A comparison of dual tire tracks to those of a 30-inch "Terra" tire on the same size tractor showed no significant difference in soil compaction on a silt loam soil (Table 2). Both tires gave a large increase in bulk density in the surface 15 cm of soil. Values for the dual tires were slightly higher below this depth.

Table 2. Soil density in tractor tracks of two tire types and adjacent undisturbed area of a silt loam.

Soil Depth	Undisturbed	Tire Types: Dual-Tires	Tire Types: Terra-Tire
cm		g/cm³	
7.5	1.1	1.4	1.4
15.0	1.1	1.4	1.4
22.5	1.3	1.4	1.4
30.0	1.4	1.4	1.3
37.5	1.4	1.5	1.4
45.0	1.4	1.6	1.5
52.5	1.5	1.6	1.4

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Various physiological responses of crops common to the Red River Valley have been observed as a result of soil compaction or related changes in the soil-root environment. In addition to reduction in yield, such quality components as size, shape, and specific gravity of potatoes have been shown to be adversely effected (1, 3, 5, 6, 7, 10). Sugarbeet responses include an increase in root sprangling and a decrease in root and sugar yield (1, 2, 4, 5, 6, 7, 8, 9, 10). The yield of hard red spring wheat has been decreased with compaction (1, 5, 6, 10). The compaction treatments in some of these studies were more severe than conditions encountered in normal field operations (1, 2, 5, 6,10).

Many machine-soil-plant interrelationships are involved in the study of soil compaction. First is the location, degree and process used where compaction occurs and second, the relative time in the crop growth cycle when soil compaction occurs.

Yields of soybeans taken from the tractor wheel tracks on a Bearden silty clay loam were 50 percent lower compared with those adjacent to the wheel tracks (Table 3). With a 20 percent decrease in stand in wheel tracks and considering the ability of soybeans to compensate for a decreased population with increased yield per plant, the difference in yield is very significant. However, plants in the wheel track were much later in nodulating and maturing. This would offset the crop's ability to compensate for a reduced stand. The combined yield was calculated using the tracked rows as accounting for 11 percent of the total surface area. The yield of the area was reduced by 5 percent with two tractor wheel tracks.

Table 3. Plant population and yield of soybeans in and out of tractor wheel tracks on Bearden silty clay loam.

Parameter	Non-track	Track –
Popultion (plants/10 ft row)	37	29
Yield (bu/A)	32.0	16.1
Yield—(2 track rows/19 rows)	30.3	

Research is continuing on the effects soil compaction has on plant growth processes, particularly those producing harvestable roots or tubers. Simple solutions are sought for problems arising from compacted soils caused by farm operations. Current recommendations are to prevent compaction where possible by careful soil management. The moisture content of a soil when worked is important. Excess soil water provides a lubricant that allows soil aggregates to be crushed or compacted, eliminating large soil pores essential for good aeration and soil tilth.

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