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Soil Compaction in Kentucky

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Soil compaction results from pressing a given amount of soil into a smaller volume, thereby increasing the soil's bulk density. Soil compaction alters pore space and distribution, often leading to poor root growth in the compacted layer. These changes in pore space can cause reduced crop yields.

How widespread is soil compaction in Kentucky? How severe is it when it occurs and under what conditions do you most commonly encounter it? These are questions to which we had few answers before this study.

Soil compaction is a by-product of farming in Kentucky. We have recognized it for years and have talked about its effects and prevention. We saw its effects on end rows in cropped fields and had problems with it in tobacco in wet springs. We have pushed soil probes and rods into the soil to determine the extent of the compaction by "feel."

Development of the lower priced soil penetrometers has added a new dimension in determining the extent and amount of soil compaction in fields. This tool allows us to actually quantify soil resistance to pressure. While soil resistance is a more accurate measure of soil strength than soil compaction, it is a good indicator of compaction because increased soil bulk density is usually related to soil strength when measured under the right moisture conditions. Almost every county Extension office in Kentucky now has a soil penetrometer, and agents have been trained to use these tools. With the help of some of these agents, we have completed a study that helps us better estimate the extent of soil compaction in Kentucky. Keep in mind that because the penetrometer measures soil resistance (strength) instead of bulk density, naturally occurring layers that are resistant to pressure, such as high content of clay or fragipans, give high penetrometer readings that may not indicate compaction caused by farming practices.

Methods

In 1992 and 1993, county agents in 17 counties in the central and western parts of Kentucky used soil penetrometers to survey 210 fields. The results were accumulated and analyzed.

Penetrometer readings were made in a random fashion over each field, similar to the method recommended when taking a sample for soil testing. Depending on the size of the field, 10 to 40 individual measurements were made in each field. The readings were taken when the moisture in the fields was close to field capacity (too wet for tillage). The resistance reading in pounds per square inch (psi) was recorded for each site in the field. The top and bottom depth of any layer with high resistance was also recorded in most fields.

The internal drainage classification and the cropping and tillage history for the last 3 years were also recorded on most fields. After harvest, the farmers were asked to assess crop yield relative to their own experience and that of their neighbors.

The location of the counties and number of fields are listed in Table 1. The agents attempted in most cases to select fields throughout the county that reflected the dominant soil types, as well as the common cropping and tillage systems represented in the county.

Although this is not a true random selection of fields, it is the best and only extensive survey that has been made and provides some insight on the importance of soil compaction in the central and western parts of the state.

Table 1.--List of Counties and Fields Reported in the Soil Compaction Study

Total Fields = 210

COUNTY	# OF FIELDS	COUNTY	# OF FIELDS
Carlisle	9	McCracken	8
Carter	8	Marion	6
Casey	6	Muhlenberg	7
Christian	39	Owen	9
Graves	21	Shelby	9
Hickman	14	Trigg	5
Hopkins	26	Warren	18
Larue	2	Wayne	14
Livingston	9		

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Soil Compaction Categories

In order to summarize the data, the fields were divided into four different soil compaction categories. The divisions were somewhat arbitrary and are delineated in Table 2. Based on limited research, only the top two categories (moderate and severe) would be expected to have a significant effect on crop yields. The reduction in yield for corn and tobacco would probably be 10 to 30% for the severe category.

Table 2. Soil Compaction Categories Into Which the Surveyed Fields Were Divided.

1. Little or None — Less than 30% of the penetrometer readings in the field were 300 psi or greater.
2. Slight — 30 to 50% of the penetrometer readings in the field were 300 psi or greater.
3. Moderate — 50 to 75% of the penetrometer readings in the field were 300 psi or greater.
4. Severe — 75 to 100% of the penetrometer readings in the field were 300 psi or greater.

Results

Compaction in Kentucky

The number of fields with soil compaction is shown in Table 3. One-half of the fields (51%) had little or no compaction and an additional 16% had only slight compaction. For these fields (a total of 67%), soil compaction would not be expected to limit crop yields. A surprisingly large number of the fields (33%) fell into the moderate and severe categories which would be expected to limit yields on some crops.

Table 3. Surveyed Fields Found To Be in Each Compaction Category

	Fields	
Degree of Compaction	**No.**	**%**
Little or None	108	51
Slight	34	16
Moderate	33	16
Severe	35	17
TOTAL	**210**	**100**

Soil Drainage

Soil drainage is highly related to the presence of soil compaction in fields. In fact, it seems to be more closely related than any other factor in the study (Table 4). Fields with the best drainage had the least compaction while fields with poor drainage had the most. There was a progressive relationship from one category to the other. This can best be seen in the "little or no compaction" category and also in the "severe" category. Combining the "little or none" and the "slight" compaction categories, 81% of the fields were well drained, 67% were moderately drained, 45% were somewhat poorly drained but only 20% were poorly drained. This means that in the moderately and severely compacted categories, where some crop yields would be reduced, 80% of the fields were poorly drained, 55% were somewhat poorly drained and only 33% and 20% were moderately drained and well drained. Only 24% of the fields surveyed were somewhat poorly or poorly drained.

Table 4. Effect of Drainage on Compaction of Fields

			Amount of Compaction			
	Field		Little	Slight	Moderate	Severe
Drainage	**No.**	**%**		**%**		
Well	57	30	60	21	15	4
Moderately	86	46	50	17	14	19
Somewhat Poorly	29	16	28	17	21	34
Poorly	15	8	13	7	33	47
TOTAL	**187**	**100**				

Depth of Compaction

The depth at which a compaction layer was encountered varied greatly and was not related to recent cropping or tillage history. However, the most common depth to the top of the compacted layer was 8 inches, and was 14 inches to the bottom of the layer. This pattern is usually associated with conventional types of tillage using a chisel or moldboard plow. These layers can persist for years and is probably the reason they were not related to the recent tillage or cropping history.

Tillage

The dominant form of tillage was recorded on 169 of the fields (Table 5). If more than one method of tillage was used during the last 3 years, the most common method was used for the summary.

The most common form of tillage during the 3-year history was conventional, occurring on 56% of the fields. This was primary tillage such as chisel or moldboard plow. Only 4% of the fields were subsoiled and is such a small percentage of the total that any conclusions drawn from this would probably be unreliable.

The only method of tillage that was quite different was discing. The fields where discing was primarily used had much higher compaction percentages. In fact, 70% of these fields had compaction that would be expected to limit yields of some crops. However, these figures are confounded with the fact that the dominant form of tillage on somewhat poorly and poorly drained soils was discing (Table 6). So, both discing and trafficking wetter soils were probably responsible for the increased compaction in these fields. This survey also seems to indicate that compaction occurs no more often with no-tillage than with conventional tillage.

Cropping

Grain was the predominant crop over the last 3 years on 73% of the fields surveyed (Table 7). Tobacco and forages were the other two crops reported. Grain fields had a higher percentage of compaction, probably resulting from the use of heavy equipment and tillage. Almost all of the somewhat poorly and poorly drained fields had grain as the dominant crop. Tobacco was grown on a surprisingly low percentage of the fields with moderate or severe compaction, considering the high amount of tillage used for tobacco. The records indicate that most of the tobacco fields were rotated from sod. This, combined with the fact that over 90% of the tobacco fields were well or moderately drained, probably helped reduce the compaction. It is not surprising that the fields that were dominantly forages had little compaction considering the lack of traffic and that all of these fields were well or moderately drained.

Table 5. Effect of Tillage on Compaction of Fields

			Amount of Compaction			
Tillage	**Field**		**Little**	**Slight**	**Moderate**	**Severe**
History	**No.**	**%**		**%**		
No-Till	32	19	50	22	15	13
Disc	37	22	27	3	24	46
Conven-tional	94	56	45	25	17	13
Subsoiled	6	4	67	0	16	17
TOTAL	**169**	**100**				

Table 6. Dominant Tillage of Fields in Different Drainage Classes

			Drainage Class			
Tillage	**Field**		**Well**	**Moderate**	**Somewhat Poorly**	**Poorly**
History	**No.**	**%**		**%**		
No-Till	32	19	59	28	6	6
Disc	37	22	8	30	30	24
Conven-tional	94	56	28	53	14	3
Subsoiled	6	4	17	33	33	17

Table 7. Effect of Cropping on Compaction of Fields

			Amount of Compaction			
Cropping	**Field**		**Little**	**Slight**	**Moderate**	**Severe**
History	**No.**	**%**		**%**		
Grains	139	73	38	21	18	23
Tobacco	32	17	63	10	19	9
Forages	19	10	84	5	11	0
TOTAL	**190**	**100**				

Yields

The farmers' assessment of their relative yield is a subjective measurement because of the differences among the farmers and their level of satisfaction with their yields. Also, compaction is only one of many factors that affect plant growth and yield. This may help explain why there is very little correlation between the amount of compaction in the fields and the relative yield (Table 8). This is probably also a reflection of the fact that unless the compaction is severe or extreme, the yield reductions are usually small.

The only figure in Table 8 that seems to be significant is that only 7% of fields with severe compaction still had excellent yields.

Table 8. Effect of Compaction on Relative Yields of Fields

			Amount of Compaction			
Relative	**Field**		**Little**	**Slight**	**Moderate**	**Severe**
Yield	**No.**	**%**		**%**		
Poor	14	9	50	21	8	21
Average	91	56	47	13	13	27
Excellent	58	36	52	17	24	7
TOTAL	**163**	**100**				

Conclusions

Based on this survey, compaction seems to be a significant factor affecting crop production in many Kentucky fields. About 1/3 of the fields surveyed had levels of compaction that have the potential to reduce yields of some crops. The fields with the greatest amount of compaction were usually associated with somewhat poorly and poorly drained soil types where discing was the primary tillage method and grain crops were grown. However, some severely compacted fields were found in all soil types using any of the tillage methods for any of the crops identified in the survey.

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