

Some of the Most Revealing and Significant Findings from 8 years of Work with the Use of Annual Ryegrass on Fragipan Soils

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INTRODUCTION

A fragipan is a very hard layer in the soil resulting from two separate soil formation events. The soil above and below the fragipan are silt loams. Roots and water will not pass through the fragipan, which effectively makes these soils shallow. If the fragipan could be reduced or completely broken up, then the effective rooting depth would be deeper.

The fragipan has been studied extensively but there have been very few attempts to change the fragipan. These few attempts resulted in no or minimal success.

Beginning in 2012-2013, a team of UK soil scientists found several common chemical compounds and two plants were found to have properties that would dissolve the binding agent in the fragipan that caused it to stop root growth and water infiltration. Annual ryegrass (ARG) was chosen as the most practical solution to pursue for further research.

Research in the greenhouse verified what was found in the laboratory. Annual ryegrass (ARG) grown in rotation with soybeans through 6 rotations was found to break apart to top 10 inches for the fragipan.

Since that time, a significant amount of information has been gleaned from field research and farmer's fields concerning the effect of ARG on the fragipan and its effects on soil improvement and crop production. Findings from this effort can be seen in the following tables below.

INCREASED SOIL DEPTH TO TOP OF THE FRAGIPAN

The top of the fragipan receded at different rates in research trials and side by side field comparisons. Some of the factors that may be involved with the different rates of fragipan breakdown are the varying strength of the fragipan, length of yearly growth time and number of years of ARG, variety of ARG grown and use of manure.

1. Todd County (Sadler Silt loam)
Corn/soybean no-till rotation with 5 years of ARG cover crop over 10-year period. ARG planted after soybeans about October 1 and terminated in April. No cover crop N added. 5.5 inches of fragipan degradation with 5 years ARG (1.1 inches/year with ARG).

2. Ballard County (Grenada Silt loam)
Corn/soybean no-till rotation with 3 years of ARG cover crop. ARG planted about October 1 and terminated in April. No cover crop N was added. 4.7 inches of fragipan degradation (1.56 inches/year with ARG)
3. Logan County (Sadler Silt loam)
ARG as a forage in 5 of 10 years. ARG planted about October 1 and harvest for hay in April. 5.3 inches of fragipan degradation (1.06 inches/year with ARG)
4. Caldwell County (UKREC) (Zanesville Silt loam)
Corn/soybean no-till rotation with 5 years of continuous ARG cover crop. ARG planted in late September and killed late March. No cover crop N added. 3.0 inches of fragipan degradation (0.6 inches/year).
5. Dubois County, Indiana (SIPAC) (Zanesville Silt loam)
Forage grazing/hay doubled cropped with warm season forage and cool season mix with ARG. ARG planted in September and killed in April. About 100 lb/ac. N applied as manure. 6.0 inches fragipan degradation in 10 years (0.6 inches/yr.)
6. Dubois County, Indiana (Zanesville Silt loam)
ARG forage grazing/hay double cropped with corn silage for 6 years. ARG planted early September and harvested as forage in May. High manure rates supplied high N rates. 14.0 inches fragipan degradation (2.3 inches/year)
7. Massac County, Illinois. (Stoy silt loam)
Corn/Soybean rotation double cropped with ARG and rye for grazing. ARG planted about October 1 and killed in April. 4.3 inches degradation in 6 years (0.7 inches/year)

INCREASED TOPSOIL DEPTH AND ORGANIC MATTER CONTENT

Yield gains that have been experienced with the use of ARG as a cover crop on fragipan soils in field trials and by a number of farmers probably goes beyond the degradation of the fragipan and is partly due to improved topsoil.

Ballard County

Corn/soybean no-till rotation compared to same rotation with ARG cover crop for 3 years. 1.2 inches increased topsoil depth (0.4 inches/yr.).

Dubois County, Indiana

ARG forage grazing/hay double cropped with corn silage and heavy manure over 6 years compared to fescue for grazing. 6.2 inches increased topsoil depth (1.03 inches/yr.).

Dubois County, Indiana

Forage grazing/hay double cropped with warm season forage and cool season mix with ARG compared to fescue hay/grazing over 10 years. 2.3 inches increased topsoil depth (0.23 inches/yr.).

Massac County, Illinois

Corn/soybean no-till rotation double cropped with ARG and rye for grazing compared to corn/soybean no-till rotation. 4.0 inches increase in topsoil depth over 6 years (0.65 inches/yr.).

Caldwell County

Corn/soybean no-till rotation with 5 years of continuous ARG cover crop compared to corn/soybean no-till rotation. 0.7 inches of increase of topsoil depth over 6 years (0.12 inches/yr.).

Todd County

Corn/soybean no-till rotation with 5 years of ARG cover crop over 10 years compared to fescue sod. No differences in topsoil depth between the treatments.

Logan County

ARG as a forage in 5 to 10 years compared to fescue forage over same time period. No differences in topsoil depth between practices.

ORGANIC MATTER

Caldwell County (UKREC), 6 years of annual ryegrass cover crops

Corn/soybean no-till rotation with ARG cover crop over 6 years compared to same rotation without cover crop. Change in organic matter by soil depth.

Soil Depth (inches)	O.M. Increase
0-6	23%
6-12	17%
12-18	19%
18-24	23%

INCREASED ROOTING DEPTH

Visual examination of two-inch cores from research trial and field studies give strong evidence of vertical zones of weakness in the fragipans. The aggressive nature of ARG roots allows for the roots to explore these zones of weakness. ARG rooting in these zones proliferate and cause the fragipan to breakdown resulting in vertical zones that will probably break through the fragipan much quicker than the even horizontal break down of the top of the fragipan moving downward over time. As the vertical zones lengthen and enlarge drainage should improve and water holding capacity should improve as well as yields. An example of this is shown in the field trial below.

Bremer Farm – Massac Co., Illinois, 6 years of annual ryegrass cover crops

Three fields in a no-till corn/soybean rotation with a rye/ARG cover crop grazed by livestock over a 6-year period compared to a no-till corn/soybean rotation with no cover crops.

Item	No Cover Crop	Cover Crop
	----- inches -----	
Top of fragipan	19.5	23.8
Rooting depth	23.5	37.8

All 3 soil changes (increased topsoil depth, degradation of top of fragipan and increased volume and depth of fragipan zones of weakness) improve water availability, soil porosity, soil health and yields.

INCREASED YIELDS

A concerted effort was made beginning in 2018 to find the effect of ARG cover cropping on yields of fragipan soils. The data was gathered from research trials and side by side field comparisons. All treatments were no-tilled in corn/soybean rotations. The comparison was no cover crop or ARG cover crop.

YIELD DIFFERENCES Averaged Across Corn and Soybean in Rotations		
<u>Location</u>	<u>Annual Ryegrass</u> Years	<u>Yield Difference</u> % a
2018		
UKREC	3	+8.0 c
UKREC	3	+3.9 c
UKREC	3	+3.1 c
UKREC	3	+6.8 c
UKREC	6	+3.5 c
Caldwell Co.	3	+13.0 d
Carlisle Co.	4	+23.8 d
Ballard Co.	2	+2.6 c
Ballard Co.	3	+9.5 c
2019		
UKREC	4	+3.6 c
Caldwell Co.	3	+20.0 d
2020		
Massac Co. Illinois	6	+33.0 e
UKREC	4	-11.0 b
Average Across All Years	3.6	+9.2
a Yield increased was measured for the crop in the final year listed in each comparison and is not combined across yields for all years in each comparison. b Excessive rainfall resulted in water logging in ARG strips that caused N loss. c Replicated trials d Long side by side comparisons in a field e Comparisons of adjoining fields		
2000-2014 Only long-term comparison available Hamilton Co. Illinois (AGR-250)		
	15	+32%

SUMMARY

There is mounting evidence that annual ryegrass will dissolve the binding agent which makes the fragipan impermeable to water and roots. The degradation of this fragipan (as of now) is a slow process but effective. A significant number of years are required to make substantial progress. Overall, the practice is effective and economical. It not only breaks down the fragipan but significantly improves the soil.

This discovery is only a rudimentary beginning. Many of the changes that occur are unknown or unmeasured. There are many avenues available to improve this and other possible practices.

Not much is known beyond what is written here and in AGR-250. Any significant advances would certainly improve Kentucky agriculture and the 50 million acres of fragipan soils in the nation.