THE SOIL DOCTOR - A FIELD TRIAL

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INTRODUCTION AND OBJECTIVES

The growing environmental concerns of the nation are causing some changes in production agriculture. One of the environmental areas receiving attention is NO_3-N in the ground water. A number of universities and private companies have directed attention to this problem. The pre-sidedress nitrate test is the most common approach to reducing excess nitrogen application on corn in the humid eastern U.S. Several researchers have developed systems to use this test. Fields are sampled to a foot depth when the corn is 8 to 12 inches in height and NO_3-N is determined by a laboratory or with a NO_3 testing kit. A nitrogen sidedress recommendation is then made based on the NO_3-N found in the sample. An alternate approach is being marketed by the Crop Technology Co. of Houston, Texas. It markets a liquid N applicator with an on-the-go NO_3-N detection system. It has an on-board computer system and ground speed device. The system is designed to almost instantly determine NO_3-N in the top foot of soil, calculate fertilizer N needed based on information supplied by the operator and then apply the estimated N need. The system can consider a number of factors before calculating the final rate of N applied. A maximum rate to be applied can be set and the rate adjusted downward depending on the NO_3-N found in the soil. The actual rate of N applied with this system is variable since the amount of NO_3-N found in the soil changes with location. The registered name of this system is the Soil Doctor.

This system represents a significant departure from traditional thinking and traditional methods. So, many people (including myself) are quite curious as to the concept and accuracy of the system. The system has been tested for 2 years in Logan County, Kentucky. The testing was limited. The tests were designed to evaluate the machine under farm conditions. The primary focus was to compare the NO_3-N detected by the Soil Doctor with that found in a routine NO_3-N laboratory analysis of a soil sample from the surface foot of soil and compare corn yields between the N fertilizer rate commonly used by the farmer and the reduced rate supplied by the Soil Doctor.

METHODS

The tests were carried out in 1990 and 1991 in Logan County, Kentucky on the Halcomb Farm. The Soil Doctor equipment and expertise was supplied by Crop Technology. The soil type was a Pembroke silt loam, a deep well-drained soil derived from limestone with an organic matter content of about 1.5-2%. In 1990 some Nolin silt loam was also in the trial. The fields have no previous manure history and have been intensively

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cultivated for approximately 20 years with a crop rotation of 3 crops in 2 years (corn-wheat-double cropped soybeans). N rates of corn and wheat have been 150 and 100 lb/ac., respectively. Corn was planted using 10 lb/ac N in the row and the remaining amount sidedressed. All statistical differences were at the 0.05 level unless otherwise indicated.

1990

The corn was planted on May 1 and on May 31 soil samples were taken in 1 foot increments for laboratory analysis using 1 N KCl extraction on a Technicon autoanalyzer. June 1, the Soil Doctor sidedressed the corn with 28% liquid N injected into the soil. Treatments consisted of 1) Maximum rate of 150 lb N/ac with the Soil Doctor adjusting downward based on NO_3-N found in the soil 2) Maximum rate of 120 lb. N/ac with the Soil Doctor adjusting downward 3) Constant rate of 140 lb N/ac (farmer's traditional program) 4) No N applied. A flow meter was attached to the Soil Doctor to determine actual rates of N applied. These treatments were each 1 ac. in size and harvested by machine and weighed on an approved and tested scale. Two small plot trials were also established nearby. One on a Pembroke soil and the other on a Nolin soil. Both used ammonium nitrate as the N source and were sidedressed at 0, 50, 100, or 150 lb N/ac. These trials were hand harvested.

1991

The corn was planted on April 17. On May 7, sodium nitrate was broadcast over selected small strips at the rate of 50 and 100 lb N/ac and then on May 21 (after 3 to 4 inches of rain) the Soil Doctor passed through the plots to interrogate the soil for NO_3-N. A large strip test was also established to compare corn yields using a 150 lb N/ac constant sidedress rate and a variable rate using the Soil Doctor with a 150 lb N/Ac. as a maximum rate before the soil NO_3-N is considered. Small plots were also established to help determine the sidedress rate needed. Ammonium nitrate was used as the N source and the rates of N were 0, 50, 100, and 150 lb. N/ac. These plots were hand harvested.

RESULTS AND DISCUSSION

Detection of NO_3-N in Soil

It is impossible to actually sample the same soil the Soil Doctor uses for detection. So, the approach taken here was to work with averages and see if there is a reasonable agreement between the NO_3-N detected by the Soil Doctor and that found by the more conventional approach of soil sampling and laboratory analysis.

1990

Table 1 shows the average amounts of NO_3-N found using both methods. The overall agreement seems to be good (39 vs. 42). However, there were differences in the strips and the machine did seem to change the amount of NO_3-N detected as the maximum N setting was changed. Later discussions with the inventor (Mr. John Colburn) indicate that this was due to calculation formulas in computer software which has since been corrected. The data indicate it did not occur in 1991.

1991

Table 2 shows the average amounts of NO_3-N found using both methods. The small strip plots were 75 feet long and 20 feet wide and were designed to check detection rates. The conventional sampling was carried out at 10 cores per plot. This is a sampling density of 290 cores/ac., much higher than the recommended rate. This probably greatly improves the accuracy and reduces variability of this method compared to the recommended rate of about 2 cores/ac. or less. The average difference with the zero pre-sidedress N was 15 lb/ac and the differences decreased as the rates increased. Additional information can be gathered from the small plot area on one side of these small strip plots and the larger strip plots (2.8 ac) on the other side. In some cases, the differences were greater than one would like to see. In other cases, the agreement seemed to be fairly close. According to John Colburn of Crop Technology, the Soil Doctor will be equipped to interrogate a large volume of the soil next year which he feels will improve the accuracy of the system.

Yield Comparisons

It seems that the most important consideration for the farmer would be the effect of reducing N fertilization when using the Soil Doctor and its effect on yield and net economic returns. In order to look at this, large strip plots were used comparing the farmer's present program with that of the Soil Doctor. Small plots were also utilized to help determine the N fertilizer rates which resulted in maximum yields.

1990

This year was droughthy and yields were reduced and there was very little response to any treatments. Table 3 shows the effect of two Soil Doctor treatments on yield as compared to what the farmer's customary program (140 lb/ac N) and no N. There was no significant differences in yield although there was a slight trend for added N to increase yields as well as for the reduced rates of N supplied by Soil Doctor to result in the highest yields. The small plots indicated that there was no response to sidedressed N on the more droughty Pembroke soil and that only 50 lb/ac of N was required of maximum yields on the Nolin soil which supplied more water. The 130 bu/ac yield at 50 lb/ac on the Nolin soil indicates that the 101 lb/ac N supplied by the Soil Doctor was sufficient for 150 to 170 bu/ac had the conditions been more favorable. The University of Kentucky recommendations would be 125 lb/ac for this soil type, although most farmers use more to insure excellent yields under good conditions. Table 5 shows that 73 lb/ac of NO_3-N was found in the top 3 feet of the soil when averaged across all treatment areas.

1991

Environmental conditions were good this year and yields were good. Table 6 shows the results of the large strip tests which compare the reduced N rates applied by the Soil Doctor with those the farmer was applying. There was a small but significant increase in yield for the reduced rates applied by the Soil Doctor. The small plots (Table 7) showed a significant yield increase for 50 lb/ac N sidedressed with an insignificant trend at slightly higher rates of N. The amount of N found in the top 3 feet of the soil profile at sidedressing is shown in Table 5. This year both NO_3-N and NH_4-N were determined and a significant amount of NH_4-N was found in the profile.

Economics

Compared to this farmer's traditional program the amount of nitrogen applied by the Soil Doctor averaged 41 lb/ac less over the two years. If the farmer traditionally uses liquid N, then this represents a savings of about $8/ac. However, if the farmer traditionally uses anhydrous ammonia there would be no savings because (at the present time) the Soil Doctor is not equipped for anhydrous ammonia. The use of the cheaper source of N at the higher traditional rate would be about the same as the reduced rate with liquid N.

If the trend towards a higher yield with the reduced rates of N is real (significant one of two years), then this would have to be considered an economic return. The average yield increase for the 2 years was 4 bu/ac and at $2.50/bu this would equate to $10/ac.

SUMMARY AND CONCLUSIONS

There are many questions that remain about the Soil Doctor. It is such a radical change from conventional systems and thinking that many questions naturally arise. This study was not designed to and does not answer many of these questions. This study was designed to evaluate the Soil Doctor under farm field conditions and compare its effectiveness against the accepted practice of sidedressing N without soil N determinations.

The following conclusions are based on the conditions under which the research was accomplished.

The Soil Doctor appeared to detect NO_3-N in the surface foot of soil reasonably well compared to laboratory analysis at a high sampling density. It is unknown as to how it compares with a much lower density of sampling that is presently recommended. By accounting for the detected N, the Soil Doctor made substantial reductions in the amount of N applied sidedressed compared to the farmer's traditional program. The average reduction over two years was 41 lb. N/ac (151 vs. 110 lb N/ac). There was also a 4 bu/ac yield increase associated with the reduced N rates applied by the Soil Doctor. This increase was significant one of two years. The above nitrogen savings can translate into substantial net returns, but this depends on the sources of N used by the farmer and if the trend for a slightly higher yield is real.

There are many questions that remain to be answered and these will take time, research and experience to bring into focus. But, one would have to say that based on these very limited findings that the Soil Doctor offers promise as an alternative method for sidedressing N on corn.

Table 1. Average NO_3-N Detected in the Surface Foot of Soil in 1990 by the Soil Doctor and by Conventional Sampling and Laboratory Analysis

Method	NO_3-N (lb/ac) Strip 1	Strip 2	Strip 3	Avg.	Overall Avg.
Soil Doctor					
120 N Variable Rate	27	37	26	30	39
150 N Variable Rate	55	49	42	49	
Conventional	38	41	48	42	

Table 2. Average NO_3-N Detected in the Surface Foot of Soil in 1991 by the Soil Doctor and by Conventional Methods

Treatment	NO_3-N (lb/ac)					
Small Strips	PSN[1]	R1	R2	R3	R4	Avg.	Range[3]
Soil Doctor							
	0	67	57	58	22	51	-
	50	51	60	68	42	55	-
	100	75	70	118	90	88	-
Conventional[2]							
	0	35	38	36	35	36	32-41
	50	77	65	58	64	66	52-99
	100	102	97	95	77	93	64-118
Small Plots - Adjacent to Small Strips - Conventional							
	0	36	50	46	46	45	-
Large Strips - Adjacent to Small Strips - Soil Doctor							
	0	34	39	41	43	39	-

[1] Pre-sidedress nitrogen added as $NaNO_3$ two weeks prior to sidedress

[2] Average of 3 separate samplings and 5 laboratory analysis

[3] Range of individual plots with only one analysis

Table 3. Corn Yields in 1990 in Large Strip Tests (1 ac.) Comparing the Soil Doctor (Variable Rates) with the Farmer's Traditional Rates

Treatment			Yields (bu/ac) @ 15.5% H_2O		
N Goal lb/a	Delivery Method	N Applied lb/ac	Rep 1	Rep 2	Avg.*
120	Variable	90	98.9	86.6	92.8 A
150	Variable	101	97.2	86.1	91.7 A
140	Constant	144	91.9	83.7	87.8 A
0	-	0	79.7	83.7	81.7 A

* Replication 3 was eliminated because it included 2 soil types and yields were directly proportional to the amount of Nolin Soil in the treatment.

Table 4. Corn Yields in 1990 at Different Rates of Sidedressed N in Small Plots on Two Soil Types (Avg. of 4 Replications)

N Rate lb/ac.	Yield (bu/ac) @ 15.5% H_2O	
	Pembroke	Nolin
0	89 A	90 B
50	92 A	131 A
100	92 A	131 A
150	87 A	137 A

Table 5. Soil N Found in Profile of Yield Trials Using Conventional Sampling and Laboratory Analysis

Soil Depth Foot	N in Profile (Avg. All Reps) lb/ac		
	1990	1991	
	NO_3-N	NO_3-N	NH_4-N
0-1	42	37	28
1-2	16	12	12
2-3	15	10	10
TOTAL	73	59	50
		109	

Table 6. Corn Yields in 1991 on Large Strip Tests (3 ac.) Comparing the Soil Doctor (Variable Rates) with the Farmer's Traditional Rates

N Goal lb/ac	Delivery Method	N Applied lb/ac	Yield @ 15.5% H_2O bu/ac Rep 1	Rep 2	Rep 3	Rep 4	Avg.
150	Variable	118	143	146	141	142	143 A*
150	Constant	157	140	139	140	137	139 B

* Significantly different at the 0.1 level.

Table 7. Corn Yields in 1991 at Different Rates of N in Small Plots (Average 4 Replications)

N Sidedressed lb/ac	Yield @ 15.5% H_2O bu/ac
0	111 B
50	135 A
100	141 A
150	140 A

PROCEEDINGS OF THE TWENTY-FIRST

NORTH CENTRAL EXTENSION - INDUSTRY SOIL FERTILITY CONFERENCE

November 13-14, 1991, Holiday Inn St. Louis Airport

Bridgeton, Missouri

Volume 7

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