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Precision Agriculture: The Effect of Variable Rate Fertilizer Application On Soil Test Values

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Use of variable rate fertilizer spreaders (VRS) is available to farmers in many areas of Kentucky. For use of VRS, a soil fertility map must be prepared for the field to be spread which requires subdividing the field into subunits. Each subunit is then soil sampled separately. A common procedure in commercial use is to grid a field into 2.5 acre blocks and to take a composite sample of 6-8 cores along the perimeter of a circular radius of 60-80 ft from the center of each block. Each block receives a separate fertilizer recommendation based on results from the soil test. With this information, a VRS can be programmed to apply the recommended rate of fertilizer on-the-go to each specific block as it drives across the field. The objective is to direct the amount (or kind) of fertilizer to soil test variations which occur within the field. This approach assumes that the result from each soil sample of each block uniformly represents the soil test level for all the area within that block. It also assumes that the VRS applies fertilizer (amount and kind) uniformly across its swath width and along the pathway it is driven across each block. These assumptions may be questionable. We conducted a study to measure soil test levels within blocks of a field which had been soil tested on a grid, before fertilizer was applied and at harvest, 6 months later. The objective was to define soil test variability within blocks before and after VRS fertilization. This information should provide insight into the effectiveness of on-the-go VRS fertilizer application in lowering soil test variability between individual blocks.

DESCRIPTION OF STUDY

A 90 acre field comprised of Crider silt loam soils in Hardin County, Kentucky, was selected for conducting the study on no-till corn during 1997. The field had been gridded into 35, 2.5 acre blocks by a local farm supply dealer and soil sampled by compositing 8, 0-4 inch depth soil cores taken along the perimeter of a circular 60-80 ft radius around the center of each block. The blocks were rectangular in shape. A VRS with the capability of applying 5 different fertilizer materials on-the-go, individually or simultaneously in any combination, was programmed to apply a pre-determined specific kind and amount of fertilizer to each individual 2.5 acre block in the field.

Immediately before fertilizer was spread onto the field, we laid out a linear sampling transect across the center of 2 blocks (Blocks B and C). The width of the fertilizer spreader swath was 60 ft, so we sampled at 6 sites across each 60 ft swath of the spreader. The width of each 2.5 acre block sampled was 240 ft, so the spreader made 4 swaths across each block. Sample sites along the traverse were marked by wire flags and also by geographic positioning systems (GPS) technology. A soil sample consisting of 6, 0-4 inch depth cores was taken at each of the resulting 24 sample sites across each of the 2 blocks, just before fertilizer was applied (April 3, 1997), and again, immediately following corn harvest (September 17, 1997) at the exact same site the sample was taken before fertilization. Block B was selected because it had been programmed to receive a "low" rate of fertilizer (40 lbs P_2O_5, 30 lbs K_2O, 25 lbs Zn, and 50 lbs pelleted limestone per acre). Block C was selected because it had been programmed to receive a "high" rate of fertilizer (120 lbs P_2O_5, 90 lbs K_2O, 25 lbs Zn, and 100 lbs pelleted limestone per acre). These recommendations were made by the farm supply dealer. Based on UK's interpretation of soil test phosphorus (STP) and soil test potassium (STK) results from the central composite sample taken by the farm supply dealer (168 STP and 483 STK for block B, and 88 STP and 309 STK for block C), no fertilizer would have been recommended for either block.

A detailed small plot study of the effect of P and K rates was conducted in a block (A) adjacent to block B, providing a more precise measure of 40 and 80 lbs/A each, of P and K on soil test values.

Soil samples were tested in the University of Kentucky's soil testing laboratory at Lexington, Kentucky, using the Mehlich-III extractant for nutrients.

RESULTS

Effect of VRS on Soil Test Variability

Average values for STP and STK are shown in table 1 for the 24 samples taken from each of the 2 blocks. Results are summarized in terms of ranges and variability, both before and after fertilization, in table 2. For STP, there was a wide range of soil test levels measured within each block. One on-the-go pre-programmed rate of fertilizer, even if uniformly applied to each of the 2.5 acre blocks tested, could not have leveled out this degree of variability. As shown (table 2) in soil test ranges measured after fertilization, it did not. It did, however, lower the variability somewhat for STP, more in block C which received 120 lbs P_2O_5/A than in block B which received only 40 lbs P_2O_5/A.

There was also about a 2x range in STK. Although there was little change in variability, either at the 90 or 30 lb rate of K_2O/A, levels of STK dropped by about 20% between April and September. A drop of this magnitude, especially with addition of potash, cannot be accounted for by crop uptake alone. While the reason for this is unknown, we speculate that it is related to the effect of droughty soil conditions on the equilibrium levels of exchangeable and non-exchangeable soil K. Studies of some Kentucky soils have previously shown that drying soil can lower STK under certain conditions of clay mineralogy and levels of exchangeable K.

Effect of a High or Low Fertilizer Rate on Soil Test Values Across the Swath

Changes in soil test values across a 60 ft VRS swath width are shown in table 3 for a low rate of fertilization, and in table 4 for a high rate of fertilization. Values shown for each swath are averages of 6 soil samples taken across the 60 ft swath width. Soil pH dropped slightly, even with 50 or 100 lbs pelleted lime per acre. The “low” rate of fertilizer raised STP levels slightly, while the “high” rate of fertilizer raised STP substantially. As previously noted, STK levels dropped significantly, regardless of amount of K_2O applied.

Rate Effect of Phosphate and Potash on Soil Test Values

Table 5 summarizes the effect of rates on changes in soil test values. The 0, 40, and 80 lb/A P_2O_5 and the 80 lb/A K_2O rate effects were measured in a small plot rate study in another block (A), located adjacent to block B. The small drop in STP with no P_2O_5 was probably due to crop uptake effects, where no-till corn yields were in the 100-150 bu/A range. Additions of P_2O_5 raised average STP levels, increasingly more at each additional rate. Average levels of STK, as previously mentioned, dropped significantly, regardless of rate of K_2O applied. Crop uptake would not account for all of the drop in STK, which we speculate was mostly due to very dry soil conditions during July-September, causing the potassium to become temporarily unavailable.

SUMMARY

The variability of STP and STK found within the two 2.5 acre blocks studied was high prior to fertilization, and an application of on-the-go rates of P_2O_5 and K_2O by a VRS did not overcome variability in STP or STK values in the two blocks. Athough the degree of variability in STP dropped sharply when a “high” rate of phosphate was added, the variability of STK was largely unchanged. Average values for STP were increased with increasing rates of phosphate application. Values for STK dropped significantly, regardless of rate.

Extension Soils Specialist

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Table 1. Average Soil Test Values of 24 Samples Taken From Each Block Before and After VRS Application of Fertilizer.

					Standard Deviation			
	STP		STK		STP		STK	
Block	Before	After	Before	After	Before	After	Before	After
B	76	79	384	290	24	21	74	53
C	71	104	353	289	44	40	61	57

Table 2. Range and Variability of Soil Test Values of 24 Samples Taken From Each Block Before and After VRS Application of Fertilizer

	Range in STP[1/]		STP Variability[2/]		Range in STK[1/]		STK Variability[2/]	
ck	Before	After	Before	After	Before	After	Before	After
B	41-140	51-113	32	27	261-501	201-411	19	18
C	29-212	54-225	62	39	272-533	228-461	17	20

1/ lbs/A of soil test phosphorus (STP) and soil test potassium (STK).
2/ % coefficient of variation (the higher the number, the greater the variability).

Table 3. Soil Test Values Before and After VRS Application of a "Low"[1/] Rate of Fertilizer.

	Block B					
	pH		STP (lbs/A)		STK (lbs/A)	
Swath[2/]	Before	After	Before	After	Before	After
1	5.9	5.8	51	60	320	248
2	5.8	5.7	72	74	334	254
3	5.7	5.7	86	89	427	329
4	5.6	5.5	94	93	454	327
Av	5.75	5.68	76	79	384	290

1/ VRS programmed to apply 40 lbs P_2O_5, 30 lbs K_2O, 25 lbs Zn, and 50 lbs pelleted limestone per acre.

2/ Values shown are the average of 6 separate soil samples taken across a 60-ft spreader swath

Table 4. Soil Test Values Before and After VRS Application of a “High”[1/] Rate of Fertilizer.

	Block C					
	pH		STP (lbs/A)		STK (lbs/A)	
Swath[2/]	Before	After	Before	After	Before	After
1	6.2	5.9	123	151	420	339
2	6.0	5.7	84	102	368	256
3	5.8	5.5	33	75	292	266
4	5.7	5.5	45	86	332	295
Av	5.9	5.7	71	104	353	289

1/ VRS programmed to apply 120 lbs P_2O_5, 90 lbs K_2O, 25 lbs Zn, and 100 lbs pelleted limestone per acre.

2/ Values shown are the average of 6 separate soil samples taken across a 60-ft spreader swath

Table 5. Rate Effects of Phosphate and Potash on Soil Test Values

lbs P_2O_5/A	STP (lbs/A) Before	After	% Change
0[1/]	57	53	-7
40[2/]	70	72	+ 3
80[3/]	61	77	+ 26
120[4/]	71	104	+ 46

lbs K_2O/A	STK (lbs/A) Before	After	% Change
0[1/]	409	297	-27
30[5/]	384	290	-24
40[2/]	400	329	-18
80[3/]	390	323	-17
120[4/]	353	289	-18

1/ 3/ 5/ Av. of 16 plots within a fertilizer rate study conducted in an adjacent block.

2/ Av. of 16 plots from a rate study conducted in an adjacent block and 24 sites sampled across block B.

4/ Av. of 24 sites sampled across block C.