Extension Service
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Precision Soil Sampling and Nutrient Application—An Evaluation of the Economic Benefits through Case Study

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What is Precision Agriculture?

With the end of the cold war, satellite-based technology that was only available to the armed forces was released for civilian use. With this release has come the proliferation of many electronic Global Position System (GPS) units that help car owners, hunters and sailors know where they are and where they are headed.

This technology has also been used by progressive individuals in agriculture. The use of satellites for geo-referenced data collection, computers to convert the data to soil fertility maps, and machines for the site-specific application of nutrients have resulted in the development of a new farming system called precision agriculture. Precision agriculture's viability has been evaluated for weed control, insect control, nutrient needs and yield estimates through infrared photography and the use of yield monitors on combines. This data is then used to generate maps that illustrate yield differences, weed problems. Beginning in 1997 through the Greenbrier Hydrological study, yield monitors were evaluated for hay baling, silage making and corn harvest. A much greater impact was found when evaluating fields for nutrient needs using zone sampling.

Figure 1 - Soil Sampling with GPS Referencing
This geo-referenced soil fertility information is then used to apply variable rates of nutrients or lime to a field.

Figure 2 - GPS Control of Nutrient Application

Soil Sampling for Variable Rate Lime and Fertilizer Application

The use of this technology alone does not change a farming system from a conventional to a precision system. The conventional method of nutrient and lime treatment evolved from one analysis recommendation representing a field, with the entire field receiving the same rate of nutrients or lime (composite sampling). Precision agriculture includes a process of data collection, conversion of data to knowledge and application of the knowledge to site-specific management within field boundaries. Thus any evaluation of precision farming must include validation of sampling data; determination of accuracy of soil maps, and documentation of economic and environmental benefits of switching from conventional to a precision based farming based system.

The technology used in precision farming is very fascinating. For nutrient management this technology is based on collecting soil samples on a grid and using the soil test results to produce soil fertility maps.

Thus, the success or failure of precision agriculture is determined by the accuracy of the soil fertility maps, and the variance in nutrient content throughout the field. A map produced by using many sampling points is likely to be more accurate than one produced with a few data points. However, when we increase sampling intensity that also increases the cost of setting up a precision farming system. Thus, it is important to have an optimum grid soil sampling intensity.

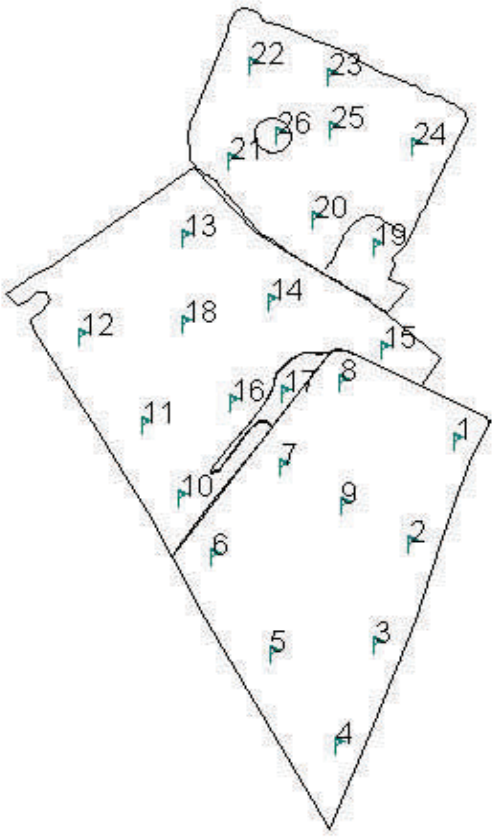


Figure 3 - Sampling Grid

Case Studies

Over several years, studies have been done that compared conventional sampling with a composite sample of each field versus precision sampling. Those studies have occurred in Barbour, Jefferson, Monroe, and Nicholas Counties. Nutrient prices have continued to climb over the last several years and with world demand for nutrients, the increasing cost of oil and the demand for crops as sources of energy as well as food and fiber, it is hard to imagine a decline in the value of nutrients in the near future. The three main nutrient sources in West Virginia for nitrogen, phosphorous and potassium are Urea (46-0-0), Diamoniumphosphate (18– 46– 0), and muriate of potassium (0-0-60). Table 1 depicts the rapid change in the value of these nutrients.

Average Values				
Point of Reference	Date	DAP	0-0-60	Urea
1	5/18/2005	$312.00	$274.60	$353.50
2	2/24/2006	$354.40	$295.20	$409.80
3	12/5/2006	$337.25	$293.00	$353.25
4	9/10/2007	$501.60	$317.40	$486.40
5	1/15/2008	$669.00	$422.50	$574.50
6	2/5/2008	$778.33	$490.00	$640.00

Table 1

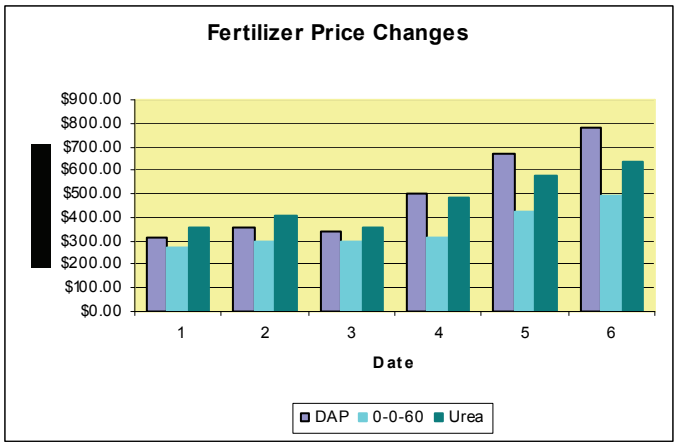


Figure 4 - Fertilizer Prices over the last three years

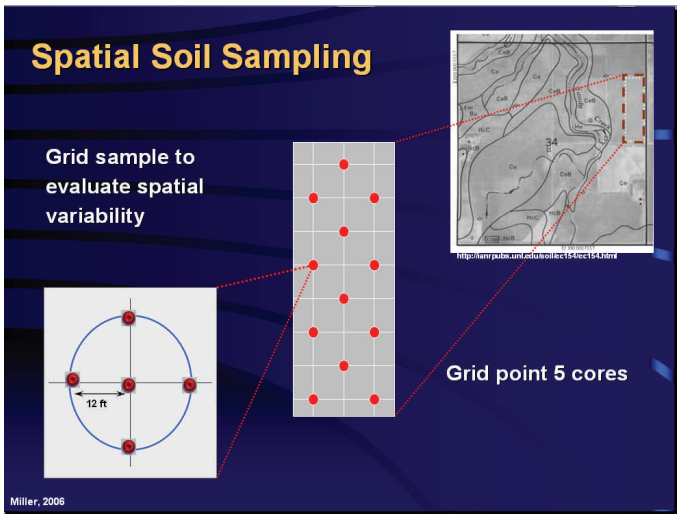
The rising nutrient costs related to agriculture have warranted a fresh evaluation of the differences between precision sampling and application versus conventional sampling and application.

The following cost assumptions have been used in this evaluation:

Table 2 (February 4, 2008)

Item	Conventional	Precision
Soil Sampling and analysis through commercial lab	$3.00 per acre	$10.00 per acre
Lime Spreading	$6.00 per ton	$12.00 per acre
Fertilizer Spreading	$7.50 per acre	$12.00 per acre
18-46-0	$778.00 per ton	$778.00 per ton
0-0-60	$490.00 per ton	$490.00 per ton
Lime	$27.00 per ton	$27.00 per ton

The difference between a precision soil sample and a conventional soil sample are significant. The precision soil sample involves marking the global position of each sample and not only taking one soil sample in that position, but actually five separate cores that are then combined and analyzed. If twenty precision samples are taken in a field, that represents 100 soil cores. Approximately three times as much soil is analyzed through precision sampling versus conventional soil sampling.



Below are detailed analysis from eight case farms. Samples were taken in 2006 and 2007.

Farms in Monroe County:

Bob Allen –Bobbitt Farm
Conventional Method Cost Analysis

Pasture Size: 88 acres

Lime & Fertilizer & Spreading Cost	
Sampling Fee	$ 264.00
18-46-0 8.58 ton	$6,675.24
0-0-60/Acre 0 ton	$ 0.00
Spreading Fee 88 acres	$ 660.00
Lime 1.5 ton/Acre = 132 ton	$3,564.00
Lime Spreading 132 ton	$ 792.00
Total Cost Conventional Method	**$11,955.24**

Precision Agriculture Cost Analysis

Total Amount of Fertilizer Needed on 88acres Boundary	
113.5 ton of Lime	$3,064.50
5.72 ton of 18-46-0	$4,450.00
1.3 ton of 0-0-60	$ 637.00
Total Lime & Fertilizer	$ 8,151.50

Technology Expenses	
Sampling Fee	$ 880.00
Lime Spreading Fee	$ 1,056.00
Fertilizer Spreading Fee	$ 1,056.00
Total Technology Fees $2,992.00	
Total Precision Ag Expenses	**$11,143.50**
Advantage Precision	***$811.74***

Kee Hill Farms –Tree Farm
Conventional Method Cost Analysis

Pasture Size: 45 acres -30 acres spreadable

Lime & Fertilizer & Spreading Cost	
Sampling Fee	$ 135 .00
18-46-0 3 ton needed	$ 2,334.00
0-0-60 1.5 ton needed	$ 735 .00
Spreading Fee 45 acres	$ 337.50
Lime 2 ton/Acre 60 ton	$ 1,620.00
Lime Spreading 60 ton	$ 360.00
Total Cost Conventional Method	**$ 5,521.5**

Precision Agriculture Cost Analysis

Total Amount of Fertilizer Needed on 30acres Boundary	
38.5 ton of Lime	$ 1,039.50
2.8 ton of 18-46-0	$ 2,178.40
.325 ton of 0-0-60	$ 159.25
Total Lime & Fertilizer	$ 3,377.15

Technology Expenses based on 30 acres	
Sampling Fee	$ 300.00
Lime Spreading Fee	$ 360.00
Fertilizer Spreading Fee	$ 360.00
Total Technology Fees	$ 1,020.00
Total Precision Ag Expenses	**$4,397.15**
Advantage Precision	***$1,124.35***

KeeHill—Campbell—Pastures (1& 2), (3&4)
Conventional Method Cost Analysis

Pastures 1&2
Pasture Size: 42 acres

Lime & Fertilizer & Spreading Cost	
Sampling Fee	$ 126 .00
18-46-0 3.76 ton	$ 2,925.00
0-0-60 5.01 ton	$ 2,455.00
Spreading Fee 42 acres	$ 315.00
Lime 0 ton	$ 0.00
Lime Spreading	$ 0.00
Total Cost Conventional Method	**$ 5,821.00**

Pastures 3&4
Pasture Size: 34 acres

Lime & Fertilizer & Spreading Cost	
Sampling Fee	$ 102 .00
18-46-0 3.42 ton	$ 2,696.00
0-0-60 2.5 ton	$ 1,225.00
Spreading Fee 34 acres	$ 255.00
Lime 0 ton	$ 0.00
Lime Spreading	$ 0.00
Total Cost Conventional Method	**$ 4,278.00**

Total Conventional Cost	**$10,099.00**

Precision Agriculture Cost Analysis

Total Amount of Fertilizer Needed on 76acres Boundary	
0 ton of Lime	$ 0.00
7.31 ton of 18-46-0	$ 5,763.00
4.81 ton of 0-0-60	$ 2,357.00
Total Lime & Fertilizer	$ 8,112.00

Technology Expenses based on 47 acres	
Sampling Fee	$ 420.00
Lime Spreading Fee	$ 0.00
Fertilizer Spreading Fee	$ 504.00
Total Technology Fees	$ 924.00
Total Precision Ag Expenses	**$ 9036.00**

Advantage Precision	***$1,063.00***

These four farms saved a total of $3,939.99 on 241 acres or $16.35 per acre by using precision sampling and application over conventional methods.

Nicholas County Farm

Taylor Tully
Conventional Method Cost Analysis

Pasture Size: 85 acres

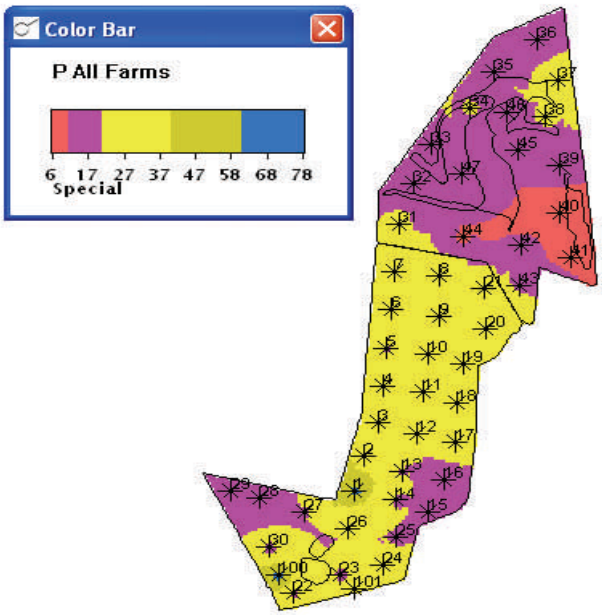
Lime & Fertilizer & Spreading Cost	
Sampling Fee	$ 255 .00
18-46-0 9.1 ton	$ 7,083.00
0-0-60 8.3 ton	$ 4,067.00
Spreading Fee 85 acres	$ 637.50
Lime 195.5 ton	$ 5,278.50
Lime Spreading 195.5 ton	$ 1173.00
Total Cost Conventional Method	**$ 18,494.00**

Precision Agriculture Cost Analysis

Total Amount of Fertilizer Needed on 85acres Boundary	
195 ton of Lime	$ 5,265.00
8.9 ton of 18-46-0	$ 6,927.00
11.9 ton of 0-0-60	$ 5,831.00
Total Lime & Fertilizer	$18,886.00

Technology Expenses based on 85 acres	
Sampling Fee	$ 850.00
Lime Spreading Fee	$ 1020.00
Fertilizer Spreading Fee	$ 1020.00
Total Technology Fees	$ 2890.00
Total Precision Ag Expenses	**$21,776.00**

Advantage Conventional	***$3,282.00***



Barbour County Farm

Roger Nestor
Conventional Method Cost Analysis

Pasture Size: 113 acres

Lime & Fertilizer & Spreading Cost	
Sampling Fee	$ 339.00
18-46-0 12.7 ton	$ 9,884.80
0-0-60 11.5 ton	$ 5,635.00
Spreading Fee 113 acres	$ 847.50
Lime 32.8 ton	$ 885.60
Lime Spreading 32.8 ton	$ 196.80
Total Cost Conventional Method	**$ 17,788.70**

Precision Agriculture Cost Analysis

Total Amount of Fertilizer Needed on 85acres Boundary	
62.9 ton of Lime	$ 1,698.30
11.4 ton of 18-46-0	$ 8,872.96
8.9 ton of 0-0-60	$ 4,361.00
Total Lime & Fertilizer	$14,932.26

Technology Expenses based on 85 acres	
Sampling Fee	$ 1130.00
Lime Spreading Fee	$ 1,356.00
Fertilizer Spreading Fee	$ 1,356.00
Total Technology Fees	$ 3,842.00
Total Precision Ag Expenses	**$18,774.26**

Advantage Conventional ***$985.56***

Doward Matlick
Conventional Method Cost Analysis

Pasture Size: 80 acres

Lime & Fertilizer & Spreading Cost	
Sampling Fee	$ 240.00
18-46-0 4.2 ton	$ 5,523.80
0-0-60 2.7 ton	$ 1881.60
Spreading Fee 80 acres	$ 600.00
Lime 183 ton	$ 4,941.00
Lime Spreading 83 ton	$ 1,098.00
Total Cost Conventional Method	**$ 14,284.40**

Precision Agriculture Cost Analysis

Total Amount of Fertilizer Needed on 80 acres Boundary	
144 ton of Lime	$ 3,888.00
7.1 ton of 18-46-0	$ 5,523.80
5.33 ton of 0-0-60	$ 2,611.70
Total Lime & Fertilizer	$ 12,023.50

Technology Expenses based on 80 acres	
Sampling Fee	$ 800.00
Lime Spreading Fee	$ 960.00
Fertilizer Spreading Fee	$ 960.00
Total Technology Fees	$ 2,720.00
Total Precision Ag Expenses	**$ 14,743.50**

Advantage Conventional ***$459.10***

Jefferson County Farm

Meadow Green Farm
Conventional Method Cost Analysis

Pasture Size: 72.1 acres

Lime & Fertilizer & Spreading Cost	
Sampling Fee	$ 216.30
18-46-0 1.75 ton	$ 1,361.50
0-0-60 1.5 ton	$ 735.00
Spreading Fee 72.1 acres	$ 540.75
Lime 36 ton	$ 972.00
Lime Spreading 36 ton	$ 262.00
Total Cost Conventional Method	**$ 4,041.55**

Precision Agriculture Cost Analysis

Total Amount of Fertilizer Needed on 72.1 acres Boundary	
23 ton of Lime	$ 621.00
4 ton of 18-46-0	$3,112.00
2.3 ton of 0-0-60	$1,127.00
Total Lime & Fertilizer	$4,860.00

Technology Expenses based on 85 acres	
Sampling Fee	$ 721.00
Lime Spreading Fee	$ 865.00
Fertilizer Spreading Fee	$ 865.00
Total Technology Fees	$ 2,451.40
Total Precision Ag Expenses	**$ 7,311.40**

Advantage Conventional ***$3,269.85***

Bullwala Farm

Conventional Method Cost Analysis

Pasture Size: 45.9 acres

Lime & Fertilizer & Spreading Cost	
Sampling Fee	$ 137.70
18-46-0 4.2 ton	$ 3,762.60
0-0-60 2.7 ton	$ 1,323.00
Spreading Fee 45.9 acres	$ 344.25
Lime 83 ton	$ 2,241.00
Lime Spreading 83 ton	$ 498.00
Total Cost Conventional Method	**$ 7,811.55**

Precision Agriculture Cost Analysis

Total Amount of Fertilizer Needed on 45.9 acres Boundary	
92 ton of Lime	$ 2,484.00
4.2 ton of 18-46-0	$ 3,267.60
1.2 ton of 0-0-60	$ 588.00
Total Lime & Fertilizer	$ 6,339.60

Technology Expenses based on 85 acres	
Sampling Fee	$ 459.00
Lime Spreading Fee	$ 550.80
Fertilizer Spreading Fee	$ 550.80
Total Technology Fees	$ 1,560.60
Total Precision Ag Expenses	**$ 7,900.20**
Advantage Conventional	***$88.65***

Summary

	Green means that Precision used less nutrients or was less costly than conventional sampling					**Red means that Precision required more nutrients be applied and was more costly that conventional sampling**					
Farm	**Acres**	**Lime Requirements (tons per acre)**		**18—46 – 0 (pounds per acre)**		**0 - 0 - 60 (pounds per acre)**		**Cost Conven-tional**	**Cost Precision**	**Differ-ence**	**Advantage?**
		Conventional	**Precision**	**Conventional**	**Precision**	**Conventional**	**Precision**				
Bob Allen—Bobbit Farm	88	1.5	1.29	195	130	0	30	$11,955.24	$11,143.50	$811.74	Precision
Kee Hill—Tree Farm	30	2.0	1.28	200	187	100	22	$5,521.50	$4,397.15	$1,124.35	Precision
Kee Hill—Campbell	76	0	0	189	192	198	127	$10,099.00	$9,036.00	$1063.00	Precision
Taylor Tully	85	2.30	2.29	214	209	195	280	$18,494.00	$21,776.00	$3,282.00	Conventional
Roger Nestor	113	.29	.56	225	202	204	158	$17,788.70	$18,774.26	$985.56	Conventional
Doward Matlick	80	2.29	1.8	105	177.5	68	133	$14,284.4	$14,743.50	$459.10	Conventional
Meadow Green	72.1	.50	.32	48.5	111	42	64	$4,041.55	$7,311.40	$3,269.85	Conventional
Bullwala Farm	45.9	1.81	2.00	183	183	118	52	$7,811.55	$7,900.20	$88.65	Conventional
Total	***590***	***722.3***	***668.9***	***62.29***	***51.43***	***35.71***	***36.065***	***$89,995.94***	***$95,082.01***	***$5,086.07***	
Average	xxxxxx	1.34	1.19	170	174	116	108	$11,249.49	$11,885.25	$635.76 per farm	$8.62 per acre
Maximum	xxxxxx	2.3	2.29	225	209	204	280	$18,494.00	$21,776	$1,124.35	
Minimum	xxxxxx	0	0	48.5	111	0	22	$4041.55	$4397.15	$3,282.00	
Variability	xxxxxx	+ or - .93	+ or - .83	+ or - 60.95	+ or - 34.85	+ or - 77.65	+ or - 85.87	+ or - $5,383.31	+ or - $6,035.56	+ or - $1,791.76	

Summary

Precision sampling took place in the spring of 2006 and 2007 on five farms located in the limestone regions of West Virginia and three farms located in the central portion of the state. Each farm provided its own unique set of nutrient requirements. No consistent pattern of differences in requirements were found, there was not a consistent additional cost or savings by using precision methods.

Summarizing Table 1 shows 13 times (54.2%) precision sampling made a recommendation that was less than would have been applied conventionally. It also shows that 9 times (37.5%) precision sampling showed that the soil required more nutrients than the conventional sampling method showed. In only two instances (8.3%) did the two sampling methods agree on the nutrients needed . Only one farm required less lime, 18,46,0 and 0,0,60 than what was called for by conventional sampling.

What is not clear is how do plants respond to optimum nutrient levels and are those agricultural products valuable enough to pay for the extra costs of sampling and nutrients. What is clear is that producers are uncomfortable with field variability and want to take steps to reduce the inconsistencies that can be found in these fields.

Further investigation of the economic response of forages to nutrient applications is warranted.

Acknowledgements

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