MISSOURI GRID SOIL SAMPLING PROJECT

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ABSTRACT

A grid soil sampling project has been conducted over the past three years in S.E. Missouri for creating a database to provide for variable fertilizer application within fields. Results have shown widely varying soil test levels in excess of 100% variation for P and K. Gross returns to variable spreading of P and K are estimated using an expected soil test and nutrient response function. As may be anticipated, returns to variable fertilization application within a field are also highly variable.

INTRODUCTION AND OBJECTIVES

Over the past three years nearly 10,000 acres of cropland in the Mississippi delta region of southeast Missouri have been soil sampled on a 330 lineal foot grid for use in applying variable rates of fertilizer across fields. This work has been conducted with the leadership of Mr. Bill Holmes, a farmer near Oran, MO, and with financial and/or cooperative support through Missouri Department of Natural Resources, Soil Conservation Service, University of Missouri Extension, Delta Growers Cooperative, Southeast Cooperative, Soil Teq, Inc., and others. In this work, only phosphorus (P) and potassium (K) have been varied. Nitrogen (N) has not yet been varied within the fields. Limestone applications have not been made to date, but numerous fields require varied rates of lime. As a largely commercial venture, some estimate of economic return to fertilizing at variable rates across the field is warranted. Without actual yield data, only theoretical evaluations can be made.

Most will agree that applying varied rates of fertilizer within a field based on soil sampling is a sound practice. Just as we moved from the average rate a dealer spread for everyone in the trade area to using a soil sample to dictate a rate for a single field, now we use soil samples to dictate needed changes within a field. Those points are hard to argue. However, is it worthwhile? There is a cost for sampling, analyses, interpretation, mapping, spreading, and data management. There may also be environmental returns to variable spreading that must be considered in some field situations.

The purpose of this paper is to outline the successful procedures used in developing the field maps, present examples of field variation, and to propose a theoretical method to evaluate return from varied application of P and K.

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PROCEDURE

Soil samples were taken using a grid sampling technique every 330 feet (2.5 acre). The boundary distances of the field were determined and transect's were laid out beginning at a point 165 feet from two field borders. A sample was taken at that point as a composite of 12 subsamples within a 10 foot radius of that point. Using radar technology, an all terrain vehicle was then driven 330 feet down the field to obtain the next sample. This procedure continued until the entire field was sampled. Samples were taken from the 0-6 inch depth and then analyzed by routine methods of the MU Extension Soil Testing Laboratory. Results were mapped and contours of nutrient variation established using computer software assistance. The variations were grouped into similar soil test interpretation areas and recommendations developed for each area using MU Extension soil test interpretations and recommendations. Some fields were variably spread by flagging areas and making up varying blends spread with a conventional fertilizer applicator. In fall 1990, a truck outfitted with the Soil Teq, Inc. equipment technology was leased by the two cooperatives to spread additional sampled acreage.

SOIL TEST VARIATIONS

Most fields have systematic variations in P and K soil tests exceeding 100%. Variations appear related to soil textural changes, landscape positions, previous nutrient applications including manures, and many, as yet, unknown factors. Most of the variation is not predictable from conventional soil survey information. Examples of variation from three southeast Missouri fields are shown in Table 1. Observing these variations, one could easily draw the conclusion that managing through variable nutrient application would be worthwhile. However, some attempt to estimate crop yield enhancement or fertilizer savings should be made.

ESTIMATING GROSS RETURNS

Applying fertilizer according to the average soil nutrient status for a field results in misapplication that is either in excess of crop needs or insufficient to establish maximum crop potential. But, does that misapplication result in economic loss or environmental concern? An attempt has been made to theoretically evaluate yield loss and/or excess fertilizer application on three fields in S.E. Missouri when comparing the average spread to a better system of variable spreading. The three fields are not the same fields shown in Table 1. Limitations of no more than five different spreads were evaluated since the current computer software with Soil Teq, Inc. equipment is limited to five spreads per field.

In comparing average nutrient recommendations to the better system of variable recommendations within a field, it is assumed the farmer would be using this average recommendation. However, in most situations the farmer was not using this average recommendation. Instead, the previous applications may have been vastly different. This was because the soil test data from a field composite sample taken previously was vastly different, due to field variability and sampling technique, or that the farmer did not follow soil tests from that field as a guide. Thus, one can see an implied advantage to the detailed soil sampling. Simply, your data set from which to draw fertilizer recommendations is far superior to anything used previously.

The theoretical technique to establish yield response to the variable spreading employs the use of Missouri's fertility index equation (Figure 1) as developed by Dr. T. R. Fisher (Fisher, 1974). The equation takes the form:

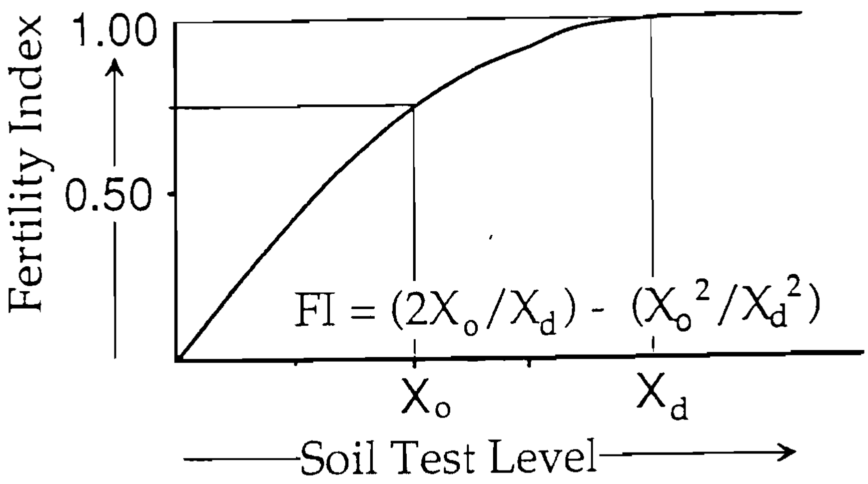

Figure 1. Relationship of soil test level to fertility index.

Where: FI = fertility index or relative yield
X_d = Desired level where no yield loss is expected
X_o = actual or observed level

The X_d and X_o are used either as soil test levels or fertilizer application rates of phosphorus or potassium. The X_d level implies maximum yield with no potential for yield loss. The interpreted value used for these calculations was the P or K soil test level where Missouri recommends no additional nutrient applied for the given crop. In the examples to be given those values are 68 lbs P/a from the Bray & Kurtz No. 1 extract and 1.5(220 + 5(CEC)) lbs K/a from the 1N NH_4OAC extract. The fertilizer F.I. value uses the recommended P or K from the variable recommendations as X_d and the average recommended P or K for the X_o.

Those two F. I.'s must then be combined to evaluate actual yield loss from applying the incorrect amount of each nutrient. This can be accomplished with the equation:

Combined F.I. = ((1 - Soil test F.I.)(Fertilizer F.I.)) + (Soil test F.I.)

A weighted averaged combined F.I. would predict yield loss from the field due to using an average fertilizer application rate.

Example Field 1 (Table 2)

On the field used in the original extension demonstration project (Table 2), the expected yield from average application was 0.897 of the variable application. On this field assuming 150 bushel corn yield potential with variable spreading, one would expect 134.5 bushels per acre with average application, or a loss of 15.5 bushels per acre. At a corn price of $2.50 per bushel the gain from variable spread application would amount to $38.75 per acre.

Additionally, phosphate fertilizer was applied at 20 pounds per acre on 34.3 acres that did not require the nutrient. That cost at $0.25 per pound of P_2O_5 would average $2.14 per acre. The total gross return to variable spreading the phosphate on this 80 acre field would be $3721.20 or $40.89 per acre.

Example Field 2 (Table 3)

In this example, both P and K were varied within the field. Assuming 150 bushel average yield, gains from variable spread of phosphate would be 4.5 bushels per acre and from potash only 0.6 bushels per acre for a total of 5.1 bushels per acre or $12.75 per acre.

Additional unneeded fertilizer savings through variable spreading amounted to $2.76 per acre for phosphate and $0.87 per acre for potash. Total gain to variable spreading would be estimated at $1346 or an average of $16.38 per acre on the 82.2 acre field.

Example Field 3 (Table 4)

This field had relatively good soil P and K levels. Average gain to phosphate, assuming 150 bushel yield average, was 1.8 bushels per acre. Potash gains were 0.6 bushels per acre, for a total of 2.4 bushels or $6.00 per acre.

Over fertilization cost an average of $2.96 per acre for phosphate and $0.18 for potash. Total gain would be estimated at $1587 or $9.14 per acre.

SUMMARY

One can return to the original question, "is it worthwhile?". Considering a variable spreading of P and K on 1 year gross returns, the answer is "yes, maybe, and probably not". Estimated costs for the data collection, management, and spreading run from $10 to $15 per acre. That cost varies widely with dealers. One must remember that in the examples only P and K were varied and therefore evaluated. Potential to vary N application will also improve returns. Most fields in the acid soil regions will have varying lime requirements, also. As information begins to be gathered on a geographic basis within fields, the spinoff uses will begin to happen. Yield mapping will improve our ability to accurately predict N requirements, optimum plant population, appropriate hybrids or varieties, and maintenance P and K needs. Spot spreading of micronutrient also becomes a reality.

We may not all agree on the potential benefits of this technology on possible surface and ground contamination. However, public perception and acceptance of fertilizing specific field areas with tailored application rates will be positive. This management just makes good sense.

LITERATURE CITED

Fisher, T.R. 1974. Some considerations for interpretation of soil tests for phosphorus potassium. Missouri Agricultural Experiment Station Bulletin 1007.

Table 1. Examples of field soil nutrient variations from sampling on a 330 foot grid system (Data from Bill Holmes, Oran, MO).

	Field 1			Field 2			Field 3		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Acres	187.5			175			82		
pH (0.01 $CaCl_2$)	4.2	6.7	5.5	4.4	7.2	5.9	5.5	6.6	6.3
Bray 1-P (lbs/a)	18	207	72	26	117	55	10	109	52
Exch K (lbs/a)	160	557	266	154	613	403	190	420	277
CEC (meq/100g)	3	28	6.5	11	31	23	10	26	18

Table 2. Phosphorus soil test and fertilizer application indices for calculating the yield loss to applying average recommendations versus four varying rates on a S.E. MO field. (Example field 1)[¶]

	P Soil Test		P_2O_5 Fert. Rec.		Combined
Acres	lbs/a	F.I.	lbs/a	F.I.	F.I.
Variable recommendations					
11.4	18	0.459	100	0.360	0.654
26.7	33	0.735	80	0.438	0.851
7.6	47	0.905	60	0.556	0.958
34.3	112	1.0	0	1.0	1.000
			Weighted average		0.897
Field Average recommendations					
80	66		20		

[¶]Yield goal = 150 bu/a F.I. = Fertility index

Table 3. Phosphorus and potassium indices for calculating yield loss to applying average recommendations versus five varying rates on a S.E. MO field. (Example field 2)[¶]

Acres	P Soil Test lbs/a	P Soil Test F.I.	P_2O_5 Rec. lbs/a	P_2O_5 Rec. F.I.	Combined P F.I.	K Soil Test lbs/a	K Soil Test F.I.	K_2O Rec. lbs/a	K_2O Rec. F.I.	Combined K F.I.
Variable recommendations										
11.6	19	0.481	100	0.750	0.870	260	0.790	60	0.993	0.999
9.4	23	0.562	95	0.776	0.902	398	0.941	30	1.000	1.000
35.8	52	0.945	45	0.988	0.999	249	0.809	65	0.976	0.995
12.1	52	0.945	45	0.988	9.999	362	0.934	35	1.000	1.000
13.3	94	1.000	0	1.000	1.000	224	0.748	70	0.954	0.988
		Weighted average			0.970					0.996
Field average recommendations										
82.2	51		50			280		55		

[¶]Yield goal = 150 bu/a F.I. = Fertility index

Table 4. Phosphorus and potassium indices for calculating yield loss to applying recommendations versus five varying rates on a S.E. MO field. (Example field 3)[¶]

Acres	P Soil Test lbs/a	P Soil Test F.I.	P_2O_5 Rec lbs/a	P_2O_5 Rec F.I.	Combined P F.I.	K Soil Test lbs/a	K Soil Test F.I.	K_2O Rec lbs/a	K_2O Rec F.I.	Combined K F.I.
Variable recommendations										
16.9	40	0.830	75	0.782	0.963	314	0.873	50	0.840	0.980
56.8	43	0.865	70	0.816	0.975	386	0.946	35	0.980	0.999
7.9	61	0.989	20	1.000	1.000	251	0.830	55	0.793	0.965
71.3	59	0.982	25	1.000	1.000	424	0.972	25	1.000	1.000
20.7	83	1.000	0	1.000	1.000	498	0.997	20	1.000	1.000
		Weighted aveage =			0.988					0.996
Field average recommendation										
173.6	55		40			402		30		

[¶]Yield goal = 150 bu/a F.I. = Fertility index

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