Site-Specific Management Guidelines

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The First Step in Precision Agriculture: Sampling Old Farmsteads Separately from the Rest of the Field

Summary

Many of the small farms that dotted the countryside a hundred years ago had enclosures where horses, cows, and hogs were kept. Manure from animals contained in these enclosures still impacts soil properties today. Most fertilizer recommendations rely on the collection of representative soil samples. Aerial photographs stored by USDA Farm Services Agency (FSA) offices provide clues to past management. The objective of this Guideline is to demonstrate the importance in sampling old homesteads separately from the rest of the field. In grid soil sampled fields located in South Dakota and Missouri, historical aerial photographs were used to identify old homesteads. By sampling the old homesteads separately from the rest of the field, the 80% confidence interval of a 20 core composite sample was reduced by as much as 97% and the soil test phosphorus (P) levels were decreased. These results were attributed to excluding areas with very high P concentrations from the composite sample. Improved sampling protocols constitute a savings for producers because the soil test results are more representative of the crops needs.

Introduction

Most fertilizer recommendation programs contain these crucial steps: 1) collecting representative soil samples; 2) conducting accurate and precise laboratory analysis; and 3) using a well-calibrated fertilizer recommendation model to estimate fertilizer recommendations. The first step...collecting a soil sample...may seem simple, but it is not. And obtaining an accurate and representative soil sample is important because it is the basis for fertilizer recommendations from soil test results.

A representative soil sample is one that adequately portrays the nutrient content of the area sampled. There are several excellent papers that review various aspects of soil sampling protocols (Kitchen et al.,1990; Blackmer et al., 1991; Buchholz, 1993; Skopp et al., 1995; Clay et al., 1997; Franzen and Cihacek, 1998; Franzen, 1999; Fleming et al., 1999; Franzen and Kitchen, 1999; Fergusen and Hergert, 2000; Clay et al., 2002; Chang et al., 2003; Clay et al., 2004). These papers recommend that a soil sampling protocol should consider how the fertilizer is applied, that at least 12 to 20 cores should be combined into a single sample, and that individual samples should be collected from sub-field areas where differential management occurred. As a rule, the more soil nutrient variability within the sampling zone the more difficult it is to obtain a representative sample. In other words, if the nutrient concentrations of a sampling area are highly variable, then obtaining a representative sample is very difficult.

Clay et al. (2002) proposed four specific guidelines for soil sampling fields impacted by prior management. First, producers need to keep track of where fertilizers containing immobile nutrients are band-applied. Application of this type may cause small-scale variability for many years after application. To avoid over-sampling fertilizer bands, sampling protocols for fields with residual bands should be followed. Second, sample areas where animals were confined separately from the rest of the field. Third, whenever possible avoid soil sampling guess rows (i.e., edge rows of planter passes). Fourth, recommendations are improved by including at least 15 to 20 individual cores in a composite sample. If the residual bands are present, and the placement is unknown, then the number of samples per composite may be closer to 30. In many situations, the importance of sampling old homesteads separately from the rest of the field is underestimated. The first step in precision nutrient management should be to identify and sample old homesteads or animal confinement areas separately from the rest of the field.

Materials and Methods

Soil samples (0 to 6 in. depth) from at least a 200 by 200 ft. grid were collected from fields located in eastern South Dakota and north-central Missouri (Clay et al., 2002). South Dakota samples were analyzed for Olsen-P, while Missouri samples were analyzed for Bray-1 extractable-P (Brown and Rodriguez, 1983). Parent materials in the South Dakota sites were glacial till or loess, while at the Missouri site the soil

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was weathered loess with a well defined claypan. Elevation, latitude and longitude, and apparent electrical conductivity surveys were conducted in all fields (Johansen et al., 2001; Lund et al., 1999; Kitchen et al., 2003). Evidence at the site or historical photographs obtained from the USDA-FSA offices were used to identify old homesteads. For comparative purposes the 80% confidence interval for a composite sample containing 20 individual cores was determined. The mean and standard deviation were both calculated using Microsoft Excel (Microsoft Corporation, Seattle, Washington).

Results and Discussion

Sampling protocols that consider historical management are important, particularly in fields where farm animals were confined or fed. Soil samples taken within these areas may have elevated P and potassium (K) levels for decades after the animals have been removed. These samples will influence both the composite core sampling requirement (variance or standard deviation) and the soil nutrient concentration. For example, a survey of 13 grid soil sampled fields showed that excluding the old farmsteads from the composite sample decreased P concentration and the confidence intervals associated with composite sample (**Table 1**). High confidence intervals can result in accurate fertilizer recommendations. These results were attributed to very high soil nutrient concentrations in the area of the old homesteads and that excluding these areas from a composite sample reduced the nutrient variation within the remaining sampling zone (**Figure 1**).

Table 1. The influence of excluding the old farmstead from a whole field composite sample on P soil test results and 80% confidence interval.

		Soil test P		80% CI for 20 cores	
		Farmstead		Farmstead	
Location	site #	Included	Excluded	Included	Excluded
		ppm	ppm		
South	1	23	17	70	9.9
Dakota	2	32	16	371	8.1
	3	21	16	58	3.4
	4	42	20	202	32.2
	5	7	6	2	0.2
	6	7	7	2	0.9
	7	10	6	15	0.5
	8	40	27	92	20.0
	9	10	7	8	1.6
	10	13	12	6	3.6
	11	21	18	22	20.3
	12	16	12	27	15.9
Missouri	13	14	12	8	2.3

Not including the homestead area in the composite sample improved the precision (80% confidence interval) by as much as 97%. These results show that the first step in collecting reliable soil samples for fertilizer recommendation is to identify and sample old farmsteads separately from the rest of the field and that the fertilizer recommendation may be compromised if these areas are not excluded.

[1] *Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.*

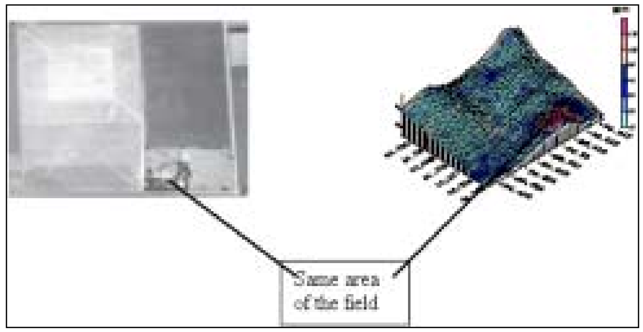

Figure 1. A 1956 USDA-NRCS aerial image collected from a South Dakota field and a soil P contour map based on soil samples collected in 1995. Current images show that the farmsite has been removed from the field.

After old homesteads have been identified and sampled separately, the resulting fertilizer recommendation will be improved. Another consideration is management changes over time. Most fields have been managed differently than current management (**Figure 2**). In much of the U.S. Midwest prior to 1960, fields sizes were typically 40 acres or less. Aerial photographs show that, over time, larger fields were created by combining small fields (**Figure 2**). It is difficult to provide guidance on which historical management practices should be considered and which ones can be ignored. An assessment must be conducted on a field-by-field basis.

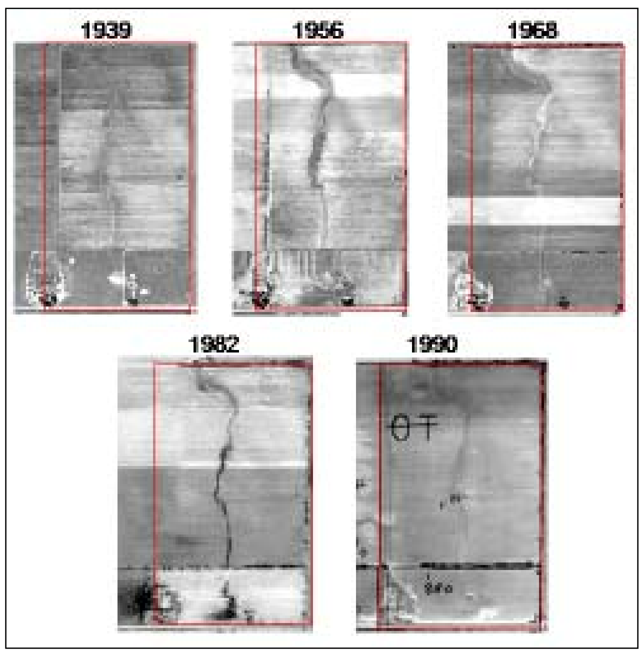

Figure 2. A sequence of aerial images collected between 1939 and 1990 from a Missouri field.

If the field shown in **Figure 2** is subdivided based on the 1982 rotational sequence (**Figure 3**), the resulting analysis shows sub-field areas A, B, C, and D have soil test P values of 10, 8, 11, and 20 parts per million (ppm) P, respectively. If the fertilizer recommendation for this field was based on a whole field sample (mean 12 ppm), then

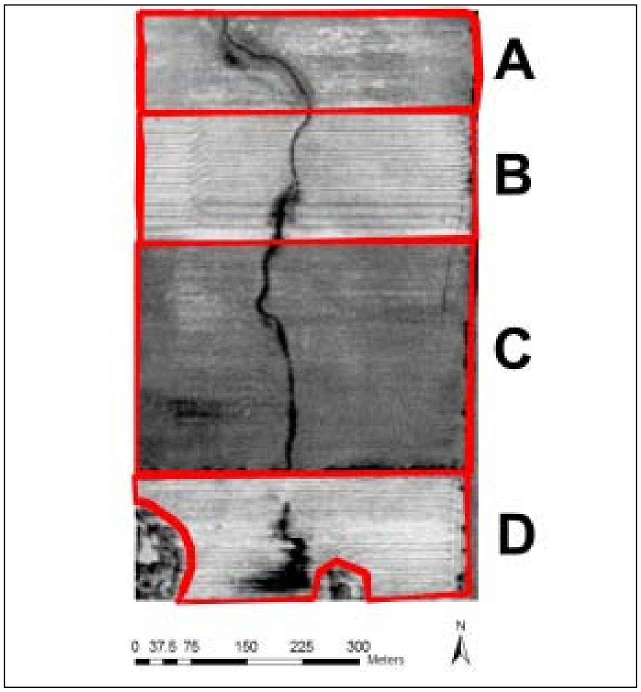

Figure 3. **A 1982 aerial photo showing how polygons were drawn around four areas with different historical management practices. Two farmstead areas on the south end of the field were removed and the field divided as it was cropped in 1982.**

area B would be under-fertilized and area D would be over-fertilized. It is important to point out that sampling the four sub-field zones separately increased the sampling requirement. Prior to sub-dividing, a manager needs to ask the question: Is the value of the spatial information worth the cost of data collection and analysis?

Summary and Conclusion

A consequence of larger farms has been the loss of farmstead sites. In many cases, these sites have been put into crop production. For example, in Brookings County, South Dakota a random survey of 384 quarter sections in aerial photographs collected in 1950 and 1990 showed that the number of quarter sections with building sites decreased from 218 to 180 over the 40 years. Given the number of management changes that have occurred in production fields over the past 100 years, it is difficult to provide step-by-step guidance for developing sampling protocols that account for historical management. When considering immobile soil nutrients like P and K, farmers and agricultural consultants need to realize that fields maintain a memory.

Factors that should be considered when developing soil sampling protocols include: locations of historic home-sites, fence lines, farming directions, crops, consolidation of fields, roads, abandoned railroads, stock ponds, and feedlots.

Understanding historical changes in management is important because row crops often received more fertilizer and lime than pastures and manure was typically applied to fields close to the farmstead. Human-induced effects have a lasting impact on soil test results. Isolating areas impacted by historical management prior to soil sampling is paramount for developing reliable crop nutrient plans. ■

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References

Blackmer, A.M., D.R. Keeney, R.D. Voss, and R. Killorn. 1991. Estimating nitrogen needs for corn by soil testing. PM 1381 Iowa State University Extension, Ames Iowa, 50011.

Brown, J.R., and R.R. Rodriguez. 1983. Soil testing in Missouri: a guide for conducting soil tests in Missouri. Extension Circular 923. Univ. of Missouri Extension Division, Columbia, Missouri.

Buchholz, D.D. 1993. How to get a good soil sample. Missouri agricultural publication g09110. University of Missouri. Available at http://muextension.simmouri.edu/splo/agguides/soil/g09110.htm. Accessed 5/6/02

Chang, J., D.E. Clay, C.G. Carson, S.A. Clay, D.D. Malo, R. Berg, and W. Wiebold. 2003. Different techniques to identify management zones impact nitrogen and phosphorus sampling variability. Agron. J. 95:1550-1559.

Clay, D.E., C.G. Carlson, and J. Chang. 2004. Identifying the "Best" Approach to Identify Nutrient Management Zones: A South Dakota Example SSMG 41. Clay et al. (Ed) Site-Specific Management Guidelines. Potash & Phosphate Institute. Norcross, GA.

Clay, D.E., C.G. Carlson, K. Brix-Davis, J. Oolman, and B. Berg. 1997. Soil sampling strategies for estimating residual nitrogen. J. Production Agriculture. 10:446-451.

Clay, D.E., N.R. Kitchen, C.G. Carlson, J.L. Kleinjan, and W.A. Tjentland. 2002. Collecting representative soil samples for N and P fertilizer recommendations. Online. Crop Management doi:10.1094/CM-2002-12XX-01-MA.

Ferguson, R.B., and G.W. Hergert. 2000. Soil sampling for precision agriculture. Univ. Nebraska extension EC 154. Available at http://www.ianr.unr.unl.edu/pubs/soil/ec154/ec154.html. (accessed 5/6/02).

Fleming, K.L., D.G. Westfall, and D.W. Wiens. 1999. Field testing of management zones for VRT. SSMG 21. *In* Site-Specific Management Guidelines. Potash & Phosphate Institute. Available online at http://www.ppi-far.org/ssmg

Franzen, D. 1999. Site-specific farming- #2 soil sampling and variable-rate fertilizer application. North Dakota State University. Available at http://www.ext.nodak.edu/extpubs/plantsci/soilfert/sfl176-2.htm. (accessed 5/6/02).

Franzen, D., and L.J. Cihacek. 1998. Soil sampling as a basis for fertilizer application NDSU extension service. SD 990. Available online at http://www.sbreb.org/brochures/soilsampling/soilsamp.htm. (Accessed 5/6/02)

Franzen, D.W., and N.R. Kitchen. 1999. Developing management zones to target nitrogen applications. SSMG-5. *In* Site-Specific Management Guidelines. Potash & Phosphate Institute. Available online at http://www.ppi-far.org/ssmg.

Johansen, D.P., D.E. Clay, C.G. Carlson, K.W. Stange, S.A. Clay, D.D. Malo, and J.A. Schumacher. 2001. Vertical accuracy of two differential corrected global positioning systems. J. Soil Water Conservation 56:198-201.

Kitchen, N.R., J.L. Havlin, and D.G. Westfall. 1990. Soil sampling under no-till banded phosphorus. Soil Sci. Soc. Am. J. 54:1661-1665.

Kitchen, N.R., S.T. Drummond, E.D. Lund, K.A. Sudduth, and G.W. Buchleiter. 2003. Soil electrical conductivity and topography related to yield for three contrasting soil-crop systems. Agronomy Journal: 95:483-495.

Lund, E.D., C.D. Christy, and P.E. Drummond. 1999. Practical applications of soil electrical conductivity mapping. p. 771-779. *In* J.V. Stafford (ed.) Precision Agriculture '99- Proc. of the 2nd Eur. Conf. on Precision Agriculture. Odense Congress Centre, Denmark, 11-15 July 1999. SCI, Sheffield, UK.

Skopp, J., S.D. Kachman, and G.W. Hergert. 1995. Comparison of procedures for estimating sampling numbers. Commun. Soil Sci. Plant Anal. 26:2559-2568.

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