BENCHMARK SAMPLING OF AGRICULTURAL FIELDS

D. Keyes and G. Gillund

ABSTRACT

Benchmark (BM) sampling of agricultural fields involves soil sampling a representative area 100 ft X 100 ft within a field. Fifteen to 20 cores are taken within the BM site to make a composite sample for analysis. This study compares results from BM and conventional sampling methods. Five samples were taken by each method from each of 2 contrasting fields. On the topographically more uniform field, BM samples yielded results similar to conventional sampling for nitrogen and phosphorus. Results from the two sampling methods were more similar for the uniform field than for the non-uniform field. A single set of samples, one benchmark and one conventional, taken from 13 other fields showed very close agreement between the two methods.

INTRODUCTION

Soil testing provides valuable information for determining the optimum rate of fertilization. Soil analysis can be done quickly and accurately. However, the accuracy of the overall soil testing procedure is limited by our ability to obtain a soil sample that adequately represents the field being tested.

Research has been done on soil variability (Guertal et. ***al.,*** 1992) and its effect on the accuracy of soil sampling (Cameron ***et.al.***, 1971). This information, however, has not changed our approach to soil sampling which has remained the same over the past forty years. With new technology for variable rate fertilizer and pesticide application (Carr ***et. al.*** ,1991; Wibawa et. al., 1993) comes renewed interest in sampling accuracy.

The conventional method of soil sampling is to take samples from 15 to 20 more or less random locations within a field, avoiding "non-representative" areas. A major limitation to this approach is the subjectivity of defining which locations are representative. The locations chosen will vary year-to-year and will depend on who does the sampling. Conventional sampling is also very time consuming because the person taking the samples must travel over the entire field.

Benchmark sampling may provide an alternative means of sampling that avoids many of the problems associated with conventional sampling. In contrast to conventional sampling, BM sampling requires that a composite sample be taken from only one small representative area within a field or management unit. This same area is sampled in subsequent years. The BM method requires less time, and by returning each year to the same benchmark site within a field, sampling error should be reduced.

We have selected fields from three locations in Alberta to conduct research to compare (BM) sampling to conventional sampling. Only the data for the Smoky Lake site are presented here, however. In addition to this research, the BM sampling method has also been tested to a limited extent by agronomists across western Canada.

[1]Norwest Soil Research
[2]Alberta Agriculture

METHODS

Site Characteristics:

The Smoky Lake site was chosen to test benchmark sampling on a uniform and adjacent non-uniform field. The east field and west field have been farmed more or less the same: using the same tillage operations, the same fertilizer rates, and growing the same crops. They are very different in topography and soil type, however. The west field is nearly level and has a thick Ap horizon throughout. The east field is hilly with slopes up to 50% and varied soil depth. This field has also had solid manure applied to some parts on occasion. The west field could be considered a "typical field' whereas the east field is extremely variable.

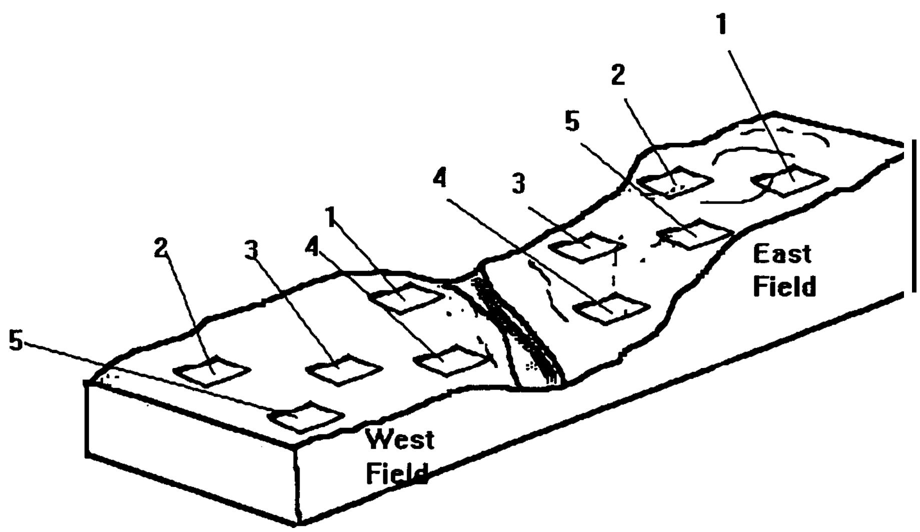

Figure 1. Smoky Lake Site (not to scale)

Sampling Protocol:

Prior to sampling, a grid was established over the fields, with intersecting points every 100 feet. Conventional sampling was simulated using a stratified random sampling procedure. For each field, cores were obtained by sampling, at random, 4 intersection points from each of the 4 east-west grid line. Sampling locations for all 5 replicates were determined prior to sampling and selected so that each intersection point was sampled about the same number of times. Although the grid was the same each year, new sets of random points were selected for conventional samples. This method ensures i) that the field is adequately covered by each conventional sample, ii) that conventional samples are composed of samples from a different set of points, iii) that the average of all conventional samples is a reasonable approximation of the true field average, iv) that different sets of points are sampled each year, and v) that the average of the 5 samples are comparable between years.

Benchmark sites were chosen from the cells making up the grid. Cells were chosen more or less arbitrarily, avoiding those with obviously high internal variability. Also, an attempt was made to space the 5 benchmark sites over the field to ensure different soils/landscapes were represented. Cores were taken roughly in a 4 X 4 grid pattern within the BM area.

Test of BM Sampling Application:

Because most soil samples taken in western Canada are taken by fertilizer dealers, we asked dealers to try BM sampling to determine how appropriate it would be in practical application. Westco Fertilizer representatives from across western Canada sampled 13 fields and submitted a conventional and a BM sample from each to Norwest Labs for analyses.

Chemical Analyses:

Samples from the research sites were taken back to the laboratory and placed in a drier at 60°C either the same day or the following morning. After drying, the soil was ground to pass through a 2 mm sieve. A standard volume of soil was scooped for extraction. Nitrate and sulphate were determined using a $CaCl_2$ extracting solution. Phosphorus and potassium were extracted using Nor-west's modified Kelowna solution. The concentration in parts per million (ppm) of each nutrient in soil was calculated based on 2 million pounds of soil per acre for each 6" of soil depth. Quantitative analyses were done to a maximum of 60 ppm for nitrate-N, 80 ppm for phosphorus; 500 ppm for potassium; and 20 ppm for sulphur. Only sulphur routinely exceeds these maxima in agricultural soils. Soil pH was measured in a 1;2 soil:CaC1 solution.

RESULTS AND DISCUSSION

The two methods of sampling give the same values ($P<0.05$) for all parameters when an AVOVA is performed to compare the averages obtained using the two sampling methods. Of practical interest, however, is how well does a ***single*** benchmark site represent the entire field? The answer to this may vary depending on the particular field and the parameter being measured.

The east field (figure 2) shows more variability among BM sites in nitrate and phosphate, whereas the west field (figure 3) shows greater variability in sulphate and potassium, compared to conventional samples. Where there is more variability among BM sites there is obviously less chance that any one BM will represent the field average. In most cases, however, the BM value is within a few ppm of the field average determined by conventional sampling. Notable exceptions may be the sulphate found for BM 3 and BM 4 of the west field in 1994. These high sulphate values would indicate that the field is adequately supplied with sulphur, whereas in fact (based on other samples and the previous year's data) sulphur is deficient.

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Figure 2. Benchmark (BM) values for 1993 and 1994 are represented by the bars. The horizontal lines represent the conventional sampling data: dashed lines are for 1993, solid lines are for 1994; heavy lines are the minimum and maximum, light lines are the average of five conventional samples. (East Field Nutrients)

Figure 3. Benchmark (BM) values for 1993 and 1994 are represented by the bars. The horizontal lines represent the conventional sampling data: dashed lines are for 1993, solid lines are for 1994; heavy lines are the minimum and maximum, light lines are the average of five conventional samples. (West Field Nutrients)

Conventional sampling also showed considerable variation in some cases. For example nitrate-N ranged from 16 to 25 ppm and potassium from 60 to 165 ppm on the west field in 1994. Sulphate-S ranged from less than 5 to more than 20 ppm on the same field in 1993. The topographically more variable east field generally shows less variability among conventional samples than among BM samples. This is likely because, even though the location-to-location variability is high, each sample was a composite of cores from a similar set of locations. True conventional sampling is not done in any systematic way. Therefore, individual bias would likely lead to greater variability.

The most straight-forward way of comparing BM to conventional samples is to look at how many of the BM samples fall within the range of results attainable by conventional sampling. For example nitrate-N by BM sampling on the west field fell within the range of conventional sampling results five out of five times in 1994 . On the other hand, in 1993, only two out of five BM samples were within the range from conventional samples that year. How well the BM results fit within this range depends on the variability among the BM samples as well as the variability (range) of the conventional samples.

Again, the portion of the BM sites that fit within the range obtained with conventional sampling depends on the parameter, the particular field and even the particular year. On the west field, results from any one of the BM sites (except possibly BM 4) would have likely been as good as a conventional sample. On the east field the choice of a BM site is complicated by the difference in phosphorus between the upper and lower part of the field, and the relatively low nitrate for BM 2. Sites BM 1 and BM 5 are most similar to the conventional sampling results. These two sites also best represent the topography of the field.

Another factor to consider in comparing BM to conventional sampling is whether BM samples provide more reliable estimates of year to year variation in residual nutrients. If the soil test is to be used as an indicator of the effects of cropping systems and management practices on nutrient reserves, changes in test levels may be more important than the test value itself.

The results indicate that, on the west field, BM samples provided slightly less variability but on the east field, the BM samples actually showed greater year-to-year variability than conventional sampling. At least one more year of data on these same fields is required to determine conclusively whether BM sampling has an advantage over conventional sampling for monitoring nutrient changes.

Results from samples taken by Westco representatives (figure 4) showed closer agreement between the two sampling methods than was found at the Smoky Lake site. This is encouraging because it indicates that BM sampling may be greatly improved by selecting sites strategically using basic knowledge of field variability. It also shows that BM sampling is feasible for the fertilizer dealers.

	Extractable Nutrient Concentrations (ppm) in Surface Samples							
Field	Nitrate-N		Phosphorus		Potassium		Sulphate-S	
	BM	Con.	BM	Con.	BM	Con.	BM	Con.
1	5	5	12	14	297	333	8	9
2	6	6	16	18	264	343	7	9
3	5	4	7	8	287	254	10	12
4	12	12	18	20	579	421	6	5
5	1	1	29	25	261	342	7	6
6	5	4	16	11	206	162	>20	>20
7	14	14	13	17	423	422	>20	>20
8	12	11	2	2	169	194	>20	5
9	7	9	24	13	189	189	8	17
10	8	11	15	19	360	341	11	14
11	4	5	10	8	157	205	8	9
12	2	4	9	11	291	222	14	11
13	6	16	21	16	237	280	13	>20

Figure 4. Comparison of nutrients in samples taken by bench mark (BM) and conventional (Con.) sampling methods from fields throughout western Canada

CONCLUSIONS

The preliminary results of this research are encouraging. It appears that BM sampling would generally be as reliable as conventional sampling for providing information on which to base fertilizer rate decisions. The extent and pattern of field variability determines how likely it is that a chosen BM area will adequately represent the field. How well a BM site represents year-to-year changes in field nutrients has not been resolved. Samples are scheduled to be taken again this year and the additional results should help in this regard. Future research will also focus on establishing criteria for selecting BM sites.

ACKNOWLEDGMENTS

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East Field Nutrients

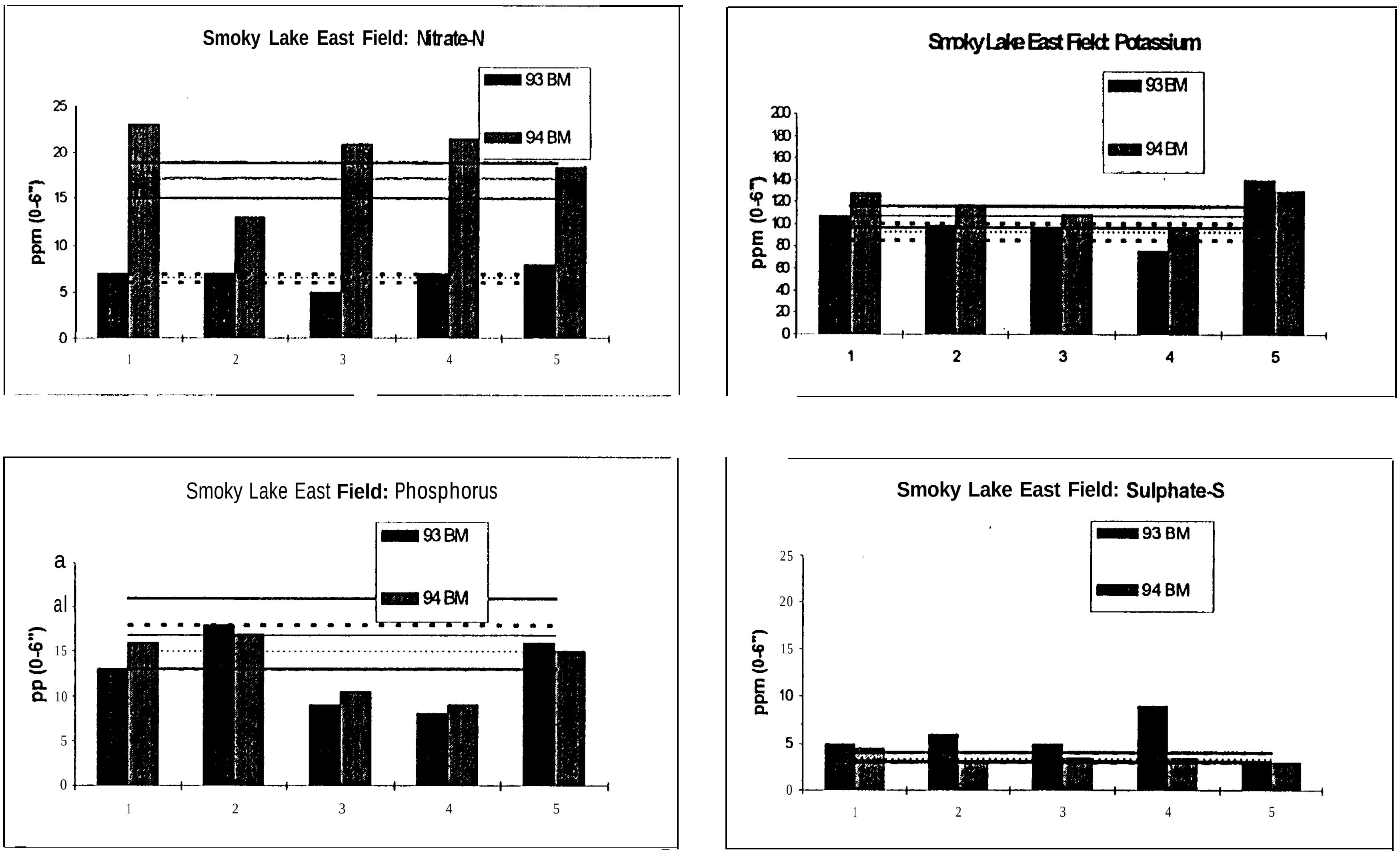
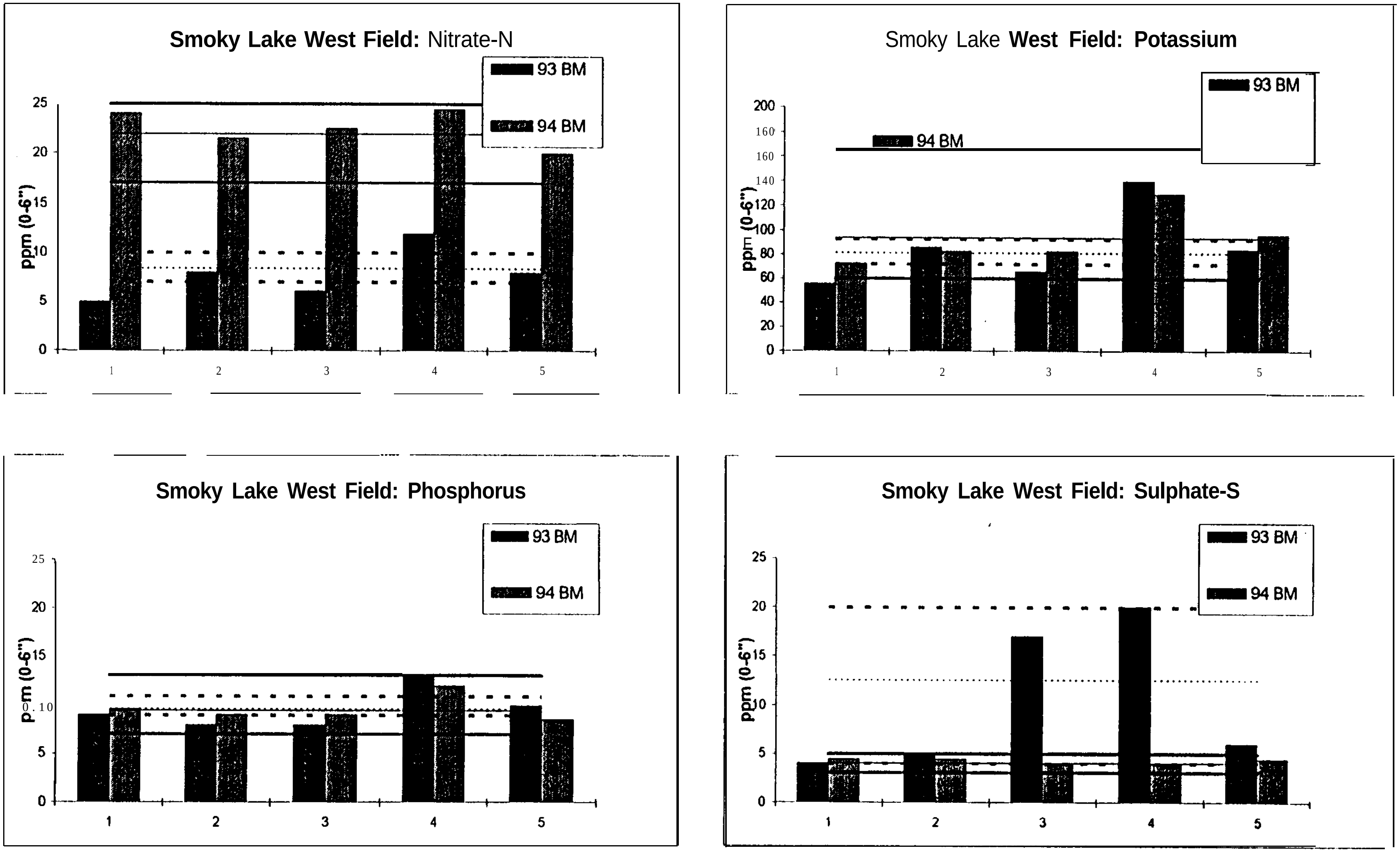


Figure 2. Benchmark (BM) values for 1993 and 1994 are represented by the bars. The horizontal lines represent the conventional sampling data: dashed lines are for 1993, solid lines are for 1994; heavy lines are the minimum and maximum, light lines are the average of **five conventional samples.**

West Field Nutrients



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