SF-990 (Revised)

Soil Sampling as a Basis for Fertilizer Application

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Importance of Soil Sampling

Soil tests measure the relative nutrient status of soils and are used as a basis for profitable and environmentally responsible fertilizer application. The accuracy of a soil test result is influenced by the laboratory analysis but may be influenced even more by the quality of the soil sample. Sample collection is extremely important in the accuracy and repeatability of a soil test. Sample handling following collection is also important. A soil sample which does not represent the area being sampled will be misleading and result in over or under-application of fertilizer. It is therefore very important to collect and handle soil samples properly.

There have been several changes in field sampling methods since the last revision of this circular. This revision will help direct soil samplers in methods for determining a composite soil test, but will also introduce site-specific methods for revealing within-field nutrient levels. The challenge has been to provide meaningful information about field and within field nutrient levels with minimal costs to the producer.

When to sample

Soil samples to be analyzed for soil pH, salt content, zinc (Zn) and phosphorus (P) can be taken nearly any time of year. Potassium (K) values from samples taken in frozen soil may test high compared to other times of the year. Sulfur (S) and chloride (Cl) are mobile in the soil, so sampling in the fall or spring is recommended.

Most soil samples in North Dakota are taken for nitrate-nitrogen (NO_3-N) analysis. When samples are collected in the fall before September 15, a sampling date adjustment (SDA) should be used to compensate for additional N releases anticipated from soil organic matter and previous crop residue decomposition. Soil samples for NO_3-N may be taken without sampling date adjustment after September 15. After this date, most additional N releases from soil micro-biological activity are low. Soil samples may be taken for NO_3-N as early as August 1. The SDA adds one-half pound of NO_3-N to the soil test analysis for each day the sample is collected prior to September 15 (Table 1).

Producers should not be reluctant to sample in early August following small grain harvest because of fear of greater N release from organic matter and residues compared to late fall sampling. If yields were relatively high, the SDA adjustment represents potential N release well. Sampling fields before tillage also increases the reliability of the 0-6 inch soil core depth because of more uniform soil conditions compared to tilled fields. Waiting to sample small grain fields until late fall increases the risk of N uptake by small grain regrowth, which may contain up to 100 lb N/acre. Sampling standing row crops for NO_3-N is not recommended.

Table 1. Sampling date adjustments if soil samples are taken in the fall prior to September 15.

Date of sampling	Sampling date adjustment
	lb NO_3-N/acre
August 1	23
August 15	15
August 30	8
September 5	5
September 15	0

Fall soil sampling results for NO_3-N and S are similar in most years to spring sampling. However, warmer than normal winters followed by an early spring combined with good soil moisture could increase NO_3-N and S levels through organic matter and residue mineralization. Green sugarbeet leaves or other crop residues with relatively high N content may also contribute to early mineralization and increase spring NO_3-N levels compared to a fall soil sampling. In sandy soils with high rainfall or snow-melt following a fall sampling, levels of NO_3-N and S in the spring compared to a fall sampling may decrease as nitrate and sulfate is leached out of the sampling zone. In most situations, however, fall sampling is a good guide to N and S application.

Depth of Sampling

Soil sampling and analysis assumes 2,000,000 lb/acre of soil from 0-6 inches in depth. This weight per unit volume (bulk density) assumes a medium soil texture with some compaction typically found following cropping and harvest. Bulk density differences can make a difference of 10% in soil test results. Bulk density is ignored in commercial soil sampling, but consistency in soil sampling techniques is important because of soil bulk density differences, especially in surface cores. The depth of sampling required depends mainly on the nutrient of interest, the crop to be fertilized, and in some cases, the tillage system in place (Figure 1).

Nutrients

For soil pH, P, K, Zn, copper (Cu) and manganese (Mn), sampling the 0-6 inch depth is adequate. In long-term no-till fields, soil pH, P, and K may become stratified. Most studies for P and K suggest that stratification is not important as long as the fertilizer P and K rates based on a 0-6 inch value is followed. However, soil pH may be important in the surface 0-2 inch layer because of possible herbicide interaction with lower pH levels. The 0-6 inch depth is also important for soluble salts, in addition to the 6-24 inch depth.

Soil Surface	Soil Properties	Crops
0-6 inch	pH, P,K, OM, Cl, S Ca, Mg, CEC, Zn, NH_4^+-N, Fe, Mn, Cu, soluble salts, NA	Alfalfa, clovers (analyze only 0-6 inch depth, nitrate analysis at deeper depths not necessary).
6-24 inch	Soluble salts, NO_3-N, S, Cl (in addition to 0-6 inch depth)	Wheat, barley, oats, durum, corn, soybean, dry bean, potato, canola, crambe, mustard, sunflower, grass hay, pasture, millet, canary seed, flax, safflower, buckwheat, lentil, field pea, sorghum, sudangrass. (Separate 0-24 inch depth into a 0-6 inch and 6-24 inch depth.)
24-48 inch	NO_3-N, in addition to the 0-6 inch and 6-24 inch depths	Sugarbeet, malting barley. (Sunflower if greater than 30 lb N/acre are anticipated at the 24-48 inch depth.) (Separate cores into 0-6 inch, 6-24 inch and 24-48 inch depths.)

Figure 1. Depth recommended generally for soil analysis of certain properties and nitrate analysis for crops.

To determine soil NO_3-N, S and Cl, samples are taken from at least the 0-24 inch depth. The 0-24 inch sample should be broken into a 0-6 inch depth and a 6-24 inch depth, so that the relative position of N in the soil can be determined. In some years, NO_3-N can be leached to lower depths so that large amounts are in the 6-24 inch layer but only a small amount may be left in the 0-6 inch layer. Depending on the crop, soil NO_3-N may need to be determined on the 24-48 inch depth (2-4 foot) also. A few areas within the Red River Valley have a history of poor sugarbeet quality due in part to the presence of especially high levels of soil NO_3-N at deep depths. In these special areas, deep N to 6 feet may also need to be checked.

Crop

For most crops, NO_3-N should be determined on the 0-24 inch depth. For sugarbeet and malting barley, the 24-48 inch depth should also be sampled to fine-tune N rates necessary to improve beet and grain quality. Sunflower also may use deep N; however, deeper sampling is conducted not to improve quality, but to save money on N fertilizer when there is reason to suspect the presence of large quantities of N at deep depths, such as following years of growing shallow rooted crops, following fallow, and when previous crop yields have been low.

Tillage system

Under conventional tillage and conservation tillage, sampling 0-6 inch, 6-24 inch and the 24-48 inch depths described previously are appropriate. Under long-term no-till, stratification of soil non-mobile nutrients and soil pH will occur. Phosphate and soil pH stratification are common, with high P and lower pH levels at the surface 0-2 inch depth and lower P and higher pH levels at deeper depths. If the lower depths become depleted in P, application of more deeply placed P may be beneficial, especially in drier seasons. Soil pH tends to become acid at the surface, especially if N fertilizers are applied to the surface. Separating the 0-6 inch depth into a 0-2 inch depth and 2-6 inch depth would identify these trends (Figure 2).

Special sampling situations

Ridge-till is occasionally used in North Dakota, but it is a popular tillage system in some areas of the corn-soybean belt. In ridge till, ridges are built by deep cultivation during the growing season and remain in the field following harvest and through the winter. At planting, the top of the ridge is removed, exposing moist soil for seeding, and soil from the top of the ridge is moved into the row middles. Starter fertilizer is often used at planting, and sometimes deep-placed fertilizer is applied right under the ridge-top in the fall. Ridge-till should be sampled 6 inches to either side of the ridge-top and straight down into the ridge (Figure 2).

Fields with a history of large band applications of P and K are special problems, especially where within-field P and K levels are to be determined. When band rates greater than about 30 lb P_2O_5 or K_2O are used, there may be a residual effect of the fertilizer band for several years. If the bands can be located, they should be avoided when sampling. In North Dakota, high reproducibility of P levels has been achieved in grids or zones using eight to 10 soil cores where 20-30 lb P_2O_5 has been applied annually. For sampling whole fields, the 20 cores per field recommendation is appropriate.

Sampling Tools

Soil is variable not only over an area, but also with depth. A proper soil sample is taken from a uniform volume from the top of the sample depth to the bottom. Wedge shaped samples, or a handful of soil from the surface and one at depth, are not appropriate and will not give consistent results. The best sample is taken using a soil probe (Figure 3). There are hand-probes and automated probes available at nearly every price range. The probe should be designed to gather soil from the appropriate depth.

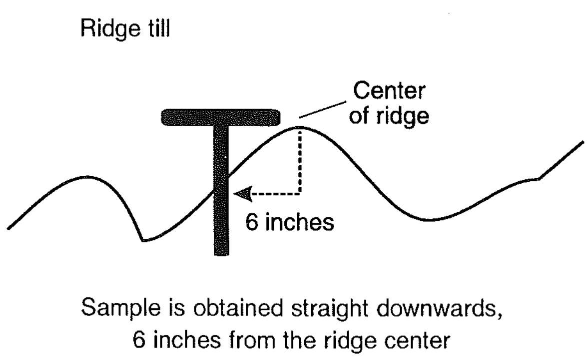
After a recent tillage operation, an automated probe sometimes has difficulty obtaining a consistent 0-6 inch sample. The consistency of a surface sample may be improved by sampling in wheel tracks, but it is sometimes difficult to find a wheel track when the probe is centered in the cab. Hand probes may be a better method to take a 0-6 inch sample, because the soil can be firmed with pressure from a footprint and a consistent sample can be taken. Automatic probes are very good at taking a 6-24 inch and 24-48 inch core, even following tillage. Automatic probes take a much more consistent surface sample when fields have not yet been tilled.

In many soils, a lubricant is needed to prevent soil plugging in a soil probe. Table 2 shows the effect of lubricants on soil analysis. For most soil nutrients, the use of lubricants, especially the most popular lubricants, should not affect soil test results. Exceptions would be certain micronutrients, iron (Fe), Zn, Mn and Cu. For these micronutrients, obtaining a 0-6 inch core without a lubricant is suggested, especially where deficiencies are suspected.

Soil Sample Handling

Samples intended for NO_3-N sampling should be stored in ice chests during transport. Moist samples subjected to heat will increase N mineralization and test values will increase during transport/storage. Samples intended for NO_3-N determination should be air-dried immediately after collection to prevent alteration of NO_3-N concentrations due to microbial activity. Spread samples uniformly on clean paper in a dust free area. Another procedure is to transport the samples immediately to a soil testing laboratory in a cold ice chest. Usually, the soil laboratory attaches a drying charge for wet soil samples. Rubber gloves should be used to handle samples intended for chloride analysis to prevent contamination from chloride in perspiration.

Soil samples intended for Zn analysis should not come into contact with any galvanized surface, including the soil sampling tool, bucket, drying container or grinder.



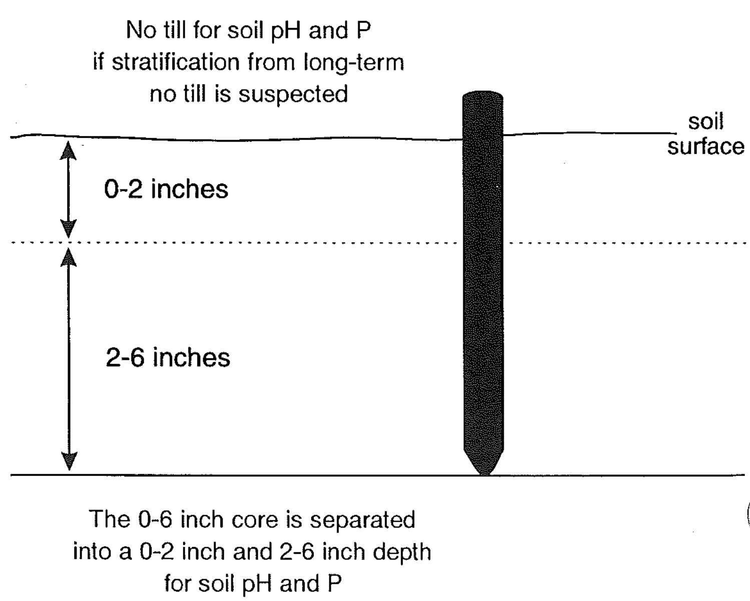


Figure 2. Sampling under special tillage conditions.

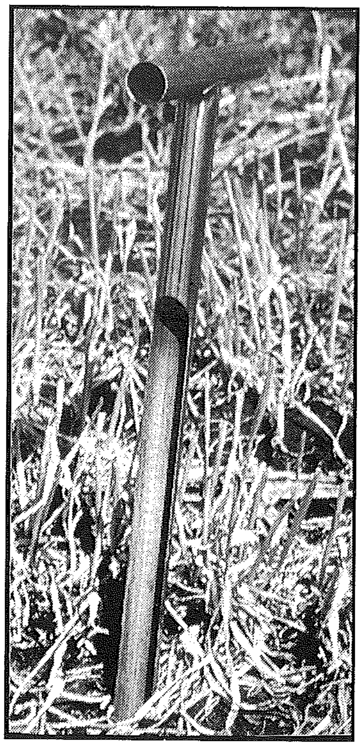


Figure 3.
Soil hand probe. ▶

Automated probe. ▼

Table 2. Effects of soil probe lubricants on soil chemical analysis (Blaylock et al., 1995. Wyoming).

Lubricant	Organic Matter	NO_3-N	P	K	Fe	Mn	Zn	Cu
	%	ppm						
No lubricant	1.67	1.4	14	249	11.4	1.5	0.8	1.7
WD-40	1.59	1.3	16	248	13.2	1.8	1.0	2.0
PAM	1.66	2.1	16	263	13.5	3.8	1.1	2.3
Dove dishwashing liquid	1.67	2.6	14	280	10.1	1.3	0.7	1.2
Motor oil	1.63	1.6	16	265	12.5	1.4	0.9	2.0
Silicone	1.62	1.3	16	246	9.9	1.3	0.6	1.0
$LSD_{0.05}$	NS	NS	NS	NS	0.7	0.8	0.2	0.3

Soil Sample Collecting, Where and How

Where to collect a soil sample and how many samples to collect depends on the sampling goal. Traditionally in North Dakota, the goal has been to provide one soil test level to describe a field. This approach works well in some situations, especially when the test value is low. However, because of the variability of nutrients in the field, one test level from a field may not represent a large part of the field. Some producers, having received a high soil test report, continue to apply the same fertilizer rates as in the past because they lack confidence in the test. Recent research has developed methods to increase the confidence in soil test values while keeping sampling costs low.

Sampling goals can be separated into two categories; determining nutrient levels in **Whole Fields**, or determining **Within Field Values.**

Determining whole field nutrient values

Collecting a selectively random sample composite is the traditional North Dakota sampling strategy for determining whole field nutrient values. A field composite sample should consist of at least 20 selectively random soil cores. A field sampled in this manner should give the field mean plus or minus 15% at least 80% of the time (Figure 4).

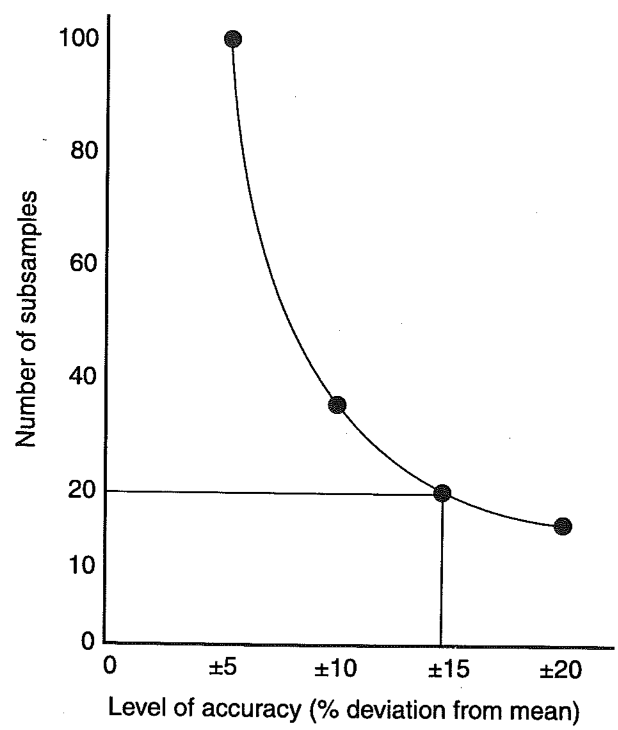


Figure 4. The number of subsamples required for a composite soil sample for NO_3-N with various levels of accuracy for an 80°H precision level. (Adapted from Swenson et al., 1984).

Selectively random sampling means that the field is sampled only in areas which represent most of the field area. Unusual landscape features such as eroded areas, saline or sodic zones and old building lots are not sampled. Also, avoid sampling in dead furrows or back furrows, under old manure or hay piles, sugarbeet tare piles, animal droppings, next to ditches, sloughs and roads, known banded fertilizer locations, and small depressions.

There are often questions about what constitutes a "field." Some samplers collect one composite sample per section or one per quarter-section. Others separate the field into large landscape zones and treat each as a field. Some may divide a quarter into three to four equal sub-fields and sample each individually. Generally, the smaller the area, the more representative of the area the sample values will be. Figure 5 shows two examples of a suggested way to obtain representative samples from fields.

Using a composite soil sample to direct fertilizer recommendations has several advantages:

- It is relatively inexpensive. Soil sampling is relatively quick, only 20 to 30 cores are needed to represent a field, and only one analysis is required for each field.
- Results are mostly reproducible.
- Results can easily be tracked from year to year.

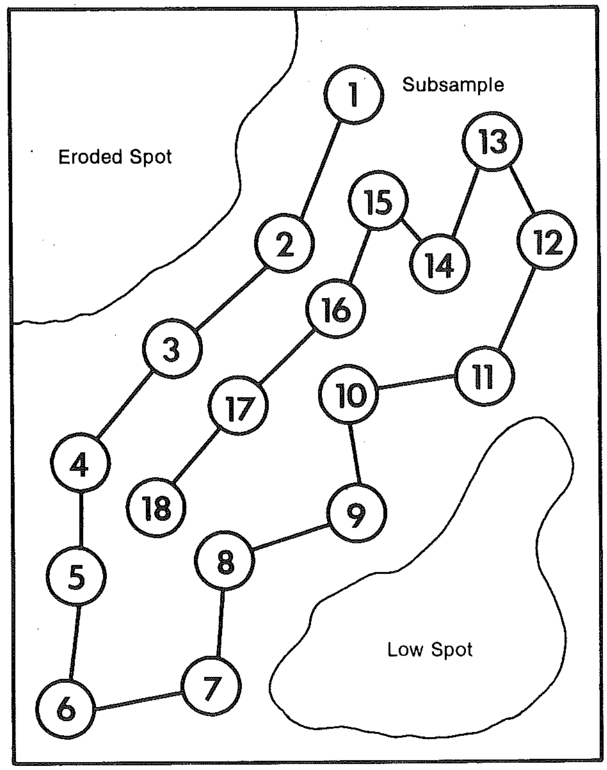
Composite soil samples, however, have several inherent disadvantages:

- "Unusual areas" not sampled may comprise significant acreage in a field.
- Large portions of the field may be over- or under-fertilized.
- There is a low level of confidence that high soil test values represent most of the field.
- Sometimes it is difficult to distinguish which locations are unusual.

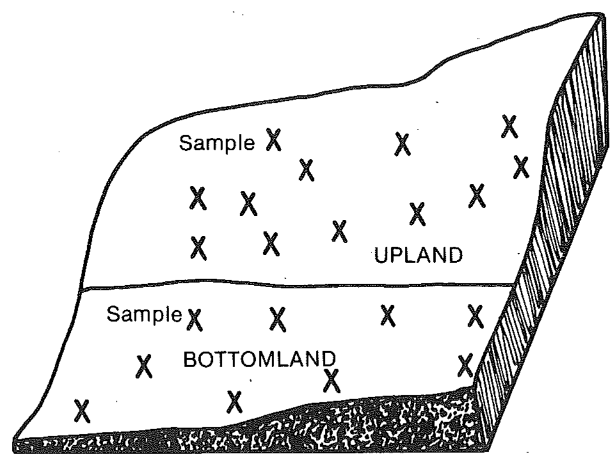
Composite sampling is most representative when within field variability is low. Low within field variability is most common when composite soil test levels are low. A field composite test of 20 lb NO_3-N/acre means that at least 95% of the area sampled contains levels between 10 and 30 lb NO_3-N/acre.

Collecting at least 20 soil cores from a field results in a large amount of soil being collected. In some soils, such as fine sandy loams, the soil may break up easily in a bucket, enabling thorough mixing before a 2/3 pint subsample is obtained for analysis. However, many soils do not break up easily. It may be necessary to take the entire sample out of the field, dry and grind it to obtain a good mixture. The resulting sample, whatever the method of collection and preparation, must represent the 20 core locations to provide the most accurate and reproducible results.

Figure 5.



Composite soil sampling plan for glacial landscapes.



Composite soil sampling plan for rolling landscapes.

Sampling for within-field nutrient levels

Because of the limitations of composite soil testing, and because of the growing popularity of site-specific farming, different methods of obtaining nutrient values within fields are needed. Sampling for determining within-field nutrient levels can be accomplished through two different methods; grid sampling and directed sampling. Grid sampling reveals fertility patterns through dense systematic sampling, while the directed sampling method assumes there is a predictable and logical reason for fertility patterns to exist and uses this reason to reduce sample number while maintaining high quality information compared to dense grid sampling. Directed sampling has also been called "zone sampling," "smart sampling"and "smart zones."

Grid sampling

Grid samples were first taken in a regular, predictable pattern across the field (Figure 6).

However, the regular grid can easily contain bias because of streaking of fertilizer or manure applications in the past. With GPS technology (Global Positioning Satellite receivers), grid sampling need not be regularly spaced. Irregularly spaced interval positions can reproducibly be located as accurately as regularly spaced grids. Irregular grids, such as the systematic unaligned grid, also provide the opportunity for greater statistical evaluation through a process called "kriging" (pronounced "kreeging"). Many researchers prefer kriging as an estimator of values between actual samples because it carries an estimate of error along with the estimated value. Other estimators such as inverse distance, polynomial and triangulation carry no such estimate of error. Other grid sampling types are random, random stratified, staggered start, and the diamond/triangle/hexagon grid pattern.

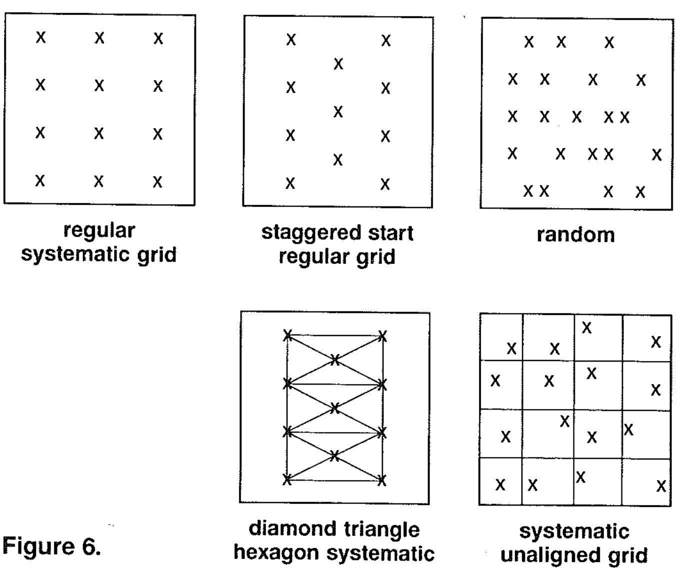


Figure 6.

Grid sampling can be a good tool for sampling within field nutrient levels if samples are taken densely enough. The accepted grid spacing from recent research, including in North Dakota, is about one sample per acre. This approach, however, is very expensive and time-consuming, and has forced many commercial soil samplers and producers to accept less information about their fields and use a 2.5 acre grid or larger. In North Dakota, even a 2.5 acre grid is considered expensive and prohibitive. A 4-5 acre grid is more commonly used. The 4-5 acre grid has been used to reveal variability in soil test levels, but it may not be very accurate in representing within-field nutrient levels nor does it represent fertility patterns well (Figure 7). The use of a 4-5 acre grid should not be considered a dense systematic grid.

Directed sampling

Landscape/topography sampling

A more practical approach for North Dakota producers that combines low cost with a high degree of meaningful nutrient information is directed sampling. Directed sampling is based on some prior knowledge of the field, or some logical basis. The basis of most North Dakota directed sampling is the effect of landscape position on soil nutrient levels, particularly nitrogen. Soil pH, P, K, and Zn are non-mobile factors or nutrients in soil. The levels and patterns of non-mobile nutrients within fields are similar from year to year. North Dakota research has also shown that patterns of NO_3-N, S and Cl, which are mobile soil nutrients, are also stable between years because the patterns are affected by the landscape (Figure 8). Directed sampling based on landscape, or topography, has been shown to be similar to a one-sample-per-acre grid in providing within-field nutrient levels while requiring only a fraction of the sampling time and expense. Topography sampling of several fields across North Dakota only required four to seven samples per 40-acre field, compared to 36 for the one-sample-per-acre grid approach.

Additional methods for directed sampling

Directed sampling should be considered an iterative process (a process that takes more than one attempt) in which information is added progressively to the general knowledge of the field. Producers will not have the 110- foot grid sample research base researchers at NDSU have to back up assumptions on where important management zones are located and where the boundaries might be. Several methods of determining management zones should be used in addition to topography to help the producer judge what areas are important.

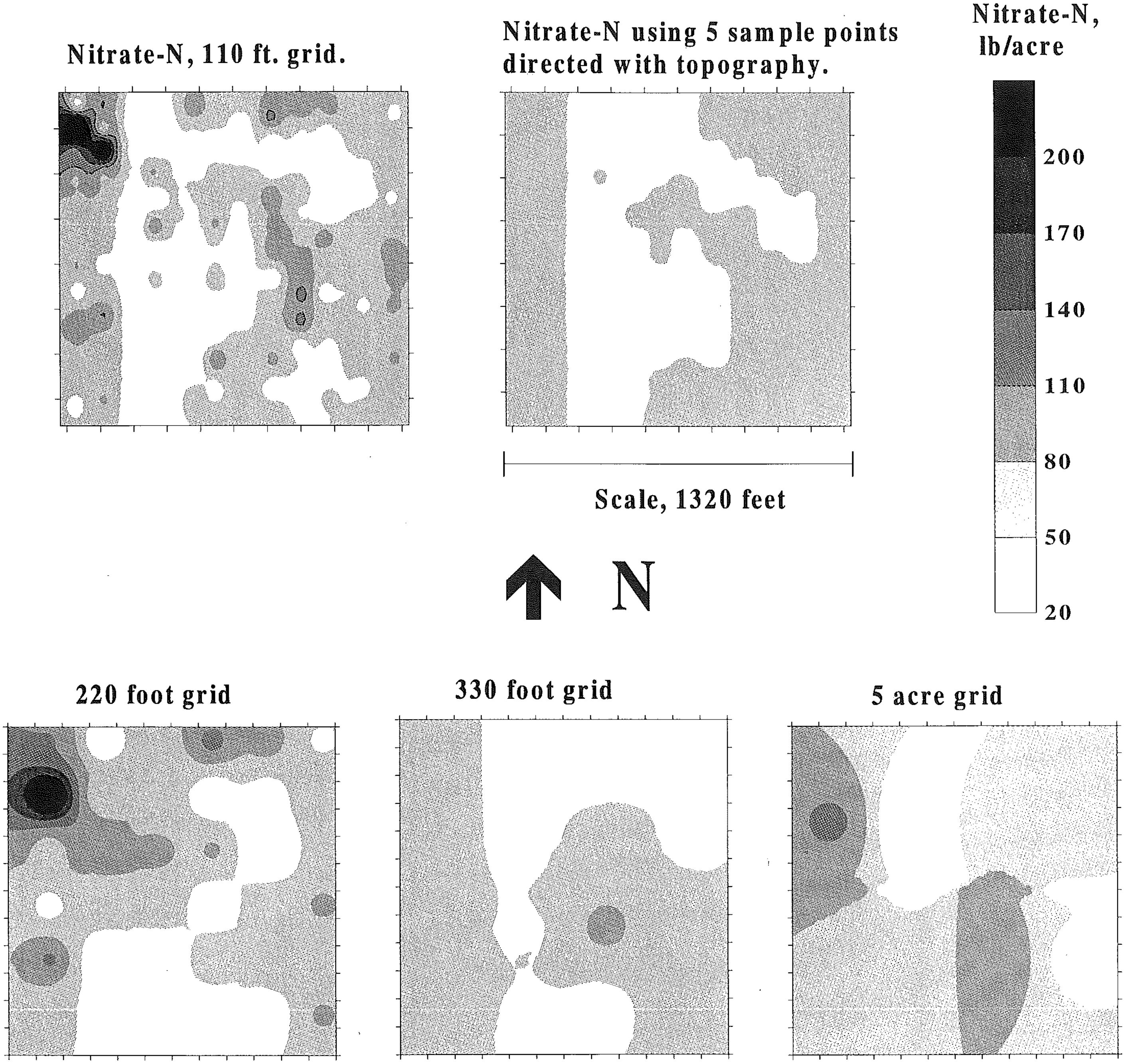


Figure 7. Comparison at Valley City, 1995, of NO_3-N mapping using topography and selected grid spacings.

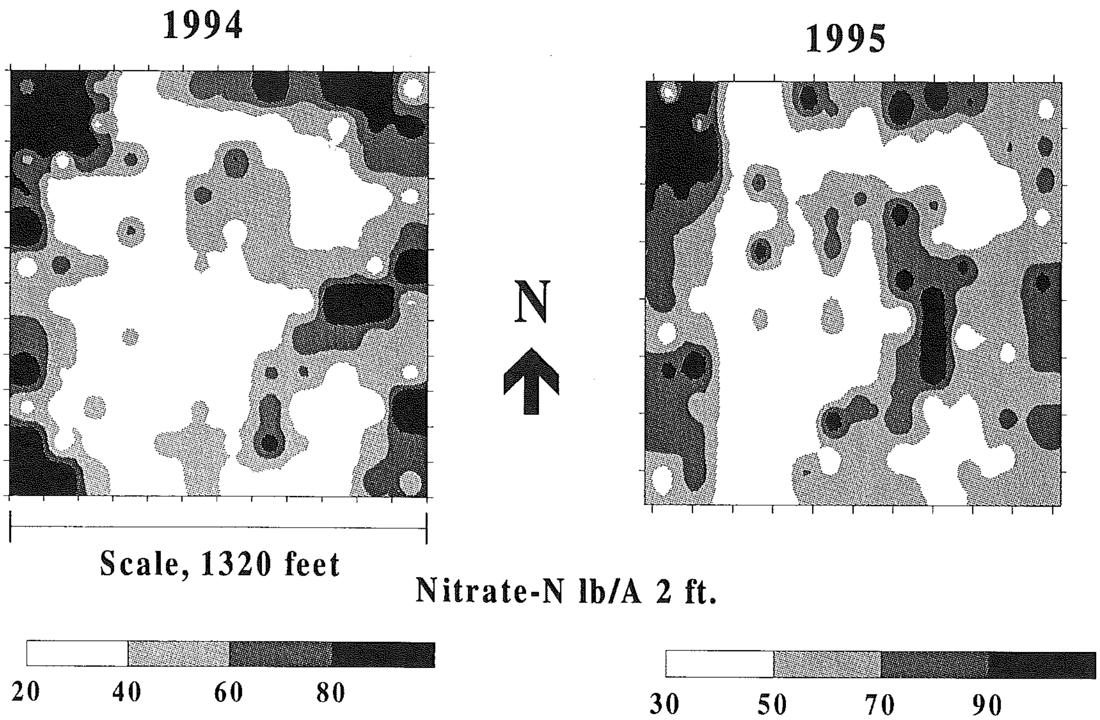


Figure 8. Valley City NO_3-N levels, 1994-1995.

Aerial photography and the use of satellite imagery can be used to show differences in soil color and differences in crop growth patterns and crop color. In years that are very dry or very wet, these areas will probably be related to topography. Aerial photography and satellite imagery has been shown to reveal patterns in sugarbeet leaf color which is especially useful to soil samplers.

Old FSA (ASCS) aerial photographs in slide format are available for most fields in North Dakota because of verification photography taken over the last 20 years of federal farm programs. These photographs may not only reveal past field boundaries and long-gone building sites, but provide patterns from past crops that align with present-day information. This information is inexpensive to acquire and can be scanned into computer software for use in decision making.

Yield monitor data may be useful to define some boundaries However, so many factors affect yields that unless yield is mainly affected by a single nutrient of interest in one year, most yield patterns may cross over several soil fertility levels. Yield monitor data has been most useful in recent North Dakota studies by identifying particularly poor yielding areas. These areas may have abnormally low fertility levels causing the poor yields, or they may have unusually high fertility levels if another factor is limiting yields, resulting in accumulation of excess nutrients in that location.

On-the-go soil electrical/electromagnetic soil conductivity sensors may help define management zones. It is not possible to determine directly what the different levels of conductivity mean without sampling to ground-truth the areas, but they can reveal patterns that initially direct, reinforce or redefine existing layers of information regarding zonal boundaries.

Digitized GIS soil survey maps should be used with caution and not without the aid of other layers of information. Although soil surveys give generally reliable information useful in determining the general productivity of farms, the information is usually not fine enough in scale to direct site-specific decisions.

Pros and cons of different within-field sampling methods

The following are criteria for choosing grid sampling over a directed sampling approach:

- The field history is unknown
- Fertility levels are high due to high rates of fertilizer application.
- There is a history of manure application.
- Small fields have been merged into large fields.
- Non-mobile nutrient levels are of primary importance (P, K, Zn).

The following are criteria for choosing directed sampling methods over grid sampling:

- Yield monitor data or remote imaging show a relationship with landscape.
- There is no history of manure application.
- Relatively low fertility levels are present, or low fertilizer rates of non-mobile nutrients (less than maintenance) have been applied over the most recent years.
- Mobile nutrients, especially N, are important to map.

Another strength of the grid approach is that the procedure requires a lower level of interpretive skills by the sampler. Grid locations are imposed on a field map by the computer with a prompt to drive to the next location. Anyone who can drive and read a map can sample a field in a grid. The drawback is the expense of sampling and analysis, which may result in a less than adequate grid size needed to represent a field.

Directed sampling requires a much more intelligent approach. By using the zone method, either the sampler or the sampling supervisor who provides the sample location map to the sampler must have a high degree of agronomic savvy. It takes time to review aerial photography, satellite imagery, topography maps, and other layers of information, manipulate the maps to look for complementary patterns between different layers, and decide where the best management zone boundaries are located. Although the sampling and analysis expense of a directed approach to soil sampling is far less than a one-sample-per-acre grid approach, the expense of interpretation is considerably higher.

The value of determining within-field nutrient levels

Determining within-field nutrient levels allows the variable-rate application of fertilizers. When considerable variability is present, immediate economic returns are possible, provided the variability is on a portion of the yield/nutrient curve which allows increased yield or quality if application rates are varied. The rapid movement toward variable-rate N application in sugarbeets has been driven by the relationship between N levels and crop value.

Another important reason for determining within-field nutrient levels is to reveal the range of levels and location of the levels. In determining soil pH, for example, composite tests from 95% of North Dakota fields show a pH level of greater than 7. This led one author to announce that North Dakota "does not have an acid soil problem." However, in site-specific studies on five fields, three in the Red River Valley and two outside, the three fields in the Red River Valley all contained small areas (2-3% of total area) with values less than 7, and the fields outside the Red River Valley contained over one-half of each field area with pH levels less than 6. In one field, pH varied from 4.9 to 7.8. The pH ranges have implications on herbicide carryover, herbicide activity and the performance of some major crops with pH sensitivity. So what is the level of pH on the 20 million acres of cropland west of the Red River Valley? We really do not know, but perhaps up to half of these acres may have pH values lower than 7.

When a soil test shows high levels of nutrients in a composite soil test, does that mean that the whole field does not require fertilizer? Many producers have run on-farm tests in the past and have found that applying nutrients when composite soil test show that none are needed results in yield increases. Some producers simply do not trust a composite soil test. Sampling in a more intelligent manner using a directed approach should provide more accurate soil test results. The high soil test areas will be separated from the rest of the field, and areas needing fertilizer will be revealed. Whether or not variable-rate fertilization is used, more confidence in the soil test will result.

Sample core number and confidence in the sample value

Cell sampling or point sampling can be used to gather soil from a grid or management zone. Cell sampling (Figure 9) is a method where samples are gathered randomly from the grid or zone area, while point sampling limits the sample collection area to a 10-20 foot radius from a central area location. Point sampling is most often used in grid sampling, whereas cell sampling appears to better represent

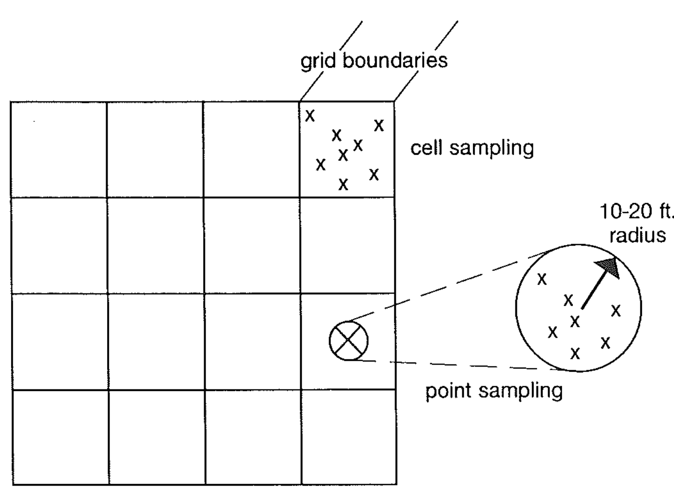


Figure 9. Cell sampling and point sampling.

zone levels. Both methods require multiple soil cores. There is enough small-scale variability in most areas of fields that single cores are not likely to represent a grid or zone well (Table 3). Research on small-scale variability suggests that eight to 12 soil cores may be required to represent a grid or zone.

Once a sample value is obtained through careful sampling and analysis, what does that value mean and how much of the grid or zone is represented by that value? The lower the sample value is for NO_3-N, the more confidence there is in the value. For example, in a 10-acre zone, if a value is 20 lb NO_3-N/acre, then it would be expected that 9.9 acres of the zone test 10-30 lb NO_3-N/acre. However, if the value in the 10 acre zone were 100 lb NO_3-N, then only about 6.5 acres would test between 70 lb and 130 lb NO_3-N and the remaining 3.5 acres would have values above or below that range.

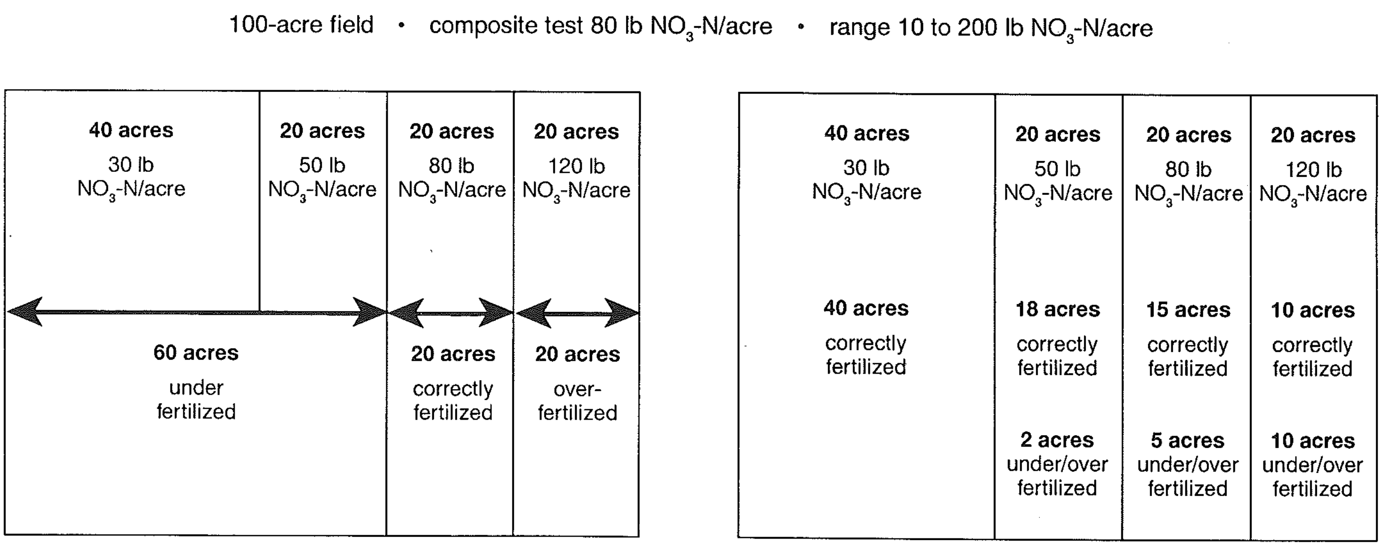
Some producers have become disillusioned with determining within-field nutrient levels because on closer inspection some areas have small-scale variability as great as the variability in the entire field. However, careful analysis of a field shows that even though some areas have extreme variability, most others do not.

Consider a 100-acre field with a NO_3-N composite test of 80 lb/acre (Figure 10) with a range from 10 to 200 lb

Table 3. The percentage of composite NO_3-N values falling into a range of the mean ± 20% with the cores taken in a random manner throughout a 60 foot X 60 foot plot area with individual sample cores obtained in a ten-foot grid. (Franzen and Dennis Berglund, 1997).

		Number of sample cores used to estimate a sampling area mean				
Site	Mean	1	3	5	8	10
	lb/acre	--- percent of composite values falling into the mean range ---				
1	15.6	26	44	50	62	62
2	54.7	0	52	70	86	88
3	60.6	30	56	78	86	92
4	27.6	54	82	90	98	98
5	12.3	52	78	90	96	98

NO_3-N/acre. Forty acres has a test level of 30 lb, 20 acres tests 50 lb, 20 acres tests 80 lbs, and 20 acres tests 120 lbs. Using the 80 lb/acre composite test over-fertilizes 20 acres while under-fertilizing 60 acres. The within-field method fertilizes 40 acres in the lowest category correctly, fertilizes 18 out of 20 acres testing 50 lb correctly, 15 of 20 acres at the 80-lb level correctly and 10 of 20 acres at the 120 lb level are fertilized correctly. The composite sample only fertilized 20 acres out of 100 correctly, while the within-field sampling method fertilized 83 acres out of 100 correctly. Even though some areas of the within-field approach were highly variable, the majority of the field benefits from revealing within-field variability.



N application based on a composite test for NO_3-N

20 acres correctly fertilized

N application based on a site-specific testing approach for NO_3-N

83 acres correctly fertilized

Figure 10. An example of the properties of a field correctly and incorrectly fertilized with N using either a composite soil test-based or site-specific soil test based N approach.

Summary

Soil testing is the basis for fertilizer recommendations in North Dakota. A composite soil sample is a good first step in understanding relative levels among fields. Within-field management of nutrients based on grid sampling or directed sampling may inspire more confidence in soil test recommendations and provide more accurate field nutrient level information.

A composite field test requires from 20 to 30 cores to represent a field. By sampling three to four zones in the field, each with eight soil cores, the time spent sampling in the field and the cost of analysis is only increased a small amount, while the information gathered about the field is greatly increased.

Sampling should be considered seriously and soil samples handled properly to provide consistent results. Producers would not dare go to the field without checking the oil in their tractor engines. One should approach soil testing in a similar manner.

For more information on this and other topics, see: www.ag.ndsu.nodak.edu

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