Idaho Dairy Nutrient Management Standard

PURPOSE

The Idaho Dairy Nutrient Management Standard (NMS) shall regulate the rate, source, placement, and timing of plant nutrients and soil amendments to improve soil health and crop productivity while reducing environmental impacts on all Grade A dairy farms in the State of Idaho.

CONDITIONS WHERE NMS SHALL BE APPLIED

All fields operated by Grade A dairy farms where plant nutrients and soil amendments are applied.

ENVIRONMENTAL/NUTRIENT MANAGEMENT PLAN (E/NMP) DEVELOPMENT

General Criteria Applicable to All Plans

Develop an E/NMP for nitrogen (N), phosphorus (P), and potassium (K), which accounts for all known measurable sources and removal of these nutrients. These plans must include full and complete documentation of all nutrient imports, exports, and on-farm transfers.

An annual budget for phosphorus that considers all potential sources of nutrients, including, but not limited to commercial fertilizers, animal manures, legume nitrogen fixation, green manures, plant or crop residues, compost, organic by-products, municipal and industrial biosolids, wastewater, organic materials, soil, and irrigation water.

E/NMPs shall be written and/or approved by individuals who have met certification requirements as set forth by ISDA.

Soil Testing and Analysis.

E/NMPs shall be drafted, approved and administered based on current soil test results (no older than one (1) year) from all dairy fields receiving nutrient application in accordance with UI guidance, or industry practice when recognized by the University of Idaho (UI). Soil test P shall be determined using the Bray 1 method for soils with no free lime (pH < 6.5) and the Olsen method ($NaHCO_3$) for soils with free lime (pH > 6.5).

Soil samples shall be collected and analyzed annually from all fields receiving nutrient application according to Table 1 to accurately determine fertilizer needs utilizing the UI Fertilizer Guidelines or other published guidelines for crop production in the state. Soil samples collected from the first foot shall be analyzed for inorganic N (NO_3-N and NH_4-N), P and K, samples collected from the second foot should be analyzed for inorganic N.

Table 1. Soil sampling depth and testing criteria for annual budget development. All analysis should be accepted by and follow UI guidelines.

Depth (inches)	Soil Constituent Analyzed
0 -12"	NO_3-N, NH_4-N, P, & K
12-24"	NO_3-N, NH_4-N

Soil samples shall be collected and prepared such that they are representative of the entire field or portion of the field to be managed separately. Requirements for soil sampling shall follow the specifications outlined in the UI publication "Soil Sampling" UI Bulletin 704 (see Appendix).

Fields that are part of a long-term sod, pasture, or alfalfa rotation, may not require annual soil tests. Soil tests are to be taken when nutrients will be applied as part of an on-going management program.

For soil test analyses, use laboratories successfully meeting the requirements and performance standards of the North American Proficiency Testing Program under the auspices of the Soil Science Society of America and NRCS or use an alternative NRCS- or State-approved certification program that considers laboratory performance and proficiency to assure accuracy of soil test results.
http://www.extension.uidaho.edu/nutrient/soil_plant_water_manure/accredited.html

Manure, Organic Byproduct, and Biosolid Testing and Analysis.

Prior to application, all nutrients streams to be land applied shall be sampled and tested to determine the appropriate volume of nutrients to be applied to each field, pursuant to the expected phosphorus uptake of the crop to be planted and the current soil test P concentration recorded in each field (Phosphorus Threshold) or the Phosphorus Site Index Value (P Site Index). Dairy farms operating on 'Phosphorus Threshold' (PT) may use nutrient book values to calculate land application on any fields that soil test less than forty (40) ppm phosphorus. Dairy farms operating on 'Phosphorus Indexing' (PSI) may default to nutrient book values to calculate land application on any fields assessed as "low risk". Nutrients applied to any fields testing above 40 ppm P (PT) or assessed as anything except "low risk" (PSI) must be tested prior to application. Collect, prepare, store, and ship all manure, organic by-products, and biosolids following UI guidance (CIS 1139) or industry practice when recognized by the UI. In the absence of such guidance, test at least annually (no more than 3 months prior to application), or more frequently if needed to account for operational changes (e.g., feed management, animal type, manure handling strategy, etc.) impacting manure nutrient concentrations.

OPTIONAL: If no operational changes occur and operations can document a stable level of nutrient concentrations for the preceding 3 consecutive years, manure may be tested less frequently, if approved by ISDA. Follow UI guidelines regarding required analyses and test interpretations. Analyze, at a minimum, total N, total P or total P_2O_5, total K or total K_2O, and percent solids.

When planning for new or modified livestock operations, and manure tests are not available yet, the planner/producer may use "book values" from the ASAE Standard D384.2 MAR2005. However, the E/NMP must be updated and resubmitted to ISDA for approval once nutrient test samples are received, prior to application in the forthcoming planting season. http://www.agronext.iastate.edu/immag/pubs/manure-prod-char-d384-2.pdf

For manure analyses, laboratories must meet the requirements and performance standards of the Manure Testing Laboratory Certification program established by the Minnesota Department of Agriculture.

Nutrient Loss Risk Assessments.

E/NMPs shall use one (1) of the following methods to calculate and manage P application:

P Site Index - To assess the site-specific risk of P loss, the P site index risk assessment must be completed for all fields under the E/NMP, pursuant to the 2017 Idaho Phosphorus Site Index Reference.

Phosphorus Threshold - Plans may use a soil test P threshold to determine P application (Table 2). Any field using the P threshold must have a documented agronomic need for P, based on soil tests of each field receiving nutrients and UI nutrient recommendation or industry practice when recognized by the UI, before additional nutrients can be applied. Soil samples taken for comparison to the P threshold and for tracking P trends will be taken from the 0-12" sampling depth.

Table 2	
P Threshold Concentration	
Olsen	**Bray 1**
40ppm†	60ppm†

†Soil phosphorus test results are understood to have an average variability of 10%

When soil test P concentrations are above the threshold value, the planner and producer will design a Environmental/Nutrient Management Plan E/NMP that will reduce soil test P. Grade A dairy farms that register a soil test P concentration of greater than one hundred (100) parts per million (via Olsen method) on at least one (1) field shall be required to resubmit an E/NMP to ISDA that utilizes the Phosphorus Site Index Method for nutrient management of all fields in the plan.

Irrespective of P Site Index rating, no land application of P shall be permitted on any fields or pastures that possess a soil P level exceeding three hundred (300) parts per million, as determined by the required annual soil test (via Olsen method).

Application of Liquid Byproduct

For purposes of this standard, animal byproduct containing less than 10% solids will be classified as a liquid.

Application of liquid byproduct shall not be made outside the active growing period of the crop, unless the producer receives direct prior authorization from ISDA under the following conditions:

1. The E/NMP is up-to-date and all fields to receive liquid nutrients are listed within the plan
2. The volume of nutrients to be land applied is predetermined
3. Recent soil samples (within the last year) exist on all fields to receive liquid nutrients
4. Application of nutrients is consistent with management plan of the field (i.e. will not exceed agronomic needs of the crop or force an upward trend in soil phosphorus)
5. Weather forecast predicts no measurable precipitation for the next twenty-four (24) hours.
6. Liquid byproduct shall be applied at amounts not to exceed soil water holding capacity in the crop-rooting zone using UI irrigation scheduling technique (CIS 1039) or similar soil moisture balance method. Application of liquid byproduct through surface or sprinkler irrigation systems will be timed to prevent deep percolation or runoff.
7. ISDA affirms the need to apply liquid nutrients outside of the active crop growing period is necessary and appropriate.

Application of solid byproduct

Do not surface apply nutrients when there is a risk of runoff, including when—

- Soils are frozen.
- Soils are snow-covered.
- The top 2 inches or more of soil are saturated.

Exceptions for the above criteria can be made when adequate conservation measures are installed to prevent any offsite delivery of nutrients. ISDA will define adequate treatment levels and specified conditions for applications of manure if soils are frozen and/or snow covered or the top 2 inches or more of soil are saturated. At a minimum, producers must consider the following site and management factors:

- Historic growing season (long-term)
- Weather (short-term)
- Soil characteristics
- Slope
- Areas of concentrated flow
- Organic residue and living covers
- Amount and source of nutrients to be applied
- Setback distances to protect local water quality

PLANS AND SPECIFICATIONS

An approved Environmental/Nutrient Management Plan document shall contain the following items:

- Aerial site photograph(s), imagery, topography, or site map(s).
- Soil survey map of the site.
- Soil information including: soil type, surface texture, erodibility factor (K_w), slope, hydrologic soil group, drainage class, permeability (K_{sat}), available water capacity, depth to water table, depth to bedrock, restrictive features, and flooding and ponding frequency.
- Distance to surface water
- Location of designated sensitive areas and the associated nutrient application restrictions and setbacks. Assessment of vulnerability of sensitive areas, on a site-specific basis, must address nitrogen, using a nitrogen balance worksheet (see Forms) and/or phosphorus, using the Phosphorus Site Index.
- Current and planned plant production sequence or crop rotation.
- Realistic yield goals for the crops.
- All available required test results (e.g. soil, water, compost, manure, organic by-product, and plant tissue sample analyses) upon which the nutrient budget and management plan are based. This shall include nutrient testing results of all material exported from site.
- Results of P site index ratings
- Nitrogen Balance Worksheet, where appropriate
- Recommended application rates for N, P, and K for the entire plant production sequence or crop rotation.
- Listing, quantification, application method and timing for all planned nutrient sources and documentation of all nutrient imports, exports, and onsite transfers.
- Listing of all management practices to control nutrient runoff from site
- When soil P levels are above an agronomic level of 30 ppm, include a discussion of the risk associated with P accumulation and a proposed P draw-down strategy.
- If soil P concentrations are expected to increase above an agronomic level (i.e., when N-based rates are used), E/NMP must include the following documentation:
- Soil P levels at which it is desirable to convert to P-based planning.
- A long-term strategy and proposed implementation timeline for soil test P drawdown from the production and harvesting of crops.
- Management activities or techniques used to reduce the potential for P transport and loss.
- Calculation of manure produced in excess of crop nutrient requirements.

OPERATION AND MAINTENANCE

Dairy producers shall review or revise plans at least annually to determine if adjustments or modifications are needed with each soil test cycle, P Site Index calculation, and change in crop type, crop and manure management, or volume analysis. E/NMPs must also be updated or revised when a dairy farm alters the number of acres available for nutrient application (i.e. – bought or sold acreage) or makes any other operational change that impacts the phosphorus excretion from the dairy farm.

Changes greater than ten (10%) percent in animal numbers or a change in feed management shall necessitate additional manure analyses to establish a revised average nutrient content. Grade A dairy farms implementing such changes into their operation shall be required to submit a revised/updated E/NMP document to be approved by ISDA.

Document the nutrient application rate. When the applied rate differs from the planned rate, provide appropriate documentation to explain the difference.

Maintain records for at least 5 years to document plan implementation and maintenance. Records must include—

- All test results (soil, water, compost, manure, organic by-product, and plant tissue sample analyses) upon which the nutrient management plan is based.
- Listing and quantification of all nutrient sources that are planned for use and documentation of all nutrient imports, exports and onsite transfers.
- Date(s), method(s), and location(s) of all nutrient applications.
- Plants and crops planted, planting and harvest dates, yields and plant or crop residues removed.
- Dates of plan review, name of reviewer, and recommended adjustments resulting from the review.

Suggested additional records include:

- Irrigation Water Management evaluations
- Recommended conservation practices and management actions that can reduce the potential for nutrient movement.

Nutrient Stewardship and Best Management Practices

Manage nutrients based on the 4Rs of nutrient stewardship—apply the right nutrient source at the right rate at the right time in the right place—to improve nutrient use efficiency by the crop and to reduce nutrient losses to surface and groundwater and to the atmosphere.

Nutrient Source.
Choose nutrient sources compatible with application timing, tillage and planting system, soil properties, crop, crop rotation, soil organic content, and local climate to minimize risk to the environment.

Determine nutrient values of all nutrient sources (e.g. commercial fertilizers, manure, organic by-products, biosolids) prior to land application.

Determine nutrient contribution of cover crops, previous crop residues, and soil organic matter.

In areas where salinity is a concern, select nutrient sources that limit the buildup of soil salts. When manures are applied, and soil salinity is a concern, monitor salt concentrations to prevent potential plant or crop damage and reduced soil quality.

Apply manure or organic by-products on legumes at rates no greater than the UI estimated N removal rates in harvested plant biomass, not to exceed P risk assessment limitations.

For any single application of nutrients applied as liquid (e.g., liquid manure, nutrients in irrigation water, fertigation)—

- Do not exceed the soil's infiltration rate or water holding capacity.
- Apply so that nutrients move no deeper than the current crop rooting depth.
- Avoid runoff or loss to subsurface tile drains.

Nutrient Rate.
Plan nutrient application rates for N, P, and K using UI recommendations or industry practices when recognized by the UI.

Nitrogen testing should be conducted using soil samples that were collected and testing in the same planting season, prior to land application, and after the average daily temperature rises above 50^{o}F. Nitrogen planning using soil test results older than thirty (30) days is unreliable and will result in an inaccurate management plan. It is recommended to use the current approved N balance sheet (See Forms) to track N inputs and outputs from fields.

At a minimum, determine the rate based on crop/cropping sequence, current soil test results, and ISDA approved nutrient risk assessments (Phosphorus Site Index Evaluation) using realistic yield goals.

Use plant tissue testing, when applicable, for monitoring or adjusting the nutrient management plan in accordance with UI guidance, or industry practice when recognized by the UI.

For new crops or varieties where UI guidance is unavailable, industry-demonstrated yield and nutrient uptake information may be used when approved by ISDA.

Estimate realistic yield potentials or realistic yield goals using UI procedures or based on historical yield or growth data, soil productivity information, climatic conditions, nutrient test results, level of management, and/or local research results considering comparable management and production conditions.

Calibrate application equipment to ensure accurate distribution of material at planned rates. For products too dangerous to calibrate, follow equipment manufacturer guidance on proper equipment design, plumbing, and maintenance.

Nutrient Application Timing and Placement.
Consider the nutrient source, management and production system limitations, soil properties, weather conditions, drainage system, and P site index assessment to develop optimal timing of nutrients. For N, time the application as closely as practical with plant and crop uptake. For P, planned surface application when runoff potential is low.

For crop rotations or multiple crops grown in one year, do not apply additional P if it was already added in an amount sufficient to supply all crop nutrient needs.

To avoid salt damage, follow UI recommendations for the timing, placement, and rate of applied N and K in starter fertilizer and manure or follow industry practice recognized by the UI.

Apply conservation practices to avoid nutrient loss and control and trap nutrients before they can leave the field(s) by surface, leaching, or subsurface drainage (e.g., tile, other drainage) when there is a significant risk of transport of nutrients. Suggested best management practices (as defined in the 2017 Idaho Phosphorus Site Index) include, but are not limited to: Contour Farming, Cover & Green Manure Crop, Dike or Berm, Drip Irrigation, Filter Strip, PAM – Furrow Irrigation, PAM – Sprinkler Irrigation, Residue Management/Conservation Tillage, Sediment Basin, Tailwater Recovery & Pumpback Systems, Established Perennial Crop.

When irrigating, apply irrigation water in a manner that reduces the risk of nutrient loss to surface and ground water.

ADDITIONAL CONSIDERATIONS

Excessive levels of some nutrients can cause induced deficiencies of other nutrients, (e.g., high soil test P levels can result in zinc deficiency in corn).

Use soil tests, plant tissue analyses, and field observations to check for secondary plant nutrient deficiencies or toxicity that may impact plant growth or availability of the primary nutrients.

Do not apply K in situations where an excess (greater than soil test K recommendation) causes nutrient imbalances in crops or forages.

Monitor fields receiving animal manures and biosolids for the accumulation of heavy metals.

Use winter hardy grass cover crops to take up excess N after the main growing season, and include the contribution of the N to next plant or crop in fertilizer calculations.

Use conservation practices that slow runoff, reduce erosion, and increase infiltration (e.g., filter strip, contour farming, or contour buffer strips).

Use application methods, timing, technologies or strategies to reduce the risk of nutrient movement or loss, such as—

- Split nutrient applications.
- Banded applications.
- Injection of nutrients below the soil surface.
- Incorporate surface-applied nutrient sources when precipitation capable of producing runoff or erosion is forecast within the time of a planned application.
- High-efficiency irrigation systems and technology.
- Enhanced efficiency fertilizers
    - Slow or controlled release fertilizers
    - Nitrification inhibitors
    - Urease inhibitors.
- Drainage water management.
- Tissue testing, chlorophyll meters, or real-time sensors.

Use legume crops and cover crops in lieu of commercial fertilizers to provide nitrogen through biological fixation and nutrient recycling.

Modify animal feed diets to reduce the nutrient content of manure following guidance contained in Conservation Practice Standards (CPS) code 592, Feed Management.

Use the adaptive nutrient management learning process to improve nutrient use efficiency on farms as outlined in the NRCS National Nutrient Policy in GM 190, Part 402, Nutrient Management.

Protect workers from and avoid unnecessary contact with nutrient sources. Take extra caution when handling anhydrous ammonia or when managing organic wastes stored in unventilated tanks, impoundments, or other enclosures.

Use material generated from cleaning nutrient application equipment in an environmentally safe manner. Collect, store, or field apply excess material in an appropriate manner.

REFERENCES and RESOURCES

Certified Manure Testing Laboratories. http://www2.mda.state.mn.us/webapp/lis/manurelabs.jsp

ISDA. Phosphorus Site Index. https://agri.idaho.gov/main/wp-content/uploads/2018/01/Phosphorus-Site-Index-reference-2017-revised.pdf

North American Proficiency Testing Program Certified Soil Testing Laboratories. https://www.naptprogram.org/pap/labs

University of Idaho. Soil Sampling. Bulletin 704. http://www.cals.uidaho.edu/edcomm/pdf/ext/ext0704.pdf

University of Idaho. Manure and Wastewater Sampling. CIS 1139. http://www.cals.uidaho.edu/edcomm/pdf/cis/cis1139.pdf

University of Idaho. Irrigation Scheduling: Using water-use tables. CIS 1039. https://www.cals.uidaho.edu/edcomm/pdf/CIS/CIS1039.pdf

USDA NRCS. Conservation Practice Standard. Feed Management. Code 592. https://efotg.sc.egov.usda.gov/references/public/WI/Archived_592_WI_CPS-(2016-07)_171011.pdf

USDA NRCS. Adaptive Nutrient Management Process. Agronomy Technical Note No. 7. https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=33791.wba

NITROGEN MANAGEMENT PLAN WORKSHEET

NAME ____

Crop Year (Harvested) ___________________________

Field ID _______________________________________

Acres ____

Crop Nitrogen Management Planning		**N Applications/Credits**	**Recommended/ Planned N**	**Actual N**
1. Crop		**Manure/Organic Material N**		
2. Production Unit		8. Available N in Manure/Compost (lbs/acre)		
3. Projected Yield (units/acre)		**Nitrogen Fertilizers**		
4. N Recommended (lbs/acre)		9. Dry/Liquid N (lbs/acre)		
		10. Foliar N (lbs/acre)		
Post Production Actuals		**11. Total Available N Applied (lbs/acre)**		
5. Actual Yield (units/acre)		**Nitrogen Credits**		
6. Total N Applied (lbs/acre)		12. Available N in soil (lbs/acre)		
7. N Removed (lbs/acre)		13. N in Irrigation Water (lbs/acre)		
Notes:		**14. Total N Credits (lbs/acre)**		
PSNT Test:		**15. Total N Applied & Available**		

Certified By:	
Date:	

Instructions

1. This is the crop that is planted in the year for which the information is recorded.
2. This is the crop yield units ie. bushels, tons, cwt, etc.
3. Projected yield (units/acre). This is the yield that you are anticipating for this crop in this year.
4. N Recommended (lbs/acre). This is the amount of N recommended based on the projected yield.
5. Actual Yield (units/acre). The actual harvested yield on this field for this crop.
6. Total N Applied (lbs/acre). The actual amount of total N that was applied to this crop during this season from line 11.
7. N Removed (lbs/acre). The amount of N that was removed with the crop (calculated by summing all of the biomass removed multiplied by the tissue N concentration of the different biomass pools)
8. Available N in Manure/Compost (lbs/acre). This is the total amount of plant available N applied for the growing season including previous fall applications. Use Table 1 to determine the % PAN of total N in manure/compost/liquid/slurry etc.
9. Dry/Liquid N (lbs/acre). This is the total amount of N applied as fertilizer including starter fertilizer, broadcast applications, in season side-dress applications and any N applied with irrigation.
10. Foliar N (lbs/acre). This is the total amount of N applied as a foliar spray during the growing season.
11. Total Available N Applied (lbs/acre). This is the sum of blocks 8, 9 and 10.
12. Available N in soil (lbs/acre). This is determined from pre-plant soil samples collected within 3 weeks of planting. This must include soils from 0 to 12". The lbs/acre is calculated by multiplying the average ppm N (NH_4 + NO_3) in the 0 to 12" sample by 4. It is preferential to account for the N in the top 2' of soil. If you have soil samples from 0 to 12" and 12 to 24" you would multiply each sample by 4 and then add them together (0 to 12" ppm N x 4) + (12 to 24" ppm N x 4). Alternatively, if you only have a 0 to 12" soil sample you could multiply the ppm N x 8 to represent the first 2', however this is not as accurate.
13. N in irrigation water (lbs/acre). If irrigation water contains N, the N applied with irrigation water must be included.
14. Total N Credits (lbs/acre). This is the sum of blocks 12 and 13.
15. Total N Applied and Available. This is the sum of blocks 11 and 14.

Table 1. Plant available N in manure

Manure Source	N available (%)
Lagoon Liquid	80
Lagoon Slurry/Sludge	60
Solid Stacked Manure (corral)	30
Composted Manure	10

Soil Sampling

Environmental concerns have brought nutrient management in agriculture under increased scrutiny. A goal of sound nutrient management is to maximize the proportion of applied nutrients that is used by the crop (nutrient use efficiency). Soil sampling is a best management practice (BMP) for fertilizer management that will help improve nutrient use efficiency and protect the environment.

Soil sampling is also one of the most important steps in a sound crop fertilization program. Poor soil sampling procedures account for more than 90 percent of all errors in fertilizer recommendations based on soil tests. Soil test results are only as good as the soil sample. Once you take a good sample, you must also handle it properly for it to remain a good sample.

A good soil testing program can be divided into four operations: (1) taking the sample, (2) analyzing the sample, (3) interpreting the sample analyses, and (4) making the fertilizer recommendations. This publication focuses on the first step, collecting the soil sample.

Once you take a sample, you must send it to a laboratory for analysis. Then the Extension agricultural educator or fertilizer fieldman in your county can interpret the analysis and make specific fertilizer recommendations. Fertilizer guides from the University of Idaho Cooperative Extension System are also available to help you select the correct fertilizer application rate.

The soil sampling guidelines in this publication meet sampling standards suggested by federal, state, and local nutrient management programs in Idaho.

What is a soil test?

A soil test is a chemical evaluation of the nutrient-supplying capability of a soil at the time of sampling. Not all soil-testing methods are alike nor are all fertilizer recommendations based on those soil tests equally reliable.

Reliable fertilizer recommendations are developed through research by calibrating laboratory soil test values and correlating them with crop responses to fertilizer rates. These soil test correlation trials must be conducted for several years on a particular crop growing on a specific soil type. If soil test calibration is incomplete, fertilizer recommendations based on soil-test results still can only be best guesses.

A soil test does not measure the total amount of a specific nutrient in the soil. There is usually little relationship between the total amount of a nutrient in the soil and the amount of a nutrient that plants can obtain.

A soil test also does not measure the amount of plant-available nutrients in the soil because not all the nutrients in the soil are in a form readily usable by plants. Through research, however, a relationship can usually be established between soil test nutrient levels and the total amount of a nutrient in the soil.

What does a soil test measure?

Present soil-testing methods measure a certain portion of the total nutrient content of the soil. During testing, this portion is removed from the soil by an extracting solution that is mixed with the soil for a given length of time. The solution containing the extracted portion of the nutrient is separated from the soil by filtration, and then the solution is analyzed.

A low soil-test value for a particular nutrient means the crop will be unable to obtain enough of that nutrient from the soil to produce the highest yield under average soil and climatic conditions. A nutrient deficiency should be corrected by adding the nutrient as a fertilizer. The amount of nutrient that needs to be added for a given soil-test value is calculated based on results from the correlation research test plots.

Sampling timing

Because nutrient concentrations in the soil vary with the season, you should take soil samples as close as possible to planting or to the time of crop need for the nutrient. Ideally, take the soil samples 2 to 4 weeks before planting or fertilizing the crop. It usually requires 1 to 3 weeks to take a soil sample, get the sample to the testing laboratory, and obtain results.

Sampling very wet, very dry, or frozen soils will not affect soil test results though collecting soil samples under these conditions is difficult. Do not sample snow–covered fields. The snow makes it difficult to recognize and avoid unusual areas in the field, so you may not get a representative sample.

Sampling frequency

For best soil fertility management, especially for the mobile nutrients, sample each year and fertilize for the potential yield of the intended crop. Having an analysis performed for every nutrient each year is not necessary. Whether you need an analysis of a nutrient depends on such things as its mobility in the soil and the nutrient requirements of the crop.

Take soil samples at least once during each crop rotation cycle. Maintain a record of soil test results on each field to evaluate long-term trends in nutrient levels.

Sampling procedure

One of the most important steps in a soil testing program is to collect a soil sample that represents the area to be fertilized. If the soil sample is not representative, the test results and recommendations can be misleading.

The correct steps in soil sampling are illustrated in figure 1. Before sampling, obtain necessary information, materials, and equipment from the Extension agricultural educator or fertilizer fieldman in your county.

Use proper soil sampling tools. A soil auger or probe is most convenient, but you can use a shovel or spade for shallow samples. You will need a plastic bucket or other container for each sample to help you collect and mix a composite sample.

Be sure that all equipment is clean, and especially be sure it is free of fertilizer. Even a small amount of fertilizer dust can result in a highly erroneous analysis. Do not use a galvanized bucket when analyzing for zinc (Zn) or a rusty shovel or bucket when analyzing for iron (Fe). If the sample will be analyzed for Fe or manganese (Mn), do not dry the soil sample before shipping.

When sampling, avoid unusual areas such as eroded sections, dead furrows, and fence lines. If the field to be sampled covers a large area with

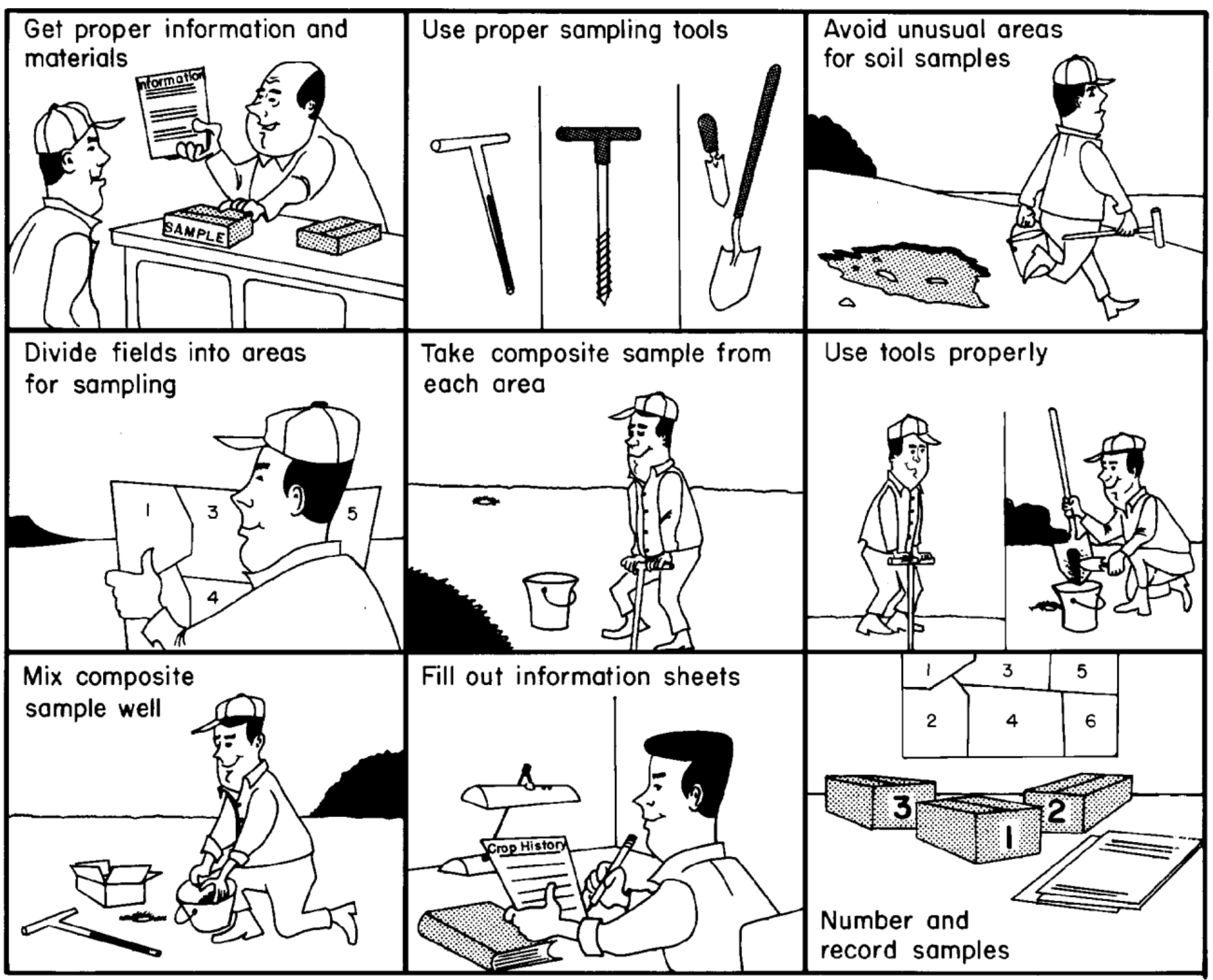


Fig. 1. Follow these steps to obtain a good sample for testing (redrawn courtesy of the National Fertilizer Institute).

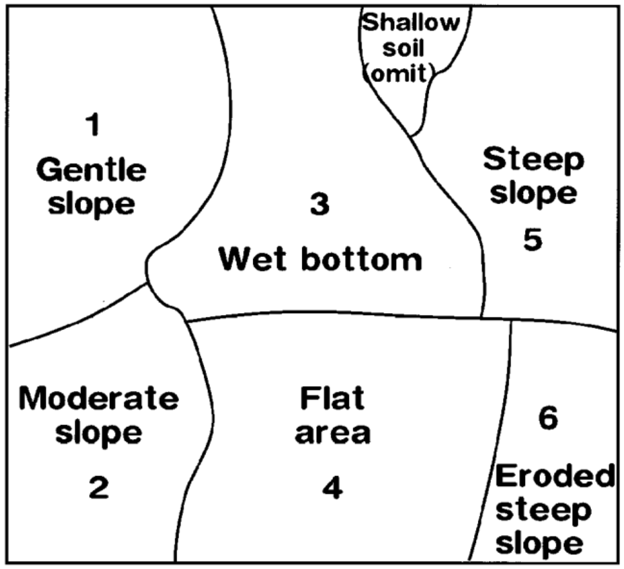


Fig. 2. A field with areas identified as sampling units.

Table 2. Effective rooting depth for some common Idaho crops.

Crop	Depth (feet)
Cereals (wheat, barley, oats)	5 to 6
Corn	5 to 6
Alfalfa, rapeseed	4 to 5
Hops, grapes, tree fruits	4 to 5
Sugarbeets	2 to 3
Peas, beans, lentils, onions, potatoes, mint	2
Vegetable seed	1 to $1\frac{1}{2}$

varied topography, subdivide it into relatively uniform sampling units (fig. 2). Sampling subdivision units that are too small to fertilize separately may be of interest, but impractical if you do not treat the small units differently from the rest of the field. Omit these areas from the sampling.

Within each sampling unit take soil samples from several different locations and mix these subsamples into one composite sample. The number of subsamples needed to obtain a representative composite sample depends on the uniformity and size of the sampling unit (table 1). Although the numbers of subsamples in table 1 give the best results, they may be unrealistic if you plan to take a great number of samples. An absolute minimum of 10 subsamples from each sampling unit is necessary to obtain an acceptable sample. The more subsamples you take, the better the representation of the area sampled.

Table 1. Number of subsamples recommended for a representative composite sample based on field size.

Field size (acres)	Number of subsamples
fewer than 5	15
5 to 10	18
10 to 25	20
25 to 50	25
more than 50	30

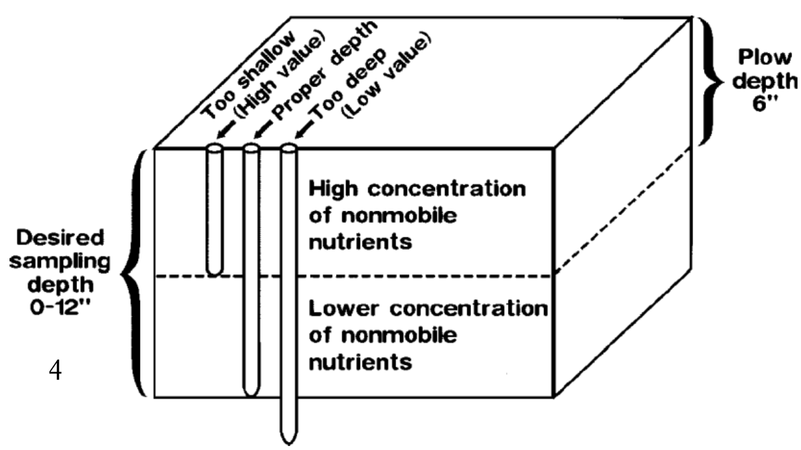
Take all subsamples randomly from the sampling unit, but be sure to distribute subsample sites throughout the sampling unit. Meander or zig-zag throughout each sampling unit to sample the area. Special considerations are necessary in eroded areas, furrow irrigation, under no-till, and where fertilizer is banded (see "Special Sampling").

The total amount of soil you collect from the sampling unit may be more than you need for analyses. Mix the individual subsamples together thoroughly and take the soil sample from the composite mixture. The composite sample should be at least 1 pint—about 1 pound—in size.

Sampling depth

Depth of sampling is critical because tillage and nutrient mobility in the soil can greatly influence nutrient levels in different soil zones (fig. 3). Sampling depth depends on the crop. cultural practices, tillage depth, and the nutrients to be analyzed.

Because the greatest abundance of plant roots, greatest biological activity,



and highest nutrient levels occur in the surface layers, the upper 12 inches of soil are used for most analyses. The analyses run on the surface sample include soil reaction (pH), phosphorus (P), potassium (K), organic matter, sulfur (S), boron (B), zinc (Zn), and other micronutrients.

Sampling depth is especially critical for nonmobile nutrients such as P and K. The recommended sampling depth for nonmobile nutrients is 12 inches (fig. 3).

The tillage zone, typically 6 to 8 inches deep, usually contains a relatively uniform, high concentration of nonmobile nutrients. Below the tillage zone the concentration is usually lower. Therefore, a sample from the tillage zone will usually have a higher content of nonmobile nutrients than a sample from the desired 0- to 12-inch sample depth. This can lead to erroneous results.

Depth sampling

When sampling for mobile nutrients such as nitrogen (N), boron (B), and sulfur (S), take samples by 1-foot increments to the effective rooting depth of the crop (fig. 4). This can be a depth of 5 to 6 feet (table 2) unless the soil has a root-limiting layer such as bedrock or hardpan. For each foot depth, take 10 or more subsamples at random from the sampling unit.

If you plan to sample less than a year after banding or injecting fertilizer or if you have any question about fertilizer placement, use the sampling technique described under "Areas Where Fertilizer Has Been Banded." Irrigation or precipitation should disperse mobile nutrients over a period of a year.

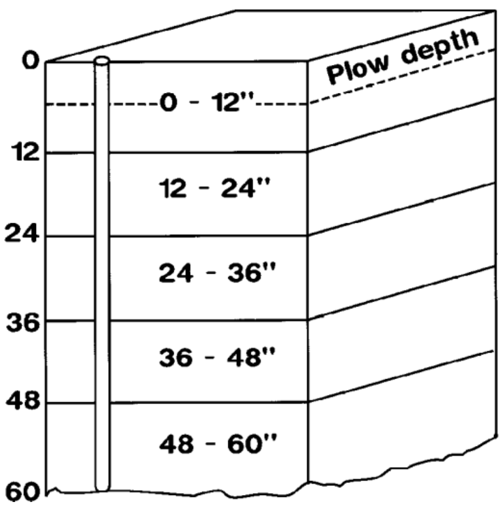


Fig. 4. Depth sampling (successive samples by 12-inch increments) for mobile nutrients (especially N) should be continued to rooting depth, which may be 5 to 6 feet for some crops.

Sample handling

Soil samples need special handling to ensure accurate results and minimize changes in nutrient levels because of biological activity. Keep moist soil samples cool at all times during and after sampling. Samples can be frozen or refrigerated for extended periods of time without adverse effects.

If the samples cannot be refrigerated or frozen soon after collection, air dry them or take them directly to the soil testing laboratory. Air dry by spreading the sample in a thin layer on a plastic sheet. Break up all clods or lumps, and spread the soil in a layer about 1/4 inch deep. Dry at room temperature. If a circulating fan is available, position it to move the air over the sample for rapid drying.

Caution: Do not dry where agricultural chemical or fertilizer fumes or dust will come in contact with the samples. Do not use artificial heat in drying. Ask the Extension agricultural educator or fertilizer fieldman in your county for more details concerning special handling of soil samples.

When the soil samples are dry, mix the soil thoroughly, crushing any coarse lumps. Take from the sample about 1 pint (roughly 1 pound) of well-mixed soil and place it in a soil sample bag or other container. Soil sample bags and soil test report forms are available from the Cooperative Extension System office in your county or from a fertilizer fieldman.

Label the bag carefully with your name, the sample number, sample depth, and field number. The field number should correspond with a field or farm map showing the areas

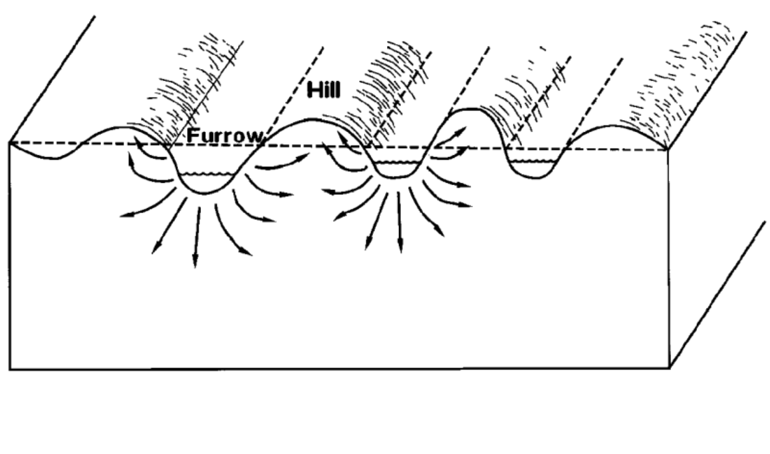


Fig. 5. Movement of mobile nutrients in furrow-irrigated fields.

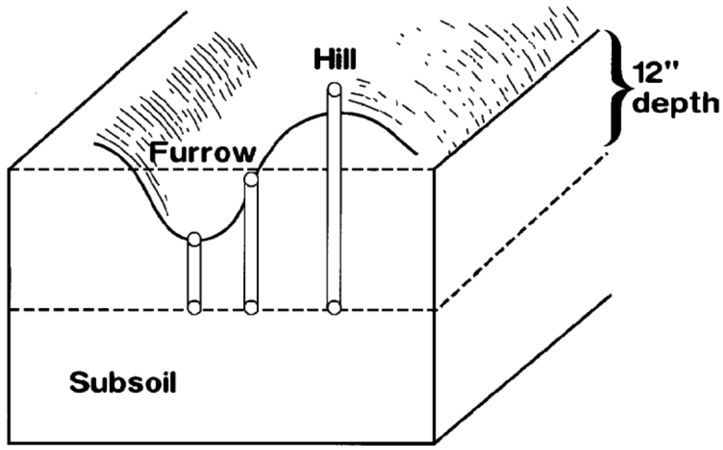


Fig. 6. Special sampling techniques are required when soil sampling furrow-irrigated fields.Take a sample from the hilltop, the furrow bottom, and at the midpoint between the hilltop and furrow bottom.The 12-inch sampling depth is based on the midpoint sampling location.

sampled.This will help you keep an accurate record of soil test reports. Provide information on crop to be grown, yield potential, recent history of crops grown, yields, fertilizer applied, and other information.

Sample analysis

Analyze regularly only for those nutrients that have been shown to be yield limiting in your area or for the crop to be grown. In general, all soils should be analyzed for N, P, K, and S. For determination of potential need for micronutrients, refer to PNW 276, *Current Nutrient Status of Soils in Idaho, Oregon, and Washington.* Occasional analyses for micronutrient concentrations may be advisable.

Special sampling

Special sampling problems occur in fields that have been leveled for irrigation, fields that have lost all or most topsoil as a result of erosion, fields that are surface (furrow) irrigated, fields that have had a fertilizer band applied, and fields that are not thoroughly tilled.

Land-leveled and eroded areas

Areas that have been eroded or artificially leveled for irrigation usually have little or no original topsoil.The soil surface may be exposed subsoil material.These areas should be sampled separately if they are large enough to be managed differently from where topsoil has not been removed. Subsoil material is usually low in organic matter and can be high in clay, calcium carbonate (lime), or both.

Furrow-irrigated fields

For a representative soil sample, sample furrow-irrigated fields before the furrowing operation. If furrowing has already been completed, follow the special sampling procedures described here.

The movement of water and dissolved plant nutrients can create unique nutrient distribution patterns in the hills between the furrows (fig. 5).To obtain a representative sample, you need to be aware of furrow direction, spacing, and location, and to take closely spaced soil samples perpendicular to the furrow (fig. 6).

Approximately 20 sites (with at least three samples per site) are needed for a representative composite soil sample. At each sampling site, take a sample from the hilltop, from the midpoint between the hilltop and furrow, and from the furrow bottom.The sampling depth at the midpoint between the hilltop and furrow bottom should be 12 inches.The bottom point of this sample should be the same as for the furrow and hilltop samples.Thus, the furrow sampling depth will be less than 12 inches, while the hilltop sampling depth will be more than 12 inches (fig. 6).

Mix the hilltop, midpoint, and furrow samples to make a composite sample for each site. Mix the site samples for a representative composite field soil

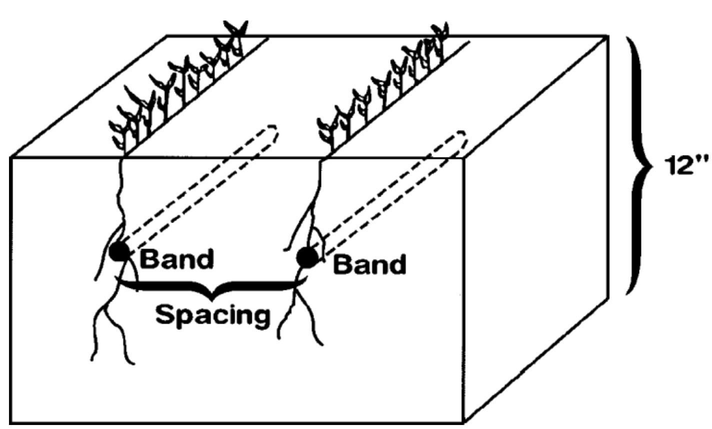


Fig. 7. Diagram of fertilizer location in soil where fertilizer has been banded.

sample to be analyzed for nonmobile nutrients (P, K, and micronutrients). Deeper profile sampling (depth sampling) is recommended for mobile nutrients (N and S).

Areas where fertilizer has been banded

Banding of fertilizers is becoming a more common practice (fig. 7). In fields where fertilizers have been banded and tillage has occurred before soil sampling, regular sampling procedures can be followed. However, if tillage has not adequately mixed the soil, special soil sampling is required. If a field has had a banded fertilizer application the previous growing season and has not been plowed, an ideal sample would be a continuous slice 1 to 2 inches thick and 12 inches deep extending from the center of one band to the center of the next band.

Little research has been conducted to determine the best method of sampling banded fields. Currently three different approaches are used widely. Each method produces a satisfactory representative sample, but the effort required to obtain these samples differs considerably.

Systematic sampling method. If you know the direction, depth, and spacing of the fertilizer band, you can obtain a representative soil sample with this sampling procedure. Take 5 to 10 soil samples perpendicular to the band row beginning in the edge of a fertilizer band and ending at the edge of an adjacent band (fig. 8). Follow this procedure on at least 20 sampling sites in each field or portion of a field being sampled. Mix and composite the soils collected from each site to obtain a representative soil sample.

Controlled sampling method. You also should know the direction, depth, and spacing of the fertilizer bands to obtain a representative soil sample with this method. Take 20 to 30 soil cores from locations scattered throughout the field or portion of the field. Avoid sampling directly in a fertilizer band.

The composite sample should adequately represent the area being sampled. This method may result in slightly lower soil test values of nonmobile nutrients (P, K, and micronutrients) than the systematic and random sampling methods.

Random sampling method. Use this sampling method when the location of the previous season's fertilizer bands is not known. Take 40 to 60 random soil cores to form a composite sample of the area being sampled.

Reduced tillage or no-till fields

You may need special approaches to soil sampling with reduced tillage or no-till fields because the soil has been disturbed so little that fertilizer, whether broadcast on the surface or banded below the surface, is not mixed into the soil. You need to know the history of fertilization, tillage, and other management practices to determine how to obtain a representative sample.

If nonmobile nutrients (P, K, and micronutrients other than B) have been surface broadcast and little or no tillage has been used since their application, remove the surface 1 inch of soil before sampling. Nutrients in the top inch of soil will probably not be available to the growing crop.

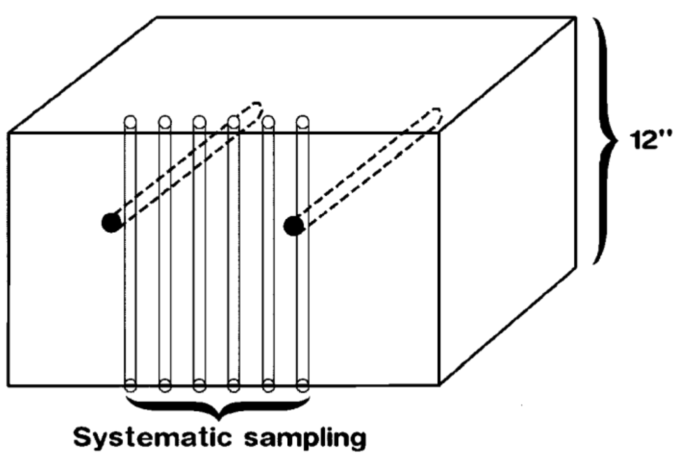


Fig. 8. Systematic soil sampling in a field where fertilizer has been banded (sampling method 1).

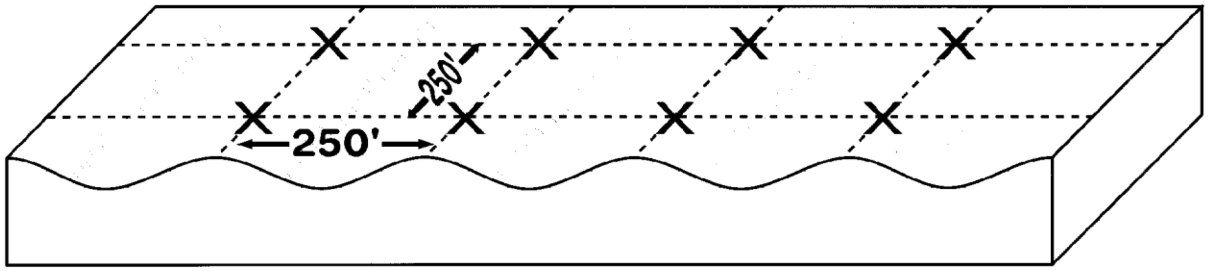


Fig. 9. Grid soil sampling pattern where samples are collected every 250 feet. Note that a complete soil sample is collected at each spot marked with an X.

If fertilizer has been banded with the no-till system, consider methods suggested in "Areas Where Fertilizer Has Been Banded." If a field has been under a continuous no-till system for a long time, determine the pH of the surface foot at 3-inch intervals (0 to 3, 3 to 6, 6 to 9, 9 to 12 inches) every 3 to 5 years. Soil pH will affect the availability of fertilizer nutrients as well as the activity of commonly used herbicides, insecticides, and fungicides.

Grid sampling in nonuniform fields

Many fields are not uniform and vary both horizontally and vertically across landscapes. Traditional soil sampling procedures average nutrient levels in soil subsamples to determine average nutrient levels in the field. The nutrient values obtained are good, but the manager must realize that many of the values in the field are either less than or greater than the values determined. When fields are broken into grids with shorter distances between the sampling points a more precise soil map can be developed to determine nutrient needs.

The technology is now available to combine grid sampling with variable rate fertilizer application to handle spatial variability within a field. These application techniques make fertilizer nutrient application more precise, resulting in greater nutrient use efficiency and reducing pollution potential.

Irrigated fields including individual pivots should be set up in a 200- to 300-foot grid for potato, sugarbeets, corn, and other potentially high-N-use crops (fig. 9). A wider grid of 400 feet may be used for small grains, beans, and other crops where N management is less intensive or under dryland conditions.

Soil nutrient needs for each segment of the grid are entered into a computer-driven system mounted on specialized commercial fertilizer application equipment. Variable rates of nutrients are then applied based on individual soil samples over the entire field.

A similar system designed for fertilizer applications through pivot sprinklers is being developed by the University of Idaho. This system has the potential to apply variable rates of nutrients and water specifically related to changes across individual fields.

The Soil Conservation Service has a digitized soil survey information system (SSIS), which when combined with the results of grid sampling provides specific information and recommendations for soils and soil types within a field. The SSIS can locate pockets of sandy or coarse-textured soils where leaching is a major concern or areas of finer-textured soils where pockets of residual N may occur. The SSIS also indicates where erosion or surface runoff may be high and where areas should be targeted for federal programs such as the Conservation Reserve Program.

Another computer-mapping technique, Geographic Information Systems (GIS), can be combined with the results of grid sampling to provide growers and land managers with information for land-use planning.

Additional information on proper soil sampling procedures can be obtained from the Extension agricultural educator or fertilizer fieldman in your county.

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