2022 DISTRICT SOILS PROGRAM

IMPORTANT - DIRT MUST BE DRY & FREE OF LARGE CLUMPS

AIR DRY ON NEWSPAPER & CRUMBLE

Application Date ____________________

Name____________________

Address____________________

City____________________**Zip**__________

Phone____________________

Email ____________________

Soil Test: __**Garden** __**Hay** __**Lawn**

__**Orchard** __**Pasture Land** __**Silage**

__**Forage Testing**

Send Results_____**Email Results Phone**

When Results Are In _____

Landowner may bring their dried soil samples and/or forage samples to the SWCD office to be sent into a certified lab. (Bin outside office door)

The SWCD will handle shipping and pay for the soils test costs at no charge for Dearborn County landowners. Soil samples eligible are: gardens, hay land, lawns, pasture land, and orchards.

Shipping bags are available at the SWCD office.

Also, the SWCD has a hay probe available for loan to Dearborn County landowners at no charge, and the district will ship and pay for the forage testing.

Any questions, please contact **Vickie Riggs at vickie.riggs@in.nacdnet.net**
Dearborn County SWCD office at
812-926-2406 ext. 3 or
Work Cell 812-532-9799

Sample#	Farm #	Tract #	Field #	Acres	Crop

DATE SAMPLE SHIPPED ____________________

SAMPLE (S) ____________________

UPS COST ____________________

TOTAL COST: $ ____________________

DO NOT USE TOP 3" - GO DOWN AND GATHER SOIL 3" - 5" DEEP

NRCS Natural Resources Conservation Service

Soil Testing

Small Scale Solutions for your Farm in Indiana

Do You Have Problems With:

- Nutrient deficiencies in crops
- Poor plant growth and response from applied fertilizers
- Hard to manage weeds
- Low crop yields
- Poor quality forages
- Irregular plant growth in your fields
- Managing manure or compost applications

Soil Tests help to Identify Production Problems

Soil Testing Can Help

Benefits of Soil Testing:

- Determines nutrient levels in the soil
- Determines pH levels (lime needs)
- Provides a decision making tool to determine what nutrients to apply, how much, and when
- Potential for higher yielding crops
- Potential for higher quality crops
- More efficient fertilizer use

Soil Sampling—Take 15-20 Cores for One Sample

Costs:

Generally soil tests cost $7 to $10.00 per sample.

The costs of soil tests vary depending on:

1. Your state.
2. The lab that is used.
3. The items being tested for (the cost increases as more nutrients are being analyzed).

NOTE: Most labs charge $7-$10 for the basic test which typically includes analyses for a wide range of items (pH, available phosphorus, nitrogen, potassium, calcium, magnesium, and organic matter). Additional costs may be charged for testing for micronutrients. One soil test should be taken for each field, or for each 20 acres within a field. See example on page 3.

Soil Testing

How Often Should I Soil Test?

Generally every 3-5 years. More often if manure is applied or you are trying to make large nutrient or pH changes in the soil.

Don't Guess—Soil Test

When to soil test?

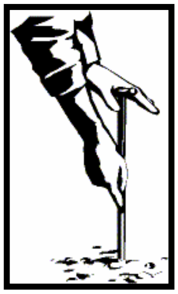
Sample fields the same time each year to achieve more accurate trends in the soil fertility.

- For cropland and vegetable production, it is best to sample in the fall of the year
- For pastures and perennial crops, it is best to sample during the late summer period

How to soil test?

1. **Find or select a soil testing lab.**
   Your local NRCS office or Extension office can provide information on labs that are available in your area

2. **Tools Needed:**
   - Clean plastic pail to collect soil samples.
   - Soil sampling tube, auger, or spade
   - Large paper or plastic bag to hold 15-20 soil cores or sub-samples (grocery bags work well)
   - Sample bag/box from the soil test lab



Soil Sampling Tube

3. **Sampling Depth:**
   - For fields that are plowed or chisel plowed (8 inches deep)
   - For fields that are no-tilled consistently (8 inches deep for P and K and a sample 4 inches deep for pH)
   - Pasture fields are generally sampled to a depth of 4 inches

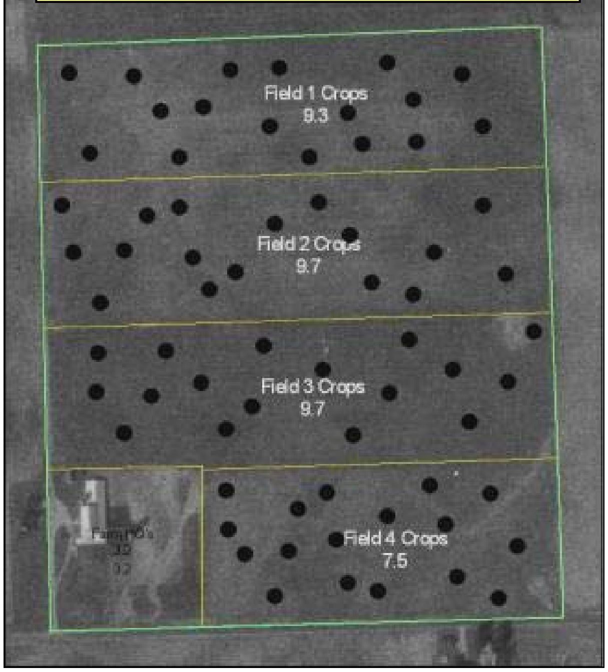
Sample Depth for Pastures is 4 Inches.

4. **Sampling areas to avoid:**
   - Farm lanes and field borders
   - Fertilizer bands in crop rows
   - Any area that is very different from the rest of the field: (severely eroded areas, sandy spots, wet areas)

Sample Depth for Cropland is 6-8 Inches

Soil Testing

The black dots represent the 15-20 "zigzag" sample points within the field to get "one" field soil test sample.



Collecting the Soil Sample:

1. Divide the sampling areas by field and areas less than 20 acres within a field
2. Use a random zigzag pattern across the sampling field/area
3. Collect 15 to 20 individual samples at the required depth (usually 8 inches) to represent the **"one"** sample for the area and place the samples in the plastic pail
   - If using a soil auger or soil core tool to collect samples: simply put all the sub-samples in the plastic pail
   - If using a spade to collect samples: (1) remove a spade of soil to the desired depth and lay to the side, (2) remove a thin slice of soil to the desired depth and place in the plastic sample pail
4. After collecting and placing the 15-20 sub-samples in the plastic pail:
   - Pour the entire amount into a plastic or paper grocery bag (if taking more than one soil test) – then continue taking the next field sample
   - Take the sample from the grocery bag and pour it out on newspaper where it can air-dry (**do not add heat or microwave**)
   - When the soil is dry, mix the entire sample then place enough of the soil in the soil testing bag/box
   - Complete the sample information form for sample identification, field history, and planned crops

What Does a Soil Test Provide?

1. The pH level in your soil. This will tell you if you need to apply lime.
2. The plant available nitrogen (N), phosphorus (P), and potassium/potash (K) levels. This will tell you if you have sufficient phosphorus and potassium levels or if you need to apply fertilizer to meet your crop needs and yield goals.
3. Magnesium and calcium levels in the soil.
4. If requested, the percent organic matter level in the soil .
5. If requested (depends on the soil testing lab), the soil test report will provide the recommended amounts of nitrogen, phosphorus, and potassium to apply in lbs/acre.

Fertilizer Application

Help is Available

NRCS Natural Resources Conservation Service

SMALL SCALE SOLUTIONS FOR YOUR FARM IN INDIANA

Technical Help Is Available

Your local Natural Resources Conservation Service (NRCS) office has experienced conservationists that can assist you with soil testing and interpreting soil tests. They can also help you develop a Conservation Plan to solve other concerns you have identified on your farm.

There is no charge for our assistance. Simply call your local office to set up an appointment and we will come to your farm. Requests for our assistance are numerous, but we will assist you as quickly as we can.

You may also be eligible to receive financial assistance through a state or federal program. Your NRCS office will explain any programs that are available so you can make the best decision for your operation. All NRCS programs and services are voluntary.

Helping People Help the Land

For More Information Contact the:

Natural Resources Conservation Service at the USDA Service Center for your county
On the web at http://offices.sc.egov.usda.gov/locator/app
Or
Located in the phone book under 'United States Government, United States Department of Agriculture, USDA Service Centers'

AURORA SERVICE CENTER - NRCS/SWCD
10729 RANDALL AVE - AURORA, IN 47001
812-926-2406 EXT. 3

Office hours: M-F, 8:00 am to 4:00 pm (closed on federal holidays)

Reproduced with assistance from Indiana Grazing Lands Conservation Initiative.

ACCOUNT NUMBER
86402

a&lgreatlakes LABORATORIES

Scientists who don't mind getting dirty.™

3505 Conestoga Drive
Fort Wayne, IN 46808
260.483.4759
algreatlakes.com

LAWN & GARDEN SOIL TEST

REPORT TO		FOR	
Name	DEARBORN COUNTY SWCD	Name	
Street	10729 RANDALL AVE	Street	
PO Box	812-926-2406 ext. 3	PO Box	
City, State, Zip	AURORA, IN 47001	City, State, Zip	
E-mail Address	vickie.smith@in.nacdnet.net	E-mail Address	

SAMPLE INFORMATION

LAB USE ONLY	SAMPLE ID	TEST PACKAGES*			TO BE GROWN*		
		S10	S11	OTHER	OPTION 1	OPTION 2	OPTION 3

*TEST PACKAGES AND FEES (per sample)

Payment must accompany samples unless prior arrangements are made. Reports will be mailed within 3-4 working days after samples are received.

S10 **Basic Test** - $20.00 (includes up to 3 fertilizer recommendations selected from FERTILIZER RECOMMENDATION OPTIONS)
Analyses include organic matter, phosphorus, potassium, calcium, magnesium, CEC, pH and buffer pH. Graphic report format.

S11 **Complete Test** - $30.00 (includes up to 3 fertilizer recommendations selected from FERTILIZER RECOMMENDATION OPTIONS)
Analyses include organic matter, phosphorus, potassium, calcium, magnesium, sodium, CEC, pH, buffer pH, conductivity, boron, copper, iron, manganese, sulfur, and zinc. Graphic report format.

#FERTILIZER RECOMMENDATION OPTIONS

Lawn & Turf

101 - Lawn Maintenance (established lawn)

102 - Lawn Seeding and Establishment

Garden

109 - Flowers

110 - Fruit Trees

111 - Small Fruits

112 - Vegetable Garden

Landscape

113 - Acid Loving Shrubs

114 - Broadleaf Shrubs

115 - Evergreen Shrubs

116 - Ground Covers

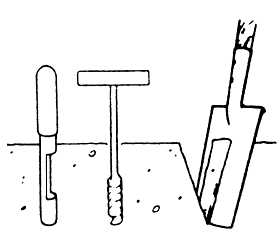
117 - Roses

118 - Shade Trees

Note: These tests and recommendations are not appropriate for greenhouse media and soil mixes.

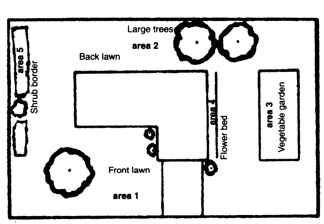
HOW TO TAKE A SOIL SAMPLE

1.



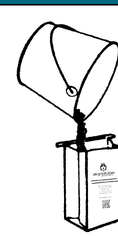
To take the sample, use a sampling tube, spade, trowel or long knife. Sample 6-8 inches deep for gardens shrubs or trees and 3-4 inches for turf. Discard any surface residue, thatch or stones.

2.



Sample different areas of the turf, garden or landscape separately. From each distinct area take several cores or slices.

3.



Combine the cores or slices in a bucket and mix well. Transfer one (1) cup of the mixed sample to a soil sample or plastic bag. Label and number the sample bag.

4.

Enclose the soil sample bag in a shipping box. Place this information sheet along with payment into the box with the samples. Fasten securely and ship via UPS or Parcel Post.

Boron essential for alfalfa, but don't pour on more than needed

Alfalfa growers should consider whether or not boron should be added to their potassium and phosphorus application, said a Purdue University specialist.
Alfalfa requires more boron than other crops for good growth and productivity, said Keith Johnson, Purdue Extension forage management specialist.
"It's an essential micronutrient for all plants, but alfalfa requires higher amounts," Johnson said. "Boron is more likely to be deficient in soils with low organic matter, sandy soils and in the unglaciated soils of southern Indiana."

Symptoms of boron deficiency include a shortening of the plant's internodes, which leads to a shorter plant and yellowing, Johnson said.
"It actually looks very similar to potato leafhopper damage," he said.
Growers should randomly collect the upper 6 inches of 50 alfalfa plants and submit plant tissue to a laboratory for analysis. A tissue analysis costs between $20 and $30 and could more than pay for itself if there is a deficiency, he said. A list of laboratories is available online at http://www.agry.purdue.edu/ext/soiltest.html.

"Because boron is a micronutrient, an application of only 1 to 3 pounds per acre per year is sufficient if the tissue test indicates a need," Johnson said. "It may be that boron only needs to be applied every other year. It's important to have a tissue analysis done because it can be beneficial from a cost savings standpoint, and too much can be toxic for a following corn, soybean or other grain crop."
Growers should check and make sure they get what they asked for from their fertilizer dealers, Johnson said.

"Some may get a standardized mix with potassium, phosphorus and boron when a grower may not need to add boron this year," he said. "It's best to check and make sure everything matches up from what the soil needs to produce a good stand, to what you're purchasing and applying."
Jim Camberato, Purdue Extension soil fertility specialist, said if a tissue analysis shows a need for boron, it can be foliar applied when it's not practical to apply the granular form.

"The foliar application of boron should be sprayed on alfalfa stubble after a cutting if possible and should be limited to no more than 0.5-pound of boron per acre to minimize foliage burn," Camberato said. "If a field is very low in boron, multiple foliar applications may be needed to fulfill the crop's boron requirement."

If boron is combined with a pesticide, growers should check both the fertilizer and pesticide labels to ensure compatibility, Camberato said.

FEED ANALYSIS

A & L SAMPLING GUIDE

A&L Great Lakes Laboratories, Inc.
3505 Conestoga Drive
Fort Wayne, IN 46808
260-483-4759

Agricultural Feed Analysis Sampling Guide

**Accuracy of the feed analysis depends on the sample submitted. Care must be taken to collect a sample representative of the feed lot.

Hay Sampling

Hay may be sampled as it is stored, if it is dry enough to keep without further curing. Different cuttings should be sampled and analyzed separately unless different cuttings are being fed at the same time, in which case they may be sampled in the same proportions as they are being fed.

Hay samples should be taken with a core sampler, if possible.

1. Ensure that tips are sharp enough to cut through the hay to prevent selective sampling.
2. Core sampler should penetrate at least 12”-18” into the bale.
3. If using an electric drill or a hand brace, run the drill at slow speeds. High speeds heat the probe and can damage supplies.
4. At least 12 cores of hay should be taken from random bales or locations if loose or chopped hay.

When sampling hay to be fed on your farm, avoid sampling decayed or moldy hay or other portions of hay that will be discarded or would likely be refused when fed to animals free choice. However, include deteriorated materials if the hay will be ground, sold, or purchased in order to best describe all the hay. Place the entire sample into a plastic bag and seal tightly.

Square or Round Bales

Collect one sample from each of 15-20 bales (from a single lot) by coring straight in from the center of the end of square bales and from the wrapped circumference of round bales. When sampling hay to be fed on your farm, avoid sampling decayed or moldy hay or other portions of hay that will be discarded or would likely be refused when fed to animals free choice. However, include deteriorated materials if the hay will be ground, sold, or purchased in order to best describe all the hay. Place the entire sample into a plastic bag and seal tightly.

Loose or Compressed Hay Stacks

Use a hay probe to collect 15 or more samples from each “lot”. Sample loose hay stacks from the top and from the side. Compressed loaf stacks require six sampling locations: 1) top front, 2) top middle, 3) top rear, 4) lower front side, 5) lower middle side, and 6) lower rear side *(Figure 1)*.

Figure 1. Sampling Compressed Hay Stacks

As different stacks are sampled, alternate the two sides and rotate through the six collection locations. Stand on the stack and insert the probe vertically between feet when top samples are collected. When sides are sampled, use a slight downward angle with the probe to avoid sampling parallel to stems in the stack. As with bales, do not sample deteriorated hay unless it is to be ground prior to feeding, sold, or purchased. Place samples into a plastic bag and seal tightly.

Chopped or Ground Hay

Take about 10 small grab-samples from each “lot” of hay during grinding and place all the samples into one plastic bag. Seal tightly. Sample previously ground or chopped hay beneath the surface. Collect about one-fourth of the samples from the top half of the pile and the rest from the lower half. Avoid allowing fines to sift between fingers.

Pasture

Obtaining a good sample can be difficult due to fertility and moisture differences in a single pasture. Sample by picking at random 8-10 locations. Remove the forage from a square foot area at grazing height. Mix all the collected forage and take a representative sample for analysis.

A second method is to take forage being selectively grazed by the animals at several locations for the sample. This is a preferred method in unimproved pasture where selective grazing is evident.

Sampling Silage, High Moisture Grain, Haylage and Fresh Forage

Silage, high moisture grain, and haylage can be sampled at harvest if moisture content is low enough to prevent seepage. Corn silage at dent stage or beyond should not seep. If seepage is expected, wait until seepage has stopped before sampling, or take samples as it is being fed.

Silage

Silage may be sampled either before it enters the silo or when it is fed. Collect some samples at harvest to use for early rotation balancing.

Sampling at Harvest - Collect silage in a large plastic bucket or container for several representative loads by taking random handfuls (may be taken as loads are brought to the silo). Mix thoroughly and fill plastic sample bag from this composite. Seal and send immediately or you may freeze sample to prevent decomposition, until such time as you are ready to send for analysis. *Use all precautions in preventing moisture loss of material.*

When forage is properly ensiled, results from fresh samples will agree closely with fermented forage. Collect samples at feeding for the most accurate nutritional information for ration formulation. Avoid rotted or poorly preserved material that will not be fed or consumed if fed. Such material often comes from the top of upright silos or from the shallow end and slopes of horizontal silos.

Sampling after Ensiling - Secure random handfuls of silage from at least 10 different spots over the exposed surface area of the silage. If top unloading silo or bunker, dig down a foot or more to secure handfuls to make composite. If sampling as silage is being unloaded, allow unloader to make one or more revolutions before selecting random handfuls for composite.

Upright Silos at Feeding

(Grab sample) Collect 2-3 gallons in 1-2 quart increments by passing a clean plastic container beneath the chute while unloading. Alternatively, collect 20 handfuls from different sections of the feed-bunks while feeding. Avoid contamination with old feed or supplements. Mix and take your sample.

Silage and haylage moisture (percent dry matter content) can vary considerably from one level to another in both upright and horizontal silos. Due to many reasons, such as date of chopping, rainfall, differences in fields, etc., this factor is important when allowing for both the nutrient and fiber content in the diet.

Because silages and haylage are more variable in their dry matter content than feeds stored in the dry form, it's important to continue monitoring their moisture level on a regular basis during the feeding period. The testing interval, however, will depend on how fast the silo is emptied.

Horizontal Silos

Collect 20 or more grab samples from numerous sites off the exposed face of the silo to represent the entire exposed surface. Sample to the depth as is removed during daily feeding. Sampling from the bunk may be easier and provide an equally representative sample. Mix and subsample.

Trench Silo

If silo is open, the face of the silage should be cleaned off in the center. A column of silage 6 inches by 12 inches should be removed from top to bottom, mixed thoroughly, and then a representative sample taken.

Where the silo is not opened, a series of (four to six) holes can be dug from the top with a post hole digger or suitable equipment. Spoiled silage should be placed beside the hole to be returned after sampling. The samples of good silage from each hole are mixed and a representative sample taken. Be sure holes are packed tightly with the silage that has been removed to avoid undue spoilage.

Forage Crops in the Field

Sample the plants from several (8 to 10) locations in the field at normal harvesting heights. Whenever possible, chop the forage into small pieces (1 to 2 inch), mix, and remove a representative sample.

Sacked Feed

Although most sacked feed is already mixed, it is recommended that several sacks be sampled, mixed, and a representative sample (1 pound) be submitted for analysis. **Be aware that settling is common, even in sacked feed, making thorough sampling important.

Bulk Concentrates

Commodity feeds should be analyzed as a composite of at least 10-15 areas of a given lot of feed. When mixing the composite, avoid segregation by particle size or the true sample value may be distorted. At least 1 pound, or a quart of material, should be sent to the laboratory.

Grain in Bin

It is highly desirable to use a grain probe to obtain the sample. However, if one is not available, random grab-samples from 10-15 areas of the bin can be mixed and a representative sample (1 quart) sent in for analysis.

Sample Handling

Place samples in polyethylene freezer bags and seal tightly so the laboratory can determine a dry matter concentration similar to that in the sample when collected. Double-bag silage samples for extra protection. Use extra caution if subdividing a large hay sample. Subsampling dry hay often results in loss of fines and leaves. Although subsampling of silage and mixed feed is easier, use care to obtain a sample similar to the entire lot of silage.

Freeze samples containing over 15% moisture until shipping; store dry samples in a cool location. Avoid direct sunlight and damage to the bags.

Label the bag with your name, address, lot ID, and type of material.

*Green pasture samples are normally placed in a paper bag so that they can dry better than in a plastic bag. Promptly send the sample to the laboratory.

References

G77-331-A NebGuide - Published by Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln.

AS-1064 “Sampling Feed for Analysis” Sept 1993-North Dakota State University.

ADJUSTING LIME RATES

Lime applications should be made when a soil's acidity gets to a level that is detrimental to plant growth. The amount of lime recommended is based on using a good quality limestone source that will efficiently raise the soils pH level. Adjustments need to be made to the recommended amount based on two factors; the purity and the fineness of the lime material's particles. If these adjustments are not made, correcting the soil's low pH condition cannot be assured. This Fact Sheet provides information regarding terminology used to describe lime quality and how to adjust a lime recommendation based on its' quality.

PURITY

Liming materials will vary in their percentage of calcium and/or magnesium as well as impurities such as silt and clay. The purity of lime is expressed as it's *calcium carbonate equivalent* (CCE). Pure calcium carbonate has a CCE of 100%. Liming materials such as dolomite or hydrated lime may have a CCE greater than 100%. Other liming materials such as wastewater treatment lime tend to have a lower CCE, sometimes only 65 - 75%. With this wide variability, it is essential to adjust a lime recommendation according to the CCE.

FINENESS

Particle size varies greatly among lime sources. Agricultural limestone has a mixture of different size particles. The distribution of these particles is determined by passing the mix through various mesh sizes of sieves. Lime quality improves when a greater percentage of the particles pass through finer mesh sieves, such as a U.S. 60 or U.S. 100 mesh. Finely ground lime reacts quickly with the soil. Large particles may not react at all within a reasonable length of time. The effectiveness of the reaction is limited to a small area around each particle. Increasing the surface area exposes more lime and increases its solubility. Finer grades of lime have a significantly larger surface area per unit weight of material than coarser grades.

Some liming sources are comprised of very fine particles, even smaller than a U.S. 100 mesh sieve. Liquid lime is made from particles this small and suspended in water or fluid fertilizer. Pelletized lime is also made from very fine particles of lime and, once dissolved by soil moisture, becomes quickly available for neutralizing acidity. Liquid and pelletized lime, though, should not be used as a substitute for timely applications of agricultural limestone. Since they do not contain coarser particles, they do not provide the residual effect of agricultural limestone.

FACT SHEET

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3505 Conestoga Drive
Fort Wayne, IN 46808

Phone: 260-483-4759
Fax: 260-483-5274
lab@algreatlakes.com
www.algreatlakes.com

Fact Sheet No. 06
Revised 09/2004

REGULATING LIME QUALITY

When dealing with lime quality, state agencies do not always agree. Different terms are used in different states as well as philosophies for adjusting lime recommendations. Because of this, it is important to become acquainted with these differences, especially when comparing lime sources between states.

All of the states in the Great Lakes Region recognize the fact that a lime's purity (CCE or TNV) needs to be taken into account when adjusting for lime quality. Differences of opinion occur in how each state factors in the availability of the various size particles.

ILLINOIS

The state of Illinois refers to a limestone's *Effective Neutralizing Value* (ENV). It is based on a material's CCE and *Efficiency Factor* established from particle size distribution of the lime. Illinois recognizes the fact that applying lime prior to seeding alfalfa requires highly reactive particles, while liming for a corn/soybean rotation, a less reactive lime can be used. Because of this, lime is evaluated on both a one year after application basis and a four year after application basis.

The 1-year efficiency factor is calculated by adding up 5% of particles greater than an 8 mesh sieve, 20% of particles between a 30 mesh and 8 mesh, 50% of particles between a 60 mesh and 30 mesh, and 100% of the particles that pass a 60 mesh sieve. This result is then multiplied by the percent CCE of the material to arrive at the ENV. To correct for quality of a lime source, divide the 1-year ENV into 46.35 and multiply this result by the tons of lime recommended from a soil test report.

Efficiency Factor = (5% x (% Particles > 8 mesh) + 20% x (% Particles between 30 & 8 mesh)
+ 50% x (% Particles between 60 & 30 mesh) + 100% x (% Particles Passing 60 mesh)

Effective Neutralizing Value (ENV) = Efficiency Factor x (% CCE / 100)

1-Year Correction Factor = 46.35 / ENV of sampled limestone

The 4-year efficiency factor is calculated by adding up 15% of particles greater than an 8 mesh sieve, 45% of particles between a 30 mesh and 8 mesh, 100% of particles between a 60 mesh and 30 mesh, and 100% of the particles that pass a 60 mesh sieve. This result is then multiplied by the percent CCE of the material to arrive at the ENV. To correct for quality of a lime source, divide the 4-year ENV into 67.5 and multiply this result by the tons of lime recommended from a soil test report.

Efficiency Factor = (15% x (% Particles > 8 mesh) + 45% x (% Particles between 30 & 8 mesh)
+100% x (% Particles between 60 & 30 mesh) + 100% x (% Particles Passing 60 mesh)

Effective Neutralizing Value (ENV) = Efficiency Factor x (% CCE / 100)

4-Year Correction Factor = 67.5 / ENV of sampled limestone

INDIANA

Indiana uses the term *Neutralizing Value* (NV) interchangeably with calcium carbonate equivalent (CCE). The fineness of a lime is evaluated by summing the percent of particles passing an 8 mesh sieve with the percent passing a 60 mesh sieve and dividing the result by 2. This number is then multiplied by the percent CCE of the material to arrive at the *Relative Neutralizing Value* (RNV).

INDIANA (continued)

The average RNV for lime in the state is 60, which is the standard for lime recommendations with no adjustment for quality. Lime rates can be adjusted by dividing 60 by the RNV for the material to be spread and multiplying this by the recommended rate.

Fineness Factor = (% Particles Passing 8 mesh + % Particles Passing 60 mesh) / 2

Relative Neutralizing Value (RNV) = Fineness Factor x (% CCE / 100)

Adjustment Factor = 60 / RNV of sampled limestone

OHIO

The state of Ohio has a Liming Material Law which regulates the sales of lime. The term used to evaluate one source with another is the *Effective Neutralizing Power* (ENP). It is based on the fineness of grind (*Fineness Index*) and the calcium carbonate equivalent (CCE), which in Ohio is referred to as the *Total Neutralizing Power* (TNP). Lime is classified into a *Standard of Fineness,* which is one of five different categories (superfine, pulverized, ground, meal, and screened). The Fineness Index is a summation of 20% of the percentage of particles between an 8 and 20 mesh sieve, 60% of the percentage of particles between a 20 and 60 mesh sieve, and 100% of the percentage of particles passing a 60 mesh sieve. The result of this is multiplied by the TNP of the product and then by 2000 to arrive at the ENP per ton of lime. The ENP of a lime material can then be divided into the ENP of standard ag-ground limestone which is 1340 and multiplied by the amount recommended to adjust for the lime's quality.

Fineness Index = 20% x (%Particles between 20 & 8 mesh) + 60% x (% Particles between 60 & 20 mesh)
+ 100% x (% Particles Passing 60 mesh)

Effective Neutralizing Power (ENP) = Fineness Index x % CCE x 2000

Adjustment Factor = 1340 / ENP of sampled limestone

MICHIGAN

Lime quality in Michigan is evaluated by the *Neutralizing Value* (NV) and the *Effective Calcium Carbonate* (ECC) content. The NV is simply a measure of the ability of a liming material to neutralize acidity relative to pure calcium carbonate, which is also termed the calcium carbonate equivalent (CCE). The ECC takes into consideration the NV and fineness of the liming material. The fineness is assigned a *Fineness Factor* by the sum of 50% of material between an 8 and 60 mesh sieve and 100% of the material passing a 60 mesh sieve. This result is multiplied by the percent NV to arrive at the ECC.

The standard ECC for lime in Michigan is 60. Lime with this ECC would require no adjustments in the amount of lime recommended. Lime rates for materials with an ECC other than this can adjusted by dividing 60 by the ECC of the material to be spread and multiplying the result by the recommended rate.

MICHIGAN (continued)

Fineness Factor = 50% x (% Particles between 60 & 8 mesh) + 100% x (% Particles Passing 60 mesh)

Effective Calcium Carbonate (ECC) = Fineness Factor x (% NV / 100)

Adjustment Factor = 60 / ECC of sampled limestone

Source: Michigan State University Extension Bulletin E-471, "Lime for Michigan Soils"

WISCONSIN

In Wisconsin, the purity (CCE) and fineness, or particle size, are also used to evaluate lime. These two factors are used to calculate the *Neutralizing Index* (NI), a measurement of the relative value of the liming material. A neutralizing index of 60 to 69 is considered typical for Wisconsin lime and no adjustment to the amount recommended is made. The fineness of the lime is the sum of 20% of the particles between an 8 and 20 mesh sieve, 60% of the particles between a 20 and 60 mesh sieve, and 100% of the particles passing a 60 mesh sieve. This result is multiplied by the percent CCE to obtain the NI. Adjustments to the recommended amount of lime can be made by dividing 60 by the NI of the lime material and multiplying this by the recommended amount.

Fineness Index = 20% x (%Particles between 20 & 8 mesh) + 60% x (% Particles between 60 & 20 mesh)
+ 100% x (% Particles Passing 60 mesh)

Neutralizing Index (NI) = Fineness Factor x (% CCE / 100)

Adjustment Factor = 60 / NI of sampled limestone

Source: University of Wisconsin-Extension Publication A3671, "Choosing Between Liming Materials"

SUMMARY

States in the Great Lakes region use a combination of chemical purity and particle size to rate agricultural lime. There is considerable variation in the terminology used by states when lime recommendations are made. This can lead to confusion, particularly when growers are near state borders and may deal with vendors from different states.

Lime samples tested at our laboratory can be reported out using specific state factors, simplifying the process of comparing a liming material between states. Another means of doing this is available in a spreadsheet developed by A&L Great Lakes Laboratories. When values for test parameters are entered into the spreadsheet for a liming material, all of the various factors used within the Great Lakes region are calculated and can be printed out for review. This spreadsheet is available by contacting the laboratory.

A lime recommendation from our laboratory assumes that no adjustment for lime quality needs to be made. In other words, we assume that the quality of a liming material meets a state's minimum standard. Since this is rarely the case, our lime recommendations need to be adjusted for the quality of the lime that will be applied.

In summary, be aware of the differences in terminology used between states, but most importantly adjust the amount of lime recommended to compensate for the quality of the material.

FRUIT TREE FERTILIZATION GENERAL GUIDELINES

FACT SHEET

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Fact Sheet No. 08
Revised 05/2002

Effective management practices for productive orchards include a thorough knowledge of the crop and periodic evaluations involving both foliar and soil analysis. Because of the vast root system of a fruit tree, it is difficult to obtain a representative sample of the area where the root system is absorbing its nutrients. As a result, there is usually poor correlation between a soil test and leaf analysis for a given nutrient. This should not, however, rule out the use of soil testing as a basic tool in determining fertilizer needs. Soil fertility levels are more easily adjusted prior to new plantings. A complete nutritional picture for fruit crops though, can be obtained by using soil analysis in conjunction with foliar analysis. Leaf analysis is the best way to diagnose and confirm nutrient imbalances and/or deficiencies.

SOIL pH

The optimum pH range for most tree fruits is between 6.0 and 6.5. Soil pH levels as low as 5.5 may be tolerated. Soil pH is difficult to adjust because lime moves very slowly in the soil. It is advisable that the soil pH be adjusted to an optimum level prior to a new planting and maintained at that level with a lime application every three or four years.

NITROGEN

Nitrogen is the most important nutrient in fruit production. Rates should be based on yield, color, quality, management, soil nutrient balance, variety, age of planting, pruning, etc.

Nitrogen can generally be considered at an optimum level when the foliage is a moderate to dark green color, yield is good, and fruit color is satisfactory. Rates should be adjusted on the basis of terminal growth, fruiting characteristics of the previous season, and results of a foliar analysis.

Annual terminal growth is an indicator of whether an apple or peach tree is receiving the correct amount of nitrogen. Satisfactory nutritional conditions exist when annual terminal growth is 8 to 12 inches for mature, bearing apple trees, and 12 to 18 inches for peaches and nectarines. The nitrogen application should be reduced or eliminated the following year if growth exceeds these levels.

Apply nitrogen in late fall or early spring. Summer and early fall applications may result in poor fruit color and winter injury. Although many factors need to be considered, a general guideline for nitrogen application on young fruit plantings is 0.1 pound of actual N per tree per year of age. For mature fruit plantings, depending upon grower evaluation, vegetative growth, and fruit color, apply 50 to 75 pounds of N per acre for apples and pears, and 75 to 100 pounds of N per acre for cherries, plums, and peaches.

PHOSPHORUS

Fruit trees need little phosphorus and are unlikely to respond to additional amounts. Phosphorus, however may be needed if sod or some other cover crop is being maintained. The need for phosphorus in fruit trees can best be determined by plant analysis. Apply 0.1 pound P_2O_5 per tree per year, or 80 to 100 pounds per acre, if a need is indicated.

POTASSIUM

Potassium is frequently required. Stone fruits are generally more susceptible to potassium deficiencies than apples or pears. The need for potassium in fruit trees is best determined by plant analysis. A medium application rate for potassium is 0.1 pound K_2O per tree per year of age, or 80 to 100 pounds per acre.

MAGNESIUM

Magnesium deficiencies have sometimes been observed. Sandy soils with a low pH are most susceptible to magnesium deficiency. Magnesium deficiencies can be corrected with applications of 2 to 3 tons of dolomitic lime, or 40 to 50 pounds of magnesium as magnesium sulfate. If deficiencies are acute, magnesium may be applied in the first two cover sprays at the rate of 20 pounds of magnesium sulfate (4 pounds of elemental magnesium) per 100 gallons of water.

CALCIUM

Calcium deficiencies are most likely to occur on low pH, sandy soils. Low levels of calcium in apples often relate to certain physiological diseases such as bitter pit cork spot. Maintain the soil pH at an optimum level to help avoid calcium deficiencies. Calcium may be applied in cover sprays using 2 to 3 pounds per acre of calcium chloride (approximately 1 pound of elemental calcium) in 100 gallons of water. Make 4 applications at 2 week intervals with the last spray 2 to 3 weeks before harvest.

BORON

Of all the tree fruit crops, apples are most sensitive to boron deficiency. Sandy, low organic matter, and/or alkaline soils are most susceptible to boron deficiency. A foliar application using Solubor at 1 pound (0.2 pounds of elemental boron) per 100 gallons of water in the first two cover sprays is the preferred method for correcting boron deficiencies. Soil applications are also effective, but much slower.

MANGANESE

Manganese deficiency is usually associated with very wet, high pH soils. Deficiencies may be corrected with foliar applications of manganese sulfate at the rate of 4 pounds (approximately 1.5 pounds of elemental manganese) in 100 gallons of water in the first two cover sprays. Manganese chelate applied at the manufacture's recommended rate is also acceptable. On very low pH soils, manganese toxicity may occur. This can be avoided by maintaining optimum pH levels.

ZINC

Zinc deficiencies are normally corrected with an application of dormant spray. Applications of 1 to 2 pounds of zinc sulfate (approximately 0.5 pounds of elemental zinc) in 100 gallons of water may be used. Zinc chelate applied at the manufacture's recommended rate is also acceptable. The application should be made as late as possible but prior to opening of leaf buds.

FERTILIZING NEW PLANTINGS

Fertilizer and lime requirements should be based on soil tests prior to planting. Fertilizers and/or fertilizer solutions in the tree hole at planting time may be of little benefit if soil analyses are at optimum levels. High nitrogen levels should be avoided at planting as excessive top growth and incomplete tree hardening may result.

SAMPLING FOR FOLIAR ANALYSIS

Two types of foliage sampling may be of value in your fertility program:

Diagnostic: First there is the problem block in which some production problem has appeared. In this situation the problem area should be sampled and also where possible, an adjoining area not having the problem should be sampled for compare son.

Monitoring: The second type of sampling is that in which you desire to have periodic appraisals of the nutritional status of the tree. This type of sampling is quite desirable from a standpoint of maximum returns from your fertilizer dollar and the maintenance of optimum tree growth. Fruit tree monitoring involves testing both the leaves and fruitlets at vari ous growth stages.

Care should be taken to follow the precise directions for sampling. Standardization of sampling is necessary in order that the results may be compared with standards determined from samples collected in the same way. In this way the results will be most meaningful to you.

1) Each sample should be from only one cultivar (variety), one rootstock, and from one block, using trees of the same age. Do not sample trees less than four years old unless a severe problem is anticipated.
2) The block should be covered as completely as practical, sampling representative trees in all parts of the block or area that the sample is intended to represent.
3) A sample should consist of about 100 leaves. Dividing 100 by the number of trees available for sampling will give the number of leaves to be obtained from each tree. Thus if 25 trees are sampled, then 4 leaves per tree will be required.
4) Leaves for sampling should be selected from the outside periphery of the tree, from 4 to 8 feet in height and about equidistant around the tree. Leaves should be disease-free, undamaged leaves that include the entire petiole.
5) Leaves should be taken from terminal shoot growth which is of about average length for the tree. *The leaves should be taken from mid-portion of the current season's growth.* Leaves are easily removed with a slight jerk backwards toward the base of the shoot.

Additional information on fruit tree monitoring is available from a variety of sources, such as county extension services and universities. Other publications on foliar sampling and fertility monitoring are available from our laboratory.

INTERPRETIVE GUIDE FOR LAWN AND GARDEN SAMPLES

FACT SHEET

The Lawn & Garden Soil Test Report lists the results of analyzing a soil sample for it's general fertility status. A graphic display shows the rating for each of the results related to optimum plant growth. Along with this are general fertilizer application rates suggested to either improve the fertility of the soil or maintain it. Finally, some comments are made specific to your planting requirements as listed on the submittal form. This Fact Sheet contains additional information about each of the sections in the report.

ANALYSIS RESULTS

Organic Matter measures the amount of plant and animal residues in the soil. Usually the darker the color of the soil the more organic matter is present. Organic matter is beneficial because it helps soil tilth and also adds plant nutrients as it breaks down. Organic matter levels in the soil may be increased by adding amendments such as leaf litter, grass clippings, manure, peat or muck. Where practical, strive for a level of at least 3 to 5 percent.

Phosphorus, Potassium, Calcium and Magnesium are essential nutrients for plants. Generally, when these nutrient tests are rated very low, low or medium, sufficient fertilizer or lime must be added to build up the soil. When ratings are high or very high, either no fertilizer is needed or just enough to maintain the current nutrient level is necessary. The source of phosphorus and potassium is usually commercial fertilizer or manure. Lime is most often the source of calcium and magnesium.

Cation Exchange Capacity (CEC) measures the capacity of the soil to hold nutrients. The higher the CEC reading the greater the capacity. Muck or peat soils may have CEC's far in excess of 25; heavy clay soils have CEC's from 15 to 25; loamy soils from 5 to 15; and sandy soils below 5. Although high CEC soils can hold more nutrients, they are not necessarily more productive. Much depends on good management. Soil CEC's may be lowered by adding sands or gravels and increased by adding clay, muck or peat.

Soil pH determines the level of active soil acidity or alkalinity. A pH of 7.0 is neutral. Values lower than 7.0 are acid (sour). Higher values are alkaline (sweet). Soils commonly range in pH from 5.0 to 8.0. Most plants grow best when the soil pH is between 6.0 and 7.0. When the soil pH is greater than 7.0, phosphorus and some trace minerals may be less available to plants. There are some acid loving plants such as blueberries, azaleas and rhododendrons which prefer more acid soils (less than 6.0). When the soil pH is too low (acidic), lime should be applied. When the soil pH is too high (alkaline), sulfur may be applied to help lower the pH.

Buffer pH is used to determine the amount of lime to apply on acid soils. A value is not given when the soil pH is greater than 6.8, since no lime is needed. The buffer pH starts at 7.0 and goes downward as more lime is necessary.

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Fact Sheet No. 10
Revised 06/2002

Annual Nutrient Requirements

Lime Adding lime helps control soil acidity (pH). Lime makes the soil less acid. However, not all soils need lime. Do not apply lime unless the soil test calls for it. Agricultural grade lime may be purchased at most garden stores.

Nitrogen (N) Nitrogen is partly responsible for the green color in plants and the growth of lush foliage. Plants grown for foliage usually require more nitrogen than flowering or fruiting plants. Be careful not to over apply nitrogen on fruits, flowers, or most vegetables. Over application may result in lush foliage with little or no fruit or flowers. Because nitrogen readily leaches (washes out) of the soil, it should be applied as close to planting as possible. For flowers, garden vegetables and especially lawns it is not advisable to apply all of the nitrogen at once. Spread the application over the growing season.

Phosphate (P_2O_5) This nutrient is very important in formation of the flowering and fruiting portion of the plant. Phosphorus is therefore most important for fruits, vegetables and flowers. Unlike nitrogen, phosphorus does not leach from the topsoil. It may be readily built to high levels by the addition of fertilizers or manures.

Potash (K_2O) Growth of supportive parts of the plants such as stalks and stems requires lots of potassium. Like phosphorus, this nutrient does not leach from the topsoil. Potassium levels in the soil may be built up by repeated applications of fertilizer.

Magnesium (Mg) and Calcium (Ca) Magnesium is essential for the formation of chlorophyll in plants. For this reason it is also partly responsible for the green color. Calcium acts as the cement that holds plant cells together. Usually, when the soil is within the desirable range of 6.0 to 7.0, there is adequate magnesium and calcium for the plant. Most lime has some magnesium and lots of calcium. Lime is usually the best source of these nutrients.

Sulfur (S) This element is an important part of many of the proteins in plants. Organic matter is a good source of sulfur in the soil. Usually, when soil organic matter is greater than 3 percent, no additional sulfur is needed. Sulfur may also be used as a soil amendment to help lower soil alkalinity when it is excessively high. Elemental sulfur, ammonium sulfate, iron sulfate and aluminum sulfate may be used for this purpose.

Suggested Fertilizer to Apply

Option To select an acceptable fertilizer grade, choose from one of the two options listed. Either one of these is an acceptable alternative.

N-P-K Fertilizer Grade To meet the Annual Nutrient Requirements, the proper fertilizer materials must be selected. A fertilizer bag is labeled with the three numbers which indicate the nutrient content. The first number indicates the percent nitrogen (N), the second is the percent phosphate (P_2O_5) and the third is the percent potash (K_2O) in the fertilizer. For example, a 50 pound bag of 20-10-10 fertilizer contains 10 pounds of nitrogen, 5 pounds of phosphate and 5 pounds of potash. If the exact grade of fertilizer is not available from your supplier, use a similar grade.

Description A general description of the type of fertilizer is given here.

Annual Application Rate The exact amount of the N-P-K fertilizer grade to use is given here. The approximate size of the area to be fertilized should be calculated (area = length X width) in square feet. For small areas, a kitchen scale can be used to weigh out the proper amount of fertilizer. For even application, wherever possible, use a mechanical spreader.

GENERAL FERTILIZER RECOMMENDATIONS FOR LAWNS AND SMALL GARDENS

FACT SHEET

The amounts of fertilizer needed for lawns and small garden areas (less than 1,000 ft^2) may be quite small. It may be impractical to calculate the amount of N, P_20_5 and K_20 that is needed and may be more convenient to apply small amounts of special use fertilizer. In the following sections, recommendations are given for lawns, vegetables, and other landscape plants that will help achieve optimum fertility conditions for plant growth in the most economical and practical manner.

LAWNS

Grass, like flowers and vegetables, requires a balanced supply of N, P_20_5 and K_20. However, N is the key nutrient to maintaining vigorous growth and green color. Lawn fertilizers should have N-P_20_5-K_20 ratios of about 4-1-1 or 3-1-1 such as 20-5-5 or 23-7-7. For best results, lawn fertilizers should be applied 3 or 4 times during the growing season. Late spring, early fall, and late fall are the preferred times. Generally, a lawn should receive a total of about 3 to 4 lbs of N per 1,000 ft^2 during the growing season. This amounts to approximately 5 lbs of fertilizer per 1,000 ft^2 per application, but actual fertilizer rates are best determined by the directions on the bag.

VEGETABLES AND FLOWERS

Fertilizers with an approximate N-P_20_5-K_20 ratio of 1-1-1 are best for most garden vegetables and flowers. Common grades such as 10-10-10, 12-12-12, or 10-6-4 are all suitable. Apply 2 lbs per 1,000 ft^2 of any of these fertilizers and work into the soil prior to planting. Root crops, flowering bulbs, and tuberous plants such as potatoes and irises are heavy phosphorus feeders. Bone meal is an organic fertilizer high in phosphorus and is commonly used for feeding fall planted bulbs. Practically all vegetables and flowers require some nitrogen. However, too much can promote excessive vegetative growth with poor fruit development and too little can limit yields or flower development.

ROSES

Roses should be fertilized about 3 times per year. The first is applied as early spring growth begins, the second immediately following the early summer bloom, and the third about $1^1/_2$ months later. The first feeding should be with a high N fertilizer with an approximate 3-1-1 ratio or 2-1-1 ratio such as 23-7-7 or 20-10-5. Fertilizer applied later in the season should have an approximate 1-1-1 ratio such as 12-12-12 or 10-6-4. The total amount of fertilizer needed per growing season is $^1/_4$ to $^1/_2$ lb of fertilizer. Apply this amount around each bush and work into the soil. Where roses are planted in beds, apply 2 lbs of fertilizer per 100 ft^2.

SHADE TREES

Apply 1 to 2 lbs of high nitrogen fertilizer per inch of trunk diameter. Flowering trees should be limited to 1 lb per inch of trunk diameter. All fertilizer should be applied in holes 12-15 inches deep around the tree's perimeter. The holes should be about 2 feet apart and should not extend beyond the drip line.

NEEDLED EVERGREENS

Apply a fertilizer high in nitrogen in early spring at a rate of $^1/_3$ lb per foot of height or spread of plant, whichever is greater. For example, a 6 foot evergreen would require about 2 lbs of fertilizer while an evergreen with a 2 foot spread would need about 1 lb. Dig the fertilizer into the earth around the base of the plant and water well. Large growing evergreens such as spruce, fir, and pine normally do not require fertilizer but will respond in growth by the addition of some.

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Deciduous and Broadleaf Evergreen Shrubs

Apply a fertilizer high in nitrogen at a rate of $^1/_4$ lb per foot of the shrub's height or spread. Where shrubs are planted in beds on bare soil, apply 2 lbs per 1000 ft^2 of bed area. Dig in around the base and water well. Rhododendrons and azaleas are acid-loving plants and may require special fertilizer to lower the pH. For this kind of shrub apply aluminum sulfate or ammonium sulfate at rates similar for other fertilizers once per year.

Fruit Trees

Fertilize in late fall or early spring before the buds begin to swell. Broadcast the fertilizer in a circular band about 3 feet from the trunk and extending out to the spread of branches. Apples, plums, and cherries need $^1/_5$ to $^1/_2$ lb. of 10-10-10, or equivalent, per year of age of tree, with a maximum of 8 lbs per tree. If shoot growth is excessive reduce the rate of fertilizer.

Strawberries

During the first growing season apply 1 to 2 lbs of ammonium nitrate (33-0-0) or $^3/_4$ to $1^1/_2$ lbs of urea (46-0-0) per 100 feet of row. During the bearing year, if the plants lack vigor, apply 1 lb of ammonium nitrate or $^3/_4$ lb urea per 100 feet of row immediately after blossoming. Be careful not to apply excessive nitrogen. Excessive vegetative growth and soft berries may result. After harvest, broadcast 6 lbs of 10-10-10 or the equivalent per 100 feet of row.

Raspberries and Blackberries

During the first growing season broadcast 2 to 3 lbs ammonium nitrate (33-0-0) or $1^1/_2$ to 2 lbs urea (46-0-0) per 100 feet of row. After the first season apply 8 to 10 lbs of complete fertilizer (10-10-10) per 100 ft of row.

Blueberries

Some home garden soils are not suited for blueberries. Blueberries grow best on well aerated, high organic soils with pH levels below 5.5. During the first growing season, scatter 2 tablespoons of ammonium sulfate (21-0-0) in a circular band 12 to 18 inches from the base of each plant. In following years apply 4 tablespoons of ammonium sulfate per plant. On plants 5 years or older apply 1 cup ammonium sulfate per plant annually.

Grapes

During the first growing season apply 2 ounces ($^1/_4$ cup) of ammonium nitrate (33-0-0) or $1^1/_2$ ounces of urea (46-0-0) in an 18 inch circle around each plant 2-3 weeks after planting. In following years, broadcast 4 ounces ($^1/_2$ cup) of ammonium nitrate or 3 ounces of urea and 2 ounces of 10-10-10 around each plant. After the 4th growing season increase the ammonium nitrate to $^1/_2$ lb per plant annually.

Currants and Gooseberries

Three to four weeks after planting, broadcast 2 ounces of ammonium nitrate (33-0-0) in an 18 inch circle around each plant. After the first year apply 2 ounces of 10-10-10 and 3 ounces of ammonium nitrate or 2 ounces of urea per plant. Currants are injured by chlorides. Do not use muriate of potash as a potassium source, use potassium sulfate which contains no chlorides.

Conversion Factors

For some application situations, gardeners may have difficulty calculating how much fertilizer to use. Some equivalent values are:

1 acre contains 43,560 ft^2	1 pint of water or dry fertilizer weighs about 1 lb
An acre of mineral soil 6-2/3 inches deep weighs about 2 million lbs; an acre of muck soil, about $^1/_2$ million lbs	1 pint is equal to 2 cups or 32 tablespoons.
1 ppm means 1 part per million. Multiply by 2 to convert to lbs/acre	1 cup is equal to 8 ounces of fertilizer
20 bushels of soil mix equals about 1 cubic yard	1 tablespoon is equal to 3 teaspoons
1 bushel of manure weighs about 50 lbs	1 pint of concentrated liquid fertilizer weighs about 22 ounces

LAWNS, LANDSCAPES, AND GARDENS: ADJUSTING FERTILIZER PRODUCT RECOMMENDATIONS

FACT SHEET

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Fact Sheet No. 16
New 07/2002

When you request us to make a fertilizer application recommendation based on the soil analysis, we will suggest a fertilizer of a particular N-P-K fertilizer grade (ex. 20-3-3) that will supply the appropriate amount of nutrients. However, there may be uncertainty when the specific fertilizer grade that we recommended is not available from your local supplier.

This is not a problem; we are more interested in the proportion of N (nitrogen), P (phosphorus) and K (potassium) of the fertilizer. A fertilizer with a similar N-P-K grade that is locally available can be readily substituted for the product that we recommended.

Below are tables that list several common fertilizers, grouped by N-P-K category. The fertilizer that we recommended should be listed. Any of the other fertilizers in that group, or one with similar analysis, can supply nutrients in the proportions that we suggest.

Nitrogen Fertilizers	
31-0-0	38-0-0
37-0-0	46-0-0

Starter Fertilizers	
4-12-0	10-6-4
5-12-5	18-24-6
9-17-9	14-25-10

Equal N, P, K Fertilizers	
10-10-10	15-15-15
12-12-12	19-19-19

High N, Low P & K Fertilizer			
19-4-4	25-3-5	28-3-3	32-3-4
20-3-3	26-3-3	29-2-3	32-4-4
20-5-5	27-2-2	29-3-4	33-3-6
21-3-3	27-3-3	30-3-6	36-6-6
25-3-3	28-2-3	30-4-4	37-3-3

High N, Low P & Medium K Fertilizers			
18-3-6	20-5-10	28-3-10	30-4-10
19-5-9	23-3-13	28-3-12	31-3-10
16-8-8	25-5-8	29-4-8	32-3-10
19-5-9	25-5-15	30-0-15	34-3-11

If you use a fertilizer product other than the one we recommended, you need to adjust the fertilizer application rate so that the correct amount of nutrients will be applied. The following information and worksheet will help you calculate the proper rate.

Calculating Your Fertilizer Product Application Rate:

1. On your soil test report, under the Annual Nutrient Requirement section, find the nitrogen recommendation we made – usually between 2 and 4 pounds per 1,000 square feet. Record this in the worksheet below (step A).

2. Find your fertilizer product in the list. If your product is not in the list, buy a fertilizer of similar analysis. Record the first number (N percentage) of the fertilizer grade (28 for 28-3-3) in the worksheet (step B).

3. Calculate the annual fertilizer application rate (steps C and D).

4. We usually recommend splitting the Annual Application Rate into 2-4 applications during the growing season. The suggested number of applications should be found in the comments section of your soil test report. (step E).

5. Divide the Annual fertilizer application rate of your fertilizer by the number of applications (step F). This is the amount of your fertilizer product that should be spread at each application.

Fertilizer Product Application Worksheet			
		Example	Your Fertilizer
A.	Annual nitrogen (N) application rate (pounds per 1,000 square feet) from soil test report.	4	
B.	Nitrogen analysis of available fertilizer product (e.g. 28-3-3).	28	
C.	Divide B by 100.	0.28	
D.	Annual fertilizer application rate, pounds per 1,000 square feet (divide A by C).	14.3	
E.	Number of applications during growing season.	4	
F.	Amount of fertilizer to apply at each application, pounds per 1,000 square feet (divide D by E).	3.6	

a&lgreatlakes LABORATORIES

EXPLANATION OF A SOIL ANALYSIS REPORT

FACT SHEET

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Fact Sheet No. 23
Revised 12/2001

OFFICE INFORMATION

A **Report Number** All samples are filed by their report number. Be sure to refer to this number when contacting A & L Great Lakes Laboratories about a report.

B **Sample Number** Your soil sample I.D. Limit this number to no more than six digits and/or letters.

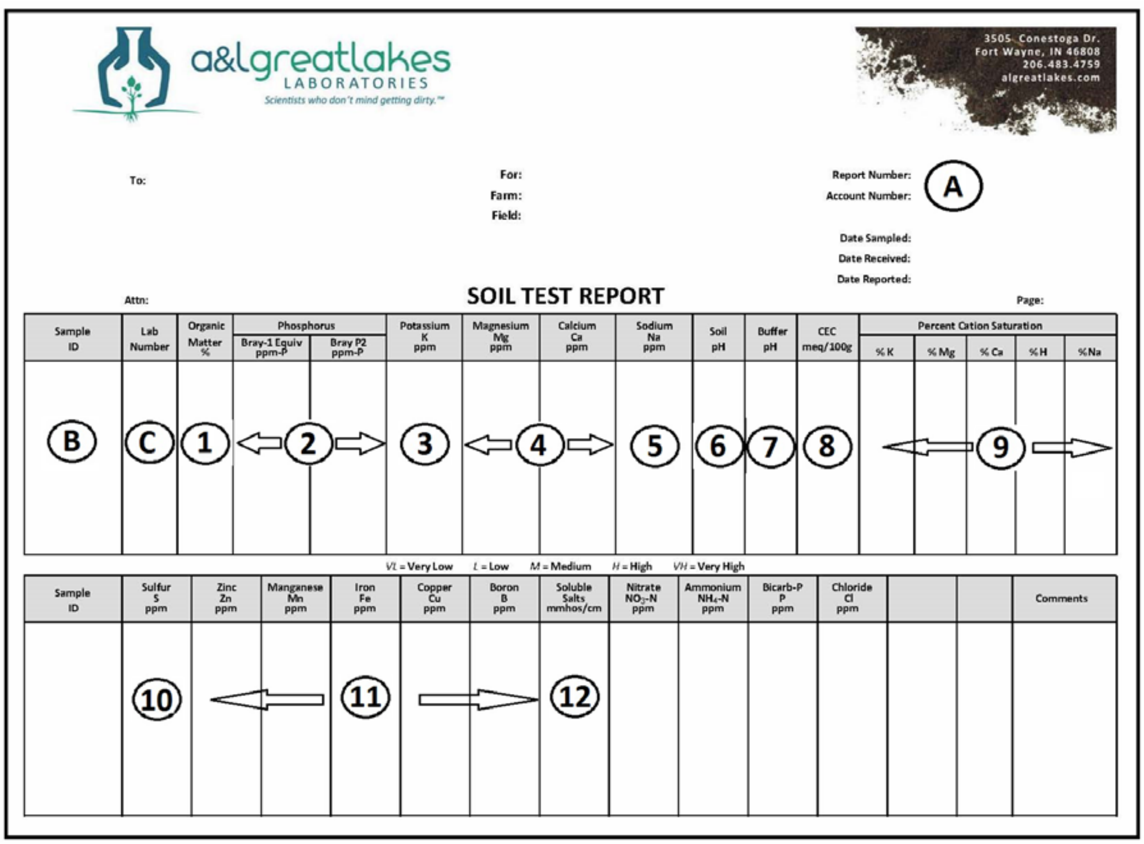
C **Laboratory Number** This number is assigned by A & L to each individual sample for tracking.

REPORT TERMS

ppm (parts per million) Results for major and minor elements are reported in ppm on an elemental basis. This unit of measurement is equivalent to pounds of nutrient per million pounds of soil. One acre of mineral soil 6 to 7 inches deep weighs about two million pounds. Therefore, to convert parts per million readings to pounds per acre, multiply by two.

meq/100g (milliequivalents per 100 grams) Soil cations including calcium, magnesium, potassium and hydrogen can be expressed in terms of their relative ability to displace other cations. The unit of measure is meq/100g. Example: One milliequivalent of potassium is able to displace exactly one milliequivalent of magnesium. The cation exchange capacity of a soil and the total amounts of individual cations are expressed in this way.

mmhos/cm (millimhos per centimeter) Electrical conductivity is used to measure the amount of soluble salts in a soil and is expressed in mmhos/cm. The conductivity of a soil increases with an increase in soluble salts. A soil is considered saline when the conductivity reading of the saturated extract reaches 2 mmhos/cm.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To: For: Report Number: (A)
Farm: Account Number:
Field:
Date Sampled:
Date Received:
Date Reported:
Attn: Page:

SOIL TEST REPORT

Sample ID	Lab Number	Organic Matter %	Phosphorus Bray-1 Equiv ppm-P	Phosphorus Bray P2 ppm-P	Potassium K ppm	Magnesium Mg ppm	Calcium Ca ppm	Sodium Na ppm	Soil pH	Buffer pH	CEC meq/100g	Percent Cation Saturation %K	%Mg	%Ca	%H	%Na
B	C	1	← 2	→	←	3	4 →	5	6	7	8	←		9		→

VL = Very Low L = Low M = Medium H = High VH = Very High

Sample ID	Sulfur S ppm	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Soluble Salts mmhos/cm	Nitrate NO_3-N ppm	Ammonium NH_4-N ppm	Bicarb-P P ppm	Chloride Cl ppm			Comments
	10	←		11	→		12							

1 **Organic Matter** Organic matter is expressed in percent. It measures the amount of decomposed plant and animal residues in a soil. Soil color is closely related to the amount of organic matter. A darker color is usually associated with high organic matter. Dark-colored soils often test above 3.5% organic matter.

2 **P1 (Weak Bray) Phosphorus** This test measures phosphorus that is readily available to plants. The optimum level will vary with crop, yield and soil conditions. Twenty to thirty ppm is adequate for most field crops. Certain specialty crops may need higher levels.

P2 (Strong Bray) Phosphorus This test measures phosphorus that is readily available and part of the active reserve phosphorus in a soil. Forty to sixty ppm is a desirable level for most crops.

Sodium Bicarbonate Phosphorus This method determines the amount of readily available phosphorus in calcareous soils. A level of 15 ppm or more is desired to produce good yields for most crops.

3 **Potassium** This test is a measure of available potassium in a soil. The optimum level will vary with the crop, yield and soil type. A potassium level of 120 to 170 ppm is adequate for most field crops. Higher levels are generally needed on soils high in clay and/or organic matter, versus soils that are sandy and low in organic matter.

4 **Magnesium and Calcium** Calcium deficiencies are rare when the soil pH is adequate. Magnesium deficiencies are more common. The levels of calcium and magnesium found in a soil are primarily affected by soil type, drainage, liming and cropping practices. These basic cations are closely related to soil pH. Magnesium levels exceeding 50 ppm are adequate for most crops.

5 **Sodium** Although sodium is an essential nutrient for some crops, its effect on the physical condition of a soil is of greater importance. High sodium in soils may cause adverse physical and chemical conditions. Excessive levels of sodium can be reduced by leaching and/or by the application of calcium sulfate (gypsum).

6 **Soil pH** This test measures active acidity or alkalinity. A pH of 7.0 is neutral. Values higher are alkaline while values lower are acid. A pH of 6.0 to 7.0 is the desired range for most crops grown in mineral soils. Organic soils require a lower pH range of 5.0 to 5.5.

7 **Buffer pH** This reading indicates a soil's potential acidity. A lower buffer pH represents a larger amount of potential acidity and thus more lime is needed to increase the soil pH to a given level.

Lime Requirement to Increase Soil pH (Tons/Acre)							
Mineral Soils (CEC > 7.0)			Organic Soils (OM > 10%)		Sandy Soils (CEC <= 7.0)		
Buffer pH	Lime to pH 6.9	Lime to pH 6.5	Soil pH	Lime to pH 5.3	Soil pH	Lime to pH 6.9	Lime to pH 6.5
6.8	1.5	1.0	5.2	0.0	6.3 - 6.6	1.0	0
6.7	2.5	2.0	5.1	0.7	6.0 - 6.2	1.5	1.0
6.6	3.5	3.0	5.0	1.3	5.7 - 5.9	2.0	1.5
6.5	4.5	4.0	4.9	2.0	5.4 - 5.6	2.5	2.0
6.4	5.5	4.5	4.8	2.6	5.1 - 5.3	3.0	2.5
6.3	6.5	5.5	4.7	3.2	<5.1	3.5	3.0
6.2	7.5	6.5	4.6	3.9			
6.1	8.5	7.0	4.5	4.5			
6.0	9.5	8.0	4.4	5.1			

8 **CEC (Cation Exchange Capacity)** CEC measures the soil's ability to hold nutrients such as calcium, magnesium and potassium, as well as other positively charged ions (sodium and hydrogen). The CEC of a soil will vary with the kind and amount of clay and percent of organic matter.

9 **Percent Base Saturation** This is the proportion of the CEC occupied by a given cation or a combination of cations, referred to as bases. The percent saturation for each of these cations will usually be within the following percentage ranges: Calcium 40-80, Magnesium 10-40, Potassium 1-5.

10 **Sulfur** This test is a measure of sulfate-sulfur. It is a readily available form preferred by plants. Optimum levels usually range from 15 to 20 ppm.

11 **Micronutrients** The available levels of micronutrients found in samples are rated from very low to very high. However, applying the recommended amount of certain micronutrients with a "low" rating will not necessarily insure a crop response because of other factors which can influence that response. Some of those factors include soil pH, soil type, physical properties, moisture and crop variety.

12 **Soluble Salts** Excessive concentrations of various salts can develop in soils. This may be natural or the result of irrigation, excessive fertilization, or contamination from chemicals or industrial waste.

Recommended Principles for Proper Hay Sampling

Dan Putnam, University of California, Davis

INTRODUCTION

Proper sampling of hay and forage is of tremendous importance to assure an accurate forage test. Remember, a lab test is only as good as the sample provided to the lab. Here's the dilemma: Hundreds of thousands of pounds of highly variable plant material must be represented in a single, tiny, thumbnail-sized sample!! Often, the sample actually analyzed by the lab is often only ½ gram! This sample must not only represent the proper leaf-stem ratio and the legume/grass mix, but also reflect the spotty presence of weeds. Sampling variation is a significant problem in hay testing, and causes millions of dollars in lost revenue each year by either buyer, seller, or in animal performance. In practice, hay sampling produces more variation in results than does lab error. However, if sampling protocol is carefully followed, sampling variation can be reduced to an acceptable level, and the potential forage quality successfully predicted. The following steps have been compiled from various recommendations that have been in place for years and are widely considered to be the key elements of a standardized sampling protocol:

STANDARDIZED PROTOCOL TO ASSURE A REPRESENTATIVE SAMPLE OF HAY

1. **Identify a single 'lot' of hay.**
   This is a key first step to proper hay sampling, and one frequently ignored. A hay lot should be identified which is a single cutting, a single field and variety, and generally be less than 200 tons. Combinations of different lots of hay cannot be represented adequately by a forage sampling method; different lots should be sampled separately. Don't mix cuttings, fields, or hay types.

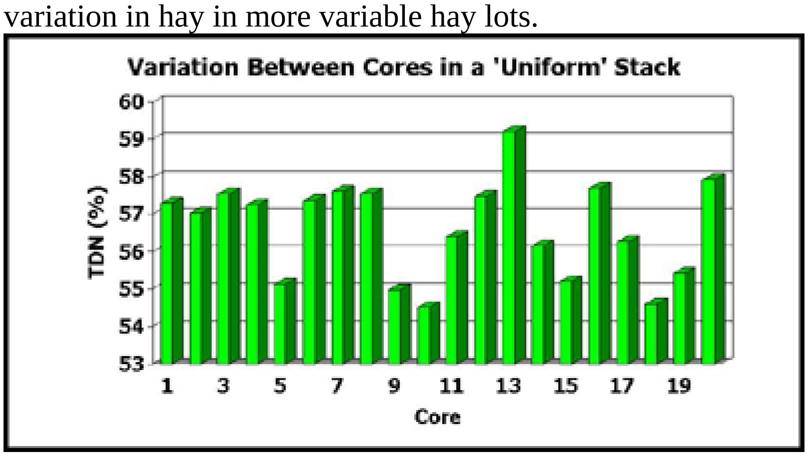
2. **When to Sample?**
   It is important to sample the hay either as close to feeding, or as close to point of sale as possible. Dry matter measurements are especially subject to changes after harvest and during storage, but other measurements may also change. Hay immediately after harvest normally goes through a process of further moisture lost known as a 'sweat'. During this period, hay may heat up due to the activities of microorganisms, driving residual moisture from the hay. Thus, moisture content is likely to be reduced in the days and weeks after harvest. If the hay has been baled at excess moisture, further biological activity may result in molding, or even (under very high moisture conditions) spontaneous combustion of hay. However, after hay has equilibrated to the range of 90% DM (10% moisture, depending upon humidity), it is typically quite stable. 'As received' dry matter measurements should be used to adjust quantity (tonnage, yield), not quality parameters, which should be compared on 100% DM basis.

3. **Choose a sharp, well-designed coring device.**
   Use a sharp coring device 3/8-3/4" diameter. Never send in flakes or grab samples, it is nearly impossible for these samples to represent a hay lot. "Hand-grab' samples have been shown to be significantly lower in quality than correctly sampled forage. The corer should have a tip 90o to shaft, not angled—studies have shown that angled shafts push aside some components of hay, providing a non-representative sample of the entire mix. Very small diameter tips (<3/8") do not adequately represent the leaf-stem ratio of the hay. Too-large diameter or too-long probes (e.g. > 24") provide good samples, but give too much forage in a 20 probe composite sample—thus the

sampler may stop before 20 cores are completed or the lab may not grind the whole sample (see below). The length of probe should allow probing to a depth of 12"-24". Studies have shown this depth to successfully characterize the variation in hay, even in large (1 ton) bales, and no significant differences were seen between a 32" and 12" probe. A range of probe tip designs have been used successfully, from serrated to non-serrated tips—it is probably most important that the tip be sharp (and maintained sharp), and not create 'fines' during the cutting action, but cleanly cut across a cross-section of hay. Some probes are power, hand-brace, or auger driven, whereas others are push-type, both of which may work well. Many (not all) probes can be used to successfully represent a hay lot as long as they follow these principles: they easily penetrate the bale, fairly represent the leaf-stem ratio, can be easily sharpened, and produce approximately ½ lb (200 g) of sample in about 20 cores to a depth of 12"-24". See a listing of probes at NFTA website.

4. **Sample at random.**
The sampler should walk around the stack as much as possible, and sample bales at random. Both ends of bales should be sampled by walking around the stack. This is sometimes difficult since all of the bales are not available to the sampler (they may be against walls of a barn or up too high for practical sampling). However, the sampler should make every attempt to sample in a random fashion—this means not to bias either for or against any bales in the stack. For example, the sampler may walk 15 steps, sample, walk 20 steps, sample, walk 5 steps, sample, while walking around stack—trying to represent all areas of the stack. Don't avoid or choose bales because they look especially bad or good--If 20 cores are taken, they won't make much difference anyway. Avoiding or choosing bales introduces bias.

5. **Take enough cores.**
We recommend a minimum of 20 cores for a composite sample to represent a hay lot. This is the same for large (e.g. 1 ton bales), or small 2-tie or 3-tie bales. This is because core-core (and bale-bale) variation in forage quality is tremendous (e.g. 5-7 % points ADF or CP). Sampling a large number of locations and bales throughout the stack to create a composite sample is a key aspect of representing the full variation contained in a hay lot. It is recommended to take more than 20 cores (e.g. up to 35) with very large lots (100-200 tons), or with highly variable lots (e.g. lots that may have non-attached leaves or are from very weedy fields). With small bales, sample 1 core per bale, >20 bales; with larger (e.g. 1 ton) bales, take 2-3 cores per bale in the center of the ends, sampling >10-12 bales. A larger number of core samples is generally better at characterizing variation in hay in more variable hay lots.



6. **Use proper technique.**
   Sample butt ends of hay bale, between strings or wires, not near the edge. Probe should be inserted at 90º angle, 12"-18" deep. Do not sample in the same exact spot twice. Do not use any technique which is likely to misrepresent the leaf-stem ratio. The sides or the top of the bale should not be sampled, since these cores will only represent one flake from a single area of the field, and additionally misrepresent the leaf-stem ratio. With round bales, sample towards middle of bale on an angle directly towards the center of the bale.

7. **Sample amount: "not too big, not too small".**
   Sampling should be done so that about ½ lb of sample is produced. Too-small samples don't fairly represent the full range of variation in the hay lot. Very big samples (common with large length or diameter probes) are excellent at representing the hay but have practical disadvantages. Large samples cannot be easily ground by the labs—many labs will simply sub-sample such large samples before grinding, defeating the entire purpose of good sampling technique! The sampler should ensure that the entire sample is ground by the lab—this is important to check. If your lab is not grinding the whole sample, ask why—it could be that your sample is too large. Only work with labs that are willing to grind the entire sample (after a DM sample for field DM is taken). But you should also assure that you are providing a reasonable ½ lb sample, so that it can be practically handled by the lab. If a probe is too big or small to produce about ½ pound in 20 cores—get a different one! (see list of probes on NFTA website)

8. **Handle samples correctly.**
   Seal Composite 20-core sample in a well-sealed plastic bag and protect from heat. Double bagging is beneficial, especially for DM measurements. Deliver to lab as soon as possible. Do not allow samples to be exposed to excess sun (e.g. in the cab of a pickup truck). Refrigeration of hay samples is helpful, however, dry hay samples (about 90% DM) are considered fairly stable.

9. **Never split samples without grinding.**
   It is important to occasionally double check the performance of your lab by comparing with another (or several other) labs. However, never split un-ground samples and send them to two different labs—the samples are likely to be genuinely different! To test two labs, either grind and carefully split the sample, or better yet, ask for your ground sample back to send to another lab. Use several samples to test average potential bias between labs. Don't work with labs that are unwilling to do this—good labs should be wiling to test their performance and answer questions with regards to consistency of lab results. Ask for their NFTA results!

10. **Choose an NFTA-Certified Lab.**
    The first step in choosing a high-quality hay testing lab is to determine whether they participate in the NFTA proficiency certification program. The National Forage Testing Association, a volunteer group set up by hay growers, sends blind samples to labs, and they must match the true mean within an acceptable range of variation. NFTA labs have demonstrated their commitment to good results, are more likely to be interested in accuracy. Additionally, programs such as California's 'California Recognized', the Midwest NIRS consortium, or other voluntary proficiency programs provide an additional opportunity for labs to prove their proficiency. However, these programs only work if the clientele (you) pays attention to them. Choose a lab that chooses EXCELLENCE! Choose an NFTA lab (see www.foragetesting.org for a listing of NFTA-certified labs)!

BP-136-W

Tomato Disease Management Timeline for Indiana

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Use this timeline to determine the appropriate disease management measures for tomato diseases common to Indiana.

Disease/Disorder	Winter/Off-season	Greenhouse	Planting	Fruit Set	Harvest
anthracnose	Rotate crops at least 2-3 years and practice fall tillage.			Begin fungicide applications at or shortly before first fruit set.	Inspect fruit for lesions.
bacterial canker	Rotate crops at least 3-4 years and practice fall tillage. May be seedborne.	Inspect seedlings for symptoms and apply fixed copper compounds as needed.	Do not plant seedlings with bacterial canker symptoms.	Inspect plants for bacterial canker symptoms.	Inspect fruit for bacterial canker symptoms. Avoid saving seed.
bacterial spot/speck	Rotate crops at least 2-3 years and practice fall tillage. May be seedborne.	Inspect seedlings for symptoms and apply fixed copper compounds as needed.	Do not plant seedlings with symptoms of bacterial spot/speck. Begin fixed copper applications on a 7-14-day schedule.		Inspect fruit for bacterial spot/speck symptoms. Avoid saving seed.
blossom-end rot	Conduct preseason soil tests for calcium and consider adding calcium and lime amendments.		Maintain regular irrigation schedule. Choose less susceptible varieties. Calcium nitrate through the drip may help reduce symptoms in future fruit sets. Foliar calcium application is not recommended.		Inspect fruit for symptoms.
Botrytis gray mold	Rotate crops at least 2-3 years and practice fall tillage. Keep calcium at adequate levels.	Keep temperatures 70°F or higher and relative humidity less than 90%.	Begin protective fungicide applications.		Inspect fruit for symptoms.
buckeye rot and Phytophthora root rot	Rotate crops at least every 3 years and practice fall tillage. Avoid poorly drained soils. Use raised beds. Mulch may lessen buckeye rot's impact.		Consider fungicide drench. Regular fungicide schedule may lessen buckeye rot effects.	Consider specialized fungicides for Phytophthora diseases.	Inspect fruit.
early blight/Septoria	Use crop rotations of at least 2-3 years for Septoria and 3-4 years for early blight.		Begin protective fungicide applications on a 7-14 day schedule.		
white mold (timber rot)	Long rotations with corn or small grains. Growers should especially avoid rotations with tomato, peppers, potato, and snap beans.	White mold may be common where tomatoes are grown yearly in the same soil such as under a greenhouse structure. The biological pesticide Contans® may be applied prior to planting or after harvest.		Inspect plants for symptoms of white mold (timber rot).	
leaf mold	Rotate crops at least 2-3 years and practice fall tillage. Use sanitation in greenhouse tomatoes.	Leaf mold is more common on tomatoes grown to maturity in the greenhouse/high tunnel than those grown in the field.	Control relative humidity by venting greenhouse and pruning. Labeled fungicides may help control leaf mold.		

Post-Harvest Care

Firm-ripe tomatoes should be cooled to 45-50°F. Clean and disinfect all picking containers and equipment. Maintain chlorine/bromine levels at 75-150 ppm at a pH of 6.5-8.5 in recirculating water systems.

More information about disease management is available in the *Midwest Vegetable Production Guide for Commercial Growers*, mwveguide.org. Keep current during the season about diseases and more with the Vegetable Crops Hotline, veghotline.org.

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Vegetable Diseases

Five Steps for Healthy Garden Tomatoes

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BOTANY PLANT · PATHOLOGY

Photos by
Daniel S. Egel (Figures 1-3) and
Elizabeth Maynard (Figures 4-5)

www.btny.purdue.edu

For many Indiana gardeners, summer really doesn't start until the harvest of that first ripe tomato. Unfortunately, there are many infectious diseases and noninfectious disorders that can reduce the yield and quality of tomatoes from the home garden.

This publication briefly describes some common tomato diseases and disorders, and then provides five steps home gardeners can take to minimize yield loss. The steps are:

1. Diagnose the problem correctly.
2. Plant resistant varieties.
3. Practice crop rotation, fall tillage, and sanitation.
4. Maintain plant vigor.
5. Use fungicides as needed.

Figure 1. Necrosis on the lower leaves of tomato plants is a symptom of both early blight and Septoria leaf blight.

Infectious Diseases

Early Blight and Septoria Leaf Spot

Perhaps the most common disease symptom homeowners mention is "My tomato plants are turning brown, starting with the bottom leaves and working toward the top of the plant."

This description fits the symptoms of two diseases: early blight and Septoria leaf spot. Both diseases cause lesions that initially appear on lower leaves (Figure 1). And both diseases can progress rapidly from lower foliage to new growth during wet weather. Early blight lesions have target-like rings or concentric circles within the brown area — a bull's-eye pattern (Figure 2). Septoria leaf spot causes small, chocolate brown, circular spots that are 1/10 to 1/8 inch in diameter (Figure 2). Both diseases attack less vigorous plants and plant parts. The fungi responsible for these diseases overwinter in infested crop residue in the garden.

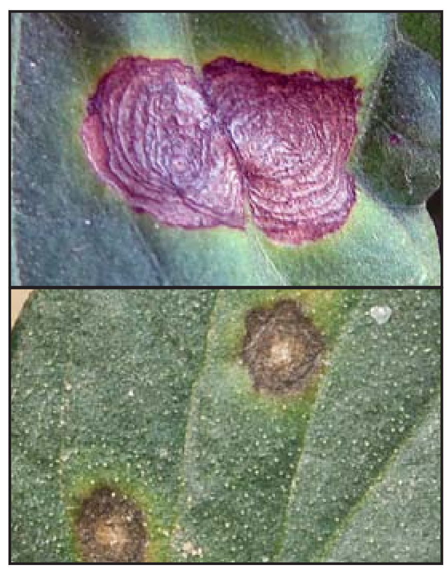

Figure 2. When viewed close up, early blight lesions (top) typically have ridges in a bulls-eye pattern. Septoria leaf blight lesions (bottom) are chocolate brown with light grey centers.

Fusarium Wilt and Verticillium Wilt

Yellowing and wilting lower leaves is the first noticeable symptom of Fusarium wilt and Verticillium wilt. The wilt may affect one side of a leaf.

Fusarium wilt may cause a seedling disease, whereas Verticillium wilt usually does not. Fusarium wilt is usually more severe on plants grown in light sandy soil. The fungi that cause these diseases survive for many years in the soil, even in the absence of tomato plants.

Bacterial Spot and Bacterial Speck

Bacterial spot and bacterial speck infections result in dark brown spots on leaves that are often smaller than those caused by early blight or Septoria leaf spot. The spots may occur on younger leaves and may occur along leaf veins where water collects. Severe infections may cause dark scabby-like lesions on fruit (Figure 3).

Root-knot Nematode

Plants affected by root-knot nematodes may appear stunted or wilted. If you dig up the roots, you may observe round galls on the roots. The galls are caused by microscopic nematode “worms” that prevent the roots from functioning properly.

As with Fusarium wilt and Verticillium wilt, the organism responsible for these symptoms may survive for many years in the absence of a host plant. Root-knot nematodes affect many diverse plants.

Other Diseases

There are, of course, other infectious diseases and disorders of tomatoes than the ones discussed here. Experienced gardeners may have heard of bacterial canker, buckeye rot, gray leaf spot, late blight, and tobacco mosaic virus (TMV). These diseases probably occur in isolated areas of Indiana every year but are not normally widespread.

Noninfectious Disorders

Blossom-end Rot

Blossom-end rot is a disorder of tomato fruit that usually occurs after rapidly growing plants endure a prolonged dry spell or after a period of unusually abundant rainfall. It is not caused by a disease or other pest (that is, it is noninfectious). Blossom-end rot most often affects the first set of fruit produced. Heavy application of nitrogen fertilizer also tends to promote blossom end rot.

Although the cause of this disorder is calcium deficiency within the fruit, environmental conditions can lead to blossom-end rot even when the soil has sufficient calcium. Adding calcium fertilizer after this disorder appears is unlikely to help. Symptoms occur on green or ripe fruit and appear as dry, leathery areas on the blossom end of the fruit (Figure 4). The leathery areas are generally concave and are usually larger than a quarter but can be as wide as the fruit itself.

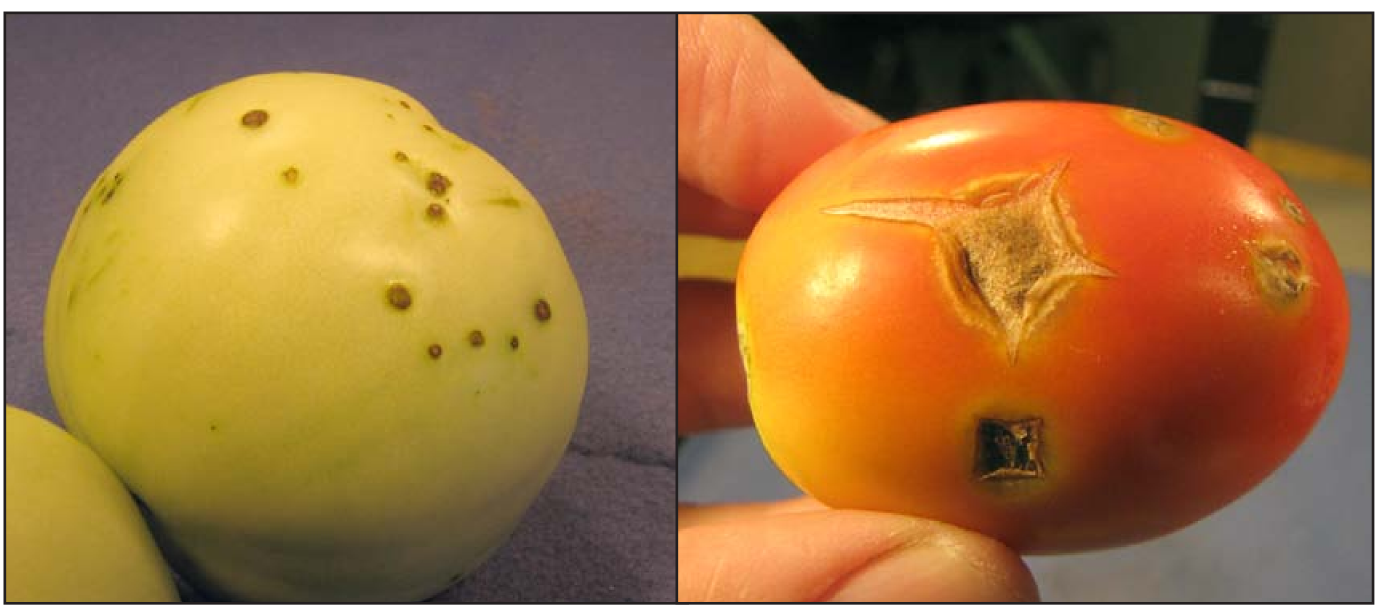

Figure 3. Bacterial spot or bacterial speck lesions range from round, scabby lesions (left) to very large, cracked lesions (right).

Figure 4. Blossom-end rot is a noninfectious disorder that causes leather-like lesions on the blossom end of tomatoes. The disorder is caused by calcium deficiency.

Catfacing

This disorder, which is also noninfectious, can be recognized by the malformed tomato fruit it causes (Figure 5). Catfacing often occurs when the flower buds were exposed to cold. Heirloom varieties exhibit a high proportion of fruit with catfacing; thus, catfacing may not detract from the marketability of these varieties. Variety selection is the most practical way to limit this problem — larger varieties tend to be more prone to catfacing.

Figure 5. Catfacing of tomatoes is often associated with cold weather during flowering.

Herbicide Injury

Being exposed to growth-regulator herbicides is one of the most common sources of tomato plant damage. Herbicide exposure is usually caused by drift (when the wind blows the herbicide away from the target area) or volatilization (when herbicide turns to a gas due to improper application). Apply liquid dandelion killers with care and when the wind is not blowing. Also, keep granular applicators away from the garden.

For more information, see *Diagnosing Herbicide Injury on Garden and Landscape Plants* (Purdue Extension publication ID-184-W), available from the Education Store, www.the-education-store.com

The Five Steps

You can increase the odds of growing tomato plants successfully if you follow these five steps.

1. Diagnose the Problem Correctly

Before you can treat any disorder, you have to identify the problem correctly. The photographs in this and other resources may help you diagnose tomato diseases. However, it may be wise to test a sample for an accurate diagnosis. You can bring a sample to your Purdue Extension county office (or educator), or you can send a sample to the Purdue Plant and Pest Diagnostic Laboratory.

Instructions on how to prepare and send a sample may be found on the Purdue Plant and Pest Diagnostic Laboratory website, www.ppdl.purdue.edu.

2. Plant Resistant Varieties

Whenever possible, choose varieties that have resistance to diseases. For example, tomato varieties are available that are resistant to Verticillium wilt, Fusarium wilt, and root-knot nematode — thus, the letters VFN are often associated with tomato varieties that have such resistances. There are no other practical means of controlling these diseases except for resistant varieties.

Some varieties also may have partial resistance to leaf (foliar) diseases such as early blight. Heirloom varieties will likely lack resistance to any diseases, so if you grow heirlooms, closely follow the remaining suggestions listed here.

When purchasing seedlings, inspect the plants and choose only green, vigorous looking seedlings. Avoid wilted plants and those with yellow leaves or brown spots on the leaves. Although no tomato variety is resistant to blossom-end rot, experienced gardeners will begin to recognize that some varieties are more prone to this disorder than others.

3. Practice Crop Rotation, Fall Tillage, and Sanitation

Whenever possible, do not plant tomatoes in the same place year after year. Many pathogens, such as the ones that cause early blight, survive from year to year in crop debris. Planting a crop unrelated to tomato for three or four years will allow the crop debris to break down and make it less likely for pathogens to survive. Crop rotation is particularly important for heirloom varieties since they are susceptible to a greater number of diseases.

If it is not possible to rotate to a different plot of ground each year, remove tomato plants from the garden as soon as you complete harvest. Plants that are not removed provide a winter haven for all sorts of tomato pathogens. You can compost or simply discard dead plants. Do not use composted tomato plants in tomato production.

Some residue can be expected to remain in the garden. Tilling the soil in the fall to a depth of 4 to 8 inches will bury this residue and hasten its decomposition.

Use clean stakes or cages each year. You should remove plants or fruit suspected of disease well away from the production area. This cleanup should be routine with all garden vegetables. You should also destroy all weeds because they can harbor tomato pathogens until spring.

4. Maintain Plant Vigor

Healthy plants tend to resist diseases better than plants that lack water or nutrition. Tomatoes planted in well-tilled, well-drained, and properly fertilized soil, will be less prone to early blight and Septoria infection. Tomatoes will grow in many different soil types, but a deep, loamy, well-drained soil is ideal. They grow best in a slightly acidic soil, pH 6.2 to 6.8. You should till the soil in spring prior to transplanting.

In the absence of a soil test, apply a complete fertilizer at 2 to 3 pounds per 100 square feet to supply the needed nitrogen, phosphorus, and potassium. Complete fertilizers include products that are labeled 5-10-10, 10-10-10, or 8-16-16. Follow fertilizer label directions carefully. Excess nitrogen promotes heavy foliage, reduces fruit yield, and increases the chance for blossom-end rot. Nitrogen deficiency predisposes plants to early blight and Septoria leaf spot.

If soil fertility is adequate before transplanting, apply material that contains nitrogen at a rate of 0.1 to 0.2 pound of nitrogen per 100 square feet. Then after fruit set, side dress with 0.1 pound of actual nitrogen per 100 square feet, and then again four weeks later (if needed) to keep plants vigorous throughout the season.

Water stress usually preceeds blossom-end rot and can make plants more susceptible to early blight and Septoria leaf spot infection. At midseason, full-grown tomato plants require about 1 inch of water a week. Add water gradually and allow it to soak into the soil. Avoid overhead irrigations, which can lead to an increase in foliar diseases. Do not allow the soil to become so hard and dry that plants wilt. Avoid fluctuations of too much and then too little water. Adding a layer of mulch can reduce evaporation and help reduce weeds. Remember to avoid using clippings from a lawn recently treated with herbicide.

5. Use Fungicides as Needed

Regardless of the efforts to prevent disease, many tomato gardens will have sufficient foliar disease to compromise yield or fruit quality. If you decide to apply fungicides, the following checklist might be helpful:

- **Be safe.** Before you purchase a fungicide, check the label to be sure that it will control the diseases your plants have, and that it is safe to use on tomatoes. By law, all fungicide labels are required to list such information. Use the rate on the label and always wear the proper protective wear. Remember that a pesticide label is the law.
- **Use a pressure sprayer for best results.** Compared to dusting plants, mixing fungicides with water and applying them with a pressure sprayer allows much better coverage and distribution of the fungicide on the plant. Fungicide products vary in effectiveness against these diseases and are available at most

garden stores or nurseries. Products that contain the active ingredient chlorothalonil are preferred, but fungicides that contain copper as the active ingredient also can be effective, especially if disease pressure is low. Copper products may be successfully used for managing bacterial spot/bacterial speck.

- **Apply fungicides before disease symptoms occur or in the early stages of the disease.** These applications will be more effective than applications made after the disease is well along. Begin sprays when plants approach 10 to 12 inches tall and continue spraying at 7- to 14-day intervals throughout the season, especially if disease has been severe in recent years. Providing good coverage over the entire season means that fungicide applications must be repeated.
- **Choose nonsynthetic products if you want to produce organic tomatoes.** Although there is no organic certification for homeowners, products with active ingredients such as copper or sulfur will allow you to produce organically.

More information about garden tomatoes are available in the following Purdue Extension publications (available from the Education Store, www.the-education-store.com):

- *Tomatoes* (HO-26-W)
- *Organic Vegetable Production* (ID-316-W)

To see other publications in the *Vegetable Diseases* series, visit the Purdue Extension Education Store, www.the-education-store.com.

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