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# Maryland Nutrient Management Manual

- Nutrient Recommendations
- Technical Standards & Criteria
- Laws and Regulations

**Maryland Department of Agriculture**
Nutrient Management Program
50 Harry S. Truman Parkway
Annapolis, Maryland 21401
410-841-5959
www.mda.state.md.us

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# Section I-A
## Introduction

# INTRODUCTION

COMAR 15.20.08.05 requires that consultants utilize site-specific soil tests and crop yield information to make nutrient recommendations. Chapter B of this section briefly explains soil tests, their interpretations and the use of crop yield goals. *Agronomic Crop Nutrient Recommendations Based on Soil Tests and Yield Goals, Plant Nutrient Recommendations Based on Soil Tests for Vegetable Crop Production, Nutrient Management Guidelines for Sod Production in Maryland and Plant Nutrient Recommendations Based on Soil Tests for Turf Maintenance* provide nutrient rates by crop or plant that shall be used.

When specific nutrient recommendation rates are not provided in this section for a specific crop or plant being grown, at least one of the listed sources, in the following order of preference, is to be used to establish the rate:

- *recommendations of the University of Maryland Cooperative Extension for similar plants;*
- *rates provided in this section for crops or plants that have similar nutrient requirements;*
- *recommendations from other state universities with similar growing conditions for specific crops or plants;*
- *any generally accepted growing practices for plants under comparable growing conditions.*

If any of these alternative sources are used by a certified nutrient management consultant to develop nutrient recommendations, the source of information and justification for its use is to be documented in the consultant's records for that agricultural operation.

When nutrient recommendations are being made for out-of-ground agricultural operations, at least one of the following sources is to be used:

- *recommendations of the University of Maryland Cooperative Extension for the specific crops being grown or for similar plants;*
- *label recommendations on fertilizer products for the crops being grown or similar plants;*
- *recommendations from other state universities for specific crops being grown or for similar plants;*
- *data from research done by accredited universities on specific crops being grown or similar plants;*
- *general nutrition guidelines for similar plants;*
- *a generally accepted growing practice for plants under comparable growing conditions.*

The source of information and justification for its use is to be documented in the consultant's records for that agricultural operation. Chapter C of this section, *Estimated Mineralization Rates, Nitrogen Credits for Legumes and Ammonia Conservation Factor for Organic Nitrogen*, shall be used to determine residual nitrogen when animal manure or other organic sources of nutrients such as legumes or biosolids are used within an agricultural operation. Chapter D of this section, *Timing of Nutrient Application*, provides general guidelines as required under COMAR 15.20.08.05H for when nutrients shall be applied and specific requirements for nutrient application in the fall and winter. Guidelines shall be used by the consultant when developing a plan and by the agricultural operator when implementing a plan.

# Section I-B1

## Nutrient Recommendations by Crop

**Agronomic Crop Nutrient Recommendations**
**Based on Soil Tests and Yield Goals**
**(University of Maryland Cooperative Extension, 2009)**

Section I-B1

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# NUTRIENT RECOMMENDATIONS BY CROP

*Source: University of Maryland Cooperative Extension, November 2009*
*Regulatory Citation: COMAR 15.20.08.05*

## AGRONOMIC CROP NUTRIENT RECOMMENDATIONS BASED ON SOIL TESTS AND YIELD GOALS

The Maryland Cooperative Extension Soil Testing Laboratory analyzed soil samples and generating plant nutrient application recommendations from 1954 until its closing in 2003. Over the years, fertility recommendations have been updated as improved laboratory methodologies have been developed, as cropping systems and crop genetics have improved, and as our understanding of the relationship between laboratory soil test results and crop yields has advanced.

### Philosophy of Soil Testing

There are several philosophies that may be embraced when developing crop nutrient recommendations. Some of these different approaches involve attempting to Abalance@ the levels of nutrients in the soil, while others aim at maintaining a constant soil fertility level. One unwavering component of Maryland's plant nutrient recommendation program has been a continuous commitment to the sufficiency level philosophy of soil testing. The sufficiency level concept is based on long-term calibrations of soil tests with field yield response data that reveal soil test levels above which no yield response to applied nutrients is observed. At soil test levels below the sufficiency level, field calibration data determine the quantity of applied nutrient that is necessary to obtain maximum yield under local growing conditions.

### Crop Yield Goals

Crop yield potential, or yield goal, also changed over the years as a reflection of the cumulative advances in crop production practices and management expertise. Practical, realistic yield goals are now included as a vital component in the development of agronomic crop nutrient recommendations based on soil testing. Realistic crop yield goals will differ among farms, among fields within a farm, and with different levels of management of a given field. A yield goal should be a realistic target yield that is achievable given favorable growing conditions.

### Soil Testing Procedures

The Maryland Cooperative Extension Soil Testing Laboratory employed the Mehlich 1 (e.g. double-acid) procedure for determining the levels of soil test phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), manganese (Mn), copper (Cu), and zinc (Zn). A hot water soil extract is used for boron (B) determination and an acidic monocalcium phosphate solution is used to extract sulfate sulfur ($SO_4$-S). All nitrogen recommendations are based on crop nitrogen requirements and yield goals.

### Soil Test Interpretive Categories

The Maryland Cooperative Extension Soil Testing Laboratory generated numerical values, or soil test results, that describe the relative availability of a given nutrient to the crop and the expected crop response to application of that nutrient to the soil. The soil test results were grouped into four interpretive categories, "Low," "Medium," "Optimum" and "Excessive."

***Low:*** The nutrient concentration in the soil is inadequate for optimum growth of most crops and will very likely limit plant growth and yield. There is a high probability of a favorable economic response to additions of the nutrient.

***Medium:*** The nutrient concentration in the soil may or may not be adequate for optimum growth of most crops. Plant growth and yield may be

limited by the availability of this nutrient. There is a low to moderate probability of a favorable economic response to additions of the nutrient.
***Optimum:*** The nutrient concentration in the soil is adequate for optimum growth of most crops. There is a very low probability of a favorable economic response to additions of the nutrient.
***Excessive:*** The nutrient concentration in the soil is more than adequate for optimum growth of most crops. Nutrient additions most likely will be unprofitable and may have undesirable effects on growth of some crops.

**Fertility Index Values**

The actual numerical soil test values are products of laboratory procedures that determine the concentrations of extractable plant nutrients in a measured volume of soil (mg nutrient per $dm^3$ soil). Thus, soil-test values are merely arbitrary index numbers and not measures of the actual quantity of plant available nutrients present in a soil.

Historically, these numerical soil test values have been converted to units of "pounds per acre" of soil test nutrient or as a concentration of the nutrient in the soil, such as parts per million (pap).

An alternative method for expressing the relative level of plant available nutrients measured by soil testing uses "fertility index values" (FIV). Fertility index values comprise a continuous relative scale that is calculated from the concentration of extractable nutrients measured in the laboratory, where the highest concentration within the "optimum" range is set equal to a fertility index value of 100 (FIV = 100). Thus, the FIV ranges for the four soil test interpretive categories are: low = 0 to 25; medium = 26 to 50; optimum = 51 to 100; and excessive = >100.

The numerical values generated by different soil testing procedures employed by different soil testing laboratories can be easily converted to the FIV scale for relative comparison. For more information on converting soil test results from one laboratory to another, see "Converting among Soil Test Analyses Frequently Used in Maryland," SFM-4, which is available from your Maryland Cooperative Extension county office, or online at http://anmp.umd.edu.

**Agronomic Plant Nutrient Recommendations**

Agronomic plant nutrient recommendations based on soil tests and yield goals for the major agronomic crops grown in Maryland are presented in Tables 1 through 10. These recommendations are based on the cumulative knowledge derived from decades of soil fertility research. Where ranges of applied nutrients are indicated, the amount of plant nutrient required depends on the exact numerical soil test value within the soil test category.

## TABLE 1. Plant Nutrient Recommendations Based on Soil Tests and Yield Goals for Corn Grain and Sorghum Grain Production

| Crop | Total Amount of Nutrients Recommended and Suggested Method of Application | Nitrogen (N) | Nitrogen if no P & K recommended | Recommended Nutrients Based on Soil Tests: Soil Test Phosphorus Category: Low | Medium | Optimum | Excessive | Soil Test Potassium Category: Low | Medium | Optimum | Excessive |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | lbs N / A | | lbs P205 / A | | | | lbs K20 / A | | | |
| **FIELD CORN FOR GRAIN** (140 bu / A yield goal) | | | | | | | | | | | |
| 1. Conventional-tillage * | Total Recommended | 140 | 140 | 65-135 | 30-65 | 20-30 | 0 | 110-180 | 60-110 | 20-60 | 0 |
| | Broadcast | 30 | 30 | 35-95 | 0-25 | 0 | 0 | 80-140 | 30-70 | 0-30 | 0 |
| | Banded with planter | 30 | 0 | 30-40 | 30-40 | 20-30 | 0 | 30-40 | 30-40 | 20-30 | 0 |
| | Sidedress | 80 | 110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2. No-tillage * | | | | | | | | | | | |
| A. Alternating No-tillage/ Conventional tillage | Total Recommended | 140 | 140 | 65-135 | 30-65 | 20-30 | 0 | 110-180 | 60-110 | 20-60 | 0 |
| | Broadcast | 30 | 30 | 35-95 | 0-25 | 0 | 0 | 80-140 | 30-70 | 0-30 | 0 |
| | Banded with planter | 30 | 0 | 30-40 | 30-40 | 20-30 | 0 | 30-40 | 30-40 | 20-30 | 0 |
| | Sidedress | 80 | 110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| B. Continuous No-tillage** | Total Recommended | 140 | 140 | 75-180 | 30-70 | 20-30 | 0 | 110-180 | 50-110 | 20-50 | 0 |
| | Broadcast | 30 | 30 | 45-140 | 0-35 | 0 | 0 | 50-110 | 30-80 | 0-20 | 0 |
| | Banded with planter | 30 | 0 | 30-40 | 30-40 | 20-30 | 0 | 30-40 | 20-30 | 20-30 | 0 |
| | Sidedress | 80 | 110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **GRAIN SORGHUM** (100 bu/A yield goal) | Total Recommended | 75 | 75 | 65-135 | 30-65 | 20-30 | 0 | 80-150 | 30-80 | 20-30 | 0 |
| | Broadcast | 45 | 75 | 35-95 | 0-25 | 0 | 0 | 50-110 | 0-40 | 0 | 0 |
| | Banded with planter | 30 | 30 | 30-40 | 30-40 | 20-30 | 0 | 30-40 | 30-40 | 20-30 | 0 |

Notes for Table 1 on following page.

*Recommendations assume that soil samples were taken from the conventional plow layer depth (0-8 inches) of all fields, including conventional, conservation, reduced and rotational tillage, as well as no-tillage management systems.

** For continuous no-tillage, a separate soil samples should be collected from the 0-2 inch depth to monitor surface soil acidity (pH only).

Where ranges of nutrients are indicated for phosphorus and potassium, precise amount of plant nutrient required depends upon the numerical soil test index value for that nutrient. A starter fertilizer is normally suggested, even on those soils testing optimum or excessive in phosphate and/or potash and where little or no total P2O5 & K2O is recommended by soil test. A starter is often beneficial in stimulating early plant growth, especially on cold wet soils. A complete starter fertilizer should supply 20 to 30 lbs/A of N, P2O5, and K2O.

**FIELD CORN FOR GRAIN**

Apply 1.0 lb N / bushel of expected grain yield up to 250 bu/A. No additional nitrogen is recommended for yield goals above 250 bu/A.
Nitrogen recommendations assume split applications (sidedress or fertigation).

For conventional-tillage or no-tillage corn:

1) Where N solution (UAN) is the N source, N rate assumes injection or subsurface band placement.
2) If UAN is surface broadcast at planting, increase rate by 15-20%.
3) If sidedress UAN is dribbled or streamed on the soil surface, increase rate by 5-10%.
4) If sidedress N source is granulated urea, increase rate by 25%.

For corn yield goals above 140 bu / A, adjust P2O5 as follows:

1) If phosphorus soil test index is less than 51, increase P2O5 0.6 lb / A for each bushel of expected yield above 140 bushels.
2) If phosphorus soil test index is between 51 and 100 lb / A, increase P2O5 0.3 lb / A for each bushel of expected yield above 140 bushels.
3) If phosphorus soil test index is greater than 100, no adjustment is necessary.

For corn yield goals above 140 bu / A, adjust K2O as follows:

1) If potassium soil test index is less than 51; increase K2O 0.8 lb / A for each bushel of expected yield above 140 bu / A.
2) If potassium soil test index is between 51 and 100 lb / A, increase K2O 0.4 lb / A for each bushel of expected yield above 140 bu / A.
3) If potassium soil test index is greater than 100, no adjustment is necessary.

**GRAIN SORGHUM**

For grain sorghum, apply 0.75 lb N / bushel of expected yield up to 125 bu / A. No additional nitrogen is recommended for yields above 125 bu / A.

For no-tillage grain sorghum:

1) Where N solution (UAN) is the N source, N rate assumes injection or subsurface band placement.
2) If UAN is surface broadcast at planting, increase rate by 15-20%.
3) If sidedress UAN is dribbled or streamed on the soil surfsace, increase rate by 5-10%.
4) If sidedress N source is granulated urea, increase rate by 25%.

For grain sorghum yield goals above 100 bu / A, adjust P2O5 as follows:

1) If phosphorus soil test index is less than 51, increase P2O5 by 0.4 lb / A for every bushel of expected yield over 100 bu/A.
2) If phosphorus soil test index is between 51 and 100, increase P2O5 by 0.2 lb / A for every bushel of expected yield over 100 bu/A.
3) If phosphorus soil test index is greater than 100, no adjustment is necessary.

For grain sorghum yield goals above 100 bu / A, adjust K2O as follows:

1) If potassium soil test index is less than 51, increase K2O by 0.6 lb / A for every bushel of expected yield over 100 bu/A.
2) If potassium soil test index is between 51 and 100 , increase K2O by 0.3 lb / A for every bushel of expected yield over 100 bu/A.
3) If potassium soil test index is greater than 100, no adjustment is necessary.

**TABLE 2. Plant Nutrient Recommendations Based on Soil Tests and Yield Goals for Corn Silage Production**

| Crop | Total Amount of Nutrients Recommended and Suggested Method of Application | Nitrogen (N) | Nitrogen if no P & K recommended | Soil Test Phosphorus Category | | | | Soil Test Potassium Category | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Low | Medium | Optimum | Excessive | Low | Medium | Optimum | Excessive |
| **CORN SILAGE** (20 ton/A yield goal) | | lbs N / A | | lbs P205 / A | | | | lbs K20 / A | | | |
| 1. Conventional-tillage * | Total Recommended | 120 | 120 | 55-125 | 35-55 | 20-35 | 0 | 150-250 | 80-150 | 20-80 | 0 |
| | Broadcast | 30 | 30 | 30-85 | 0 | 0 | 0 | 120-210 | 60-120 | 0-50 | 0 |
| | Banded with planter | 20 | 0 | 25-40 | 35-55 | 20-35 | 0 | 30-40 | 20-30 | 20-30 | 0 |
| | Sidedress | 70 | 90 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2. No-tillage ** | | | | | | | | | | | |
| A. Alternating No-tillage/ Conventional-tillage | Total Recommended | 120 | 120 | 55-125 | 35-55 | 20-35 | 0 | 150-250 | 80-150 | 20-80 | 0 |
| | Broadcast | 30 | 30 | 30-85 | 0 | 0 | 0 | 120-210 | 60-120 | 0-50 | 0 |
| | Banded with planter | 20 | 0 | 25-40 | 35-55 | 20-35 | 0 | 30-40 | 20-30 | 20-30 | 0 |
| | Sidedress | 70 | 90 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| B. Continuous No-tillage | Total Recommended | 120 | 120 | 95-165 | 35-95 | 20-35 | 0 | 150-250 | 80-150 | 20-80 | 0 |
| | Broadcast | 30 | 30 | 55-125 | 0-55 | 0 | 0 | 120-210 | 60-120 | 0-50 | 0 |
| | Banded with planter | 20 | 0 | 40 | 35-40 | 20-35 | 0 | 30-40 | 20-30 | 20-30 | 0 |
| | Sidedress | 70 | 90 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**NOTES:**

*Recommendations assume that soil samples were taken from the conventional plow layer depth (0-8 inches) of all fields, including conventional, conservation, reduced and rotational tillage, as well as no-tillage management systems.

** For continuous no-tillage, a separate soil samples should be collected from the 0-2 inch depth to monitor surface soil acidity (pH only).

Where ranges of nutrients are indicated for phosphorus and potassium, precise amount of plant nutrient required depends upon the numerical soil test index value for that nutrient. A starter fertilizer is normally suggested, even on those soils testing optimum or excessive in phosphate and/or potash and where little or no total P2O5 & K2O is recommended by soil test. A starter is often beneficial in stimulating early plant growth, especially on cold wet soils. A complete starter fertilizer should supply 20 to 30 lbs/A of N, P2O5,and K2O. Nitrogen recommendations assume split application (sidedress or fertigation).

For no-tillage corn silage:

1) Where N solution (UAN) is the N source, N rate assumes injection.
2) If sidedress UAN is broadcast after planting using drop nozzles, increase rate by 15%.
3) If sidedress UAN is dribbled after planting, increase rate by 5-10%.
4) If sidedress N source is granulated urea, increase rate by 25%.

For corn silage yields above 20 tons / A, adjust N as follows:

1) Increase nitrogen rate by 7 lb / ton for each ton of expected yield between 20 and 40 tons / A.
2) For expected corn silage yields greater than 40 tons / A, no additional nitrogen is recommended.

For corn silage yields above 20 tons / A, adjust P2O5 as follows:

1) If phosphorus soil test index is less than 51, increase P2O5 5 lbs / A for each additional ton of expected yield over 20 tons / A.
2) If phosphorus soil test index is between 51 and 100, increase P2O5 2.5 lbs / A for each additional ton of expected yield over 20 tons / A.
3) If phosphorus soil test index is greater than 100, no adjustment is necessary.

For corn silage yields above 20 tons / A, adjust K2O as follows:

1) If potassium soil test index is less than 100, increase K2O 7 lbs / A for each additional ton of expected yield over 20 tons / A.
2) If potassium soil test index is greater than 100, no adjustment is necessary.

## TABLE 3. Plant Nutrient Recommendations Based on Soil Tests and Yield Goals for Small Grain Production

| Crop | Total Amount of Nutrients Recommended and Suggested Method of Application | Nitrogen (N) | Recommended Nutrients Based on Soil Tests: Soil Test Phosphorus Category Low | Medium | Optimum | Excessive | Soil Test Potassium Category Low | Medium | Optimum | Excessive |
|---|---|---|---|---|---|---|---|---|---|---|
| | | lbs N / A | lbs P205 / A | | | | lbs K20 / A | | | |
| 1. WHEAT, BARLEY, RYE, OATS * | | | | | | | | | | |
| A. Lodging not expected | Total Recommended | 70-100 | 60-100 | 40-60 | 20-40 | 0 | 60-100 | 40-60 | 20-40 | 0 |
| | Broadcast and disk in or drill with seed. | 20-40 | 60-100 | 40-60 | 20-40 | 0 | 60-100 | 40-60 | 20-40 | 0 |
| | Topdress. | 50-60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| B. Lodging expected | Total Recommended | 50-80 | 60-100 | 40-60 | 20-40 | 0 | 60-100 | 40-60 | 20-40 | 0 |
| | Broadcast and disk in or drill with seed. | 0-20 | 60-100 | 40-60 | 20-40 | 0 | 60-100 | 40-60 | 20-40 | 0 |
| | Topdress. | 50-60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2. SPRING OATS (60-65 bu / A yield goal) | Broadcast and disk in or drill with seed. | 30-60 | 60-100 | 40-60 | 20-40 | 0 | 60-100 | 40-60 | 20-40 | 0 |
| 3. SMALL GRAIN - DOUBLE-CROP SOYBEAN (Double-crop recommendation) | | | | | | | | | | |
| A. Lodging not expected | Total recommended | 70-100 | 140-265 | 85-140 | 20-85 | 0 | 145-255 | 75-145 | 20-75 | 0 |
| | Broadcast or drill in fall | 20-40 | 70-165 | 45-100 | 20-85 | 0 | 75-155 | 35-105 | 20-75 | 0 |
| | Topdress. | 50-60 | 70-100 | 40 | 0 | 0 | 70-100 | 40 | 0 | 0 |
| B. Lodging expected | Total | 50-80 | 140-265 | 85-140 | 20-85 | 0 | 145-255 | 75-145 | 20-75 | 0 |
| | Broadcast or drill in fall | 0-20 | 70-165 | 45-100 | 20-85 | 0 | 75-155 | 35-105 | 20-75 | 0 |
| | Topdress | 50-60 | 70-100 | 40 | 0 | 0 | 70-100 | 40 | 0 | 0 |
| 4. SMALL GRAIN - LEGUME INTERSEEDED | Total recommended | 20-40 | 75-125 | 50-75 | 20-50 | 0 | 75-120 | 45-75 | 20-45 | 0 |
| | Broadcast or drill in fall | 0-20 | 75-125 | 50-75 | 20-50 | 0 | 75-120 | 45-75 | 20-45 | 0 |
| | Topdress. | 0-20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5. ICM WHEAT ** (Intensive Crop Management) (100 bu / A yield goal) | Total | 100-120 | 100-140 | 80-100 | 20-80 | 0 | 100-140 | 80-100 | 20-80 | 0 |
| | Broadcast at planting | 20-40 | 100-140 | 80-100 | 20-80 | 0 | 100-140 | 80-100 | 20-80 | 0 |
| | Topdress ** | 80-100** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6. ICM WHEAT ** - DOUBLE-CROP SOYBEAN (Intensive Crop Management) (100 bu / A wheat yield goal) | Total | 100-120 | 140-265 | 85-140 | 20-85 | 0 | 145-255 | 85-145 | 20-85 | 0 |
| | Broadcast at planting | 20-40 | 70-165 | 45-100 | 20-85 | 0 | 75-155 | 35-95 | 20-85 | 0 |
| | Topdress ** | 80-100** | 70-100 | 40 | 0 | 0 | 70-100 | 50 | 0 | 0 |

Notes for Table 3 on following page

Table 3 NOTES:

Where ranges of nutrients are indicated for phosphorus and potassium, the precise amount of plant nutrient required depends upon the numerical soil test index value for that nutrient.

* Use these recommendations for wheat yield goals of 60-70 bu / A, barley yield goals of 80-100 bu / A, winter oat yield goals of 70-80 bu / A, and rye yield goals of 30-35 bu / A. For higher yield goals, use ICM Wheat management practices.

** Split topdress N application. Apply half at green-up and half at Feekes growth stage 5-6.

For ICM wheat (Intensive Crop Management Wheat): Total nitrogen application rate is 1.0 lb N / bushel of expected wheat yield plus 20 lb N / acre when yield goal is between 80 and 120 bushels.

For all small grains production systems (conventional-tillage or no-tillage):
1) If topdress N solution (UAN) is surface broadcast, increase rate by 15-20%.
2) If topdress UAN is dribbled or streamed on the soil surface, increase rate by 5-10%.
3) If topdress N source is granulated urea, increase rate by 25%.

For ICM wheat yield goals above 100 bu / A, adjust P2O5 as follows:
1) If phosphorus soil test index is less than 51, increase P2O5 by 1 lb / A for each bushel of expected yield above 100 bu / A.
2) If phosphorus soil test index is between 51 and 100, increase P2O5 by 0.5 lb / A for each bushel of expected yield above 100 bu / A.
3) If phosphorus soil test index is greater than 100, no adjustment is necessary.

For ICM wheat yield goals above 100 bu / A, adjust K2O as follows:
1) If potassium soil test index is less than 51, increase K2O by 1 lb K2O / A for each bushel of expected yield above 100 bu / A.
2) If potassium soil test index is between 51and 100, increase K2O by 0.5 lb K2O / A for each bushel of expected yield above 100 bu / A.
3) If potassium soil test index is greater than 100, no adjustment is necessary.

For all small grain - double-crop soybean rotation with double-crop soybean yield goal above 40 bu / A, adjust P2O5 as follows:
1) If phosphorus soil test index is less than 51, increase P2O5 by 1.5 lb / A for every bushel of expected double-crop soybean yield over 40 bu / A.
2) If phosphorus soil test index is between 51 and 100, increase P2O5 by 0.75 lb / A for every bushel of expected double-crop soybean yield over 40 bu / A.
3) If phosphorus soil test index is greater than 100, no adjustment is necessary.

For all small grain - double-crop soybean rotation with double-crop soybean yield goal above 40 bu / A, adjust K2O as follows:
1) If potassium soil test index is less than 51, add 3 lb / A K2O for every bushel of expected double-crop soybean yield over 40 bu / A.
2) If potassium soil test index is between 51 and 100, add 1.5 lb/ A K20 for every bushel of expected double-crop soybean yield over 40 bu / A.
3) If potassium soil test index is greater than 100, no adjustment is necessary.

**TABLE 4. Plant Nutrient Recommendations Based on Soil Tests and Yield Goals for Soybean and Other Oilseed Production**

| Crop | Total Amount of Nutrients Recommended and Suggested Method of Application | Nitrogen (N) | Recommended Nutrients Based on Soil Tests: Soil Test Phosphorus Category | | | | Soil Test Potassium Category | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Low | Medium | Optimum | Excessive | Low | Medium | Optimum | Excessive |
| | | lbs N / A | lbs P205 / A | | | | lbs K20 / A | | | |
| **SOYBEAN (full season)** (40 bu / A yield goal) | Broadcast or banded at planting | 0* | 80 - 120 | 45 - 80 | 20 - 45 | 0 | 80 - 125 | 40 - 80 | 20 - 40 | 0 |
| **CANOLA** | | | | | | | | | | |
| A. Lodging not expected | Total | 120-150 | 60 - 80 | 40 - 60 | 20 - 40 | 0 | 60 - 80 | 40 - 60 | 20 - 40 | 0 |
| | Broadcast | 20-40 | 60 - 80 | 40 - 60 | 20 - 40 | 0 | 60 - 80 | 40 - 60 | 20 - 40 | 0 |
| | Topdress | 100-110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| B. Lodging expected | Total | 70-100 | 60 - 80 | 40 - 60 | 20 - 40 | 0 | 60 - 80 | 40 - 60 | 20 - 40 | 0 |
| | Broadcast | 20 - 40 | 60 - 80 | 40 - 60 | 20 - 40 | 0 | 60 - 80 | 40 - 60 | 20 - 40 | 0 |
| | Topdress | 50-60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SUNFLOWER** | Total | 50 | 30 | 20 | 0 | 0 | 30 | 20 | 0 | 0 |
| (0.5 ton seed / A yield goal) | Broadcast at planting | 50 | 30 | 20 | 0 | 0 | 30 | 20 | 0 | 0 |

**NOTES:**

*Nitrogen application is not recommended for soybean production, however, use of commercially available fertilizer formulations may result in application of up to 50 lb N/acre when fertilizer formulation and application rate is determined by crop $P_2O_5$, $K_2O$, S, or other nutrient needs.

Organic waste nitrogen application to full-season soybean is not recommended because it is an agronomically inefficient use of applied nutrients. Organic wastes should only be applied to small grain - double-crop soybean rotations at rates and timings to supply the recommended nitrogen rate to the small-grain crop.

For full-season soybean yield goals above 40 bu / A, adjust P2O5 as follows:

1) If phosphorus soil test index is less than 51, increase P2O5 by 1.5 lb/acre for each additional bushel of expected yield over 40 bu / A.
2) If phosphorus soil test index is between 51 and 100, increase P2O5 by 0.75 lb / A for each additional bushel of expected yield over 40 bu / A.
3) If phosphorus soil test index is greater than 100, no adjustment is necessary.

For full-season soybean yield goals above 40 bu / A, adjust K2O as follows:

1) If potassium soil test index is less than 51, increase K2O by 3 lb / A for each bushel of expected yield over 40 bu / A.
2) If potassium soil test index is between 51and 100, increase K2O by 1.5 lb / A for each bushel of expected yield over 40 bu / A.
3) If potassium soil test index is greater than 100, no adjustment is necessary.

For all small grain - double-crop soybean rotation with double-crop soybean yield goal above 40 bu / A, adjust P2O5 as follows:

1) If phosphorus soil test index is less than 51, increase P2O5 by 1.5 lb / A for every bushel of expected double-crop soybean yield over 40 bu / A.
2) If phosphorus soil test index is between 51 and 100, increase P2O5 by 0.75 lb / A for every bushel of expected double-crop soybean yield over 40 bu / A.
3) If phosphorus soil test index is greater than 100, no adjustment is necessary.

For all small grain - double-crop soybean rotation with double-crop soybean yield goal above 40 bu / A, adjust K2O as follows:

1) If potassium soil test index is less than 51, add 3 lb / A K2O for every bushel of expected double-crop soybean yield over 40 bu / A.
2) If potassium soil test index is between 51 and 100, add 1.5 lb/ A K20 for every bushel of expected double-crop soybean yield over 40 bu / A.
3) If potassium soil test index is greater than 100, no adjustment is necessary.

For sunflower seed yield goals between 0.5 and 1.5 tons / A, adjust as follows:

1) Add 25 lb N / A for each 0.25 tons / A of expected yield above 0.5 tons / A.
2) Add 5 lb P2O5 / A for each 0.25 tons / A of expected yield above 0.5 tons / A.
3) Add 10 lb K2O / A for each 0.25 tons / A of expected yield above 0.5 tons / A.
4) For expected yields greater than 1.5 tons / A, no additional nutrients are necessary.

TABLE .. Plant Nutrient Recommendations Based on Soil Tests and Yield Goals for establishment of Hay, Pasture, and Silage Crops.

| Crop: NEWLY SEEDED | Total Amount of Nutrients Recommended and Suggested Method of Application | Nitrogen (N) | Recommended Nutrients Based on Soil Tests: Soil Test Phosphorus Category Low | Medium | Optimum | Excessive | Soil Test Potassium Category Low | Medium | Optimum | Excessive |
|---|---|---|---|---|---|---|---|---|---|---|
| **ALFALFA & ALFALFA-GRASS MIX** | | | | | | | | | | |
| A. Spring seeded | Broadcast and disk in | 15-30 * | 110-205 | 70-110 | 20-70 | 0 | 185-295 | 115-185 | 20-115 | 0 |
| B. Fall seeded | Total recommended | 15-30 * | 155-280 | 100-155 | 60-100 | 0 | 205-300 | 140-205 | 80-140 | 0 |
| | Broadcast and disk in | 15-30 * | 60 | 60 | 60 | 0 | 60 | 60 | 60 | 0 |
| | Topdress following spring | 0 | 95-220 | 40-95 | 20-40 | 0 | 145-240 | 80-145 | 20-80 | 0 |
| **CLOVER, CLOVER-GRASS MIX, HAIRY VETCH, BIRDSFOOT TREFOIL** | Broadcast and disk in | 15-30 | 60-100 | 40-60 | 20-40 | 0 | 60-100 | 40-60 | 20-40 | 0 |
| **LESPEDEZA, LESPEDEZA-GRASS MIX** | Broadcast and disk in | 15-20 | 35-60 | 20-35 | 20 | 0 | 40-65 | 25-40 | 25 | 0 |
| **COOL SEASON PERENNIAL GRASSES **** | | | | | | | | | | |
| A. Spring seeded mid-March to mid-April | Broadcast or disk in | 40-60 | 60-100 | 40-60 | 20-40 | 0 | 60-100 | 40-60 | 20-40 | 0 |
| B. Late summer seeded Aug 10-Sep 10 except Garret County Aug 1 - Sep 1 | Broadcast or disk in | 15-30 | 60-100 | 40-60 | 20-40 | 0 | 60-100 | 40-60 | 20-40 | 0 |
| **TIMOTHY** | | | | | | | | | | |
| A. Spring seeded | Broadcast or disk in | 40-60 | 60-100 | 40-60 | 20-40 | 0 | 60-100 | 40-60 | 20-40 | 0 |
| B. Late summer seeded | Broadcast or disk in | 15-30 | 60-100 | 40-60 | 20-40 | 0 | 60-100 | 40-60 | 20-40 | 0 |
| **WARM SEASON PERENNIAL GRASSES ***** | Broadcast and disk in | 0 | 40-60 | 20-40 | 0 | 0 | 60-90 | 20-60 | 0 | 0 |
| **ANNUAL RYEGRASS AND/or CEREAL GRAIN FOR GRAZING** | | | | | | | | | | |
| A. Seeded Sept | Broadcast and disk in | 50 | 60-150 | 20-60 | 20 | 0 | 110-200 | 50-110 | 20-50 | 0 |
| B. Seeded Oct/Nov | Broadcast and disk in | 15-30 | 60-150 | 20-60 | 20 | 0 | 110-200 | 50-110 | 20-50 | 0 |
| **CEREAL GRAIN FOR SILAGE** | Total recommended | 75-100 | 50-100 | 25-50 | 25 | 0 | 50-100 | 25-50 | 25 | 0 |
| | Broadcast before seeding | 15-20 | 50-100 | 25-50 | 25 | 0 | 50-100 | 25-50 | 25 | 0 |
| | Topdress at greenup | 60-80 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **BUCKWHEAT** | Broadcast and disk in | 15-20 | 30-50 | 20-30 | 20 | 0 | 30-50 | 20-30 | 20 | 0 |

Where ranges of nutrients are indicated for phosphorus and potassium, the precise amount of plant nutrient required depends upon the numerical soil test index value for that nutrient. Nutrient recommendations for most forages were developed for hay production systems. Where no grazing designation for a crop is given, pasture-based producers may modify the timing and rate of nutrient applications as long 1) the total annual application rate does not exceed the total annual recommendation for each nutrient, and 2) nutrient application timing complies with "Nutrient Application Guidelines," Section I-D, of this manual.

* Organic waste nitrogen application for alfalfa establishment in excess of 30 lb / A of plant available nitrogen is not recommended due to inhibition of nodulation.

** Cool Season Perennial Grasses: orchardgrass, timothy, bromegrass, tall fescue, reed canarygrass, annual ryegrass, perennial ryegrass.

Table 6. Plant Nutrient Recommendations Based on Soil Tests and Yield Goals for Maintenance of Hay, Pasture, and Silage Crops.

| Crop | Total Amount of Nutrients Recommended and Suggested Method of Application | Nitrogen (N) | Recommended Nutrients Based on Soil Tests: Soil Test Phosphorus Category: Low | Medium | Optimum | Excessive | Soil Test Potassium Category: Low | Medium | Optimum | Excessive |
|---|---|---|---|---|---|---|---|---|---|---|
| | | lbs N / A | lbs P205 / A | | | | lbs K20 / A | | | |
| **ALFALFA & ALFALFA-GRASS MIX** (more than 25% alfalfa) | | | | | | | | | | |
| A. Yield goal: 4 tons / A | Topdress annually | 0* | 60-100 | 30-60 | 20-30 | 0 | 190-275 | 140-190 | 90-140 | 90 |
| B. Yield goal: 8 tons / A | Topdress annually | 0* | 100-120 | 50-100 | 20-50 | 0 | 470-555 | 420-470 | 370-420 | 370 |
| **CLOVER & CLOVER-GRASS MIX** (more than 25% clover) | | | | | | | | | | |
| A. Yield goal: 4 tons / A | Topdress annually | 0* | 60-100 | 30-60 | 20-30 | 0 | 190-275 | 140-190 | 90-140 | 90 |
| B. Yield goal: 8 tons / A | Topdress annually | 0* | 100-120 | 50-100 | 20-50 | 0 | 470-555 | 420-470 | 370-420 | 370 |
| **BIIRDSFOOT TREFOIL** (more than 25% trefoil) | Topdress annually | 0* | 60-100 | 30-60 | 20-30 | 0 | 125-195 | 75-125 | 40-75 | 40 |
| **BLUEGRASS-WHITE CLOVER MIX** (more than 25% white clover) | Topdress annually | 20-30 | 50-100 | 25-50 | 25 | 0 | 50-100 | 25-50 | 25 | 0 |
| **BLUEGRASS PASTURE** (with little or no clover) | Total recommended | 100-120 | 50-100 | 25-50 | 25 | 0 | 50-100 | 25-50 | 25 | 0 |
| | Topdress at greenup | 50-60 | 50-100 | 25-50 | 25 | 0 | 50-100 | 25-50 | 25 | 0 |
| | Topdress mid-late May | 25-30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Topdress in late summer | 25-30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **ORCHARDGRASS and REED CANARY GRASS** (less than 25% legumes) Yield goal: 4 tons / A | Total recommended | 160-200 | 60-150 | 20-60 | 20 | 0 | 110-200 | 50-110 | 20-50 | 0 |
| | Topdress at greenup | 80-100 | 30-80 | 20-60 | 20 | 0 | 60-100 | 50-60 | 20-50 | 0 |
| | Topdress after first harvest | 40-50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Topdress in late summer | 40-50 | 30-70 | 0 | 0 | 0 | 50-100 | 0-50 | 0 | 0 |
| **FESCUE** (less than 25% legumes). Yield goal: 5 tons / A | Total recommended | 220-250 | 60-150 | 20-60 | 20 | 0 | 110-200 | 50-110 | 20-50 | 0 |
| | Topdress at greenup | 100-125 | 30-80 | 20-60 | 20 | 0 | 60-100 | 50-60 | 20-50 | 0 |
| | Topdress after first harvest | 40-50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Topdress in late summer | 60-75 | 30-70 | 0 | 0 | 0 | 50-100 | 0-50 | 0 | 0 |
| **TIMOTHY, SMOOTH BROMEGRASS and PERENNIAL RYEGRASS** Yield goal: 3 tons / A | Total recommended | 140-180 | 60-150 | 20-60 | 20 | 0 | 110-200 | 50-110 | 20-50 | 0 |
| | Topdress at greenup | 60-80 | 30-80 | 20-60 | 20 | 0 | 60-100 | 50-60 | 20-50 | 0 |
| | Topdress after first harvest | 40-50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Topdress in late summer | 40-50 | 30-70 | 0 | 0 | 0 | 50-100 | 0-50 | 0 | 0 |
| **ANNUAL RYEGRASS and/or CEREAL GRAIN FOR GRAZING** (established previous fall) | Total recommended | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Topdress at greenup | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Topdress late April - early May | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Topdress late May - early June | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **WARM SEASON PERENNIAL GRASSES**** (except Eastern Gammagrass & improved Bermudagrass) Yield goal: 4 tons / A | Total recommended | 120 | 60-90 | 20-60 | 0 | 0 | 90-120 | 30-90 | 20-30 | 0 |
| | Topdress at greenup | 80 | 60-90 | 20-60 | 0 | 0 | 90-120 | 30-90 | 20-30 | 0 |
| | Topdress after first cutting/grazing | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 6 (continued)

| Crop: ESTABLISHED | Total Amount of Nutrients Recommended and Suggested Method of Application | Nitrogen (N) | Recommended Nutrients Based on Soil Tests: Soil Test Phosphorus Category: Low | Medium | Optimum | Excessive | Soil Test Potassium Category: Low | Medium | Optimum | Excessive |
|---|---|---|---|---|---|---|---|---|---|---|
| | | lbs N / A | lbs P205 / A | | | | lbs K20 / A | | | |
| EASTERN GAMAGRASS and IMPROVED BERMUDAGRASSES | Total recommended | 200-240 | 60-90 | 20-60 | 0 | 0 | 90-120 | 30-90 | 20-30 | 0 |
| | Topdress at greenup | 50-60 | 60-90 | 20-60 | 0 | 0 | 90-120 | 30-90 | 20-30 | 0 |
| Yield goal: 5 tons / A | Topdress after first cutting/grazing | 50-60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Topdress after second cutting/grazing | 50-60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Topdress after third cutting/grazing | 50-60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 6 NOTES:**

Where ranges of nutrients are indicated for phosphorus and potassium, precise amount of plant nutrient required depends upon the numerical soil test index value for that nutrient. Nutrient recommendations for most forages were developed for hay production systems. Where no grazing designation for a crop is given, pastured-based producers may modify the timing and rate of nutrient applications as long 1) the total annual application rate does not exceed the total annual recommendation for each nutrient, and 2) nutrient application timing complies with "Nutrient Application Guidelines," Section I-D, of this manual.

*Nitrogen application is not recommended for alfalfa, alfalfa-grass, clover, clover-grass, or birdsfoot trefoil production, however, use of commercially available fertilizer formulations may result in application of up to 50 lb N / acre when fertilizer formulation and application rate is determined by crop P2O5, K2O, S, or other nutrient needs.
Organic waste nitrogen application for maintenance of alfalfa, alfalfa-grass, clover, clover-grass, or birdsfoot trefoil is not recommended because it is an agronomically inefficient use of applied nutrients. Organic waste nitrogen may be applied to alfalfa, alfalfa-grass, clover, clover-grass, or birdsfoot trefoil stands as necessary for organic waste disposal when nutrient efficient alternatives for organic waste disposal are not available, at rates up to 140 lb/A plant available N for 4 tons/A yield goal. For yield goals above 4 tons/A, increase organic waste plant available N rate 35 lb/A for each ton of expected yield above 4 tons/A. Apply half of total rate in early spring (March) and half after first cutting.

For alfalfa & alfalfa-grass mix yield goals above 4 tons / A, adjust P2O5 as follows:
1) If phosphorus soil text index is less than 100, Increase P2O5 by 5 lb / A for each ton of expected yield above 4 tons / A.
2) If phosphorus soil test index is greater than 100, no adjustment is necessary.

For alfalfa & alfalfa-grass mix yield goals above 4 tons / A, increase K2O by 70 lb/A for each ton of expected yield above 4 tons/A, regardless of potassium soil test index.

For clover and clover-grass mixture yield goals above 4 tons / A, adjust P2O5 as follows:
1) If phosphorus soil test index is less than 100, increase P2O5 by 5 lbs / A for each ton of expected yield above 4 tons / A.
2) If phosphorus soil test index is greater than 100, no adjustment is necessary.

For clover and clover-grass mixture yield goals above 4 tons / A, increase K2O by 70 lbs / A for each ton of expected yield above 4 tons / A regardless of potassium soil test index.

Nitrogen recommendations for orchardgrass and reed canarygrass assume 4 tons/A yield. For yield above 4 tons/A, increase N application by a total of 50 lb/A for each ton of additional expected yield above 4 tons/A.

Nitrogen recommendations for perennial ryegrass, smooth bromegrass and timothy assume 3 tons/A yield. For yield above 3 tons/A, increase N application by a total of 45 lb/A for each ton of additional expected yield above 3 tons/A.

Nitrogen recommendations for tall fescue assume 5 tons/A yield. For yield above 5 tons/A, increase N application by a total of 50 lb/A for each ton of additional expected yield above 5 tons/A.

** The N recommendations for the warm-season perennial grasses including switchgrass, indiangrass, weeping lovegrass, buffalograss, caucasian bluestem, big bluestem, and little bluestem assume a 4 tons/A yield. For yield above 4 tons/A, increase N application by a total of 30 lb/A for each ton of expected hay yield above 4 tons/A.

The N recommendations for eastern gamagrass and improved bermudagrasses ( high yielding warm-season grasses), assume 5 tons/A hay yield. For yield above 5 tons/A, increase N application by a total of 50 lbs/A for each ton of additional expected yield above 5 tons/A.

When topdressing N, adjust rate as follows:
1) if UAN is surface broadcast, increase rate by 15-20 %;
2) if UAN is dribbled or streamed, increase rate by 5-10 %;
3) if granulated urea is broadcast, increase rate by 25%.

Table 7. Plant Nutrient Recommendations Based on Soil Tests and Yield Goals for Sudangrass, Millet, and Forage-Type Sorghum and Soybean.

| Crop | Total Amount of Nutrients Recommended and Suggested Method of Application | Nitrogen (N) | Recommended Nutrients Based on Soil Tests: Soil Test Phosphorus Category | | | | Soil Test Potassium Category | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Low | Medium | Optimum | Excessive | Low | Medium | Optimum | Excessive |
| | | lbs N / A | lbs P205 / A | | | | lbs K20 / A | | | |
| **SUDANGRASS, MILLET, and FORAGE-TYPE SORGHUMS** (10-15 ton / A yield goal) | Total recommended | 120-150* | 80-160 | 45-80 | 20-45 | 0 | 80-160 | 40-80 | 20-40 | 0 |
| | Broadcast and disked in | 70-100 | 80-160 | 45-80 | 20-45 | 0 | 80-160 | 40-80 | 20-40 | 0 |
| | Topdress after first harvest | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **FORAGE-TYPE SOYBEAN** (10-15 ton / A yield goal) | Broadcast and disked in | 20 | 80-160 | 45-80 | 20-45 | 0 | 80-160 | 45-80 | 20-45 | 0 |
| **SUMMER COVER CROP & WILDLIFE FEED PASTURE** | | | | | | | | | | |
| A. Sudangrass and forage-type sorghums | Broadcast before seeding | 50 | 70-130 | 40-70 | 20-40 | 0 | 70-130 | 40-70 | 20-40 | 0 |
| B. Forage-type soybean and millet | Broadcast before seeding | 25 | 70-130 | 40-70 | 20-40 | 0 | 70-130 | 40-70 | 20-40 | 0 |

Where ranges of plant nutrients are indicated for phosphorus and potassium, the precise amount of plant nutrient required depends upon the numerical soil test index value for that nutrient.

*Sudangrass, millet, forage-type sorghum: If a third harvest is planned, apply an additional 30-50 pounds of N after the second cutting.

**Table 8. Plant Nutrient Recommendations Based on Soil Tests for Maryland-type Tobacco**

| Crop | Total Amount of Nutrients Recommended and Suggested Method of Application | Nitrogen (N) | Recommended Nutrients Based on Soil Tests: Soil Test Phosphorus Category: Low | Medium | Optimum | Excessive | Soil Test Potassium Category: Low | Medium | Optimum | Excessive |
|---|---|---|---|---|---|---|---|---|---|---|
| | | lbs N / A | lbs P205 / A | | | | lbs K20 / A | | | |
| MARYLAND-TYPE TOBACCO | Total | 60-90 | 120 | 80 | 40 | 40 | 200 | 160 | 120 | 120 |
| | Broadcast | 40 | 120 | 80 | 40 | 40 | 130 | 100 | 80 | 80 |
| | Sidedress | 20-50 | 0 | 0 | 0 | 0 | 70 | 60 | 40 | 40 |

Where ranges of nurients are indicated for phosphorus and potassium, the precise amount of plant nutrient required depends upon the numerical soil test index value for that nutrient.

Potassium fertilizer should be potassium sulfate (K2SO4). Avoid fertilizers containing chloride (Cl)

**Table 9. Plant Nutrient Recommendations Based on Soil Tests for Cotton**

| Crop | Total Amount of Nutrients Recommended and Suggested Method of Application | Nitrogen (N) | Recommended Nutrients Based on Soil Tests: Soil Test Phosphorus Category: Low | Medium | Optimum | Excessive | Soil Test Potassium Category: Low | Medium | Optimum | Excessive |
|---|---|---|---|---|---|---|---|---|---|---|
| | | lbs N / A | lbs P205 / A | | | | lbs K20 / A | | | |
| COTTON | Total | 50-75 | 80-120 | 40-80 | 30-40 | 0 | 80-120 | 40-80 | 30-40 | 0 |
| | Broadcast pre-plant | 0 | 50-80 | 10-40 | 0 | 0 | 50-80 | 10-40 | 0 | 0 |
| | Banded with planter | 20-25 | 30-40 | 30-40 | 30-40 | 0 | 30-40 | 30-40 | 30-40 | 0 |
| | Sidedress | 30-50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Where ranges of nurients are indicated for phosphorus and potassium, the precise amount of plant nutrient required depends upon the numerical soil test index value for that nutrient.

**TABLE 10. Plant Micronutrient Recommendations Based on Soil Tests**

| Micronutrient | Crop | Soil Test Level (ppm in soil) | Recommended Nutrients Based on Soil Tests |
|---|---|---|---|
| BORON ( B ) | FIELD CORN, COTTON | less than 0.7 ppm B | 1 lb / A boron plowed down |
| | ALFALFA | less than 0.8 ppm B | 3 lb / A boron topdressed or with fertilizer |
| | | 0.8 to 1.2 ppm B | 2 lb / A boron topdressed or with fertilizer |
| | | greater than 1.2 ppm B | 1 lb / A boron topdressed or with fertilizer |
| | RED CLOVER, LADINO CLOVER | less than 0.8 ppm B | 2 lb / A boron topdressed or with fertilizer |
| ZINC ( Zn ) | CORN | If pH < 6.8 and P soil test index < 100 and soil test Zn < 0.8 ppm Zn | 4 lb / A zinc in band or 10-12 lb / A zinc broadcast |
| | | If pH > 6.8 or P soil test index > 100 and soil test Zn < 1.0 ppm Zn | 4 lb / A zinc in band or 10-12 lb / A zinc broadcast |
| MANGANESE (Mn) | CORN, SOYBEAN, SMALL GRAINS | less than 10 ppm Mn | 6 lb / A manganese in row, or 0.5 - 1.0 lb / A manganese, foliar spray @ 20 gal / A, apply two foliar applications, two weeks apart. |
| SULFUR ( S ) | CORN, SOYBEAN, SMALL GRAIN, ALFALFA, COTTON | For sands and sandy loam soil: If SO4-S < 6 ppm in 0-8 inch depth, and SO4-S < 20 ppm in 16-24 inch depth | 20 lb / A SO4-S |
| | | For all other soils: If SO4-S < 6 ppm SO4-S | 20 lb / A SO4-S |
| COPPER ( Cu ) | ALL CROPS | less than 0.3 ppm Cu | 2 lb / A copper if organic matter < 3.8 %<br>4 lb / A copper if organic matter 3.8 - 5.0 %<br>5 lb / A copper if organic matter 5.0 - 10 %<br>6 lb / A copper if organic matter > 10 % |

# Section I-B2

## Nutrient Recommendations by Crop

**Plant Nutrient Recommendations Based on**
**Soil Tests For Vegetable Crop Production**
**(University of Maryland Cooperative Extension, 2009)**

## PLANT NUTRIENT RECOMMENDATIONS BASED ON SOIL TESTS FOR VEGETABLE CROP PRODUCTION

*Source: University of Maryland Cooperative Extension, November 2009*
*Regulatory Citation: COMAR 15.20.06.05*

### Important Notes

1. For most vegetables grown on light-textured soils, apply the total recommended $P_2O_5$ and $K_2O$ together with 25 to 50 percent of the recommended nitrogen before planting. The remaining nitrogen can be side dressed with a fertilizer containing nitrogen only. Side dressing or topdressing potash ($K_2O$) is recommended only on extremely light sandy soils with very low cation exchange capacities.
2. It may be desirable to build up the phosphorus and potassium levels in very low-fertility loam and silt loam soils more rapidly than provided by these recommendations. In such instances, add an additional 40 to 50 pounds of $P_2O_5$ and $K_2O$, respectively, to the recommendations listed in the table for soils testing low in phosphorus and potassium. Apply the additional amounts in broadcast and plow down or broadcast and disk-in application.
3. In absence of soil tests, use recommendations listed under medium phosphorus and medium potassium levels on light-textured soils that have been in intensive vegetable production.

| Crop | Nitrogen (N) pounds per acre | Recommended Nutrients Based on Soil Tests: Soil phosphorus level Low | Medium | Optimum | Soil potassium level Low | Medium | Optimum | Total amount of nutrient recommended and suggested methods of application |
|---|---|---|---|---|---|---|---|---|
| | | $P_2O_5$ pounds per acre | | | $K_2O$ pounds per acre | | | |
| **ASPARAGUS** | Apply 1-2 pounds of boron (B) per acre every 3 years on most soils. See Table 1 for more specific boron recommendations. | | | | | | | |
| **Growing crowns** | 50 | 200 | 100 | 50 | 200 | 100 | 50 | Total recommended |
| | 50 | 200 | 100 | 50 | 200 | 100 | 50 | Broadcast & disk in |
| **New plantings** (Crown & transplant) | 75-100 | 200 | 100 | 50 | 200 | 100 | 50 | Total recommended |
| | 50 | 200 | 100 | 50 | 200 | 100 | 50 | Broadcast & plow down |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 4 wks after planting |
| **Cutting beds** | | | | | | | | |
| | 75-100 | 200 | 150 | 100 | 300 | 225 | 150 | Total recommended |
| | 75-100 | 200 | 150 | 100 | 300 | 225 | 150 | Broadcast & disk in |
| **BEANS** | Apply 1-2 pounds of boron (B) per acre every 3 years on most soils. See Table 1 for more specific boron recommendations. | | | | | | | |
| **Lima, single crop** | 60-80 | 100 | 60 | 20 | 140 | 100 | 60 | Total recommended |
| | 30-40 | 100 | 60 | 20 | 140 | 100 | 60 | Broadcast & disk in -OR- |
| | 30 | 50 | 30 | 10 | 30 | 15 | 0 | Band-place with planter |
| | 30-40 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 3-5 wks after emergence |
| **Lima, after peas** | 20 | 0 | 0 | 0 | 0 | 0 | 0 | Band-place with planter |
| **Snap, single crop** | 40-80 | 80 | 60 | 40 | 80 | 60 | 40 | Total recommended |
| | 20-40 | 40 | 40 | 0 | 40 | 40 | 0 | Broadcast & disk in |
| | 20-40 | 40 | 20 | 40 | 40 | 20 | 40 | Band place with planter |
| **Snap, after peas** | 0-20 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress at pre-bloom stage |
| **BEETS** | Apply 1½-3 pounds of boron (B) per acre in mixed fertilizer. See Table 1 for more specific boron recommendations. | | | | | | | |
| | 75-100 | 150 | 100 | 50 | 150 | 100 | 50 | Total recommended |
| | 50 | 150 | 100 | 50 | 150 | 100 | 50 | Broadcast & disk in |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 4-6 weeks after planting |

| Crop | Nitrogen (N) pounds per acre | Recommended Nutrients Based on Soil Tests: Soil phosphorus level Low | Medium | Optimum | Soil potassium level Low | Medium | Optimum | Total amount of nutrient recommended and suggested methods of application |
|---|---|---|---|---|---|---|---|---|
| | | $P_2O_5$ pounds per acre | | | $K_2O$ pounds per acre | | | |
| **BROCCOLI** | Apply 1½-3 pounds of boron (B) per acre in mixed fertilizer. See Table 1 for more specific boron recommendations. | | | | | | | |
| | 150-200 | 200 | 100 | 50 | 200 | 100 | 50 | Total recommended |
| | 50-100 | 150 | 100 | 50 | 150 | 100 | 50 | Broadcast & disk in |
| | 50 | 50 | 0 | 0 | 50 | 0 | 0 | Sidedress 2-3 weeks after planting |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 4-6 weeks after planting |
| **BRUSSELS SPROUTS, CABBAGE & CAULIFLOWER** | Apply 1½-3 pounds of boron (B) per acre and 0.2 pound molybdenum (Mo) as 0.5 pound sodium molybdate per acre with broadcast fertilizer. | | | | | | | |
| | 100-150 | 200 | 100 | 50 | 200 | 100 | 50 | Total recommended |
| | 50-75 | 200 | 100 | 50 | 200 | 100 | 50 | Broadcast & disk in |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 2-3 weeks after planting |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress if needed according to weather |
| **CARROTS** | Apply 1-2 pounds of boron (B) per acre with broadcast fertilizer. See Table 1 for more specific boron recommendations. | | | | | | | |
| | 50-80 | 150 | 100 | 50 | 15 | 100 | 50 | Total recommended |
| | 50 | 150 | 100 | 50 | 150 | 100 | 50 | Broadcast & disk in |
| | 25-30 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress if needed |
| **CELERY** | Apply 1½-3 pounds of boron (B) per acre with broadcast fertilizer. See Table 1 for more specific boron recommendations. | | | | | | | |
| | 150-175 | 250 | 150 | 100 | 250 | 150 | 100 | Total recommended |
| | 50-75 | 250 | 150 | 100 | 250 | 150 | 100 | Broadcast & disk in |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 2-3 weeks after planting |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 6-8 weeks after planting |
| **CUCUMBER** | 100-125 | 150 | 100 | 50 | 200 | 150 | 100 | Total recommended |
| | 25-50 | 125 | 75 | 25 | 175 | 125 | 75 | Broadcast & disk in |
| | 25 | 25 | 25 | 25 | 25 | 25 | 25 | Band-place with planter |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress when vines start to run, or apply in irrigation water |
| **EGGPLANT** | Apply 1-2 pounds of boron (B) per acre with broadcast fertilizer. See Table 1 for more specific boron recommendations. | | | | | | | |
| | 125-150 | 250 | 150 | 100 | 250 | 150 | 100 | Total recommended |
| | 50-100 | 250 | 150 | 100 | 250 | 150 | 100 | Broadcast & disk in |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 3-4 weeks after planting |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 6-8 weeks after planting |
| | NOTE: If crop will be mulched with plastic but NOT drip/trickle fertilized, broadcast 225 pounds of nitrogen (N) per acre with recommended $P_2O_5$ and $K_2$ and disk-in or incorporate prior to laying mulch. See "Eggplant" in nutrient recommendation section for drip/trickle fertilization at the end of this chapter. | | | | | | | |
| **ENDIVE, ESCAROLE & LEAF LETTUCE** | 100-125 | 200 | 150 | 100 | 200 | 150 | 100 | Total recommended |
| | 50-75 | 200 | 150 | 100 | 200 | 150 | 100 | Broadcast & disk in |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 3-5 weeks after planting |

| Crop | Nitrogen (N) pounds per acre | Recommended Nutrients Based on Soil Tests: Soil phosphorus level Low | Medium | Optimum | Soil potassium level Low | Medium | Optimum | Total amount of nutrient recommended and suggested methods of application |
|---|---|---|---|---|---|---|---|---|
| | | $P_2O_5$ pounds per acre | | | $K_2O$ pounds per acre | | | |
| **GARLIC** | Apply 1-2 pounds of boron (B) per acre with broadcast fertilizer. See Table 1 for more specific boron recommendations. | | | | | | | |
| Fall-planted | 125 | 200 | 100 | 50 | 200 | 100 | 50 | Total recommended |
| | 75 | 200 | 100 | 50 | 200 | 100 | 50 | Broadcast & disk in |
| | 25 | 0 | 0 | 0 | 0 | 0 | 0 | Topdress when 6 inches tall |
| | 25 | 0 | 0 | 0 | 0 | 0 | 0 | Topdress May 1 |
| **HORSERADISH** | Apply 1-2 pounds of boron (B) per acre with broadcast fertilizer. See Table 1 for more specific boron recommendations. | | | | | | | |
| Loamy sands & sandy loams | 150-200 | 200 | 150 | 100 | 200 | 150 | 100 | Total recommended |
| | 50 | 200 | 150 | 100 | 200 | 150 | 100 | Broadcast & disk in |
| | 50-100 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 3-5 weeks after planting |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress later in season if needed |
| Loams & silt loams | 100-150 | 200 | 150 | 100 | 200 | 150 | 100 | Total recommended |
| | 100 | 200 | 150 | 100 | 200 | 150 | 100 | Broadcast & disk in |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 4-6 weeks after planting if needed |
| **LETTUCE, ICEBERG (HEAD)** | 60-80 | 200 | 150 | 100 | 200 | 150 | 100 | Total recommended |
| | 25-50 | 200 | 150 | 100 | 200 | 150 | 100 | Broadcast & disk in |
| | 25-30 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 3-5 weeks after planting |
| **LEAFY GREENS: COLLARDS, KALE, MUSTARD & TURNIP GREENS** | 50-80 | 150 | 100 | 50 | 150 | 100 | 50 | Total recommended |
| | 50 | 150 | 100 | 50 | 150 | 100 | 50 | Broadcast & disk in |
| | 25-30 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress if needed |
| **LEEK** | Apply 1-2 pounds of boron (B) per acre with broadcast fertilizer. See Table 1 for more specific boron recommendations. | | | | | | | |
| | 100-125 | 200 | 150 | 100 | 200 | 150 | 100 | Total recommended |
| | 50-75 | 200 | 150 | 100 | 200 | 150 | 100 | Broadcast & disk in |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 3-4 weeks after planting if needed |
| **MUSKMELON** | Apply 1-2 pounds of boron (B) per acre with broadcast fertilizer. See Table 1 for more specific boron recommendations. | | | | | | | |
| | 75-100 | 150 | 100 | 50 | 200 | 150 | 100 | Total recommended |
| | 25-50 | 125 | 75 | 25 | 175 | 125 | 75 | Broadcast & disk in |
| | 25 | 25 | 25 | 25 | 25 | 25 | 25 | Band-place with planter |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress when vines start to run, or apply in irrigation water |
| | NOTE: If crop will be mulched with plastic but NOT drip/trickle fertilized, broadcast 100-150 pounds of nitrogen (N) per acre with recommended $P_2O_5$ and $K_2$ and disk-in or incorporate prior to laying mulch. See "Muskmelon" in nutrient recommendation section for drip/trickle fertilization at the end of this chapter. | | | | | | | |
| **OKRA** | Same as Eggplant | | | | | | | |

| Crop | Nitrogen (N) pounds per acre | Recommended Nutrients Based on Soil Tests: Soil phosphorus level Low | Medium | Optimum | Soil potassium level Low | Medium | Optimum | Total amount of nutrient recommended and suggested methods of application |
|---|---|---|---|---|---|---|---|---|
| | | $P_2O_5$ pounds per acre | | | $K_2O$ pounds per acre | | | |
| **ONION** | Apply 1-2 pounds of boron (B) per acre with broadcast fertilizer. See Table 1 for more specific boron recommendations. | | | | | | | |
| **Bulb** | | | | | | | | |
| | 75-100 | 200 | 100 | 50 | 200 | 100 | 50 | Total recommended |
| | 50-75 | 200 | 100 | 50 | 200 | 100 | 50 | Broadcast & disk in |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 4-5 weeks after planting |
| **Green (scallion)** | 150-200 | 200 | 100 | 50 | 200 | 100 | 50 | Total recommended |
| | 50-75 | 200 | 100 | 50 | 200 | 100 | 50 | Broadcast & disk in |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 4-5 weeks after planting |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 3-4 weeks before harvest |
| **PARSLEY** | 150-175 | 200 | 150 | 100 | 200 | 150 | 100 | Total recommended |
| | 50-75 | 200 | 150 | 100 | 200 | 150 | 100 | Broadcast & disk in |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress after first cutting |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress after each additional cutting |
| **PARSNIP** | Apply 1-2 pounds of boron (B) per acre with broadcast fertilizer. See Table 1 for more specific boron recommendations. | | | | | | | |
| | 50-75 | 150 | 100 | 50 | 150 | 100 | 50 | Total recommended |
| | 25-50 | 150 | 100 | 50 | 150 | 100 | 50 | Broadcast & disk in |
| | 25-30 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 4-5 weeks after planting |
| **PEAS** | 40-80 | 120 | 80 | 40 | 120 | 80 | 40 | Broadcast & disk in before seeding |
| **PEPPER** | Apply 1 pound of boron (B) per acre if soil test boron is low. See Table 1 for more specific boron recommendations. | | | | | | | |
| | 100-150 | 200 | 150 | 100 | 200 | 150 | 100 | Total recommended |
| | 50 | 200 | 150 | 100 | 200 | 150 | 100 | Broadcast & disk in |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress after first fruit set |
| | 0-50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress later in season if needed |
| | NOTE: If crop will be mulched with plastic but NOT drip/trickle fertilized, broadcast 150 pounds of nitrogen (N) per acre with recommended $P_2O_5$ and $K_2$ and disk-in or incorporate prior to laying mulch. See "Pepper" in nutrient recommendation section for drip/trickle fertilization at the end of this chapter. | | | | | | | |
| **POTATO, SWEET** | 50-75 | 200 | 100 | 50 | 300 | 200 | 100 | Total recommended |
| | 25 | 200 | 100 | 50 | 300 | 200 | 100 | Broadcast & disk in |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress when vines start to run |
| **POTATO, WHITE** | Apply 1 pound of boron (B) per acre if soil test boron is low. See Table 1 for more specific boron recommendations. | | | | | | | |
| Sandy loams & loamy sands | 150 | 200 | 150 | 100 | 300 | 200 | 100 | Total recommended |
| | 50 | 200 | 150 | 100 | 300 | 200 | 100 | Broadcast & disk in |
| | 100 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 4-6 weeks after planting |

| Crop | Nitrogen (N) pounds per acre | Recommended Nutrients Based on Soil Tests: Soil phosphorus level Low | Medium | Optimum | Soil potassium level Low | Medium | Optimum | Total amount of nutrient recommended and suggested methods of application |
|---|---|---|---|---|---|---|---|---|
| | | $P_2O_5$ pounds per acre | | | $K_2O$ pounds per acre | | | |
| **POTATO, WHITE, cont'd** | 125-150 | 200 | 150 | 100 | 300 | 200 | 100 | Total recommended |
| Loams & silt loams | 50 | 100 | 100 | 0 | 200 | 100 | 0 | Broadcast & disk in |
| | 75-100 | 100 | 50 | 100 | 100 | 100 | 100 | Band-place with planter |
| | NOTE: If soil test levels for $P_2O_5$ or $K_2O$ are above optimum (high), an additional 30 pounds of each nutrient may be used to replace crop removal. | | | | | | | |
| **PUMPKIN & WINTER SQUASH** | 50-100 | 150 | 100 | 50 | 200 | 150 | 100 | Total recommended |
| | 25-50 | 150 | 100 | 50 | 200 | 150 | 100 | Broadcast & disk in |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress when vines start to run |
| **RADISH, RUTABAGA & TURNIP** | Apply 1-2 pounds of boron (B) per acre with broadcast fertilizer. See Table 1 for more specific boron recommendations. | | | | | | | |
| | 50 | 150 | 100 | 50 | 150 | 100 | 50 | Broadcast & disk in before seeding |
| **SPINACH** | | | | | | | | |
| **Spring or fall planting** | 100-195 | 200 | 150 | 100 | 200 | 150 | 100 | Total recommended |
| | 50-75 | 200 | 150 | 100 | 200 | 150 | 100 | Broadcast & disk in |
| | 25-40 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress or topdress after first cutting |
| | 25-40 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress or topdress after each cutting |
| **Overwintered crop** | 80-120 | 0 | 0 | 0 | 0 | 0 | 0 | Total recommended |
| | 50-80 | 0 | 0 | 0 | 0 | 0 | 0 | Topdress late February |
| | 30-40 | 0 | 0 | 0 | 0 | 0 | 0 | Topdress in March |
| **SUMMER SQUASH** | Apply 1-2 pounds of boron (B) per acre with broadcast fertilizer. See Table 1 for more specific boron recommendations. | | | | | | | |
| | 75-100 | 150 | 100 | 50 | 200 | 150 | 100 | Total recommended |
| | 25-50 | 150 | 100 | 50 | 200 | 150 | 100 | Broadcast & disk in |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress when vines start to run |
| | 25-30 | 0 | 0 | 0 | 0 | 0 | 0 | Apply through irrigation system |
| **STRAWBERRY** | | | | | | | | |
| **Annual production system** | Apply 1-2 pounds of boron (B) per acre with broadcast fertilizer. See Table 1 for more specific boron recommendations. | | | | | | | |
| Loamy sands & sandy loams | 90-120 | 165 | 115 | 65 | 165 | 115 | 65 | Total recommended |
| | 60-75 | 165 | 115 | 65 | 165 | 115 | 65 | Disk in before bedding |
| | 15-25 | 0 | 0 | 0 | 0 | 0 | 0 | Inject through drip at first spring flowering |
| | 15-25 | 0 | 0 | 0 | 0 | 0 | 0 | Inject through drip at fruit enlargement |
| Loams & silt loams | 70-90 | 150 | 100 | 50 | 150 | 100 | 50 | Total recommended |

| Crop | Nitrogen (N) pounds per acre | Recommended Nutrients Based on Soil Tests: Soil phosphorus level Low | Medium | Optimum | Soil potassium level Low | Medium | Optimum | Total amount of nutrient recommended and suggested methods of application |
|---|---|---|---|---|---|---|---|---|
| | | $P_2O_5$ pounds per acre | | | $K_2O$ pounds per acre | | | |
| | 50-60 | 150 | 100 | 50 | 150 | 100 | 50 | Disk in before bedding |
| | 20-30 | 0 | 0 | 0 | 0 | 0 | 0 | Inject through drip at first spring flowering |
| | See "Strawberry" section at the end of this chapter for fertilizer recommendations for plants grown on plastic mulch. | | | | | | | |
| **STRAWBERRY, cont'd.** | Apply 1-2 pounds of boron (B) per acre with broadcast fertilizer. See Table 1 for more specific boron recommendations. | | | | | | | |
| **Matted row system, new planting** | 110-150 | 165 | 115 | 65 | 165 | 115 | 65 | Total recommended |
| Sandy loams, loamy sands & sands | 30 | 165 | 115 | 65 | 165 | 115 | 65 | Broadcast & disk in deep |
| | 20-30 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 2 weeks after planting |
| | 20-30 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress when first runners start |
| | 30-40 | 0 | 0 | 0 | 0 | 0 | 0 | Topdress in mid-August |
| | 10-20 | 0 | 0 | 0 | 0 | 0 | 0 | Topdress in February or March |
| **Matted row system, new planting** | | | | | | | | |
| Loams & silt loams | 90-120 | 150 | 100 | 50 | 150 | 100 | 50 | Total recommended |
| | 30 | 150 | 100 | 50 | 150 | 100 | 50 | Broadcast & plow or disk in deep |
| | 30-40 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress when first runners start |
| | 30-50 | 0 | 0 | 0 | 0 | 0 | 0 | Topdress in mid-August |
| **Matted row system, established** | | | | | | | | |
| Sandy loams, loams & silt loams | 50-60 | 165 | 115 | 65 | 165 | 115 | 65 | Topdress at renovation |
| | 30 | 0 | 0 | 0 | 0 | 0 | 0 | Topdress in February or early March |
| | NOTE: Plantings in clay or clay loam soils should receive total nitrogen rates to 25 percent and also reduce the spring application rate to 0-50 percent. | | | | | | | |
| Loamy sands & sands | 60-80 | 165 | 115 | 65 | 165 | 115 | 65 | Topdress at renovation |
| | 30 | 0 | 0 | 0 | 0 | 0 | 0 | Topdress in February or early March |
| **SWEET CORN** | Apply 1-2 pounds of boron (B) per acre with broadcast fertilizer. See Table 1 for more specific boron recommendations. | | | | | | | |
| **Fresh Market** | 125-150 | 160 | 120 | 80 | 160 | 120 | 80 | Total recommended |
| | 40-60 | 120 | 100 | 60 | 120 | 100 | 60 | Broadcast & plow down |
| | 20 | 40 | 20 | 20 | 40 | 20 | 20 | Band-place with planter |
| | 50-75 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress when corn is 12-18 inches tall |
| | NOTE: For early plantings when soil temperatures are low, band 20 pounds of $P_2O_5$ and $K_2$ when soil test levels are above optimum (high). On very light sandy soils, sidedress 40 pounds of nitrogen per acre when corn is 6 inches tall and another 40 pounds of nitrogen per acre when corn is 12-18 inches tall. | | | | | | | |

| Crop | Nitrogen (N) pounds per acre | Recommended Nutrients Based on Soil Tests: Soil phosphorus level Low | Medium | Optimum | Soil potassium level Low | Medium | Optimum | Total amount of nutrient recommended and suggested methods of application |
|---|---|---|---|---|---|---|---|---|
| | | $P_2O_5$ pounds per acre | | | $K_2O$ pounds per acre | | | |
| **SWEET CORN, cont'd.** | Apply 1-2 pounds of boron (B) per acre with broadcast fertilizer. See Table 1 for more specific boron recommendations. | | | | | | | |
| **Processing** | 125-175 | 120 | 80 | 60 | 120 | 80 | 60 | Total recommended |
| | 55-80 | 80 | 60 | 40 | 80 | 60 | 40 | Broadcast before plowing |
| | 20 | 40 | 20 | 20 | 40 | 20 | 20 | Band-place 2 inches below and 2 inches to the side of the seed (2x2) |
| | 50-75 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress 2 weeks after emergence |
| | NOTE: For early plantings when soil temperatures are low, band 20 pounds of $P_2O_5$ and $K_2$ when soil test levels are above optimum (high). | | | | | | | |
| **TOMATO** | | | | | | | | |
| **Fresh market** | Apply 1½-3 pounds of boron (B) per acre with broadcast fertilizer. See Table 1 for more specific boron recommendations. | | | | | | | |
| Sandy loams & loamy sands | 80-90 | 200 | 150 | 100 | 300 | 200 | 100 | Total recommended |
| | 40-45 | 200 | 150 | 100 | 300 | 200 | 100 | Broadcast & plow down |
| | 40-45 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress when first fruits set |
| Loams & silt loams | 50-80 | 200 | 150 | 100 | 200 | 150 | 100 | Total recommended |
| | 50 | 200 | 150 | 100 | 200 | 150 | 100 | Broadcast & plow down |
| | 25-30 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress when first fruits set, if needed |
| | NOTE: See "Tomato" in nutrient recommendation section for drip/trickle fertilization at the end of this chapter. | | | | | | | |
| **Processing, transplants for machine harvest** | Apply 1-2 pounds of boron (B) per acre with broadcast fertilizer. See Table 1 for more specific boron recommendations. | | | | | | | |
| Sandy loams & loamy sands | 50-75 | 200 | 150 | 100 | 250 | 150 | 100 | Total recommended |
| | 0 | 100 | 50 | 0 | 150 | 50 | 0 | Broadcast & plow down |
| | 25 | 100 | 100 | 100 | 100 | 100 | 100 | Broadcast & disk in |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Sidedress at first cultivation |
| Loams & silt loams | 50 | 200 | 150 | 100 | 250 | 150 | 100 | Total recommended |
| | 0 | 100 | 100 | 50 | 150 | 100 | 50 | Broadcast & plow down |
| | 50 | 100 | 50 | 50 | 100 | 50 | 50 | Broadcast & disk in |
| | NOTE: Excess nitrogen hinders concentration of fruit maturity for machine harvest. NOTE: See "Tomato" in nutrient recommendation section for drip/trickle fertilization at the end of this chapter. | | | | | | | |
| **WATERMELON** | | | | | | | | |
| **Non-irrigated** | 80-100 | 150 | 100 | 50 | 200 | 150 | 100 | Total recommended |
| | 50 | 150 | 100 | 50 | 200 | 150 | 100 | Broadcast & disk in |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Topdress when vines start to run |

| Crop | Nitrogen (N) pounds per acre | Recommended Nutrients Based on Soil Tests: Soil phosphorus level Low | Medium | Optimum | Soil potassium level Low | Medium | Optimum | Total amount of nutrient recommended and suggested methods of application |
|---|---|---|---|---|---|---|---|---|
| | | $P_2O_5$ pounds per acre | | | $K_2O$ pounds per acre | | | |
| Irrigated | 125-150 | 150 | 100 | 50 | 200 | 150 | 100 | Total recommended |
| | 50 | 150 | 100 | 50 | 200 | 150 | 100 | Broadcast & disk in |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Topdress when vines start to run |
| | 25-50 | 0 | 0 | 0 | 0 | 0 | 0 | Topdress after first harvest |

NOTE: Higher N rates may lead to increase in hollow heart in seedless watermelon varieties; apply 125 pounds of nitrogen (N) per acre of seedless watermelon. See "Watermelon" in nutrient recommendation section for drip/trickle fertilization at the end of this chapter.

## Boron Fertilization on Vegetable Crops

The most practical way to apply boron to the soil is as an additive bought specifically for the crop or field where it is needed and mixed in the fertilizer. Do not use fertilizer containing more than 0.5 pound of boron (B) per ton of fertilizer for crops not listed below, unless specifically recommended. To avoid possible boron toxicity damage to crops, apply boron in broadcast fertilizer rather than banded or sidedressed. Boron may be broadcast preplant as a soluble spray alone or with other compatible soluble chemicals.

**Table 1. Boron Recommendations Based on Soil Tests for Vegetable Crops**

| Interpretation of boron soil tests | | | | |
|---|---|---|---|---|
| Parts per million | Pounds per acre | Relative level | Crops that often need additional boron[1] | Recommended pounds boron (B) per acre[2] |
| 0.0-0.35 | 0.0-0.70 | Low | Beets, broccoli, Brussels sprouts, cabbage, cauliflower, celery, rutabaga, turnip | 3 |
| | | | Asparagus, carrot, eggplant, horseradish, leek, muskmelon, okra, onion, parsnip, radish, squash, strawberry, sweet corn and tomato | 2 |
| | | | Pepper and sweet potato | 1 |
| 0.36-0.70 | 0.71-1.40 | Medium | Beets, broccoli, Brussels sprouts, cabbage, cauliflower, celery, rutabaga, turnips | 1½ |
| | | | Asparagus, carrot, eggplant, horseradish, leek, muskmelon, okra, onion, parsnip, radish, squash, strawberry, sweet corn and tomato | 1 |
| >0.70 | >1.40 | High | All crops | 0 |

[1] If boron deficiency is suspected in vegetable crops not listed above, use soil and/or plant tissue test results as a basis for treatment recommendations.

[2] Approximate conversion factors to convert elemental boron (B) to different boron sources:

Boron (B) x 9 = borax (11.36% B)
Boron (B) x 7 = fertilizer borate granular (14.3% B)
Boron (B) x 6.7 = fertilizer borate-48 (14.91% B)
Boron (B) x 5 = fertilizer borate-65 (20.2% B) or Solubor® (20.5% B)
Boron (B) x 4.7 = fertilizer borate-68 (21.1% B)

Example: Using **borax, apply 9 x 1.5 = 13.5 pounds borax** per acre to meet a **1.5 pound boron (B)** per acre recommendation.

## Nutrient Recommendations for Drip/Trickle Fertilization

### Introduction to Fertigation

Trickle-irrigated crops are usually fertilized during the growing phase through the irrigation system, or fertigated. When using trickle/drip irrigation in combination with plastic mulch, apply the recommended rate of preplant nutrients and incorporate 5-6 into the soil before laying the mulch. If equipment is available apply the preplant fertilizer at the recommended rates only to the soil area that will be covered by the mulch. This is more cost-effective than broadcasting fertilizer over the entire field.

All rates of soluble fertilizers delivered through fertigation are determined on a 3-foot-wide surface area, even though the crops are grown on 5-foot rows. A "fertilized-mulched acre" is an acre (43,560 sq. ft.) of soil surface covered by the mulch. For example, when 4-foot-wide plastic mulch is laid on 5-foot row centers with 6 inches of each edge buried, 2 feet of the 5-foot row is uncovered while 3 feet is covered by the mulch. This means that only 3/5 or 60% of the field acreage is fertigated. All recommendations for fertigation through a trickle/drip system are based on the fertilized-mulched acre.

### Eggplant

Before mulching, adjust soil pH to around 6.5 and then apply enough farm-grade fertilizer to supply 60 pounds per acre of N, $P_2O_5$ and $K_2O$. Then thoroughly incorporate into the soil. If soil tests medium or less in soil potassium, apply a fertilizer with a ratio of 1-1-2 or 1-1-3 carrying 60 pounds of nitrogen per acre.

After mulching and installing the trickle irrigation system, apply completely soluble fertilizers to supply 40 pounds (10 to 20 pounds in Pennsylvania) of N, $P_2O_5$ and $K_2O$ per fertilized-mulched acre during each application (a description of a fertilized-mulched acre may be found in the "Irrigation" section of this publication). On soils testing low and low to medium in boron and that have not received any preplant boron fertilizer, include 0.25 pound of actual boron per fertilized-mulched acre in each soluble fertilizer application.

The first soluble fertilizer application should be applied through the trickle irrigation system within 1 week after field transplanting the eggplants. The same rate of soluble fertilizer should be applied about every 3 weeks during the growing season for a total of six to seven applications. In Pennsylvania, do not exceed 120 pounds of nitrogen per acre per season.

**Muskmelon**

Before mulching, adjust soil pH to around 6.5, apply enough farm-grade fertilizer to supply 50 pounds per acre of N, $P_2O_5$ and $K_2O$, and thoroughly incorporate into the soil.

After mulching and installing the trickle irrigation system, apply completely soluble fertilizer to supply 50 pounds (5 to 15 pounds in Pennsylvania) of N, $P_2O_5$ and $K_2O$ per fertilized-mulched acre during each application. (A description of a fertilized-mulched acre may be found in the "Irrigation" section of this publication.) On soils testing low and low to medium in boron and that have not received any preplant boron fertilizer, include 0.5 pound of actual boron per fertilized-mulched acre in each soluble fertilizer application.

The first soluble fertilizer application should be applied through the trickle irrigation system within 1 week after field transplanting the melons. The same rate of soluble fertilizer should be applied again when the first fruit set. The third application should be applied about 2 weeks before the first harvest.

Heavier late yields have been achieved by applying another application at the same rate of soluble fertilizer in between the first and second soluble fertilizer applications or about 2 weeks after the first soluble fertilizer application. In Pennsylvania, do not exceed 80 pounds of nitrogen per acre per season.

**Pepper**

Before mulching, adjust soil pH to around 6.5 and then apply enough farm-grade fertilizer to supply 50 pounds (40 pounds in Pennsylvania) per acre of N, $P_2O_5$, and $K_2O$ and then thoroughly incorporate into the soil. If the soil tests medium or less in soil potassium, apply a fertilizer with a ratio of 1-1-2 or 1-1-3 carrying 50 pounds of nitrogen per acre.

After mulching and installing the trickle irrigation system, apply completely soluble fertilizers to supply 30 pounds (15 pounds in Pennsylvania) of N, $P_2O_5$, and $K_2O$ per fertilized-mulched acre during each application. (A description of a fertilized-mulched acre may be found in the "Irrigation" section of this publication.) In Pennsylvania, do not exceed 80 to 90 pounds of N per acre per season. On soils testing low and low to medium in boron, also include 0.25 pound of actual boron per fertilized-mulched acre in each soluble fertilizer application.

The first soluble fertilizer application should be applied through the trickle irrigation system within 1 week after field transplanting peppers. The same rate of soluble fertilizer should be applied about every 3 weeks during the growing season for a total of 6 applications through the trickle irrigation system. The soluble fertilizer may be delivered in 12 equally timed applications through the growing season, provided the soluble nutrients are applied at half the above suggested rates per application so that the total seasonal rates of N, $P_2O_5$, $K_2O$ and B are the same. The number of fertilizer applications can be reduced for late plantings and in areas where the growing season is short.

These rates were developed on sandy loam soils with a cation exchange capacity (CEC) of 3 to 5. If your soil has a lower CEC, you may wish to increase the total seasonal soluble fertilizer nutrient rates by at least one-third. On very coarse, very low CEC soils, you may wish to increase the total seasonal soluble fertilizer nutrient rates by two-thirds.

On the heavier textured soils with CEC above 3 to 5, you may wish to decrease the total seasonal soluble fertilizer nutrients by one-half to three-quarters. In very heavy soils with high CEC, you may wish to broadcast the total seasonal plant nutrient requirements (according to soil test) before mulching and installing the trickle irrigation system. In this case, only water would be applied through the trickle irrigation.

**Strawberry (annual production system)**
**Growing on plastic mulch**

Pre-plant: Test the soil to determine specific nutritional needs. Broadcast and work into beds a complete fertilizer containing 60 to 75 pounds of actual nitrogen per fertilized-mulched acre. Include $P_2O_5$, $K_2O$ and boron at the rates recommended previously in this section. Prepare raised beds (30 to 40 inches wide and 6 to 8 inches high) on 5- to 5½-foot row centers. Beds should be center-crowned and firm.

Follow the spring fertilizer injection timing and rates under the strawberry listing for annual production system. Depending upon soil type, plant vigor and plant tissue test results, it may be justified to inject an additional 30-40 pounds nitrogen per fertilized-mulched acre. For late summer renovation, apply 60 pounds of N, $P_2O_5$, and $K_2O$ per fertilized-mulched acre in early September.

**Tomato**

Before mulching, adjust soil pH to around 6.5 and then apply enough farm-grade fertilizer to supply 40 pounds per acre of N, $P_2O_5$, and $K_2O$, then thoroughly incorporate into the soil. If the soil tests medium or less in soil potassium, apply a fertilizer with a ratio of 1-1-2 or 1-1-3 containing 40 pounds of nitrogen per acre.

After mulching and installing the trickle irrigation system, apply completely soluble fertilizer to supply 40 pounds (in Pennsylvania use 5 to 15 pounds) of N, $P_2O_5$, and $K_2O$ per fertilized-mulched acre during each

application. (A description of a fertilized-mulched acre may be found in the "Irrigation" section of this publication.) On soils testing low and low to medium in boron, also include 0.5 pound of actual boron per fertilized-mulched acre in each of the three or four fertilizer applications.

The first soluble fertilizer application should be applied through the trickle irrigation system within 1 week after field transplanting the tomatoes. The same rate of soluble fertilizer should be applied again when the first fruit reach 1 inch in diameter and again when the fruit begin to turn color and ripen. A fourth application of the same rate of soluble fertilizer 2 weeks after the third application has helped to increase yield, but may not be economical. In Pennsylvania, do not exceed 90 pounds of nitrogen per acre per season.

**Watermelon**

Before mulching, adjust soil pH to around 6.5, apply enough farm-grade fertilizer to supply 50 pounds per acre of N, $P_2O_5$, and $K_2O$, then thoroughly incorporate into the soil.

After mulching and installing the trickle irrigation system, apply completely soluble fertilizers to supply 25 pounds (5 to 15 pounds in Pennsylvania) of N, $P_2O_5$, and $K_2O$ per fertilized-mulched acre during each application. On soils testing low and low to medium in boron, also apply 0.25 pound of actual boron per fertilized-mulched acre in each soluble fertilizer application.

The first soluble fertilizer application should be applied through the trickle irrigation system within 1 week after field transplanting the watermelons. The same rate of soluble fertilizer should be applied 2 weeks later. The third application should be made when the first fruit set. Make a fourth application 2 weeks before the first harvest. The fifth application should be applied right after the first harvest. To maintain good production late into the season, apply another application three weeks after the fifth complete fertilizer application. In Pennsylvania, do not exceed 80 pounds of nitrogen per acre per season.

# Section I-B3

## Nutrient Recommendations by Crop

**Plant Nutrient Recommendations Based on**
**Soil Tests For Sod Production**
**(University of Maryland Cooperative Extension, 1999)**

# PLANT NUTRIENT RECOMMENDATIONS BASED ON SOIL TESTS FOR SOD PRODUCTION

*Source: University of Maryland Cooperative Extension, March 2003*
**Regulatory Citation: COMAR 15.20.08.05**

## NUTRIENT MANAGEMENT GUIDELINES FOR SOD PRODUCTION IN MARYLAND

### Introduction

Nutrient management laws passed by the Maryland Legislature in 1998 require that turfgrass sod producers in Maryland participate in agriculture nutrient management programs. This publication is intended to serve as a nutrient management guideline for the production of sod in Maryland in an efficient, timely, and environmentally sound manner. A nutrient management plan incorporating these guidelines must be developed by a certified farm operator or a nutrient management consultant certified and licensed by the Maryland Department of Agriculture.

Some differences exist between the goals and practices of general agriculture and sod production. The primary goal in most crops is to maximize yield in a manner that makes economic sense. The goals in sod production are substantially different. The primary goals in sod production are twofold: 1) producing turfgrass of sufficient quality that it is marketable, and 2) producing harvestable sod in the quickest manner possible.

Quality sod needs to be dense, relatively uniform, and free of weed, disease, and insect pests. Sod must also be harvestable, i.e., it must be sufficiently knit that it holds together when cut, can be rolled, can be transported, and can be unrolled and laid onsite without falling apart. A good nutrient management program is a major component of producing quality sod that is marketable.

For economic purposes, sod must also be produced in the most timely manner possible. The seasonal window for seeding cool season turfgrass species in Maryland to produce sod is relatively narrow. Seeding must be done from late summer through early fall if sod is to be harvestable before the prime seeding period is reached again the next year. Failure to produce harvestable sod within this timeframe means that sod production is on a two-year rather than a one-year cycle, which has serious economic consequences. Again, a good nutrient management program is critical in producing sod in an economically timely fashion.

### Water Quality

Properly managed turfgrass has been shown to be an environmental asset. Water runoff is greatly reduced and water infiltration increased compared to most other

agriculture systems. Once turfgrass is established, soil loss is negligible. Runoff from established turf has compared favorably to forested land. Also, turfgrass is an organic matter producing system. Thus, little nitrogen (N) or phosphorus (P) is lost from turfgrass sites if sound nutrient management practices are followed.

Indeed, onsite monitoring and numerous research studies have shown that nutrient loss from turfgrass sites is very small. However, research has also shown that certain types of improper N applications on specific types of sites can result in excessive nitrate ($NO_3$) leaching. This problem is very specific and has occurred as follows:

1. Very high rates of N were applied using soluble $NO_3$-N containing fertilizers (such as ammonium nitrate [$NH_4NO_3$]),

2. The fertilizer was applied to dormant turf (such as bermudagrass during the winter),

3. Soils were predominantly sand, and

4. The sites had high water tables.

A sound turfgrass nutrient management plan shall take into consideration this set of conditions which can cause a potential problem.

Soil erosion from established turf is not a problem. However, from the time of soil preparation to the time seed has germinated and plants have become established, soil erosion can occur. Enhancing the rapidity of sod establishment, therefore, is an important factor in minimizing potential soil erosion. A sound nutrient management program is an important factor in enhancing rapid establishment and minimizing the potential for soil erosion.

## Nitrogen Applications

Nitrogen fertility is of primary importance in producing quality sod in an economically timely fashion. Nitrogen has a major impact on both root and shoot growth rates. The density of sod, the ability to withstand the encroachment of weeds (thus also reducing the need for herbicide applications), the incidence of some diseases, the recovery from summer stress problems, and the length of time from seeding to harvestable sod are all highly dependent on adequate N.

Three major factors shall be considered in developing a N application plan:

1. What types of N should be applied,

2. How much N needs to be applied at seeding and during the year for production, and

3. When should N be applied?

## Sources of N

A wide range of N-containing fertilizers are available to the sod producer. These fertilizers generally fall into one of two broad categories: 1) fertilizers that contain only soluble, quickly available N; and 2) fertilizers that contain some N in a slowly available form which is not immediately available for plant use.

Quickly available N-fertilizers contain $NO_3$-N or $NH_4$-N or both, which is soluble and readily available for uptake by turfgrass plants. Turfgrass uptake may occur within a few days with $NO_3$-N fertilizer. Nitrogen uptake may begin within 7 – 10 days with $NH_4$-N fertilizers, as $NH_4$-N is converted to $NO_3$-N in the soil. Nitrogen uptake by turfgrass roots is predominately in the $NO_3$ form.

Leaching and runoff potential is much higher for $NO_3$-N. Thus, where conditions exist that are conducive to leaching or runoff, fertilizers that contain significant amounts of $NO_3$-N should not be used. These conditions include sandy sites (sands and loamy sands) with high water tables when turf is not actively growing, and sites that are highly sloped. Fertilizers high in $NO_3$-N include $NH_4NO_3$, potassium nitrate, and calcium nitrate.

Slow release fertilizers contain significant amounts of N that is not immediately available for plant uptake. Examples of fertilizer sources that contain various amounts of slow release N include: sulfur coated ureas, polymer coated ureas, methylene ureas, ureaformaldehydes, IBDU, natural organics, and various types of sludge. Slow release fertilizers, while varying considerably in individual characteristics, typically provide more even turfgrass response, provide N over a longer period of time, and are less prone to N leaching and runoff as compared to soluble N fertilizers. The expense of slow release fertilizers makes their widespread use in sod production limited. Their use, however, should be considered on the aforementioned sites that are prone to leaching or runoff, and when N applications need to be made to turfgrass that is not in prime growing conditions.

## Total N Requirements

**Establishment** - Whereas the annual N requirements vary somewhat with turfgrass species, particularly after the first year of growth, the N requirements at the time of seeding are rather uniform. It is recommended that up to 45 lbs. of readily available (soluble) N per acre be applied prior to seeding if fertilizer is broadcast. If fertilizer is incorporated deeper than 2 inches, then up to 90 lbs. of readily available N per acre may be applied and incorporated into the soil. Research would indicate, however, that there is no great advantage in sod production with the incorporation of N deeper than the surface 2 inches of soil.

If fertilizers are applied containing slow release N (water insoluble N [WIN]), no more shall be applied than that which provides the aforementioned rates of readily available N. For example, if a slow release fertilizer contains 50% WIN and the recommended application rate is 45 lbs. N per acre, then no more than 90 lbs. N per acre of this fertilizer should be applied. Also, the slow release N applied to the seedbed shall be factored into the first year's production applications of N.

**Production** – Maintenance fertilizer applications for growing sod generally begin 4 – 8 weeks after turfgrass seed has germinated. The total annual N requirements for growing quality sod in a timely manner is dependent on many factors, including: turfgrass species, length of growing season, soil type, field fertility history, and the need for recovery from stresses caused by unusual weather or pest problems. However, the annual N requirements for the most common turfgrass species grown for sod in Maryland generally fall into the ranges listed in Table 1. If fertilizer containing slow release N was applied to the seedbed at or prior to seeding, the slow release fraction (WIN) shall be included in calculating the total N applied for production of the sod in the first year.

## Table 1. Nitrogen Recommendations for Sod Production

| | Total Nitrogen Annually (lbs. N/acre) | |
|---|---|---|
| **Turfgrass Species** | **1st year** | **Subsequent Years** |
| **Cool Season Grasses** | | |
| Kentucky bluegrass | 130 - 200 | 130 - 175 |
| Turf-type tall fescue | 130 - 175 | 90 - 175 |
| Fine fescue | 90 - 175 | 45 - 130 |
| Creeping bentgrass | 175 - 260 | 130 - 220 |
| **Warm Season Grasses** | | |
| Bermudagrass | 130 - 175 | 90 - 175 |
| Zoysiagrass | 90 - 175 | 45 - 130 |

### Timing of N Applications

The primary potential for N loss from turfgrass sites is when excessive rates of $NO_3$-N are applied to turf that is not actively growing. Thus, most of the annual fertilizer requirement should be applied during periods of active shoot (leaf blades, rhizomes, stolons) or root growth.

The primary period for growth of warm season grass species (zoysiagrass, bermudagrass, buffalograss) is from mid-spring, after dormancy has broken, through mid-fall, when the first killing frost is experienced. Thus, N applications should generally be restricted to these periods; however, fertilizer that contains primarily $NH_4$-N can be applied up to a month before dormancy is typically broken in the spring so that N is available for plant uptake at this time. Applications after September 1 are not generally recommended, due to the possible enhancement of winter-kill, particularly with bermudagrass. However, if bermudagrass has been overseeded with a cool season species, such as perennial ryegrass, up to 45 lbs. N/acre may be applied after September 1 to enhance its performance.

Cool season grasses have a much longer growth period. They can exhibit growth at virtually anytime during the year if moisture and temperature conditions are conducive. The prime periods for growth are typically from late winter through early summer, and from late summer through early winter. Research would indicate that $^2/_3$ to $^3/_4$ of the total annual N should be applied during the latter period to maximize turfgrass performance and quality.

Under extended hot and dry periods during mid-summer, cool season grasses may experience a period of dormancy until rainfall occurs. If irrigation is available, or if rainfall is adequate throughout the summer, little dormancy will occur and N uptake will continue.

During the winter months, although top growth may have virtually ceased, root growth and N uptake may still occur during the periods when the ground is not actually frozen, particularly with Kentucky bluegrass. Research has shown that applications of N during this period can enhance root growth and spring performance of turf. Also, it is often difficult to fertilize sod fields in late winter to early spring due to excessive soil moisture, and there is potential for significant damage to the sod from equipment used for fertilization under those conditions. There is little risk of runoff or leaching problems from winter application of N if certain guidelines are followed. No more than 45 lbs. N per acre shall be applied, fertilizers containing significant amounts of $NO_3$-N shall not be used, and applications shall not be made to frozen ground if significant rainfall is in the immediate forecast.

## Phosphorus and Potassium

Phosphorus (P) is critical in the establishment of turfgrass. Inadequate soil P will result in very poor seedling vigor, slow establishment of grass, and a stand with very poor density and root growth. Not only will sod be unharvestable, but soil will be more susceptible to erosion. Weed encroachment will also be much more severe due to the lack of competition from the thin turfgrass stand. Thus, it is essential that sufficient P be added to the soil at the time of seeding, if harvestable sod is to be obtained.

Potassium (K) is not as critical as N or P during the initial establishment phase of sod. However, K plays an important role in mature sod regarding rhizome production and tolerances to heat, drought, and cold. Thus, sufficient K needs to be available for turfgrass use, to ensure that quality sod will be obtained after summer or winter stresses or both. Severe deficiencies of K will result in thin, chlorotic, and unvigorous turf.

Whereas N application recommendations cannot currently be obtained from soil tests, recommendations for application of P and K can be obtained from them. Any field that is going into sod production for the first time should be sampled. For fields that have previously been in production, sampling every 3 years is generally sufficient to monitor soil P and K levels. However, it is advisable to sample soil prior to any new seeding. Fields having different soil types, fields with different cropping or management histories, or fields having substantially different fertility levels, as determined by previous soil tests, should be sampled separately. Conversely, fields having similar soil types, having similar cropping and management histories, and having similar fertility levels, as determined by past soil tests, may be lumped together into one sample.

Current P and K recommendations based on soil test results for the establishment and production of sod are listed in Table 2 and Table 3. Maryland regulations require that the Phosphorus Site Index (PSI) be determined for all agricultural fields whose FIV-P is 150 or greater, if a producer intends to apply any P-bearing fertilizer materials.

**Table 2. Phosphorus Recommendations for Sod Production Based on Soil Test Results from University of Maryland.**

| | Recommended Phosphorus Based on Soil Tests | | |
|---|---|---|---|
| | Soil Test Phosphorus Category | | |
| | low | medium | optimum–excessive |
| | lbs. $P_2O_5$/acre | | |
| **Establishment** | | | |
| Broadcast or incorporated up to 2 inches | 90 – 175 | 45 – 90 | 0 – 90 |
| Incorporated over a 2 inch depth | 130 – 220 | 45 – 90 | 0 – 90 |
| **Production** | 90 – 130 | 45 – 90 | 0 – 90 |

**Table 3. Potassium Recommendations for Sod Production Based on Soil Test results from University of Maryland.**

**Recommended Potassium Based on Soil Tests**

| | Soil Test Potassium Category | | |
|---|---|---|---|
| | low | medium | optimum —excessive |
| | | lbs. $K_2O$/acre | |
| **Establishment** | | | |
| Broadcast or incorporated up to 2 inches | 90 – 175 | 45 – 135 | 0 – 90 |
| Incorporated over a 2 inch depth | 130 – 220 | 45 – 135 | 0 – 90 |
| **Production** | 90 – 175 | 45 – 135 | 0 – 90 |

## Soil Reaction

Maintaining soil pH in an optimum range is important for maximizing the efficiency of nutrient use, and can be important in reducing weed and disease problems. Turfgrass can withstand a rather broad range of soil pH, but 5.8 to 6.4 is generally considered ideal. Wide deviations from this range can result in reduced P and micronutrient availability, and can interfere with soil N metabolism and availability. Depending on turfgrass species, problems in turf may start to occur at soil pH above 7.8 and below 5.4. Thus, to maximize efficiency of nutrient availability and use, soil tests should be taken as recommended previously for soil P and K to determine soil pH.

Recommended limestone applications to achieve a soil pH of about 6.4 are shown in Table 4. If diseases such as: take-all patch of bentgrass, summer patch of Kentucky bluegrass, or spring dead spot of bermudagrass are of concern, maintaining lower soil pH (5.4 – 5.7) may be desirable, and reduced or no limestone should be applied to achieve this level. Also, it is recommended, when practical, that limestone be applied approximately 1 month or more before seeding to minimize potential P availability problems and minimize the potential for volatilization loss of applied N.

**Table 4. Limestone Recommendations for Establishment of Turfgrass (Pounds/Acre)**

| | | | coastal plain | | piedmont & mountain | |
|---|---|---|---|---|---|---|
| soil pH | loamy sands | sandy loams | loams | silt loams and silty clay loams | loams | silt loams and silty clay loams |
| | | | | | | |
| 6.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6.3 | 0 | 0 | 0 | 0 | 1090 | 1305 |
| 6.2 | 0 | 0 | 1090 | 1090 | 1525 | 2180 |
| 6.1 | 0 | 1090 | 1305 | 1525 | 1960 | 2830 |
| 6.0 | 870 | 1525 | 1740 | 1960 | 2395 | 3700 |
| | | | | | | |
| 5.9 | 1090 | 1740 | 2180 | 2395 | 2830 | 4355 |
| 5.8 | 1305 | 2180 | 2395 | 2830 | 3485 | 5010 |
| 5.7 | 1525 | 2395 | 2830 | 3265 | 3920 | 5880 |
| 5.6 | 1740 | 2615 | 3265 | 3700 | 4355 | 6535 |
| 5.5 | 1960 | 3050 | 3700 | 4140 | 4790 | 7185 |
| 5.4 | 2180 | 3265 | 4140 | 4355 | 5445 | 7840 |
| 5.3 | 2395 | 3700 | 4355 | 4790 | 5880 | 8710 |
| 5.2 | 2615 | 3920 | 4575 | 5225 | 6315 | 8710 |
| 5.1 | 2830 | 4140 | 5010 | 5665 | 6750 | 8710 |
| 5.0 | 3050 | 4575 | 5445 | 6100 | 7185 | 8710 |
| | | | | | | |
| 4.9 | 3265 | 4790 | 5880 | 6315 | 7625 | 8710 |
| 4.8 | 3485 | 5010 | 6100 | 6750 | 8275 | 8710 |
| 4.7 | 3700 | 5445 | 6535 | 7185 | 8710 | 8710 |
| 4.6 | 3920 | 5665 | 6750 | 7625 | 8710 | 8710 |
| 4.5 | 4140 | 6100 | 7185 | 8060 | 8710 | 8710 |

Notes:

1) These rates are for limestone that is tilled into the soil to a 4 to 6 inch depth. Use maintenance rates if not tilled in.
2) Divide the above rates by 2 to obtain maintenance limestone recommendations for turfgrass.
3) Do not apply more than 2000 pounds per acre for any on maintenance application to turfgrass.
4) Divide the listed rate by 43.5 to obtain rate in pounds per 1000 square feet.

# Section I-B4

## Nutrient Recommendations by Crop

**Nutrient Recommendations for**
**Commercial Christmas Tree Production**
**(University of Maryland Cooperative Extension, 2001)**

# NUTRIENT RECOMMENDATIONS FOR COMMERCIAL CHRISTMAS TREE PRODUCTION

***Source: University of Maryland Cooperative Extension, September 2001***
***Regulatory Citation: COMAR 15.20.08.05***

The nutrient requirements of Christmas trees vary according to the species. Compared to other crops, however, the nutrient requirements for most Christmas tree species are minimal during their 8-10 year growth cycle.

## Nitrogen Recommendations

Nitrogen leads to the development of the rich, green color associated with a healthy, attractive Christmas tree. Over-application of nitrogen, however, leads to undesirable growth characteristics, such as long internodes and an open growth habit.

Nitrogen requirements are species-dependent. If required, nitrogen applications are usually limited to the second year in the growth cycle and the spring before harvest.

Scots pine requires virtually no nitrogen applications. Other pines require nitrogen only the spring before harvest, unless they are being produced on sandy, low fertility soils. Spruces and most firs typically respond to nitrogen the second year in the growth cycle **AND** the spring before harvest. Fraser fir requires nitrogen annually (Table 1).

**Table 1.** Nutrient recommendations for established Christmas tree species commonly grown commercially in Maryland.

| SPECIES | TIMING | RATE/ACRE ($N$-$P_2O_5$-$K_2O$) | COMMENTS |
|---|---|---|---|
| Scots pine | ——— | 0-0-0 | Unwanted growth is stimulated by nitrogen. |
| All other pines | 2nd year | 100-0-0 | Do not apply unless trees are grown on a sandy, low fertility soil. |
| | Spring before harvest | 100-0-0 | Apply at bud break. |
| Spruce | 2nd year | 100-110-0 | Apply at bud break. |
| | Spring before harvest | 100-0-0 | Apply at bud break. |
| Fraser fir | 2nd year through 5th year | 75-75-40 | Apply at bud break. |
| | 6th year through harvest year (applied in spring) | 100-100-50 | Apply at bud break. |
| All other firs | 2nd year | 75-0-0 | Apply at bud break. |
| | Spring before harvest | 100-0-0 | Apply at bud break. |

## Phosphorus and Potassium Recommendations

Pre-establishment phosphorus (P) and potassium (K) applications should be based on the amount of available P and K, already in the soil (Table 2). For pine and fir (excluding Fraser fir), P and K applications should be limited to pre-establishment. More nutrient-demanding species, such as spruce and Fraser fir, require additional P or K, or both, during the production cycle. Both P and K-bearing fertilizers should be banded, if possible.

Over-application of P should be avoided, as it can lead to the suppression of mycorrhizal development. The mycorrhizal relationship enhances the uptake of both water and nutrients.

**Table 2.** Phosphorus (as phosphate, $P_2O_5$) and potassium (as potash, $K_2O$) recommendations for the establishment of Christmas trees.

| | Soil Test Category | | | |
|---|---|---|---|---|
| | Low (FIV 0-25) | Medium (FIV 26-50) | Optimum (FIV 51-100) | Excessive (FIV >100) |
| $P_2O_5$ | 60 | 30 | 0 | 0 |
| $K_2O$ | 40 | 20 | 0 | 0 |

## pH Management

Most Christmas tree species prefer a pH in the 6.2 to 6.4 range. An exception to this is Scots pine, which prefers a pH of 5.5.

## Fertilizer Placement

For new plantings, the recommended quantities of phosphorus-bearing and potassium-bearing fertilizers should be banded before planting near the location of tree establishment rather than broadcast.

For established trees, fertilizers should be applied within the dripline, avoiding the area within 6 inches of the trunk.

## Weed Management

If fertilizers are used to grow Christmas trees, banded application of herbicides is highly recommended. The use of fertilizers without chemical weed control will result in excessive vegetative growth of weeds in close proximity to tree seedlings, often resulting in high losses.

# Section I-B5

## Nutrient Recommendations by Crop

**Nutrient Management Recommendations for Commercial Cut Flower Production (University of Maryland Cooperative Extension, 2009)**

# NUTRIENT RECOMMENDATIONS FOR COMMERCIAL CUT FLOWER PRODUCTION

*Source: University of Maryland Cooperative Extension, November 2009*
*Regulatory Citation: COMAR 15.20.08.05*

This fact sheet was developed to help guide cut flower growers with fertilizer recommendations for cut flowers. In Maryland, cut flower growers earning $2,500 (gross) or more per year are required to have a nutrient management plan. To develop this nutrient management plan, Cooperative Extension recommendations on rates of fertilization for field grown cut flowers shall be followed. The information provided here serves as a general guideline for nutrient management in commercial cut flower production

## NITROGEN

Nitrogen applications are needed on an annual basis for production of most cut flower species. The rate of application varies with plant species and whether the plants are herbaceous or woody. For cut flower production, plant nitrogen needs are divided into three categories: "low," "medium," and high" requirements. Plants started in the fall and harvested in the spring generally have lower nitrogen requirements that crops harvested in the summer and fall. Table 6 lists common cut flowers growing in Maryland and their nitrogen categories. Woody flowering species for cut flower production, such as forsythia, pussy willow and flowering cherry, need 2-4 lbs/1,000 sq. ft. of nitrogen for optimum growth.

Nitrogen use in the higher ranges to species that flower over an extended period could benefit from split applications, i.e., dividing the total recommended amount into two or more applications, over the course of the growing season. This is especially important for water soluble forms of nitrogen, such as urea and ammonium nitrate. Controlled release nitrogen sources may be applied in full at the beginning of the growing season.

**Table 1. Nitrogen Fertilization Rate Recommendations for herbaceous cut flowers**

| Nitrogen Category | Low | Medium | High |
|---|---|---|---|
| **Rate (lbs per 1,000 sq ft)** | 1.0-1.5 | 1.5-2.0 | 2.0-3.0 |

### Cover Crops as Nitrogen Sources

Using leguminous cover crops between rotations of cutflowers can reduce the need for nitrogen supplied by fertilizer, manures or other sources. For example, no additional nitrogen application would be needed if a "low" nitrogen-using cut flower crop (see Table 1) were planted after a stand of ladino clover (see Table 2).

**Table 2. Nitrogen Credit from Leguminous Cover Crops**

| | Lbs per 1,000 sq ft | Lbs per acre |
|---|---|---|
| **Perennial Crops** | | |
| Alfalfa [1] | 2.3-3.4 | 100-150 |
| Ladino clover | 1.4 | 60 |
| Red clover | 0.9 | 40 |
| Birdsfoot trefoil | 0.9 | 40 |
| **Winter annual crops** [2] | | |
| Hairy vetch | 1.7-3.4 | 75-150 |
| Crimson clover | 1.2-2.3 | 50-100 |
| Austrian winter peas | 1.7-3.4 | 75-100 |
| **Summer annual crops** | | |
| Lespedeza | 0.5 | 20 |
| Soybeans [3] | 0.3-0.9 | 15-40 |

*Source: Agricultural Nutrient Management Program, Department of Natural Resource Sciences and Landscape Architecture, University of Maryland*

1 Amount of nitrogen credit depends on stand: >4 plants/sq. ft (good) = 150 lbs. N; 1.5-4 plants/sq. ft.(fair) = 125 lbs N; <4 plants/sq. ft.(poor) = 100 lbs N
2 Nitrogen supplied will depend upon planting date, biomass production, kill date and subsequent tillage.
Credit 1 lb N per bushel of soybeans yield; a minimum of 15 lbs N, up to a maximum of 40 lbs N

**Other Organic Nutrient Sources**

All sources of nitrogen, phosphate or potash, including manures, compost, biosolids, food processing waste, used in the production of cut flowers, must be included in a nutrient management plan. These materials must also be tested for nutrient content before they are land applied. Most soil testing labs also offer manure and organic nutrient testing. Results of these tests in combination with soil test results will guide the certified plan developer in calculating the amount of materials to apply for optimum crop growth. Table 3 shows some average values for commonly used organic nutrient sources. These values may be used only for preliminary guidelines and may not be substituted for actual test results.

**Table 3. Average nutrient values of manures (as percentage of wet weight)**

| Manure | Nitrogen (N) | Ammonia ($NH_4$) | Phosphate ($P_2O_5$) | Potash ($K_2O$) | Sulfur (S) |
|---|---|---|---|---|---|
| **Poultry** | | | | | |
| **Broiler** | 2.88 | 0.73 | 3.17 | 2.05 | 0.40 |
| **Caged layer** | 2.22 | 0.69 | 2.91 | 1.89 | 0.26 |
| **Dairy** | | | | | |
| **Solid** | 0.61 | 0.12 | 0.37 | 0.61 | 0.08 |
| **Liquid** | 0.31 | 0.11 | 0.17 | 0.26 | 0.03 |
| **Swine** | | | | | |
| **Solid** | 1.05 | 0.26 | 1.12 | 0.64 | 0.12 |
| **Liquid** | 0.47 | 0.18 | 0.29 | 0.18 | 0.04 |
| **Horse** | 0.51 | 0.03 | 0.36 | 0.42 | 0.09 |

*Source: Agricultural Nutrient Management Program, Department of Natural Resource Sciences and Landscape Architecture*

## PHOSPHOROUS AND POTASSIUM

Application rates for phosphorous and potassium are based on the amount of plant-available nutrients in the soil, as determined by soil testing. Traditionally, soil test results reported in pounds of nutrient per acre; however, a number that would be considered high for one nutrient could be low for another. More recently, University of Maryland developed a 100-point scale called the Field Index Value (FIV) in which lbs per acre of nutrients are categorized into Low, Medium, Optimum and Excessive ranges. Nutrient recommendations for Maryland crops are based on maintaining the soil nutrient levels within the FIV range of 50-100. The definitions and practical application of these categories are shown in Tables 4 and 5.

**Table 4. Field Index Value (FIV) categories and ranges compared to P and K from soil test results**

| FIV Category | FIV range | Phosphorus lbs/acre | Potassium lbs/acre |
|---|---|---|---|
| **Low** – nutrient concentration too low for optimal growth | 0-25 | 0-61 | 0-84 |
| **Medium** - nutrient concentration may be too low for optimal growth | 26-50 | 62-102 | 85-160 |
| **Optimal** - nutrient concentration at a level that can promote optimal growth | 51-100 | 103-205 | 161-320 |
| **Excessive** - nutrient concentration at a level above what is needed for optimal growth | >100 | >205 | >320 |

*Source: Agricultural Nutrient Management Program, Department of natural Resource Sciences and Landscape Architecture*

**Table 5. FIV categories and amount of Phosphorus and Potassium to apply (lbs/1,000 sq ft )**

| FIV Category (range) | Phosphorus | Potassium |
|---|---|---|
| **Low** (0-25) | 4 | 4 |
| **Medium** (26-50) | 2 | 3 |
| **Optimal** (51-100) | 1 | 2 |
| **Excessive** (>100) | 0 | 0 |

*Source: Agricultural Nutrient Management Program, Department of Natural Resource Sciences and Landscape Architecture*

## SOIL pH

Maryland soils are typically acidic (below pH 7) and may require application of a liming material to raise the pH to 6.5, which is suited to most cut flower species. Table 6 gives guidance for the amount of limestone to apply to raise pH in excessively acidic soils.

**Table 6. Limestone (50% oxides) needed to raise soil pH to target pH 6.5 for cut flowers (lbs per 1,000 sq ft)**

| Soil texture | Loamy sand | Sandy loam | Loam | | Silt loam & Clay loam | |
|---|---|---|---|---|---|---|
| Region | All regions | | Coastal plain | Piedmont & mountain | Coastal plain | Piedmont & mountain |
| Soil test pH | | | | | | |
| 6.3 | 10 | 20 | 25 | 25 | 25 | 40 |
| 6.0 | 20 | 40 | 50 | 55 | 50 | 85 |
| 5.8 | 30 | 55 | 65 | 80 | 70 | 120 |
| 5.5 | 45 | 75 | 85 | 110 | 95 | 165 |
| 5.3 | 55 | 85 | 100 | 130 | 110 | 210 |
| 5.0 | 70 | 105 | 120 | 1665 | 135 | 210 |
| 4.8 | 90 | 120 | 135 | 185 | 160 | 210 |
| 4.5 | 90 | 140 | 160 | 185 | 160 | 210 |

*Source: Agricultural Nutrient Management Program, Department of Natural Resource Sciences and Landscape Architecture*

## GREENHOUSE PRODUCTION OF CUT FLOWER TRANSPLANTS

The greenhouse shall be sited and managed to prevent runoff from the greenhouse. A greenhouse operation that produces plants for off-farm sale is require to have a nutrient management plan as specified in Sections II-D and II-E of this *Manual*. If the greenhouse will be used only to grow transplants for use on the same farm, certain records must be maintained with regards to the transplant production, including:

- Transplant production season
- Months of production
- Number of greenhouse
- Total square footage of production greenhouses
- Transplant species grown
- Substrate components (and % of each in the composition)
- Size of flats or containers
- Irrigation methods (whether hand watering, subirrigation, overhead sprinklers, etc.)
- Fertilizer analysis
- Total amount fertilizer used per season
- Injector setting

**Table 7. Nitrogen use categorization for field grown cut flowers**

| Species | Nitrogen Category[4] | Harvest Frequency or Period |
|---|---|---|
| **Group I: Spring Harvest** | | |
| *Allium*, Flowering onion | Low | Once |
| *Consolida*, Larkspur | Low | Fall planting, spring harvest |
| *Delphinium* | Low | Fall planting, spring harvest |
| *Digitalis, foxglove* | Low | |
| *Iris (perennial)* | Low | Spring harvest; late summer & early fall harvest for some newer varieties |
| *Lupinus*, Lupines (perennial) | Medium | Spring harvest over 3-4 weeks |
| *Mathiola incana, Stocks* | Low | Once |

See Table 1 for N fertilization rate recommendations.

| Species | Nitrogen Category[4] | Harvest Frequency or Period |
|---|---|---|
| ***Group 2: Summer and Fall Harvest*** | | |
| *Achillea*, Yarrow | Low | Once |
| *Ageratum* | Medium | Multiple |
| *Ammi majus* | Low | Multiple |
| *Alstroemeria* | Medium-high | May- July |
| *Aquilegia*, Columbine | Low | Once |
| *Artemisia* | Low | Multiple |
| *Asclepias* | Low | August-September |
| *Baptisia (perennial)*, Blue indigo | Low | Once |
| *Celosia*, crested, wheat, plume types | Medium-high | July-September |
| *Centaurea*, cornflower | Low | Multiple |
| *Callistephus chinensis*, China aster | Medium-high | July-September |
| *Chrysanthemum* | Medium-high | Multiple |
| *Cosmos* | Low-Medium | July-October |
| *Crocosmia (corm)* | Low | |
| *Dahlia* | Medium | July-frost |
| *Echinacea* | Low | July-August |
| *Echinops* | Low | |
| *Eucalyptus* | Low-medium | |
| *Aster ericoides* | Medium-high | Multiple |
| *Chrysanthemum parthenium*, Feverfew | Medium | Multiple |
| *Gerbera* | Medium-high | Multiple |
| *Gladiolus (bulb)* | Low | Once |
| *Gomphrena globosa*, Globe amaranth | Medium | Once or can repeat |
| *Grasses & grains* | Low | Late summer-early fall |
| *Gypsophila (perennial)*, baby's breath | Low | Once |
| *Helenium* | Low | |
| *Kniphofia*, Red hot poker | Low | Mid summer |
| *Lavendula*, Lavender | Low | Summer |
| *Lilium* (bulb), Lily | Low | Once |
| *Convallaria*, Lily-of-the-valley | Low | Early summer |
| *Eustoma grandflorum*, Lisianthus | Low-medium | Harvest over 3-4 weeks |
| *Monarda*, Bee balm | Low-medium | 1-2 months in summer |
| *Nigella* | Low-medium | |
| *Penstemon* | Low-medium | |
| *Phlox* (perennial) | Low-medium | 3-4 weeks in summer |
| *Physostegia virginiana* (perennial), Obedient plant | Low | Harvest over 3-4 weeks |
| *Poppy* | Low-medium | Once |
| Queen Anne's lace | Low | Once |
| *Ranunculus* | Medium-high | |
| *Rudbeckia* | Medium-high | Harvest over 3-6 weeks in summer |
| *Salvia* | Medium-high | Multiple |
| *Scabiosa* | Low-medium | |
| *Sedum* (perennial) | Low | August-early October |
| *Antirrhinum majus*, Snapdragon | | |
| *Limonium sinuatum*, Statice | Lo-medium | Once |
| German Statice (perennial) | Low-medium | |
| Strawflower | Low-medium | Multiple |
| *Helianthus anuus*, Sunflower | Low-medium | July-September |
| *Dianthus*, Sweet William | Medium-high | |
| *Veronica* | Low-medium | Harvest over 3-4 weeks |

# Section I-B6

## Nutrient Recommendations by Crop

**Nutrient Management for**
**Tree Fruits and Small Fruits**
**(University of Maryland Cooperative Extension, 2003)**

# NUTRIENT MANAGEMENT FOR TREE FRUITS AND SMALL FRUITS

Source: University of Maryland Cooperative Extension, August 2005
Regulatory Citation: COMAR 15.20.08.05

While the intended target of the nutrient management legislation is to protect the environment, the goals of nutrient management in fruit crops are to: 1) maximize healthy plant growth, productivity, and profitability; and 2) optimize fertilizer usage and minimize fertilizer runoff, thus reducing water pollution.

Orchards and vineyards generally use less fertilizer than row crops for two reasons. First, high fertility is not required once trees and bushes begin producing, since excess fertilizer stimulates vegetative growth and decreases fruit quality. Secondly, with their deep perennial root systems, fruit trees and bushes are capable of absorbing nutrients throughout much of the growing season. In addition, fruit plants are efficient in absorbing fertilizers and recycling nutrients.

Physiological adaptations such as mycorrhizae and bark storage proteins allow perennial fruit trees to take up and recycle a greater proportion of phosphorus and nitrogen than annual crops. Taken together, these physiological adaptations allow fruit growers to maintain productive plantings while using less fertilizer than most annual crops.

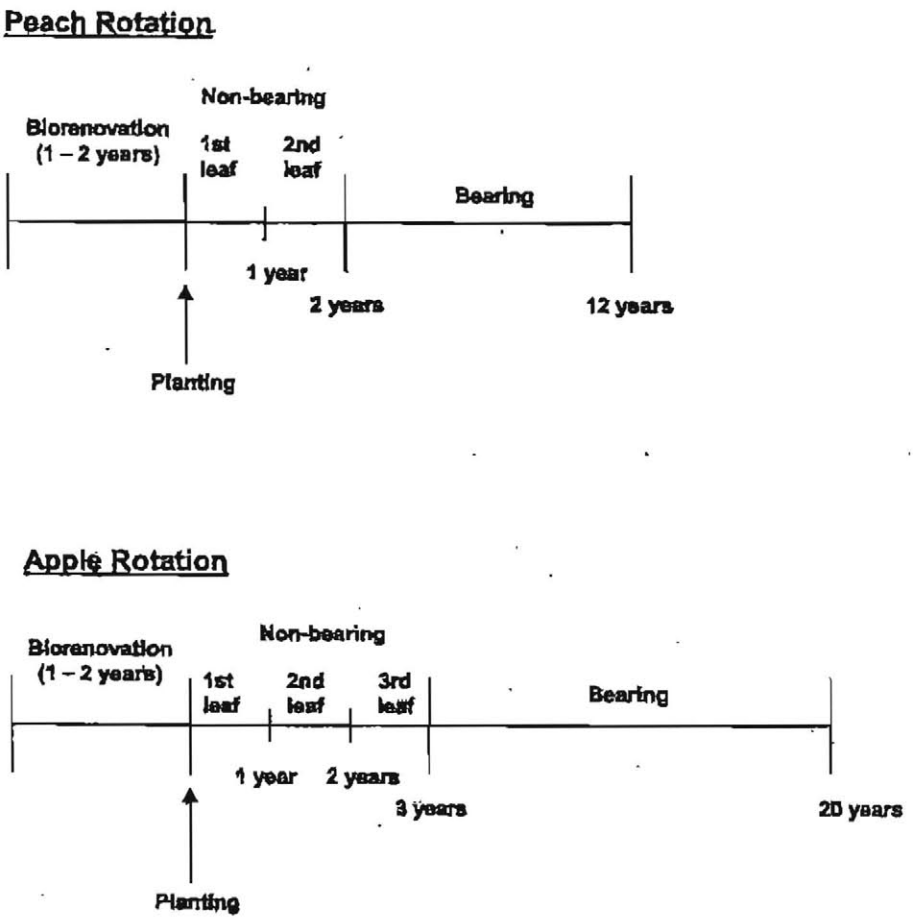
## Nutrient Management Throughout the Life of the Planting

Since the various woody perennial fruit crops have many fertility requirements in common, we have chosen to treat these crops in a similar manner. For the purpose of developing nutrient management plans, the life of the fruit planting is separated into three logical age categories. The age categories in the life of a fruit planting are:

I. Pre-planting (biorenovation) year(s);
II. Non-bearing year(s); and
III. Bearing years

During these three age categories (Figure 1), fertilizer recommendations, fertilizer applications, and agricultural practices will be handled differently. Thus, nutrient management planning must also be handled differently.

**Figure 1.** A typical rotation for peaches and apples. (The life cycles of both trees are similar, except that peach is earlier to come into production and earlier to decline.)




## I. Pre-Planting Year(s)

Prior to planting, phosphorus and potassium recommendations and lime requirements will be determined from soil tests. Adjustment of pH and plant-available phosphorus and potassium are necessary to optimize the growth of young trees. Optimal pH for fruit crops is as follows: apples and other tree fruit, 6.5; raspberry, 6.5; blackberry, 6.2; blueberry, 4.5.

To avoid nematode problems, fruit plantings should not be set directly into pasture land. Thus, prior to planting, a two-year rotation with nematode-suppressing crops is recommended. Consult EB 242, *Commercial Small Fruit Production Guide's* section on "Pre-Plant Site Biorenovation and Soil Conditioning" for details.

Whatever crop rotation is selected prior to planting, soil tests are needed to determine phosphorus and potassium recommendations, and lime requirements for the rotational crops. Nitrogen recommendations are determined by crop type and yield goal.

After biorenovation and before planting fruit crops, re-sample and re-test soil. This is the last opportunity to incorporate nutrients and lime. Implementing these nutrient recommendations before planting ensures that adequate soil fertility will be present to establish young fruit plants

and will contribute much of the nutrients required throughout the life of the planting. Consult Table 1 for pre-plant phosphorus and potassium recommendations based on soil test.

**Table 1.** Phosphorus (as $P_2O_5$ or 0-46-0 fertilizer) and potassium (as $K_2O$ or 0-0-60 fertilizer) recommendations for establishment of woody perennial fruit crops

| Soil Test Results | | Nutrient (Lbs. Per Acre) | | Recommended Fertilizer (Lbs. Per Acre) | |
|---|---|---|---|---|---|
| $P_2O_5$ | $K_2O$ | $P_2O_5$ | $K_2O$ | 0 - 46 - 0 | 0 - 0 - 60 |
| L | L | 135 - 155 | 195 - 235 | 305 - 350 | 325 - 390 |
| M | M | 90 | 130 | 205 | 215 |
| O | O | 15 | 90 | 35 | 150 |
| E | E | 0 | 0 | 0 | 0 |

L = Low (FIV 0 - 25)
M = Medium (FIV 26 - 50)
O = Optimum (FIV 51 - 100)
E = Excessive (FIV >100)

**II. Non-Bearing Year(s)**

Most fruits are grown with permanent grass sod strips between rows, with grass and weed growth beneath the trees or bushes controlled by herbicide sprays. The permanent sod crop (drive middle) and herbicide strip make spraying and harvesting easier. They also minimize root damage from plant-parasitic nematodes, and tree and fruit damage from nematode-vectored viruses and direct insect pests.

Fruit growers typically plant into bare ground that is kept weed-free by cultivation during the first growing season. This is done because young fruit plants compete poorly with grasses for water and nutrients. Because it is usually difficult to establish a good sod cover in the spring, permanent sod strips are often not established until the fall after planting.

Some growers prefer to establish the permanent sod cover the year prior to planting. Subsequently, a strip of sod is killed with herbicides, and trees or bushes are set using a 'no-till' planter. Regardless of when the sod is planted, nutrient applications to the sod cover are only required until the sod in the drive middle has become fully established.

Repeated studies of plant establishment have shown that hand placement of nitrogen fertilizer during non-bearing years is the most efficient method of applying unincorporated fertilizer. Hand placement of nitrogen fertilizer after the plants have settled in, and in the spring during the next two or three years, is the industry standard. The goal is to have plants quickly fill their allotted space, and then reduce their growth by redirecting photosynthate to the fruit crop. Hand placement of fertilizer during the early years maximizes growth while minimizing fertilizer usage.

Calcium nitrate has become the material of choice for fertilizing young plants, with the exception of blueberries. The benefits of calcium nitrate are two-fold. First, nitrate fertilizers

are taken up rapidly and stimulate strong early-season growth. Second, calcium deficiency problems, such as bitter pit and York spot in apples, occur widely in fruits and may be suppressed by calcium nitrate. Later, during the bearing years, many apple growers continue to use calcium nitrate, which helps to minimize fruit softening and breakdown in storage.

Blueberries are typically fertilized using ammonium sulfate, which supplies the nitrogen and keeps the pH reduced.

Consult Table 2 for recommended annual nitrogen application during the non-bearing year(s). While some growers use a blended fertilizer following planting, this is unnecessary if plant-available phosphorus and potassium were optimized prior to planting.

**Table 2.** Nitrogen fertilizer recommendations for young non-bearing plantings of woody perennial fruit crops (hand-placed nitrogen fertilizer per plant per year)

| | **Calcium Nitrate** (15.5% N) | **Ammonium Nitrate** (33% N) | **Ammonium Sulfate** (21% N) |
|---|---|---|---|
| **Tree Fruit** | | | |
| Apple | 8 oz | 4 oz | - |
| Peach and nectarine | 12 oz | 6 oz | - |
| Pear<br>Fireblight resistant<br>Fireblight susceptible | <br>8 oz<br>4 oz | <br>4 oz<br>2 oz | - |
| Cherry, apricot and plum | 8 oz | 4 oz | - |
| | | | |
| **Small Fruit** | | | |
| Blackberry | 10 oz | 5 oz | - |
| Blueberry | - | - | 2.25 oz |
| Raspberry | 3 oz | 1.5 oz | - |

## III. Bearing Year(s)

While soil analyses are valuable in adjusting nutrient recommendations prior to planting, University of Maryland fruit specialists recommend basing nutrient recommendations for bearing trees and small fruit crops on a **combination of soil testing and tissue analysis** for determining fertilizer needs in bearing perennial fruit crops. Soil tests and tissue analyses every 3 years may be sufficient if crop production is adequate, however, if production is poor, annual tests may be advisable.

Soil tests during the bearing years provide an important crosscheck of nutrient status. For example, if tissue analysis indicates a low level of phosphorus in leaf tissue, while the soil test level for phosphorus is optimum or excessive, the low phosphorus level in plant tissue is most likely due to a nutrient absorption problem, such as disease or nematodes, that would not be

ameliorated by application of additional phosphorus. In numerous other situations, for example, excessive manganese or low calcium, both soil tests and tissue analysis must be viewed together to fully understand nutrient status.

Observations of plant growth characteristics and crop management, such as shoot growth, leaf color, and pruning severity should also be taken into account when developing nutrient recommendations.

Phosphorus usage by woody perennial fruit crops should be low once bearing begins. Following pre-plant applications, little or no phosphorus may be required. The limited need for supplemental phosphorus comes from the development of symbionts in tree roots known as mycorrhizae (literally "fungus-root"). Mycorrhizae aid perennial plants in dissolving and taking up phosphorus, even in soils that have relatively low levels of phosphorus.

*Tissue Sampling and Analysis*

As previously indicated, in addition to soil sampling and testing, tissue sampling and analysis are essential for developing nutrient recommendations in nutrient management plans. Tissue samples are typically taken during the summer, when nutrient contents in the leaves are relatively stable (Table 3). Soil samples, which may be taken in the fall, should be taken the same year as tissue samples, and sampling sites should be in the same area of the block from which the tissue samples were collected.

At least one sample should be collected from each block. If a block contains a mixture of species or cultivars, or both, sample the dominant species and a benchmark cultivar.

**Table 3.** Sample collection summary

| Crop | Time to Sample | Number of Samples/ Plant Part | Location on Plant |
|---|---|---|---|
| Blueberries | 1st week of harvest | 40 leaves (detach petioles) | Current season's growth |
| Brambles | Aug 1st - Aug 20th | 60 leaves (detach petioles) | Non-fruiting canes |
| Fruit trees | August | 50 leaves & petioles | Select shoots at eye level from around outside of tree; select shoots that make a vertical angle of 45-60 degrees to the ground; remove 1-2 leaves from the mid-portion of new shoot growth (Figure 2). |

**Figure 2**

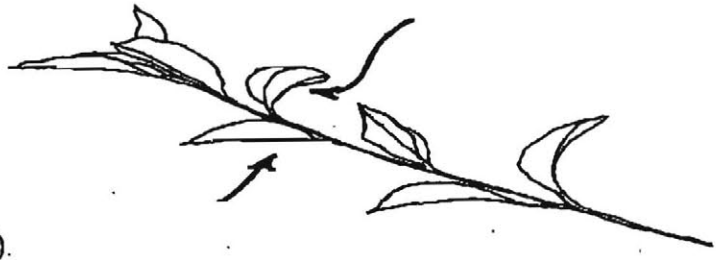
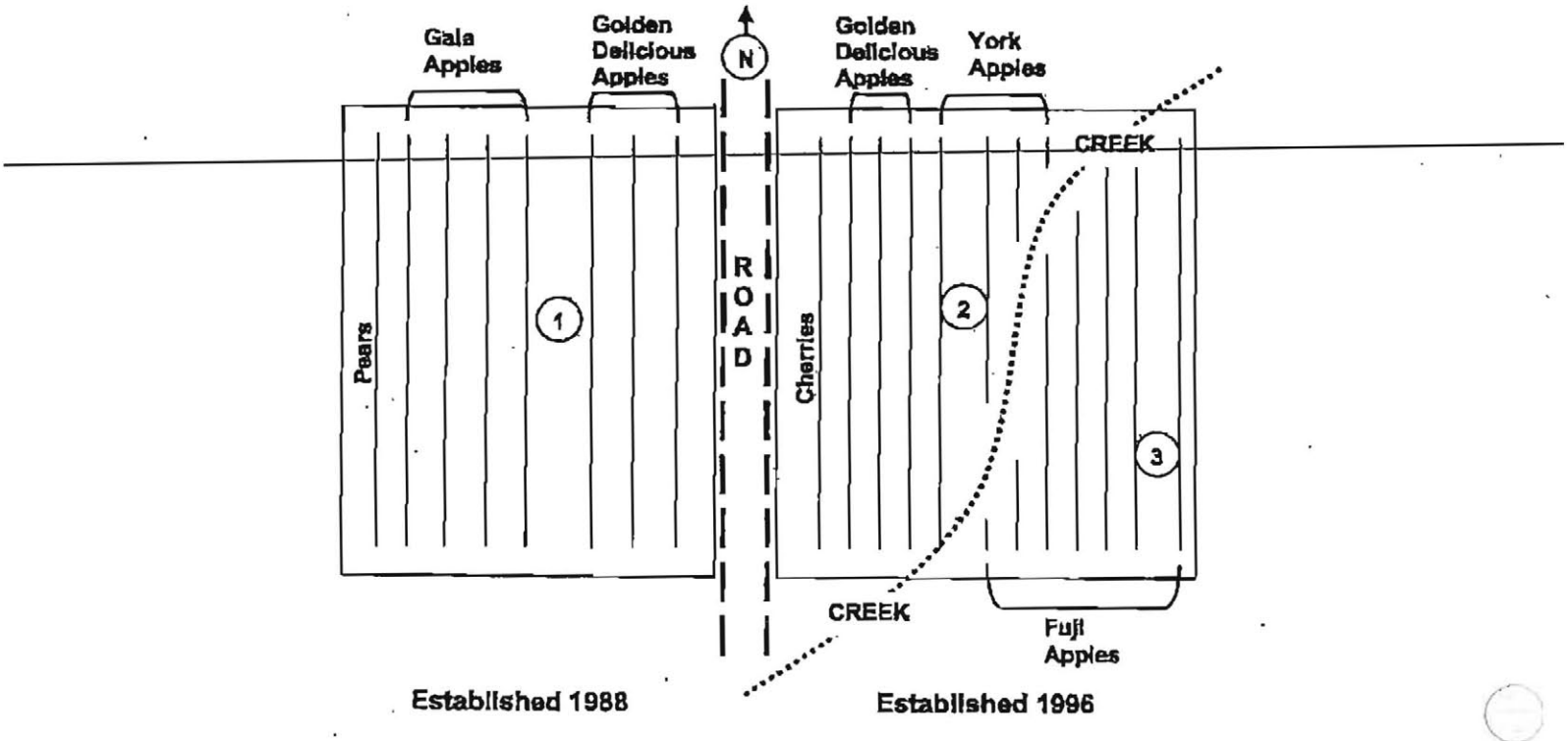


Figure was taken from "Instructions for Taking Samples for Plant Analysis" (Pennsylvania State University).

Perhaps the biggest hurdle in the tissue sampling process may be in answering the question, "*What is a block?*" and "*What should be sampled within a block?*" A typical block would best be determined by the orchard manager, and should be based on tree species and planting date. In Figure 3, two varieties of apples and a row of pears (Field 1) were planted on Murrill gravelly loam in 1998, while Fields 2 and 3 were established in 1996 on a Chandler silt loam and Edgemont channery loam, respectively. Because each of the fields consists of a distinctly different soil, each field should be sampled as a separate block. Within all the blocks, apple is the dominant species. Within Field 1 (Block 1), Gala is the variety of greater interest to the producer because of its higher economic value and should be the cultivar sampled. Using the same logic, the York variety in Field 2 (Block 2) is of greater interest to the producer so it should be the cultivar sampled. Since nitrogen usage in cherry is similar to apple, the grower would probably manage the cherries and apples in Block 2 in a similar fashion. In Field 3 (Block 3), Fuji is the only variety in the block, thus it will be the cultivar sampled.

**Figure 3.** Example of blocks



Defining a block becomes increasingly difficult as orchard size decreases, as smaller orchards in Maryland may include many species. This problem may be further compounded in small orchards if the grower has difficulty controlling fertility. Orchards and small fruit production areas smaller than five acres, set in similar soils, could probably be handled as one or two blocks, focusing on apples and peaches.

All leaves for a sample should be collected from the same cultivar. The sampling procedure should be as random as possible. It is best NOT to take multiple leaves from the same tree or bush, but collect from a wide selection of plants throughout the block and cultivar being sampled.

In apples, widely grown cultivars such as Delicious, York, or Rome are logical choices for tissue sampling in a mixed planting. Alternatively, sampling high value cultivars such as Gala and Jonagold might be needed, especially in direct market operations.

*Interpreting Tissue Analysis*

Nutrient sufficiency ranges for common woody perennial fruit crops produced in Maryland are listed in Table 4. These levels are based on a long history of research, conducted to minimize fertilizer usage, while optimizing the production of quality fruit. Complete information on deficient, low, normal, high, and excessive nutrient concentrations for tree and small fruit crops is in the Appendices.

**Table 4.** Nutrient sufficiency ranges and desired annual shoot growth for woody perennial fruit crops used to interpret foliar analyses (dry weight).

| | Apple | Pear | Peach | Cherry | Brambles | Blueberries |
|---|---|---|---|---|---|---|
| **Desired shoot growth (inches per year)** | 12 - 18 | 12 - 18[1]<br>8 - 12[2] | 18 - 24 | 15 - 18 | | |
| **Macronutrients** | | | | | | |
| Nitrogen (%) | *1.80 - 2.80 | 1.60 - 2.40 | 2.50 - 3.40 | 2.30 - 3.30 | 2.00 - 3.00 | 1.70 - 2.10 |
| Phosphorus (%) | 0.18 - 0.30 | 0.18 - 0.26 | 0.15 - 0.30 | 0.23 - 0.38 | 0.25 - 0.40 | 0.07 - 0.18 |
| Potassium (%) | 1.20 - 2.00 | 1.20 - 2.00 | 2.10 - 3.00 | 1.00 - 1.90 | 1.50 - 2.50 | 0.40 - 0.65 |
| | | | | | | |
| Calcium (%) | 1.30 - 3.00 | 1.30 - 3.00 | 1.90 - 3.50 | 1.60 - 2.60 | 0.60 - 2.50 | 0.30 - 0.80 |
| Magnesium (%) | 0.20 - 0.40 | 0.30 - 0.60 | 0.20 - 0.40 | 0.49 - 0.65 | 0.30 - 0.90 | 0.20 - 0.30 |
| Sulfur (%) | 0.20 - 0.40 | 0.17 - 0.26 | 0.20 - 0.40 | 0.15 - 0.50 | 0.21 - 0.50 | 0.12 - 0.20 |
| **Micronutrients** | | | | | | |
| Boron (ppm) | 35 - 80 | 35 - 80 | 25 - 50 | 39 - 80 | 30 - 50 | 30 - 50 |
| Copper (ppm) | 6 - 25 | 6 - 25 | 6 - 25 | 6 - 25 | 7 - 50 | 5 - 15 |
| Iron (ppm) | 40 - 100 | 50 - 400 | 50 - 200 | 50 - 250 | 50 - 200 | 70 - 300 |
| Manganese (ppm) | 22 - 140 | 20 - 200 | 19 - 150 | 18 - 150 | 50 - 200 | 50 - 500 |
| Zinc (ppm) | 20 - 200 | 20 - 200 | 20 - 200 | 20 - 200 | 20 - 50 | 15 - 30 |

* Nitrogen sufficiency ranges vary depending upon apple type and usage
[1] Fireblight-resistant varieties
[2] Fireblight-susceptible varieties

Antique peach cultivars such as Belle of Georgia, Elberta, and Raritan Rose will drop green fruit cultivars; growers should only apply half the level of nitrogen recommended for peaches. Typically, the grower would only apply the first split-application to these 'antique' varieties.

In apples, adequate nitrogen level can be further defined depending on cultivar sampled and maturity. Apple varieties can be divided into three groupings depending on firmness and storage ability (Table 5).

Tissue nitrogen levels will be reduced in biennial bearing apple trees in their 'off' year or in trees carrying a light crop.

**Table 5.** Recommended levels of nitrogen (%) for apple cultivar groups

| | Early Bearing | Mature |
|---|---|---|
| **Soft apple cultivars**<br><br>Paulared, McIntosh, Empire, Gala, Golden Delicious, Jonagold, Mutsu | 2.0 - 2.4 | 1.8 - 2.1 |
| | | |
| **Fresh market cultivars**<br><br>Delicious, Fuji, Braeburn | 2.2 - 2.4 | 2.2 - 2.25 |
| | | |
| **Fresh market and processing cultivars**<br><br>York Imperial, Rome Beauty, Stayman | 2.2 - 2.6 | 2.2 - 2.4 |

## IV. Sampling and Testing During Orchard Rotation

Sampling and testing are the bases of nutrient recommendations and vary across the life of the orchard. Consult Table 6 for a summary of sampling and testing requirements for biorenovation years and age categories of woody perennial fruit crops.

**Table 6.** Soil and tissue testing summary

| Age of Planting | Soil Test | Tissue Test |
|---|---|---|
| Biorenovation | Yes | No |
| Pre-plant | Yes | No |
| Non-bearing | No | No |
| Bearing | Yes | Yes |

## Issues During Bearing Years in Established Orchards

*Symptoms of Deficient Nitrogen*

Nitrogen deficiency symptoms appear as reduced top growth with short, spindly shoots that have pale green to yellow leaves. Generally speaking, symptoms first become evident in older leaves at the base of the shoots. In stone fruits, deficient leaves appear reddish and may exhibit a 'shothole' effect as the condition worsens. Low nitrogen fruits tend to be smaller and mature earlier. This is particularly noticeable in stone fruits. Urea sprays can be used to correct early season nitrogen deficiency in orchards. If, in the springtime, foliage is light yellow and trees are otherwise healthy, the transitional nitrogen deficiency can be corrected by spraying urea at 4 pounds per 100 gallons on a dilute basis after bloom (Pfeiffer, et al., 2001). This should be done no later than the second cover spray on mature trees. Urea may also be added to cover sprays in young, non-bearing trees at the same rate until July 15$^{th}$.

*Symptoms of Excessive Nitrogen*

Excessive nitrogen application causes excessive shoot growth, accompanied by dark green foliage and delayed leaf abscission in the fall. As nitrogen increases above the optimum, fruit color is reduced and maturity is delayed. Fruits develop less red color, and the ground color remains green rather than turning yellow. In apples and pears, flavor and storage life are generally reduced with excess nitrogen. In addition to these direct effects, other physiological disorders such as corking and bitter pit can increase, as excessive nitrogen may induce calcium deficiency symptoms.

*Timing and Split-Applications of Nitrogen Fertilizer in Peach and Nectarine Orchards*

Among all fruit crops grown in Maryland, the nitrogen requirement of peach and nectarine crops is the greatest. To minimize over-fertilization, it is common practice for peach and nectarine growers to make two applications of nitrogen fertilizer a year, each application using half of the total recommended rate. The first application is typically made at bloom time, and the second after the crop has been set (30-45 days after bloom). This allows growers to avoid excessive vegetative growth in years when the crop is lost following a late spring freeze.

*Symptoms of Deficient Phosphorus*

Phosphorus deficiencies severe enough to produce visual symptoms are rare in fruit trees (Crassweller and Greene, 1995). When they do occur, symptoms may appear first as limited and slender terminal growth with young expanding leaves that are dark green. The young leaves' lower sides, especially along the margins and main veins, frequently show purplish discoloration. The leaves may have a leathery texture and form abnormally acute angles with the stem. Leaf symptoms are most often seen early in the growing season and diminish later in the season. This likely occurs due to cold soils limiting phosphorus uptake, rather than a deficiency *per se*. When soil moisture is low, lower levels of phosphorus may also be found in leaf analyses.

*Symptoms of Excessive Phosphorus*

Effects of excessive phosphorus fertilization are usually expressed as deficiencies of one or more essential micronutrients, such as zinc, copper, iron, and manganese.

*Calcium Deficiency of Apples*

Calcium chloride sprays are often recommended when tissue sample analyses indicate low or deficient levels of calcium. Such spray regimes are often not economical for direct market growers unless there has been a history of bitter pit. Calcium chloride is difficult to apply, corrosive to equipment, and potentially phytotoxic. Applying boron (1 pound Solubor® per acre at petal fall) can increase the fruit "sink-strength" and enhance calcium uptake by the fruit. Processing varieties of apples such as York may require calcium chloride sprays for successful production if bitter pit or corking has been a problem. Calcium chloride at an annual rate of 15 – 50 pounds of product per acre can be included in cover sprays 1 through 7.

## Estimating Nitrogen Requirements for Established Fruit Plantings in the Absence of a Tissue Analysis

Some Maryland fruit growers may not have results from tissue analyses. In these instances, nitrogen application rates can be based on leaf color and shoot growth. **The information in Table 7 is presented as a temporary aid to nutrient management planners writing initial plans in the absence of tissue analyses.** It should not be used as a long-term alternative to tissue analysis.

**Table 7.** Desired shoot growth and typical nitrogen needed annually in fruit crops

| **Tree Fruit** | **Nitrogen (lbs./acre)*** | **Desired Shoot Growth (inches)** |
|---|---|---|
| Apple | 35 | 12 - 18 |
| Peach and nectarine | 65 | 18 - 24 |
| Pear | | |
| Fireblight-resistant | 35 | 12 - 18 |
| Fireblight-susceptible | 20 | 8 - 12 |
| Cherry, apricot and plum | 35 | 15 - 18 |
| **Small Fruit** | | |
| Blackberry | 60 | - |
| Raspberry (Spring-bearing) | 35 | - |
| Raspberry (Fall-bearing) | 50 | - |
| Blueberry | 30** | - |

* Optimize based on tissue test.
** N rate could be as high as 60 lbs./acre depending upon age of plants, type of mulch, and soil type.

## Phosphorus Site Index for Tree Fruits and Small Fruits

In the event tissue analysis recommends the application of phosphorus, and the producer wishes to apply phosphorus, consideration must be given to the soil test's fertility index value for phosphorus (FIV-P) levels.

Maryland regulations require that the Phosphorus Site Index (PSI) be determined for all agricultural fields whose FIV-P is 150 or greater **if a producer intends to apply any P-bearing fertilizer materials**. It is unlikely that many perennial fruit producers will be impacted by the PSI requirement during the fruit production years if fertility recommendations were followed during pre-establishment period.

The PSI requires that a series of site/transport and management/source characteristics for a field be evaluated and that a P loss rating be calculated.

The site and transport characteristics include the following:

Soil erosion;
Soil runoff class;
Subsurface drainage;
Leaching potential;
Distance from the edge of the field to surface water;
Priority of receiving watershed.

Soil erosion, which is estimated via the Revised Universal Soil Loss Equation (RUSLE), and distance from the edge of the field to surface water are the only characteristics over which the producer has any control.

Soil runoff class, subsurface drainage, and leaching potential are functions of the dominant soil-mapping unit in the field, and priority of receiving watershed is a function of geographical location.

The management and source characteristics include the following:

Soil test P;
P application rate (fertilizers and manure);
Timing and application method (fertilizers and manure).

The P loss rating, which is calculated from site/transport features and management/source characteristics, places a field in one of 4 categories (Table 8).

**Table 8.** Interpretation of P loss rating

| P Loss Rating | Interpretation of P loss Rating |
|---|---|
| 0 - 50 | • **LOW** potential for P movement from this site given current management practices and site characteristics. There is a low probability of an adverse impact to surface waters from P losses from this site.<br>• Nitrogen-based nutrient management planning is satisfactory for this site.<br>• Soil P levels and P loss potential may increase in the future due to continued nitrogen-based nutrient management. |
| 51 - 75 | • **MEDIUM** potential for P movement from this site given current management practices and site characteristics. Practices should be implemented to reduce P losses by surface runoff, subsurface flow, and erosion.<br>• Nitrogen-based nutrient management should be implemented no more than one year out of three.<br>• Phosphorus-based nutrient management planning should be implemented two years out of three during which time P applications should be limited to the amount expected to be removed from the field by crop harvest or soil test-based P application recommendations, whichever is greater. |
| 76 - 100 | • **HIGH** potential for P movement from this site given current management practices and site characteristics.<br>• Phosphorus-based nutrient management planning should be used for this site. Phosphorus applications should be limited to the amount expected to be removed from the field by crop harvest or soil test-based P application recommendations.<br>• All practical management practices for reducing P losses by surface runoff, subsurface flow, or erosion should be implemented. |
| >100 | • **VERY HIGH** potential for P movement from this site given current management practices and site characteristics.<br>• No phosphorus should be applied to this site.<br>• Active remediation techniques should be implemented in an effort to reduce the P loss potential from this site. |

The estimation of PSI is an annual function, calculated any year when P-bearing materials may be added to fields with an FIV-P greater than 150. However, soil erosion, one of the more time-consuming components of the PSI process, is estimated over the entire rotation, including pre-establishment, non-bearing, and bearing years. RUSLE integrates the effect of six factors in calculating soil erosion losses (A) expressed in tons per acre per year, according to the following equation:

$$A=RKLSCP \text{ where}$$

R = rainfall factor
K = soil erodibility factor
L = slope length
S = slope steepness
C = crop rotation and tillage factor
P = conservation practices factor

The rainfall factor is available from published data on a county basis. The soil erodibility factor is a function of the dominant soil-mapping unit of a field and is available in soil surveys and from other published sources. Slope length and gradient are measured in each field. The crop rotation and tillage factor is calculated from published sources based on crop type, tillage method, and canopy cover and is calculated as a weighted average over space and time. (An example of a calculation for the C factor in a typical orchard is shown in Table 9. The widths of grassed "drive middles" and herbicide strips were assumed to be similar for this example.) The conservation practices factor (P) can be determined from published sources.

**Table 9.** An example of the C factor for a 20-year orchard rotation

| Year | Crop Coverage | Crop / Condition | C Factor |
|---|---|---|---|
| Year 1 | Biorenovation | Soybeans - conventional tillage | .20 |
| Year 2 | Biorenovation | Corn - conventional tillage | .20 |
| Year 3 | Planting | 6 ft. whips, clean cultivation until fall when sod is seeded | .90 |
| Year 4 | Non-bearing year, medium height | 50% sod, first year after tillage, no appreciable canopy | .25 & .30, mean = .28* |
| Year 5 | Non-bearing year, medium height | 50% sod, second year after tillage, 25% canopy | .18 & .25, mean = .22 |
| Year 6 | Non-bearing year, tall | 50% sod, third year after tillage, 50% canopy | .07 & .21, mean = .14 |
| Year 7 | Bearing, tall | 50% sod, fourth year after tillage, 75% canopy | .07 & .16, mean = .12 |
| Year 8-20 | Bearing, tall | 50% sod, fifth and following years after tillage, 75% canopy | .07 & .13, mean = .10 |
| | | | |
| 20-year average | | | .17 |

* Sub-factors assume 40% ground cover (W) in herbicide strip Year 4 and after.

## References and Useful Resources

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Rouse, R. et al. 2002. Commercial Small Fruit Production Guide. EB 242. Maryland Cooperative Extension Service. 111 p.

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## Prepared by:

Christopher Walsh, Professor of Horticulture
Patricia Steinhilber, Nutrient Management Program Coordinator
Department of Natural Resource Sciences and Landscape Architecture
2102 Plant Sciences Building
University of Maryland
College Park, MD 20742-4452

# Appendix 1

## Apple (Any)

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| | **All Cultivars** | | | |
| N | Deficient | < 1.6 | Nitrogen is very low. | Increase application rate by 50% unless major renovative pruning will be performed this winter, in which case increase application by only 25%. Values lower than 1.40% may indicate other problems. Examine the trees closely and retest next year. Shoot growth can help determine your nitrogen program. Bearing trees should have 12 to 18 inches of shoot growth per year. Note: Nitrogen levels, however, can be lower on light-cropping trees. |
| | **Soft Cultivars:** Paulared McIntosh, Empire, Golden Delicious, Gala, Jonagold, Mutsu | | | |
| | Low | 1.6 - 1.8 | Nitrogen is low. | Increase application rate by 25% unless shoot growth was excessive or if major renovative pruning will be performed this winter. Shoot growth can help determine your nitrogen program. Bearing trees should have 12 to 18 inches of shoot growth per year. Note: Nitrogen levels, however, can be lower on light-cropping trees. |
| | Normal | 1.8 - 2.1 | Nitrogen is adequate. | Continue past practices if terminal growth was adequate and fruit color satisfactory. Shoot growth can help determine your nitrogen program. Bearing trees should have 12 to 18 inches of shoot growth per year. If terminal growth was excessive, fruit color inadequate or major renovative pruning was performed, the same or a reduction in rate of application of nitrogen is in order. During the early-bearing years, N levels should range between 2.0 and 2.4. Fruit destined for fresh market will have better color and firmness if N levels are reduced by 0.2%. Note: Nitrogen levels, however, can be lower on light-cropping trees. |
| | High | > 2.1 | Nitrogen is above normal. | Reduce rate of application unless shoot growth was inadequate or renovative pruning was performed the previous winter. On mature trees with adequate shoot growth and a normal crop, eliminate nitrogen application next year and retest next growing season. Shoot growth can help determine your nitrogen program. Bearing trees should have 12 to 18 inches of shoot growth per year. Note: Nitrogen levels, however, can be lower on light-cropping trees. |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| | **Fresh Market Cultivars:** Delicious, Fuji, Braeburn | | | |
| N (cont.) | Low | 1.6 - 2.2 | Nitrogen is low. | Increase application rate by 25% unless shoot growth was excessive or if major renovative pruning will be performed this winter. Shoot growth can help determine your nitrogen program. Bearing trees should have 12 to 18 inches of shoot growth per year. Note: Nitrogen levels, however, can be lower on light-cropping trees. |
| | Normal | 2.2 - 2.25 | Nitrogen is adequate. | Continue past practices if terminal growth was adequate and fruit color satisfactory. Shoot growth can help determine your nitrogen program. Bearing trees should have 12 to 18 inches of shoot growth per year. If terminal growth was excessive, fruit color inadequate or major renovative pruning was performed, the same or a reduction in rate of application of nitrogen is in order. During the early-bearing years, N levels should range between 2.2 and 2.4. Fruit destined for fresh market will have better color and firmness if N levels are reduced by 0.2%. Note: Nitrogen levels, however, can be lower on light-cropping trees. |
| | High | > 2.25 | Nitrogen is above normal. | Reduce rate of application unless shoot growth was inadequate or renovative pruning was performed the previous winter. On mature trees with adequate shoot growth and a normal crop, eliminate nitrogen application next year and retest next growing season. Shoot growth can help determine your nitrogen program. Bearing trees should have 12 to 18 inches of shoot growth per year. Note: Nitrogen levels, however, can be lower on light-cropping trees. |
| | **Processed and Fresh Market Cultivars:** York Imperial, Rome Beauty, Stayman | | | |
| | Low | 1.6 - 2.2 | Nitrogen is low. | Increase application rate by 25% unless shoot growth was excessive or if major renovative pruning will be performed this winter. Shoot growth can help determine your nitrogen program. Bearing trees should have 12 to 18 inches of shoot growth per year. Note: Nitrogen levels, however, can be lower on light-cropping trees. |
| | Normal | 2.2 – 2.4 | Nitrogen is adequate. | Continue past practices if terminal growth was adequate and fruit color satisfactory. Shoot growth can help determine your nitrogen program. Bearing trees should have 12 to 18 inches of shoot growth per year. If terminal growth was excessive, fruit color inadequate or major renovative pruning was performed, the same or a reduction in rate of application of nitrogen is in order. During the early-bearing years, N levels should range between 2.2 and 2.6. Fruit destined for fresh market will have better color and firmness if N levels are reduced by 0.2%. Note: Nitrogen levels, however, can be lower on light-cropping trees. |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| N (cont.) | High | > 2.4 | Nitrogen is above normal | Reduce rate of application unless shoot growth was inadequate or renovative pruning was performed the previous winter. On mature trees with adequate shoot growth and a normal crop, eliminate nitrogen application next year and retest next growing season. Shoot growth can help determine your nitrogen program. Bearing trees should have 12 to 18 inches of shoot growth per year. Note: Nitrogen levels, however, can be lower on light-cropping trees. |
| P | Deficient | < 0.11 | Phosphorus is very low. | Broadcast 150 lbs. $P_2O_5$ per acre as soon as convenient. Retest next year. In Maryland, the Phosphorus Site Index must be performed before adding any phosphate-bearing fertilizers when soil test FIV-P is 150 or greater. |
| | Low | 0.11 - 0.15 | Phosphorus is low. | Broadcast 125 lbs. $P_2O_5$ per acre as soon as convenient. However, unless phosphorus is incorporated it is unlikely you will see a response to surface-applied P on trees older than 5 years. In Maryland, the Phosphorus Site Index must be performed before adding any phosphate-bearing fertilizers when soil test FIV-P is 150 or greater. |
| | Normal | 0.15 - 0.31 | Phosphorus is adequate. | No further application is needed at this time. |
| | High | > 0.31 | Phosphorus is above normal. | If using a complete fertilizer, discontinue its use. Above normal levels of phosphorus can increase problems of zinc and copper deficiency. |
| K | Deficient | < 0.70 | Potassium is very low. | Broadcast 125 lbs. $K_2O$ per acre as soon as convenient. Retest next year. |
| | Low | 0.70 - 1.2 | Potassium is low. | Potassium levels can be 0.4% lower than normal during a dry summer or during years of heavy cropping. Broadcast 100 lbs. $K_2O$ per acre as soon as convenient. Note that if the cultivar is York Imperial, no potassium application is needed unless the level is below 1.0%. |
| | Normal | 1.2 - 2.01 | Potassium is adequate. | No further application is needed at this time. If tree density is greater than 500 trees per acre, potassium levels need to be monitored closely due to heavy cropping. |
| | High | > 2.01 | Potassium is above normal. | If using a complete fertilizer, discontinue its use. Excess potassium will compete with calcium and magnesium for uptake by the trees. |
| Ca | Deficient | < 0.31 | Calcium is very low | Soil test for possible low pH and apply high calcium lime as needed. If pH is normal, apply calcium chloride foliarly if bitter pit or corking has been a problem in processing apples such as York (15-50 lbs. per are per year in cover sprays 1 though 7). For other situations, apply Solubor® at petal fall (1 lb. per acre). |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| Ca (cont.) | Low | 0.31 - 1.3 | Calcium is low. | Soil test for possible low pH and apply high calcium lime as needed. If pH is normal, apply calcium chloride foliarly if bitter pit or corking has been a problem in processing apples such as York (15-50 lbs. per acre per year in cover sprays 1 though 7). For other situations, apply Solubor® at petal fall (1 lb. per acre). Low calcium and high potassium and/or magnesium may indicate too much potassium and/or magnesium is absorbed rather than low calcium. |
| | Normal | 1.3 - 3.01 | Calcium is adequate. | Apply calcium chloride in cover sprays if corking or bitter pit has been a problem in the past in processing varieties such as York. Calcium levels can be inflated by 0.25% during years of heavy cropping. Therefore in those years, if your levels are close to the lower sufficiency range of 1.30%, be sure to continue with any foliar applications of calcium during the coming growing season. |
| | High | > 3.01 | Calcium is above normal. | |
| Mg | Deficient | < 0.03 | Magnesium is very low. | Soil test for possible low pH and apply magnesium as recommended. If soil test does not indicate a magnesium recommendation, apply 15 lbs. magnesium sulfate (11% Mg) foliarly at petal fall. |
| | Low | 0.03 - 0.20 | Magnesium is low. | Soil test for possible low pH and apply magnesium as recommended. If soil test does not indicate a magnesium recommendation, apply 15 lbs. magnesium sulfate (11% Mg) foliarly at petal fall. |
| | Normal | 0.20 - 0.41 | Magnesium is adequate. | If lime is needed based on soil test results apply a high calcium lime. |
| | High | > 0.41 | Magnesium is above normal. | Excess magnesium competes with calcium and potassium for uptake by the plants. Therefore, avoid the use of dolomitic lime. |
| S | Deficient | < 0.11 | Sulfur is very low. | |
| | Low | 0.11 - 0.20 | Sulfur is low. | |
| | Normal | 0.20 - 0.41 | Sulfur is adequate. | |
| | High | > 0.41 | Sulfur is above normal. | |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| **Mn** | Deficient | < 5 | Manganese is very low | Apply 0.5 to 1.2 lbs. per acre of actual manganese as a foliar spray during the dormant season or after fruit is off but the leaves are still active and green. |
| | Low | 5 - 22 | Manganese is low. | Apply 0.5 to 1.2 lbs. per acre of actual manganese as a foliar spray during the dormant season or after fruit is off but the leaves are still active and green. |
| | Normal | 22 - 141 | Manganese is adequate. | |
| | High | > 141 | Manganese is above normal. | This most likely indicates a low soil pH. Soil test and apply lime accordingly. If phosphorus and potassium are low and manganese is above normal this usually indicates low soil pH; however, if they are not below normal it is also possible that the high level may be due to a spray residue contamination. |
| **Fe** | Deficient | < 25 | Iron is very low. | Under Maryland soil and climatic conditions, an economic return from the application of iron is unlikely. |
| | Low | 25 - 40 | Iron is low. | Under Maryland soil and climatic conditions, an economic return from the application of iron is unlikely. |
| | Normal | 40 - 101 | Iron is adequate. | |
| | High | 101 - 252 | Iron is above normal. | High levels can also be the result of spray residue. |
| **Cu** | Deficient | < 4 | Copper is very low. | Apply 0.9 to 1.3 lbs. per acre of actual copper during the dormant season or after the fruit is off but the leaves are still active and green. Another method would be to apply a copper sterilant in a fireblight control program. |
| | Low | 4 - 6 | Copper is low. | Apply 0.9 to 1.3 lbs. per acre of actual copper during the dormant season or after the fruit is off but the leaves are still active and green. Another method would be to apply a copper sterilant in a fireblight control program. |
| | Normal | 6 - 26 | Copper is adequate. | |
| | High | 26 - 202 | Copper is above normal. | High levels can also be the result of spray residue. |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| B | Deficient | < 11 | Boron is very low. | Make two applications of 0.8 lbs. per acre of actual boron (4 lbs. per acre of Solubor®, 20.5% B) as a bloom and petal fall spray or a single post-harvest foliar spray of 1.6 lbs. of actual boron. Do not exceed 1.6 lbs. per acre per year. For trees more than 3 years old apply boron annually to the soil. Apply 0.12 lbs. of actual boron per acre for 4-year old trees. For each additional year of tree age, up to 16 years, increase the rate by 0.06 lbs. per acre of actual boron. Retest the block next season. |
| | Low | 11 - 35 | Boron is low | Apply 0.8 to 1.6 lbs. per acre of actual boron (4 to 8 lbs. per acre of Solubor®, 20.5% B) in two separate sprays at bloom, petal fall or first cover or apply a single post-harvest foliar spray of 1.6 lbs. per acre of actual boron. For trees more than 3 years old, apply boron annually to the soil. Apply 0.12 lbs. of actual boron per acre for 4-year old trees. For each additional year of tree age, up to 16 years, increase the rate by 0.06 lbs. per acre of actual boron. |
| | Normal | 35 - 81 | Boron is adequate | Boron should be applied as an annual maintenance program. Each year apply a single spray of 1.0 lbs. of Solubor® (20.5% B) per 100 gallons sometime during the period of full bloom through the first cover spray. For trees more than 3 years old, apply boron annually to the soil. Apply 0.12 lbs. of actual boron per acre for 4-year old trees. For each additional year of tree age, up to 16 years, increase the rate by 0.06 lbs. per acre of actual boron. |
| | High | > 81 | Boron is above normal. | Do not apply boron fertilizers. Watch for toxicity symptoms, e.g. earlier fruit maturation, serious internal breakdown, shoot abnormalities and defoliation. |
| Zn | Deficient | < 6 | Zinc is very low. | Apply 3.2 lbs. per acre of actual zinc as a foliar spray after harvest while the leaves are still active and green or in the dormant season before the buds break. Broadcast soil applications of zinc can be made anytime at a rate of 6.4 to 12.8 lbs. per acre of actual zinc. |
| | Low | 6 - 20 | Zinc is low | Apply 3.2 lbs. per acre of actual zinc as a foliar spray after harvest while the leaves are still active and green or in the dormant season before the buds break. Broadcast soil applications of zinc can be made anytime at a rate of 6.4 to 12.8 lbs. per acre of actual zinc. |
| | Normal | 20 - 200 | Zinc is adequate | |
| | High | > 200 | Zinc is above normal. | High levels can also be the result of spray residue. |

# Appendix 2

## Peach and Nectarine (Any)

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| N | Deficient | < 2.00 | Nitrogen is very low. | Increase application rate by 50% unless major renovative pruning will be performed this winter, in which case increase application by only 25%. To minimize over-application, make two applications using half the total recommended rate at bloom time and the second half after the crop has been set (30 - 45 days after bloom). Values lower than 1.99% may indicate other problems. Examine the trees closely and retest next year. Shoot growth can help determine your nitrogen program. Bearing trees should have 18 to 24 inches of shoot growth per year. |
| | Low | 2.00 - 2.50 | Nitrogen is low. | Increase application rate by 25% unless shoot growth was excessive or if major renovative pruning will be performed this winter. To minimize over-application, make two applications using half the total recommended rate at bloom time and the second half after the crop has been set (30 - 45 days after bloom). Shoot growth can help determine your nitrogen program. Bearing trees should have 18 to 24 inches of shoot growth per year. |
| | Normal | 2.50 - 3.41 | Nitrogen is adequate. | Continue past practices if terminal growth was adequate and fruit color satisfactory. If terminal growth was excessive, fruit color inadequate or major renovative pruning was performed; the same or a reduction in rate of nitrogen is in order. To minimize over-application, make two applications using half the total recommended rate at bloom time and the second half after the crop has been set (30-45 days after boom). Shoot growth can help determine your nitrogen program. Bearing trees should have 18 to 24 inches of shoot growth per year. |
| | High | > 3.41 | Nitrogen is above normal. | Reduce rate of application unless shoot growth was inadequate, crop was light this year or renovative pruning was performed the previous winter. On mature trees with adequate shoot growth and normal crop, eliminate nitrogen application next year and retest next season. Shoot growth can help determine your nitrogen program. Bearing trees should have 18 to 24 inches of shoot growth per year. |
| P | Deficient | < 0.10 | Phosphorus is very low. | Broadcast 150 lbs. $P_2O_5$ per acre as soon as convenient. Retest next year. Values this low indicate the possibility of severe problems. In Maryland, the Phosphorus Site Index must be performed before adding any phosphate-bearing fertilizers when soil test FIV-P is 150 or greater. |
| | Low | 0.10 - 0.15 | Phosphorus is low. | Broadcast 125 lbs. $P_2O_5$ per acre as soon as convenient. However, unless phosphorus is incorporated, it is unlikely you will see a response to surface-applied P on trees older than 5 years. In Maryland, the Phosphorus Site Index must be performed before adding any phosphate-bearing fertilizers when soil test FIV-P is 150 or greater. |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| P (cont.) | Normal | 0.15 - 0.31 | Phosphorus is adequate. | No further application is needed at this time. |
| | High | > 0.31 | Phosphorus is above normal. | If using a complete fertilizer, discontinue its use. Excessive levels of phosphorus can increase problems of zinc and copper deficiency. |
| K | Deficient | < 1 .70 | Potassium is very low. | Broadcast 125 lbs. $K_20$ per acre as soon as convenient. |
| | Low | 1.70 - 2.10 | Potassium is low. | Potassium levels can be 0.4% lower than normal during a dry summer or during years of heavy-cropping. Broadcast 100 lbs. $K_20$ per acre as soon as convenient. |
| | Normal | 2.10 - 3.01 | Potassium is adequate. | No further application is needed at this time. |
| | High | > 3.01 | Potassium is above normal. | If using a complete fertilizer, discontinue its use. Potassium in excess will compete with calcium and magnesium for uptake by the trees. |
| Ca | Deficient | < 0.01 | Calcium is very low. | Soil test for possible low pH and apply high calcium lime as needed. Calcium uptake may also be limited by high levels of potassium or magnesium. |
| | Low | 0.01 - 1.90 | Calcium is low. | Soil test for possible low pH and apply high calcium lime as needed. Calcium uptake may also be limited by high levels of potassium or magnesium. |
| | Normal | 1.90 - 3.51 | Calcium is adequate. | |
| | High | > 3.51 | Calcium is above normal. | |
| Mg | Deficient | < 0.03 | Magnesium is very low. | Soil test for possible low pH and apply magnesium as recommended. If soil test does not indicate a magnesium recommendation, apply 15 lbs. magnesium sulfate (11% Mg) foliarly at petal fall. |
| | Low | 0.03 - 0.30 | Magnesium is low. | Soil test for possible low pH and apply magnesium as recommended. If soil test does not indicate a magnesium recommendation, apply 15 lbs. magnesium sulfate (11% Mg) foliarly at petal fall. |
| | Normal | 0.30 - 0.46 | Magnesium is adequate. | If lime is needed based on soil test results, apply a high calcium lime. |
| | High | > 0.46 | Magnesium is above normal. | Excess magnesium competes with calcium and potassium for uptake by the plants. Therefore, avoid the use of dolomitic lime. |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| S | Deficient | < 0.10 | Sulfur is very low. | |
| | Low | 0.10 - 0.20 | Sulfur is low. | |
| | Normal | 0.20 - 0.41 | Sulfur is adequate. | |
| | High | > 0.41 | Sulfur is above normal. | If sulfur is routinely used in cover sprays, the high levels are probably due to spray residue. |
| Mn | Deficient | < 1 | Manganese is very low. | Apply 0.5 to 1.2 lbs. per acre of actual manganese as foliar spray during the dormant season or after the fruit is off but the leaves are still active and green. |
| | Low | 1 - 19 | Manganese is low. | Apply 0.5 to 1.2 lbs. per acre of actual manganese as foliar spray during the dormant season or after the fruit is off but the leaves are still active and green. |
| | Normal | 19 - 151 | Manganese is adequate. | |
| | High | > 151 | Manganese is above normal. | This most likely indicates a low soil pH. Soil test and apply lime accordingly. If phosphorus and potassium are low and manganese is above normal, this usually indicates low soil pH; however, if they are not below normal it is also possible that the high level may be due to a spray residue contamination. |
| Fe | Deficient | < 40 | Iron is very low. | Under Maryland soil and climatic conditions, an economic return from the application of iron is unlikely. |
| | Low | 40 - 50 | Iron is low. | Under Maryland soil and climatic conditions, an economic return from the application of iron is unlikely. |
| | Normal | 50 - 201 | Iron is adequate. | |
| | High | 201 - 251 | Iron is above normal. | High levels can also be the result of spray residue. |
| Cu | Deficient | < 4 | Copper is very low. | Apply 0.9 to 1.3 lbs. per acre of actual copper as foliar spray during the dormant season or after the fruit is off but the leaves are still active and green. |
| | Low | 4 - 6 | Copper is low. | Apply 0.9 to 1.3 lbs. per acre of actual copper as foliar spray during the dormant season or after the fruit is off but the leaves are still active and green. |
| | Normal | 6 - 26 | Copper is adequate. | |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| Cu (cont.) | High | 26 - 201 | Copper is above normal. | High levels can also be the result of spray residue. |
| B | Deficient | < 11 | Boron is very low. | Make two applications of 0.75 lbs. per acre of actual boron (3 lbs. per acre of Solubor®, 20.5% B) as a bloom and petal fall spray or a single post-harvest foliar spray of 1.5 lbs. of actual boron. Foliar sprays are less likely to induce toxicity symptoms than are soil applications. Do not exceed 1.6 lbs. per acre per year. Retest the block next season. |
| | Low | 11 - 25 | Boron is low. | Apply 0.75 lbs. per acre of actual boron (3 lbs. per acre of Solubor®, 20.5% B) as a bloom or post-harvest foliar spray. Foliar sprays are less likely to induce toxicity symptoms than are soil applications. Retest the block next season. |
| | Normal | 25 - 51 | Boron is adequate. | |
| | High | > 51 | Boron is above normal. | Do not apply boron fertilizers. Watch for toxicity symptoms, e.g. necrotic lesions on leaves, crinkling of margins and tips of leaves, reduced flower bud formation and set, and pit splitting. |
| Zn | Deficient | < 6 | Zinc is very low. | Apply 3.2 lbs. per acre of actual zinc as a foliar spray after harvest while the leaves are still active and green or in the dormant season before the buds break. Broadcast soil applications of zinc can be made anytime at a rate of 6.4 to 12.8 lbs. per acre of actual zinc. Ground applications of zinc are not normally as effective, especially under high soil phosphorus levels. |
| | Low | 6 - 20 | Zinc is low. | Apply 3.2 lbs. per acre of actual zinc as a foliar spray after harvest while the leaves are still active and green or in the dormant season before the buds break. Broadcast soil applications of zinc can be made anytime at a rate of 6.4 to 12.8 lbs. per acre of actual zinc. Ground applications of zinc are not normally as effective, especially under high soil phosphorus levels. |
| | Normal | 20 - 200 | Zinc is adequate. | |
| | High | > 200 | Zinc is above normal. | High levels can also be the result of spray residue. |

# Appendix 3

## Pear (Any)

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| N | Deficient | < 1.35 | Nitrogen is very low. | Increase application rate by 50% unless major renovative pruning will be performed this winter, in which case increase application by only 25%. Values lower than 1.34% may indicate other problems. Examine the trees closely and retest next year. Shoot growth can help determine your nitrogen program. Bearing trees should have 12 to 16 inches of shoot growth per year. |
| | Low | 1.35 - 1.60 | Nitrogen is low. | Increase application rate by 25% unless shoot growth was excessive or if major renovative pruning will be performed this winter. Shoot growth can help determine your nitrogen program. Bearing trees should have 12 to 16 inches of shoot growth per year. |
| | Normal | 1.60 - 2.41 | Nitrogen is adequate. | Continue past practices if terminal growth was adequate and fruit color satisfactory. If terminal growth was excessive, fruit color inadequate or major renovative pruning was performed, the same or a reduction in rate of application of nitrogen is in order. Shoot growth can help determine your nitrogen program. Bearing trees should have 12 to 16 inches of shoot growth per year. |
| | High | > 2.41 | Nitrogen is above normal. | Reduce rate of application unless shoot growth was inadequate, crop was light this year or renovative pruning was performed the previous winter. Shoot growth can help determine your nitrogen program. Bearing trees should have 12 to 16 inches of shoot growth per year. |
| P | Deficient | < 0.15 | Phosphorus is very low. | Broadcast 150 lbs. $P_2O_5$ per acre as soon as convenient. Retest next year. In Maryland, the Phosphorus Site Index must be performed before adding any phosphate-bearing fertilizers when soil test FIV-P is 150 or greater. |
| | Low | 0.15 - 0.18 | Phosphorus is low. | Broadcast 125 lbs. $P_2O_5$ per acre as soon as convenient. However, unless phosphorus is incorporated it is unlikely you will see a response to surface-applied P on trees older than 5 years. In Maryland, the Phosphorus Site Index must be performed before adding any phosphate-bearing fertilizers when soil test FIV-P is 150 or greater. |
| | Normal | 0.18 - 0.26 | Phosphorus is adequate. | No further application is needed at this time. |
| | High | > 0.26 | Phosphorus is above normal. | If using a complete fertilizer, discontinue its use. Excessive levels of phosphorus can increase problems of zinc and copper deficiency. |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| K | Deficient | < 0.16 | Potassium is very low. | Broadcast 125 lbs. $K_2O$ per acre as soon as convenient. Retest next year. |
| | Low | 0.16 - 0.20 | Potassium is low. | Broadcast 100 lbs. $K_2O$ per acre as soon as convenient. |
| | Normal | 0.20 - 2.01 | Potassium is adequate. | No further application is needed at this time. |
| | High | > 2.01 | Potassium is above normal. | If using a complete fertilizer, discontinue its use. Potassium in excess will compete with calcium and magnesium for uptake by the trees. |
| Ca | Deficient | < 0.10 | Calcium is very low. | Soil test for possible low pH and apply high calcium lime as needed. Calcium uptake may also be limited by high levels of potassium or magnesium. |
| | Low | 0.10 - 1.30 | Calcium is low. | Soil test for possible low pH and apply high calcium lime as needed. Calcium uptake may also be limited by high levels of potassium or magnesium. |
| | Normal | 1.30 - 9.01 | Calcium is adequate. | |
| | High | > 9.01 | Calcium is above normal. | |
| Mg | Deficient | < 0.05 | Magnesium is very low. | Soil test for possible low pH and apply magnesium as recommended. If soil test does not indicate a magnesium recommendation, apply 15 lbs. magnesium sulfate (11% Mg) foliarly at petal fall. |
| | Low | 0.05 - 0.30 | Magnesium is low. | Soil test for possible low pH and apply magnesium as recommended. If soil test does not indicate a magnesium recommendation, apply 15 lbs. magnesium sulfate (11% Mg) foliarly at petal fall. |
| | Normal | 0.30 - 0.61 | Magnesium is adequate. | If lime is needed based on soil test results, apply a high calcium lime. |
| | High | > 0.61 | Magnesium is above normal. | Excess magnesium competes with calcium and potassium for uptake by the plants. Therefore, avoid the use of dolomitic lime. |
| S | Deficient | < 0.09 | Sulfur is very low. | |
| | Low | 0.09 - 0.17 | Sulfur is low. | |
| | Normal | 0.17 - 0.26 | Sulfur is adequate. | |
| | High | > 0.26 | Sulfur is above normal. | |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| Mn | Deficient | < 5 | Manganese is very low. | Apply 0.5 to 1.2 lbs. per acre of actual manganese as a foliar spray during the dormant season or after fruit is off but the leaves are still active and green. |
| | Low | 5 - 20 | Manganese is low. | Apply 0.5 to 1.2 lbs. per acre of actual manganese as a foliar spray during the dormant season or after fruit is off but the leaves are still active and green. |
| | Normal | 20 - 199 | Manganese is adequate. | |
| | High | > 199 | Manganese is above normal. | This most likely indicates a low soil pH. Soil test and apply lime accordingly. |
| Fe | Deficient | < 40 | Iron is very low. | Under Maryland soil and climatic conditions, an economic return from the application of iron is unlikely. |
| | Low | 40 - 50 | Iron is low. | Under Maryland soil and climatic conditions, an economic return from the application of iron is unlikely. |
| | Normal | 50 - 400 | Iron is adequate. | |
| | High | > 400 | Iron is above normal. | |
| Cu | Deficient | < 2 | Copper is very low. | Apply 0.9 to 1.2 lbs. per acre of actual copper during the dormant season or after fruit is off but the leaves are still active and green. |
| | Low | 2 - 6 | Copper is low. | Apply 0.9 to 1.2 lbs. per acre of actual copper during the dormant season or after fruit is off but the leaves are still active and green. |
| | Normal | 6 - 25 | Copper is adequate. | |
| | High | > 25 | Copper is above normal. | |
| B | Deficient | < 5 | Boron is very low. | Apply 0.8 to 1.6 lbs. per acre of actual boron (4 to 8 lbs. of Solubor, 20.5% B) as a foliar spray either during bloom or after harvest while the leaves are still active and green. Ground applications of boron are not normally as effective, or as easy to apply as the foliar applications. |
| | Low | 5 - 35 | Boron is low. | Apply 0.8 to 1.6 lbs. per acre of actual boron (4 to 8 lbs. of Solubor, 20.5% B) as a foliar spray either during bloom or after harvest while the leaves are still active and green. Ground applications of boron are not normally as effective, or as easy to apply as the foliar applications. |
| | Normal | 35 - 80 | Boron is adequate. | |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| B (cont.) | High | > 80 | Boron is above normal. | Do not apply foliar or ground applications of boron fertilizers. |
| Zn | Deficient | < 5 | Zinc is very low | Apply 3.2 lbs. per acre of actual zinc as a foliar spray after harvest while the leaves are still active and green or in the dormant season before the buds break. Broadcast soil applications of zinc can be made anytime at a rate of 6.4 to 12.8 lbs. per acre of actual zinc. |
| | Low | 5 - 20 | Zinc is low. | Apply 3.2 lbs. per acre of actual zinc as a foliar spray after harvest while the leaves are still active and green or in the dormant season before the buds break. Broadcast soil applications of zinc can be made at a rate of 6.4 to 12.8 lbs. per acre of actual zinc. |
| | Normal | 20 - 200 | Zinc is adequate. | |
| | High | > 200 | Zinc is above normal. | |

# Appendix 4

## Cherry (Any)

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| N | Deficient | < 2.00 | Nitrogen is very low. | Increase application rate by 50% unless major renovative pruning will be performed this winter, in which case increase application by only 25%. Values lower than 1.80% may indicate other problems. Examine the trees closely and retest next year. Shoot growth can help determine your nitrogen program. Bearing trees should have 18 to 24 inches of shoot growth per year. |
| | Low | 2.00 - 2.30 | Nitrogen is low. | Increase application rate by 25% unless shoot growth was excessive or if major renovative pruning will be performed this winter. Shoot growth can help determine your nitrogen program. Bearing trees should have 18 to 24 inches of shoot growth per year. |
| | Normal | 2.30 - 3.31 | Nitrogen is adequate. | Continue past practices if terminal growth was adequate and fruit color satisfactory. If terminal growth was excessive, fruit color inadequate or major renovative pruning was performed, the same or a reduction in rate of application of nitrogen is in order. Shoot growth can help determine your nitrogen program. Bearing trees should have 18 to 24 inches of shoot growth per year. |
| | High | > 3.31 | Nitrogen is above normal. | Reduce rate of application unless shoot growth was inadequate, crop was light this year or renovative pruning was performed the previous winter. Shoot growth can help determine your nitrogen program. Bearing trees should have 18 to 24 inches of shoot growth per year. |
| P | Deficient | < 0.20 | Phosphorus is very low. | Broadcast 150 lbs. $P_2O_5$ per acre as soon as convenient. Retest next year. In Maryland, the Phosphorus Site Index must be performed before adding any phosphate-bearing fertilizers when soil test FIV-P is 150 or greater. |
| | Low | 0.20 - 0.23 | Phosphorus is low. | Broadcast 125 lbs. $P_2O_5$ per acre as soon as convenient. However, unless phosphorus is incorporated it is unlikely you will see a response to surface-applied P on trees older than 5 years. In Maryland, the Phosphorus Site Index must be performed before adding any phosphate-bearing fertilizers when soil test FIV-P is 150 or greater. |
| | Normal | 0.23 - 0.38 | Phosphorus is adequate. | No further application is needed at this time. |
| | High | > 0.38 | Phosphorus is above normal. | If using a complete fertilizer discontinue its use. Excessive levels of phosphorus can increase problems of zinc and copper deficiency. |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| K | Deficient | < 0.80 | Potassium is very low. | Broadcast 125 lbs. $K_2O$ per acre as soon as convenient. Retest next year. |
| | Low | 0.80 - 1.00 | Potassium is low. | Broadcast 100 lbs. $K_2O$ per acre as soon as convenient. |
| | Normal | 1.00 - 1.91 | Potassium is adequate. | No further application is needed at this time. |
| | High | > 1.91 | Potassium is above normal. | If using a complete fertilizer discontinue its use. Potassium in excess will compete with calcium and magnesium for uptake by the trees. |
| Ca | Deficient | < 0.30 | Calcium is very low. | Soil test for possible low pH and apply high calcium lime as needed. Calcium uptake may also be limited by high levels of potassium or magnesium. |
| | Low | 0.30 - 1.60 | Calcium is low. | Soil test for possible low pH and apply high calcium lime as needed. Calcium uptake may also be limited by high levels of potassium or magnesium. |
| | Normal | 1.60 - 9.01 | Calcium is adequate. | |
| | High | > 9.01 | Calcium is above normal. | |
| Mg | Deficient | < 0.03 | Magnesium is very low. | Soil test for possible low pH and apply magnesium as recommended. If soil test does not indicate a magnesium recommendation, apply 15 lbs. magnesium sulfate (11% Mg) foliarly at petal fall. |
| | Low | 0.03 - 0.49 | Magnesium is low. | Soil test for possible low pH and apply magnesium as recommended. If soil test does not indicate a magnesium recommendation, apply 15 lbs. magnesium sulfate (11% Mg) foliarly at petal fall. |
| | Normal | 0.49 - 0.65 | Magnesium is adequate. | If lime is needed based on soil test results apply a high calcium lime. |
| | High | > 0.65 | Magnesium is above normal. | Excess magnesium competes with calcium and potassium for uptake by the plants. Therefore, avoid the use of dolomitic lime. |
| S | Deficient | < 0.10 | Sulfur is very low. | |
| | Low | 0.10 - 0.15 | Sulfur is low. | |
| | Normal | 0.15 - 0.50 | Sulfur is adequate. | |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| S (cont.) | High | > 0.50 | Sulfur is above normal. | |
| Mn | Deficient | < 5 | Manganese is very low. | Apply 0.5 to 1.2 lbs. per acre of actual manganese as a foliar spray during the dormant season or after fruit is off but the leaves are still active and green. |
| | Low | 5 - 18 | Manganese is low. | Apply 0.5 to 1.2 lbs. per acre of actual manganese as a foliar spray during the dormant season or after fruit is off but the leaves are still active and green. |
| | Normal | 18 - 150 | Manganese is adequate. | |
| | High | > 150 | Manganese is above normal. | This may indicate a low soil pH. Soil test and apply lime accordingly. If a recent soil test indicates normal pH, the high manganese is probably the result of spray residue contamination. |
| Fe | Deficient | < 40 | Iron is very low. | Under Maryland soil and climatic conditions, an economic return from the application of iron is unlikely. |
| | Low | 40 - 50 | Iron is low. | Under Maryland soil and climatic conditions, an economic return from the application of iron is unlikely. |
| | Normal | 50 - 400 | Iron is adequate. | |
| | High | > 400 | Iron is above normal. | |
| Cu | Deficient | < 1 | Copper is very low. | Apply 0.9 to 1.3 lbs. per acre of actual copper during the dormant season or after fruit is off but the leaves are still active and green. |
| | Low | 1 - 6 | Copper is low. | Apply 0.9 to 1.3 lbs. per acre of actual copper during the dormant season or after fruit is off but the leaves are still active and green. |
| | Normal | 6 - 26 | Copper is adequate. | |
| | High | > 26 | Copper is above normal. | |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| B | Deficient | < 5 | Boron is very low. | Apply 0.8 to 1.6 lbs. per acre of actual boron (4 to 8 lbs. per acre of Solubor®, 20.5% B) as a foliar spray either during bloom or after harvest while the leaves are still active and green. Ground applications of boron are not normally as effective or as easy to apply as the foliar applications. |
| | Low | 5 - 39 | Boron is low | Apply 0.8 to 1.6 lbs. per acre of actual boron (4 to 8 lbs. per acre of Solubor®, 20.5% B) as a foliar spray either during bloom or after harvest while the leaves are still active and green. Ground applications of boron are not normally as effective or as easy to apply as the foliar applications. |
| | Normal | 39 - 81 | Boron is adequate. | |
| | High | > 81 | Boron is above normal. | Do not apply foliar or ground applications of boron fertilizers. |
| Zn | Deficient | < 5 | Zinc is very low. | Apply 3.2 lbs. per acre of actual zinc as a foliar spray after harvest while the leaves are still active and green or in the dormant season before the buds break. Broadcast soil applications of zinc can be made anytime at a rate of 6.4 to 12.8 lbs. per acre of actual zinc. |
| | Low | 5 - 20 | Zinc is low. | Apply 3.2 lbs. per acre of actual zinc as a foliar spray after harvest while the leaves are still active and green or in the dormant season before the buds break. Broadcast soil applications of zinc can be made anytime at a rate of 6.4 to 12.8 lbs. per acre of actual zinc. |
| | Normal | 20 - 200 | Zinc is adequate. | |
| | High | > 200 | Zinc is above normal. | |

# Appendix 5

## Plum (Any)

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| N | Deficient | < 1.60 | Nitrogen is very low. | Increase application rate by 50% unless major renovative pruning will be performed this winter, in which case increase application by only 25%. Values lower than 1.39% may indicate other problems. Examine the trees closely and retest next year. Shoot growth can help determine your nitrogen program. Bearing trees should have 18 to 24 inches of shoot growth per year. |
| | Low | 1.60 - 1.80 | Nitrogen is low. | Increase application rate by 25% unless shoot growth was excessive or if major renovative pruning will be performed this winter. Shoot growth can help determine your nitrogen program. Bearing trees should have 18 to 24 inches of shoot growth per year. |
| | Normal | 1.80 - 2.61 | Nitrogen is adequate. | Continue past practices if terminal growth was adequate and fruit color satisfactory. If terminal growth was excessive, fruit color inadequate or major renovative pruning was performed, the same or a reduction in rate of application of nitrogen is in order. Shoot growth can help determine your nitrogen program. Bearing trees should have 18 to 24 inches of shoot growth per year. |
| | High | > 2.61 | Nitrogen is above normal. | Reduce rate of application unless shoot growth was inadequate, crop was light this year or renovative pruning was performed the previous winter. Shoot growth can help determine your nitrogen program. Bearing trees should have 18 to 24 inches of shoot growth per year. |
| P | Deficient | < 0.07 | Phosphorus is very low. | Broadcast 150 lbs. $P_2O_5$ per acre as soon as convenient. Retest next year. Values this low indicate the possibility of severe problems. In Maryland, the Phosphorus Site Index must be performed before adding any phosphate-bearing fertilizers when soil test FIV-P is 150 or greater. |
| | Low | 0.07 - 0.09 | Phosphorus is low. | Broadcast 125 lbs. $P_2O_5$ per acre as soon as convenient. However, unless phosphorus is incorporated it is unlikely you will see a response to surface-applied P on trees older than 5 years. In Maryland, the Phosphorus Site Index must be performed before adding any phosphate-bearing fertilizers when soil test FIV-P is 150 or greater. |
| | Normal | 0.09 – 0.30 | Phosphorus is adequate | No further application is needed at this time. |
| | High | > 0.30 | Phosphorus is above normal | If using a complete fertilizer discontinue its use. Excessive levels of phosphorus can increase problems of zinc and copper deficiency. |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| K | Deficient | < 1 .05 | Potassium is very low. | Broadcast 125 lbs. $K_2O$ per acre as soon as convenient. Retest next year. |
| | Low | 1.05 - 1.10 | Potassium is low. | Broadcast 100 lbs. $K_2O$ per acre as soon as convenient. |
| | Normal | 1.10 - 2.91 | Potassium is adequate. | No further application is needed at this time. |
| | High | > 2.91 | Potassium is above normal. | If using a complete fertilizer, discontinue its use. Potassium in excess will compete with calcium and magnesium for uptake by the trees. |
| Ca | Deficient | < 0.10 | Calcium is very low. | Soil test for possible low pH and apply high calcium lime as needed. Calcium uptake may also be limited by high levels of potassium or magnesium. |
| | Low | 0.10 - 1.00 | Calcium is low. | Soil test for possible low pH and apply high calcium lime as needed. Calcium uptake may also be limited by high levels of potassium or magnesium. |
| | Normal | 1.00 - 9.01 | Calcium is adequate. | |
| | High | > 9.01 | Calcium is above normal. | |
| Mg | Deficient | < 0.03 | Magnesium is very low. | Soil test for possible low pH and apply magnesium as recommended. If soil test does not indicate a magnesium recommendation, apply 15 lbs. magnesium sulfate (11% Mg) foliarly at petal fall. |
| | Low | 0.03 - 0.20 | Magnesium is low. | Soil test for possible low pH and apply magnesium as recommended. If soil test does not indicate a magnesium recommendation, apply 15 lbs. magnesium sulfate (11% Mg) foliarly at petal fall. |
| | Normal | 0.20 - 0.46 | Magnesium is adequate. | If lime is needed based on soil test results apply a high calcium lime. |
| | High | > 0.46 | Magnesium is above normal. | Excess magnesium competes with calcium and potassium for uptake by the plants. Therefore, avoid the use of dolomitic lime. |
| S | Deficient | < 0.10 | Sulfur is very low. | |
| | Low | 0.10 - 0.15 | Sulfur is low. | |
| | Normal | 0.15 - 0.50 | Sulfur is adequate. | |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| S (cont.) | High | > 0.50 | Sulfur is above normal. | |
| Mn | Deficient | < 5 | Manganese is very low. | Apply 0.5 to 1.2 lbs. per acre of actual manganese as foliar spray during the dormant season or after the fruit is off but the leaves are still active and green. |
| | Low | 5 - 17 | Manganese is low. | Apply 0.5 to 1.2 lbs. per acre of actual manganese as foliar spray during the dormant season or after the fruit is off but the leaves are still active and green. |
| | Normal | 17 - 200 | Manganese is adequate. | |
| | High | > 200 | Manganese is above normal. | This most likely indicates a low soil pH. Soil test and apply lime accordingly. |
| Fe | Deficient | < 40 | Iron is very low. | Under Maryland soil and climatic conditions, an economic return from the application of iron is unlikely. |
| | Low | 40 - 50 | Iron is low. | Under Maryland soil and climatic conditions, an economic return from the application of iron is unlikely. |
| | Normal | 50 - 400 | Iron is adequate. | |
| | High | > 400 | Iron is above normal. | |
| Cu | Deficient | < 1 | Copper is very low. | Apply 0.9 to 1.3 lbs. per acre of actual copper as foliar spray during the dormant season or after the fruit is off but the leaves are still active and green. |
| | Low | 1 - 6 | Copper is low. | Apply 0.9 to 1.3 lbs. per acre of actual copper as foliar spray during the dormant season or after the fruit is off but the leaves are still active and green. |
| | Normal | 6 - 26 | Copper is adequate. | |
| | High | > 26 | Copper is above normal. | |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| B | Deficient | < 5 | Boron is very low. | Apply 0.8 to 1.6 lbs. per acre of actual boron (4 to 8 lbs. per acre of Solubor®, 20.5% B) as foliar spray during the dormant season or after the fruit is off but the leaves are still active and green. Ground applications of boron are not normally as effective or as easy to apply as the foliar applications. |
| | Low | 5 - 31 | Boron is low. | Apply 0.8 to 1.6 lbs. per acre of actual boron (4 to 8 lbs. per acre of Solubor®, 20.5% B) as foliar spray during the dormant season or after the fruit is off but the leaves are still active and green. Ground applications of boron are not normally as effective or as easy to apply as the foliar applications. |
| | Normal | 31 - 81 | Boron is adequate. | |
| | High | > 81 | Boron is above normal. | Do not apply foliar or ground applications of boron fertilizers. |
| Zn | Deficient | < 5 | Zinc is very low. | Apply 3.2 lbs. per acre of actual zinc as a foliar spray after harvest while the leaves are still active and green or in the dormant season before the buds break. Broadcast soil applications of zinc can be made anytime at a rate of 6.4 to 12.8 lbs. per acre of actual zinc. Ground applications of zinc are not normally as effective, especially under high soil phosphorus levels. |
| | Low | 5 - 20 | Zinc is low. | Apply 3.2 lbs. per acre of actual zinc as a foliar spray after harvest while the leaves are still active and green or in the dormant season before the buds break. Broadcast soil applications of zinc can be made anytime at a rate of 6.4 to 12.8 lbs. per acre of actual zinc. Ground applications of zinc are not normally as effective, especially under high soil phosphorus levels. |
| | Normal | 20 - 200 | Zinc is adequate. | |
| | High | > 200 | Zinc is above normal. | |

# Appendix 6

## Blueberry (Any)

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| N | Deficient | < 1.65 | Nitrogen is very low. | Increase rate of nitrogen application by 10% for each 0.1% the sample is below desired level. If soil pH is above 5.0, use ammonium sulfate; if below 5.0, use urea. Do not use ammonium nitrate or chloride fertilizers. Apply no later than April 20. |
| | Low | 1.65 - 1.70 | Nitrogen is low. | Increase rate of nitrogen application by 10% for each 0.1% the sample is below desired level. If soil pH is above 5.0, use ammonium sulfate; if below 5.0, use urea. Do not use ammonium nitrate or chloride fertilizers. Apply no later than April 20. |
| | Normal | 1.70 - 2.10 | Nitrogen is adequate. | No alteration of present program is necessary. |
| | High | > 2.10 | Nitrogen is above normal. | Reduce rate of nitrogen application by 10% for each 0.1% the sample exceeds desired level. If soil pH is above 5.0, use ammonium sulfate; if below 5.0, use urea. Do not use ammonium nitrate or chloride fertilizers. |
| P | Deficient | < 0.06 | Phosphorus is very low. | Apply 180 lbs. per acre of triple superphosphate (0-46-0) at any time. Retest next year. In Maryland, the Phosphorus Site Index must be performed before adding any phosphate-bearing fertilizers when soil test FIV-P is 150 or greater. |
| | Low | 0.06 - 0.07 | Phosphorus is low. | Apply 180 lbs. per acre of triple superphosphate (0-46-0) at any time. However, unless phosphorus is incorporated it is unlikely you will see a response to surface-applied P on bushes older than 5 years. In Maryland, the Phosphorus Site Index must be performed before adding any phosphate-bearing fertilizers when soil test FIV-P is 150 or greater. |
| | Normal | 0.07 - 0.18 | Phosphorus is adequate. | No alteration of present program is necessary. |
| | High | > 0.18 | Phosphorus is above normal. | Omit phosphate from fertilizer program. |
| K | Deficient | < 0.35 | Potassium is very low. | Apply 400 lbs. per acre sulfate of potassium-magnesia or 160 lbs. per acre potassium sulfate in fall or early spring. |
| | Low | 0.35 - 0.40 | Potassium is low. | Apply 400 lbs. per acre sulfate of potassium-magnesia or 160 lbs. per acre potassium sulfate in fall or early spring. |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| K (cont.) | Normal | 0.40 - 0.65 | Potassium is adequate. | If potassium/magnesium ratio > 4.00, omit potassium from your fertilization program to improve the balance between potassium and magnesium in your plants. |
| | High | > 0.65 | Potassium is above normal. | Omit potassium from fertilization program. |
| Ca | Deficient | < 0.25 | Calcium is very low. | Refer to soil test and apply lime as needed if soil pH is below 4.0. Apply 1000 lbs. per acre of calcium sulfate in fall or early spring if pH is above 4.0. |
| | Low | 0.25 - 0.30 | Calcium is low. | Refer to soil test and apply lime as needed if soil pH is below 4.0. Apply 1000 lbs. per acre of calcium sulfate in fall or early spring if pH is above 4.0. |
| | Normal | 0.30 - 0.80 | Calcium is adequate. | No alteration of present program is necessary. |
| | High | > 0.80 | Calcium is above normal. | Refer to soil test for pH adjustment. |
| Mg | Deficient | < 0.18 | Magnesium is very low. | Refer to soil test and apply dolomitic limestone if pH is below 4.0. If pH is above 4.0, apply 250 lbs. per acre of magnesium sulfate or use 400 lbs. per acre sulfate of potassium-magnesia if potassium is also low. Apply in fall or early spring. |
| | Low | 0.18 - 0.20 | Magnesium is low. | Refer to soil test and apply dolomitic limestone if pH is below 4.0. If pH is above 4.0, apply 250 lbs. per acre of magnesium sulfate or use 400 lbs. per acre sulfate of potassium-magnesia if potassium is also low. Apply in fall or early spring. |
| | Normal | 0.20 - 0.30 | Magnesium is adequate. | If potassium/magnesium ratio is > 5.00, increase magnesium application to a total of 80 lbs. per acre actual magnesium to improve the balance between potassium and magnesium. |
| | High | > 0.30 | Magnesium is above normal. | May indicate high soil pH. Refer to soil test. |
| S | Deficient | < 0.06 | Sulfur is very low. | |
| | Low | 0.06 - 0.12 | Sulfur is low. | |
| | Normal | 0.12 - 0.20 | Sulfur is adequate. | No alteration of present program is necessary. |
| | High | > 0.20 | Sulfur is above normal. | |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| Mn | Deficient | < 45 | Manganese is very low. | Apply a foliar spray of 6 lbs. per 100 gal per acre of manganese chelate twice during the growing season. If product label is different from this recommendation, follow label recommendations. |
| | Low | 45 - 50 | Manganese is low. | Apply a foliar spray of 6 lbs. per 100 gal per acre of manganese chelate twice during the growing season. If product label is different from this recommendation, follow label recommendations. |
| | Normal | 50 - 500 | Manganese is adequate. | No alteration of present program is necessary. |
| | High | > 500 | Manganese is above normal. | Refer to soil test for possible pH adjustment. |
| Fe | Deficient | < 65 | Iron is very low. | Apply a foliar spray of 6 lbs. per 100 gal per acre of iron chelate in late summer and again after bloom the following year, but check product label and follow its recommendation. If condition persists for several consecutive years and soil pH is within desired range (4.5 - 5.0), apply 25 lbs. per acre of iron chelate or 15 lbs. per acre of ferrous sulfate to soil in early spring. If product label is different from this recommendation, follow label recommendation. |
| | Low | 65 - 70 | Iron is low. | Apply a foliar spray of 6 lbs. per 100 gal per acre of iron chelate in late summer and again after bloom the following year, but check product label and follow its recommendation. If condition persists for several consecutive years and soil pH is within desired range (4.5 - 5.0), apply 25 lbs. per acre of iron chelate or 15 lbs. per acre of ferrous sulfate to soil in early spring. If product label is different from this recommendation, follow label recommendation. |
| | Normal | 70 - 300 | Iron is adequate. | No alteration of present program is necessary. |
| | High | > 300 | Iron is above normal. | No application necessary. |
| Cu | Deficient | < 4 | Copper is very low. | Apply a post-bloom and post-harvest spray of 2 lbs. per 100 gal per acre of copper chelate. If product label is different from this recommendation, follow label recommendation. |
| | Low | 4 - 5 | Copper is low. | Apply a post-bloom and post-harvest spray of 2 lbs. per 100 gal per acre of copper chelate. If product label is different from this recommendation, follow label recommendation. |
| | Normal | 5 - 15 | Copper is adequate. | No alteration of present program is necessary. |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| Cu (cont.) | High | > 15 | Copper is above normal. | No application necessary. |
| B | Deficient | < 29 | Boron is very low. | Apply 1.5 lbs. per 100 gal per acre Solubor® (20.5% B) as a foliar spray in late summer and again during early bloom. If product label is different from this recommendation, follow label recommendation. If condition persists for several consecutive years and soil pH is within desired range (4.5 - 5.0), apply 5 lbs. per acre Solubor® to soil surface in early spring. |
| | Low | 29 - 30 | Boron is low. | Apply 1.5 lbs. per 100 gal per acre Solubor® (20.5% B) as a foliar spray in late summer and again during early bloom. If product label is different from this recommendation, follow label recommendation. If condition persists for several consecutive years and soil pH is within desired range (4.5 - 5.0), apply 5 lbs. per acre Solubor® to soil surface in early spring. |
| | Normal | 30 - 50 | Boron is adequate. | No alteration of present program is necessary. |
| | High | > 50 | Boron is above normal. | Consult Extension agricultural science educator or small fruit specialist if over 100 ppm. |
| Zn | Deficient | < 9 | Zinc is very low. | Apply 2 lbs. per 100 gal per acre zinc chelate post-bloom, post-harvest and late summer. If product label is different from this recommendation, follow label recommendation. If condition persists for several consecutive years and soil pH is within desired range (4.5 - 5.0), apply 10 lbs. per acre zinc sulfate to soil surface in early spring. |
| | Low | 9 - 15 | Zinc is low. | Apply 2 lbs. per 100 gal per acre zinc chelate post-bloom, post-harvest and late summer. If product label is different from this recommendation, follow label recommendation. If condition persists for several consecutive years and soil pH is within desired range (4.5 - 5.0), apply 10 lbs. per acre zinc sulfate to soil surface in early spring. |
| | Normal | 15 - 30 | Zinc is adequate. | No alteration of present program is necessary. |
| | High | > 30 | Zinc is above normal. | No application necessary. |

# Appendix 7

## Brambles (Any)

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| N | Deficient | < 1.80 | Nitrogen is very low. | Increase rate of nitrogen application by 10% for each 0.1% the sample is below desired level. Fall fruit types should be near the high end of the range. The best source of nitrogen is ammonium nitrate or calcium nitrate. Apply nitrogen prior to April 20. |
| | Low | 1.80 - 2.00 | Nitrogen is low. | Increase rate of nitrogen application by 10% for each 0.1% the sample is below desired level. Fall fruit types should be near the high end of the range. The best source of nitrogen is ammonium nitrate or calcium nitrate. Apply nitrogen prior to April 20. |
| | Normal | 2.00 - 3.00 | Nitrogen is adequate. | No alteration of present program is necessary. |
| | High | > 3.00 | Nitrogen is above normal. | Reduce rate of nitrogen application by 10% for each 0.1% the sample exceeds desired level. |
| P | Deficient | < 0.23 | Phosphorus is very low. | Apply 200 lbs. per acre triple superphosphate (0-46-0) at any time to soil surface. In Maryland, the Phosphorus Site Index must be performed before adding any phosphate-bearing fertilizers when soil test FIV-P is 150 or greater. |
| | Low | 0.23 - 0.25 | Phosphorus is low. | Apply 200 lbs. per acre triple superphosphate (0-46-0) at any time to soil surface. In Maryland, the Phosphorus Site Index must be performed before adding any phosphate-bearing fertilizers when soil test FIV-P is 150 or greater. |
| | Normal | 0.25 - 0.40 | Phosphorus is adequate. | No alteration of present program is necessary. |
| | High | > 0.40 | Phosphorus is above normal. | Omit phosphate from fertilizer program. |
| K | Deficient | < 1.45 | Potassium is very low. | Apply 50, 55, 75, 95 or 110 lbs. per acre $K_2O$ for soil textural classes clays (including silty and sandy clays), clay loams (including sandy and silty clay loams), silt loam and loam, sandy loams and sands/loamy sands, respectively. If magnesium is also low, sulfate of potassium-magnesia may also be used at 2.5 times the above rates. Do not use muriate of potash. |
| | Low | 1.45 - 1.50 | Potassium is low. | Apply 50, 55, 75, 95 or 110 lbs. per acre $K_2O$ for soil textural classes clays (including silty and sandy clays), clay loams (including sandy and silty clay loams), silt loam and loam, sandy loams and sands/loamy sands, respectively. |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| K (cont.) | Normal | 1.50 - 2.50 | Potassium is adequate. | No alteration of present program is necessary. |
| | High | > 2.50 | Potassium is above normal. | Discontinue use of potassium fertilizer. |
| Ca | Deficient | < 0.57 | Calcium is very low. | Apply lime as needed if pH is less than 6.0. See soil test recommendation for adjustment of soil pH. If pH is greater than 6.0, apply 1000 lbs. per acre calcium sulfate. |
| | Low | 0.57 - 0.60 | Calcium is low. | Apply lime as needed if pH is less than 6.0. See soil test recommendation for adjustment of soil pH. If pH is greater than 6.0, apply 1000 lbs. per acre calcium sulfate. |
| | Normal | 0.60 - 2.50 | Calcium is adequate. | No alteration of present program is necessary. |
| | High | > 2.50 | Calcium is above normal. | May indicate a higher than optimal soil pH. |
| Mg | Deficient | < 0.27 | Magnesium is very low. | If pH is below 6.0, apply dolomitic limestone according to soil test recommendation. If not, apply 200 lbs. per acre magnesium sulfate OR sulfate of potassium-magnesia to soil surface in late fall or early spring. Three foliar sprays of magnesium sulfate at 15 lbs. per 100 gal per acre at leaf expansion, after harvest and in late summer will temporarily correct the deficiency. |
| | Low | 0.27 - 0.30 | Magnesium is low. | If pH is below 6.0, apply dolomitic limestone according to soil test recommendation. If not, apply 200 lbs. per acre magnesium sulfate OR sulfate of potassium-magnesia to soil surface in late fall or early spring. Three foliar sprays of magnesium sulfate at 15 lbs. per 100 gal per acre at leaf expansion, after harvest and in late summer will temporarily correct the deficiency. |
| | Normal | 0.30 - 0.90 | Magnesium is adequate. | No alteration of present program is necessary. |
| | High | > 0.90 | Magnesium is above normal. | Omit use of magnesium. |
| S | Deficient | < 0.11 | Sulfur is very low. | |
| | Low | 0.11 - 0.21 | Sulfur is low. | |
| | Normal | 0.21 - 0.51 | Sulfur is adequate. | No alteration of present program is necessary. |
| | High | > 0.51 | Sulfur is above normal. | |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| Mn | Deficient | < 45 | Manganese is very low. | Apply a spray of manganese sulfate (2 lbs. per 100 gal per acre) or manganese chelate (6 lbs. per 100 gal per acre) after harvest but before September 15. Check soil pH. For fall fruiting types, apply in June. |
| | Low | 45 - 50 | Manganese is low. | Apply a spray of manganese sulfate (2 lbs. per 100 gal per acre) or manganese chelate (6 lbs. per 100 gal per acre) after harvest but before September 15. Check soil pH. For fall fruiting types, apply in June. |
| | Normal | 50 - 200 | Manganese is adequate. | No alteration of present program is necessary. |
| | High | > 200 | Manganese is above normal. | May indicate a low soil pH or contamination by fungicide of irrigation water. Consult soil test recommendations to determine need for lime. |
| Fe | Deficient | < 48 | Iron is very low. | Apply 4 lbs. per 100 gal per acre ferrous sulfate or 8 lbs. per 100 gal per acre iron chelate as a foliar spray between harvest and September 15. For fall fruiting types, apply in June. If condition persists for several consecutive years and soil pH is within desired range, apply 25 lbs. per acre iron chelate or 15 lbs. per acre ferrous sulfate to soil in early spring. |
| | Low | 48 - 50 | Iron is low. | Apply 4 lbs. per 100 gal per acre ferrous sulfate or 8 lbs. per 100 gal per acre iron chelate as a foliar spray between harvest and September 15. For fall fruiting types, apply in June. If condition persists for several consecutive years and soil pH is within desired range, apply 25 lbs. per acre iron chelate or 15 lbs. per acre ferrous sulfate to soil in early spring. |
| | Normal | 50 - 200 | Iron is adequate. | No alteration of present program is necessary. |
| | High | > 200 | Iron is above normal. | May be toxic if levels exceed 250 ppm. Contamination from sprays may give artificially high readings. |
| Cu | Deficient | < 6 | Copper is very low. | Apply copper chelate (4 lbs. per 100 gal per acre) in a foliar spray during leaf expansion in May. If condition persists for several consecutive years and soil pH is within desired range, apply 20 lbs. per acre copper sulfate to soil in late fall. |
| | Low | 6 - 7 | Copper is low. | Apply copper chelate (4 lbs. per 100 gal per acre) in a foliar spray during leaf expansion in May. If condition persists for several consecutive years and soil pH is within desired range, apply 20 lbs. per acre copper sulfate to soil in late fall. |
| | Normal | 7 - 50 | Copper is adequate. | No alteration of present program is necessary. |
| | High | > 50 | Copper is above normal. | May indicate low soil pH or contamination from sprays. Consult soil test recommendations to determine the need for lime. |

| Nutrient | Level | Concentration | Interpretation | Recommendation |
|---|---|---|---|---|
| B | Deficient | < 28 | Boron is very low. | Apply Solubor® to the soil in early spring at 4 lbs. per acre OR apply a foliar spray of Solubor® (20.5% B) at the rate of 1.5 lbs. per 100 gal per acre in early spring. For summer bearers, apply again after harvest. |
| | Low | 28 - 30 | Boron is low. | Apply Solubor® to the soil in early spring at 4 lbs. per acre OR apply a foliar spray of Solubor® (20.5% B) at the rate of 1.5 lbs. per 100 gal per acre in early spring. For summer bearers, apply again after harvest. |
| | Normal | 30 - 50 | Boron is adequate. | No alteration of present program is necessary. |
| | High | > 50 | Boron is above normal. | Discontinue use of boron. May be toxic if levels exceed 100 ppm. |
| Zn | Deficient | < 18 | Zinc is very low. | Apply 3 lbs. per 100 gal per acre zinc chelate at leaf expansion and after harvest in a foliar spray. For fall fruit types, apply in May and early July. If condition persists for several consecutive years and soil pH is within desired range, apply 10 lbs. per acre zinc sulfate to the soil in fall. |
| | Low | 18 - 20 | Zinc is low. | Apply 3 lbs. per 100 gal per acre zinc chelate at leaf expansion and after harvest in a foliar spray. For fall fruit types, apply in May and early July. If condition persists for several consecutive years and soil pH is within desired range, apply 10 lbs. per acre zinc sulfate to the soil in fall. |
| | Normal | 20 - 50 | Zinc is adequate. | No alteration of present program is necessary. |
| | High | > 50 | Zinc is above normal. | May indicate fungicide contamination. Toxicity may occur if levels exceed 300 ppm. |

# Section I-B7

## Nutrient Recommendations by Crop

**Nutrient Recommendations For**
**Commercial Loblolly Pine Plantations**
**(University of Maryland Cooperative Extension, 2006)**

# NUTRIENT RECOMMENDATIONS FOR COMMERCIAL LOBLOLLY PINE PLANTATIONS IN MARYLAND

Source: University of Maryland Cooperative Extension, February, 2006
Regulatory Citation: COMAR 15.20.08.05

## NUTRIENT RECOMMENDATIONS FOR COMMERCIAL LOBLOLLY PINE PLANTATIONS IN MARYLAND

### Stages of Growth

Managing the application of nutrients in commercial Loblolly pine plantations depends upon the growth stage of the plantation. For example, nutrient application at establishment is dictated by soil test levels for phosphorus and potassium, whereas nutrient application at mid-rotation thinning depends upon both soil test levels and, under some conditions, one or two indicators of tree nutrient status (i.e., Leaf Area Index (LAI) or foliar nutrient levels).

### Nutrient Management During Establishment

**Nitrogen (N)**

No commercial nitrogen fertilizer is recommended for establishment of Loblolly pine plantations.

**Phosphorous (P) and Potassium (K)**

Application of phosphorus (P) and potassium (K) to areas of Loblolly pine establishment is based on the amount of plant-available P and K already in the soil, as expressed by the Fertility Index Value (FIV). See Table 1.

**Table 1. P and K recommendations for the establishment of Loblolly pine plantations**

| Rate (lbs./acre) | Soil Test Category: Low (FIV 0-25) | Medium (FIV 26-50) | Optimum (FIV 51-100) | Excessive (FIV>100) |
|---|---|---|---|---|
| $P_2O_5$ | 115 | 115 | 55 | 0 |
| $K_2O$ | 60 | 60 | 30 | 0 |

### Nutrient Management at Mid-Rotation Thinning Using Commercial Fertilizer

Application of nutrients as commercial fertilizer at mid-rotation thinning considers both soil test FIV-P and, under some conditions, LAI or foliar nutrient levels. No potassium is recommended at mid-rotation thinning.

When soil test FIV-P is low or medium, follow recommendations in Table 2.

**Table 2. N and P recommendation at mid-rotation thinning when soil test FIV-P is low or medium**

| If soil test FIV-P is... | apply... | and apply... |
|---|---|---|
| low | 125-250 pounds N per acre | 115 pounds $P_2O_5$ per acre. |
| medium | 125-250 pounds N per acre | 55-115 pounds $P_2O_5$ per acre. |

When soil test FIV-P is optimum, determine LAI and consult Table 3 for recommendation.
For information on determining LAI, contact a consulting forester or the Extension & Natural Resource Specialist at the University of Maryland Wye Research and Education Center, or consult *Ocular LAI Comparator for Loblolly Pine*. See the "References" section for ordering information.

**Table 3. Utilizing LAI to determine N and P recommendation when soil test FIV-P is optimum**

| If LAI is between... | then... |
|---|---|
| 0.65 and 2.0 | Apply 125– 50 pounds N and 55 pounds $P_2O_5$ per acre. |
| 2.01 and 3.0 (optimum range) | Rely on foliar analysis. |
| 3.01 and 4.5 | Do not fertilize. |

When soil test FIV-P and LAI are both optimum, rely on foliar analysis. Collect a representative sample of foliage and obtain a total N and P analysis from an agricultural analytical laboratory. Compare the Loblolly pine foliage N and P levels to those reported in Table 4.

**Table 4. Interpretive information for N and P concentrations in Loblolly pine foliage**

| Nutrient | Critical Level (%) | Optimum Upper Limit (%) |
|---|---|---|
| N | 1.1 – 1.2 | 2.3 |
| P | 0.10 – 0.12 | 0.17 |

Consult Table 5 to determine the N and P recommendations when soil test P and LAI are both optimum.

**Table 5. N and P recommendation at mid-rotation thinning when soil test FIV-P and LAI are both optimum**

| If N... | then... |
|---|---|
| is less than 1.1% in the Loblolly pine foliage | apply 125 – 250 pounds N per acre. |
| is 1.1% or greater in the Loblolly pine foliage | Do not apply any N. |
| **If P...** | **then...** |
| is less than 0.10% in the Loblolly pine foliage | apply 55 pounds $P_2O_5$ per acre. |
| is 0.10% or greater in the Loblolly pine foliage | do not apply any P. |

## Organic Waste Applications

Application rates for organic wastes, such as poultry litter and biosolids, etc., at establishment and at mid-rotation thinning depend upon soil test FIV-P and the plant-available nitrogen (PAN) content of the organic waste. A representative sample of an organic waste must be collected and analyzed prior to determining the appropriate application rate. See *Sampling Manure for Nutrient Content* for information on collecting a representative sample. Consult Table 7 for organic waste application rates.

**Table 7. Organic waste application rates**

| If FIV-P is... | and growth stage is... | then... |
|---|---|---|
| between 1 and 50 (low and medium) | establishment | apply 60 pounds per acre PAN. |
| between 1 and 50 (low and medium) | mid-rotation thinning | apply 180 pounds per acre PAN. |
| between 51 and 100 (optimum) | establishment | apply 30 pounds per acre PAN. |
| between 51 and 100 (optimum) | mid-rotation thinning | apply 90 pounds per acre PAN. |
| greater than 100 (excessive) | establishment or mid-rotation thinning | do not apply organic waste. |

## Nutrient Best Management Practices (BMPs) for Loblolly Pine Plantations

BMPs should be observed and utilized to protect soil and water quality.

**Timing BMPs**

1. Application of nutrients to Loblolly pine plantations should be limited to either the spring (March 1 – May 15) or fall seasons (August 15 – October 15).
2. Do not apply nutrients to Loblolly pine plantations from October 15 to February 28.

3. Nutrient applications to newly established Loblolly pine plantations should be avoided in July and August to avoid foliage burning.

**Site BMPs**

1. Do not apply any nutrient source near watercourses or Stream Management Zones:
   - for sites with a slope between 1 – 5%, within 50 feet of a pond, stream or other water body;
   - for sites with a slope of more than 5%, within 100 feet of a pond, stream or other water body.
2. Do not apply nutrients to a site with standing water at the time of application.
3. Do not apply nutrients on bedrock outcrops.
4. Do not apply **any** P-bearing nutrient sources to sites whose soil test FIV-P is greater than 100.

**Nutrient Application Frequency BMP**

Nutrient applications may occur at mid-rotation or as often as every 5-7 years, if appropriate, based on soil test and foliar analysis or LAI.

**Organic Waste BMP**

If an organic nutrient source is applied at establishment, it is critical to apply an approved herbicide to control unwanted vegetation.

**References**

Sampson, D.A., H.L. Allen, E.M. Lunk and D.P. Blevins. *1997 Ocular LAI Comparator for Loblolly Pines*. Version 4.1. Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC, 27695-8008. ($15)

Steinhilber, P. and J. Salak. *Sampling Manure for Nutrient Content*. NM-6. University of Maryland Cooperative Extension and Department of Natural Resource Sciences and Landscape Architecture, College Park, MD 20742.

# Section I-C

## Estimated Mineralization Rates, Nitrogen Credits for Legumes, and Ammonia Conservation Factor for Organic Nitrogen

(University of Maryland Cooperative Extension, 2009)

# ESTIMATED MINERALIZATION RATES, N CREDITS FOR LEGUMES AND AMMONIA CONSERVATION FACTORS FOR ORGANIC NITROGEN

***Source: University of Maryland Cooperative Extension Revised November 2009***
***Regulatory Citation: COMAR 15.20.08.05***

Estimated nitrogen availability is based on latest data for Mid-Atlantic region, recommended by the University of Maryland Cooperative Extension Service and accepted by the Maryland Department of Agriculture. The following factors shall be used by all nutrient management consultants as basis for calculation of available nitrogen from different forms and sources of the organic wastes for the first year and from previous years of applications.

**MANURE MINERALIZATION RATES**
% organic nitrogen mineralized each year

| Manure source & type | Year of application | 1st year after application | 2nd year after application |
|---|---|---|---|
| Cattle, dairy & beef (buffalo[1]) | 35 | 18 | 9 |
| Poultry | | | |
| a. Caged layers | 60 | 10 | 5 |
| b. All other (emu[1]) | 50 | 15 | 8 |
| Swine (all types) | 50 | 15 | 8 |
| Horse (ostrich[1]) | 20 | 10 | 5 |
| Sheep (goat, alpaca, camel, llama[1]) | 30 | 15 | 5 |
| Chinchilla[2] | 15 | 7 | 3 |
| Rabbit[2] | 5 | 2 | 1 |
| Vegetable processing effluent[2] | 40 | 15 | 8 |
| Meat processing residuals[2] | 50 | 10 | 5 |
| Aquaculture waste, semi-solid[2] | 50 | 15 | 8 |
| Aquaculture effluent[2] | 80 | 5 | 0 |
| Fish emulsion[2] | 80 | 5 | 0 |
| Corn gluten, alfalfa meal, peanut meal[2] | 85 | 10 | 5 |
| Compost, where C/N<25 [2] | 5 | 0 | 0 |
| Feather meal, crab meal[2] | 60 | 10 | 5 |
| Fish powder, hydrolyzed[2] | 60 | 10 | 5 |
| Seabird guano[2] | 60 | 10 | 5 |
| Blood meal[2] | 65 | 10 | 5 |

1. Based on consultation with animal nutritionists; different animal species are grouped when they have diets and digestive systems similar to the first species in the group, for which mineralization data are available
2. Data based on values from the literature or values that specialists with expertise in the area consider to be best estimates.

## SLUDGE MINERALIZATION RATES

(Current year mineralization rates and previous year Km factors)

| Sludge Type | Mineralization rates for current application | Km factors for sludge applied (Lbs N mineralized per ton of sludge applied per % organic N) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 yr ago | 2 yrs ago | 3 yrs ago | 4 yrs ago | 5 yrs ago | 6 yrs ago | 7 yrs ago | 8 yrs ago | 9 yrs ago |
| Unstabilized | 0.40 | 2.40 | 0.96 | 0.44 | 0.24 | 0.24 | 0.24 | 0.11 | 0.11 | 0.11 |
| Lime-Stabilized or Aerobically Digested | 0.30 | 2.10 | 0.90 | 0.42 | 0.32 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| Anaerobically Digested | 0.20 | 1.60 | 0.72 | 0.42 | 0.38 | 0.38 | 0.38 | 0.36 | 0.36 | 0.17 |
| Composted | 0.10 | 0.90 | 0.50 | 0.50 | 0.48 | 0.46 | 0.46 | 0.44 | 0.42 | 0.42 |

## NITROGEN CREDITS FOR LEGUME CROPS

| Crop | Lbs. N/Acre |
|---|---|
| **Perennials** | |
| Alfalfa | 100 - 150[a] |
| Ladino clover | 60 |
| Red clover | 40 |
| Birdsfoot trefoil | 40 |
| **Winter Annuals** | |
| Crimson clover | 50 - 100[b] |
| Hairy vetch | 75 - 150[b] |
| Austrian winter peas | 75 - 150[b] |
| **Summer Annuals** | |
| Lespedeza | 20 |
| Soybeans | 15 - 40[c] |

a. Credit depends on stand:
   Good (>4 plants per square foot), credit 150 lbs
   Fair (1.5 to 4 plants per square foot), credit 125 lbs
   Poor (<1.5 plants per square foot), credit 100 lbs.

b. Depends on planting date (and biomass production), kill date and subsequent tillage.

c. A minimum of 15 lbs. and may be as much as 1 pound per bushel of soybeans, up to a maximum 40 lbs.

### Nitrogen Credit Guidelines

- If an unfertilized cereal grain cover crop was grown during the cool season, do not take a credit for the previous year's legume crop or manure application. A cover crop is defined here as an unharvested crop grown for soil erosion control, water quality improvement, or in the case of legumes, nitrogen fixation. If a crop is grazed or harvested for any purpose, it is not considered a cover crop.
- Do not take a credit for nitrogen-fertilized vegetable legumes (green beans, peas, etc.).
- If a warm-season forage legume (like alfalfa) was killed in the fall and a winter annual legume cover crop was grown in the cool season (like crimson clover), the credits for the following year are summed for the 2 crops.
- When spring seeding alfalfa, do not take a credit for the previous years' legume crop or manure application.
- If recommending organic waste on legume crops to alleviate excess waste issues, do not take credits for previous years' legume crop or manure applications.
- Do not take a credit for previous years' legume crops or manure applications for small grain for grain or grazing.

## AMMONIUM CONSERVATION COEFFICIENTS

**Liquid Manures and Organic Residuals (<10% dry matter, >90% moisture)**

| | Tillage practice (see definitions next page)* | | |
|---|---|---|---|
| Time to incorporation | Conventional | Conservation | No-till or incorporation after 3 days |
| Inject (<1 hour) | 1.0 | 1.0 | 1.0 |
| 1-24 hours | .75 | .60 | - |
| 24-48 hours | .55 | .50 | - |
| 48-72 hours | .50 | .48 | - |
| No-till (over 72 hrs) | - | - | .45 |

**Solid Manures and Organic Residuals (>10% dry matter, <90% moisture)**

| | Tillage practice (see definitions next page)* | | |
|---|---|---|---|
| Time to incorporation | Conventional | Conservation | No-till or incorporation after 3 days |
| < 1 hr | .96 | .66 | - |
| 1-24 hours | .78 | .57 | - |
| 24-48 hours | .58 | .47 | - |
| 48-72 hours | .53 | .44 | |
| No-till (over 72 hrs) | - | - | .35 |

**Poultry Litter**

| | Tillage practice (see definitions next page)* | | |
|---|---|---|---|
| Time to incorporation | Conventional | Conservation | No-till or incorporation after 3 days |
| < 1 day | .97 | .85 | |
| 1-2 days | .92 | .82 | |
| 3 days | .88 | .80 | |
| 4 days | .84 | .78 | |
| 5 days | .81 | .77 | |
| 6-7 days | .77 | .75 | |
| 8-14 days | .74 | .73 | |
| No-till (over 14 days) | | | .72 |

***Tillage Definitions** for the purpose of nutrient management planning

Conventional tillage
- Any tillage that leaves <30% residue cover
- Examples include chisel-disc-chisel or Landsman™
- Ammonium conservation maximized

Conservation tillage
- Any tillage that leaves between 30 and 70% surface residue
- Examples include light discing, plug or spike aerators (such as Aerway™), seed bed conditioners and vertical till (such as Turbotill™)
- Assumed to be approximately 25-75% as effective as conventional tillage at conserving ammonium-N ; mid-range value of 50% used to estimate conservation factor

No-till
- Residue cover >70%
- Ammonium conservation minimized

# Section I-D

## Nutrient Application Guidelines

(Maryland Department of Agriculture, 2004)

Section I-D

# NUTRIENT APPLICATION GUIDELINES

*Source: Maryland Department of Agriculture 2004*
*Regulatory Citation COMAR 15.20.08.05*

## General Guidelines

1. Nutrient applications to a crop shall be made as close to plant uptake periods as possible. Certain exceptions may be considered appropriate as follows:

   a. Use of natural organic sources of nutrients may be recommended to meet plant nitrogen needs, even if this results initially in over-application of phosphorus, provided the following fall and/or winter Application Guidelines are met. However, when the FIV is 150 or greater, management of phosphorus shall be consistent with phosphorus site index requirements under COMAR 15.20.08.05E.

   b. Rates of natural organic sources of nutrients for lengthy planting cycles, such as orchard or tree establishment may be recommended as a one time initial application, when periodic, seasonal, or surface application is not feasible.

2. Application of nutrients may vary depending on what type of crop is being grown and weather conditions; however, application timing should maximize plant utilization efficiency and minimize the potential for nutrient movement.

3. Best management practices shall be used when necessary to minimize or control nutrient movement to sensitive areas or to surrounding water bodies. The following guidelines shall be followed to be in compliance with COMAR 15.20.08.05H.

## Fall Application (September 1 thru November 15)

When applying or recommending nutrients in the fall, the consultant and operator, or the certified farm operator, shall use the following management guidelines. The guidelines address chemical fertilizer and natural organic fertilizer use separately.

**Chemical Fertilizer Use**

1. Chemical fertilizer may be recommended and applied as a starter fertilizer, provided rates and subsequent applications are made in accordance with recommendations for small grains and fall seeded crops or plants found in Section I-B of this Manual.

2. The application of liming materials without nitrogen may be recommended in the fall or winter.

**Manure Use**

1. Manure may be applied as a starter fertilizer if rates and timing follow the recommendations

for fall seeded crops found in Section I-B of the Maryland Nutrient Management Manual. (Example: For small grains, this is a maximum of 40 pounds of available nitrogen/acre)

2. Manure application above the fall recommended rate for fall seeded crops (greater than 40 pounds/acre of nitrogen) is allowed at fall planting (up to the University of Maryland's recommended rate of the fall crops' phosphorus removal requirements) only if storage is inadequate, and it is necessary to avoid application during the winter. Planting of the crop for which nutrients are being managed should occur in a time frame that would allow significant plant growth, in order for the plants to utilize any available nitrogen.

3. To avoid application during the winter, when storage is inadequate and manure is not stackable (greater than 60% moisture, such as dairy slurry), manure application may be made during the fall at levels up to the next year's warm season crops' phosphorus removal requirements. Applications shall either be made into existing vegetative cover, or a cool season grass or cereal grain shall be planted as a cover crop.

## Winter Application of Manure (November 16 thru February 28)

Manure may be applied in the winter only if the farm operation has inadequate storage, a non-stackable manure, and no other reasonable option to manage it. Application shall be made in accordance with the indicated restrictions. The following guidelines should be used as a temporary measure because of inadequate storage. All livestock and poultry operators are encouraged to have adequate manure storage to accommodate manure production through the winter months, when plants are not actively growing.

1. If the manure is stackable (equal to or less than 60% moisture, such as poultry litter), or if adequate storage is available, manure application is prohibited during the winter.

2. Manure application shall not be made on hard-frozen or snow-covered ground.

3. Winter manure application shall not be made on fields when predominant soils are the following poorly drained soil types: Portsmouth, Pocomoke, Bayboro, Johnston, and Plummer.

4. Manure applications shall not be made to land with a slope greater than 7%.

5. A setback of at least 100 feet from all surface waters shall be maintained, unless best management practices providing water quality protection equivalent to such a setback are in place. (Surface water is defined as any permanent or intermittent, continuous, physical conduit for transporting water. Shovel ditches and water leads are not included as surface waters for purposes of this policy.)

6. Rates of application shall be minimized, and available acreage used to the greatest extent practical. In no case shall the application rate per acre exceed the crops' phosphorus removal requirements.

7. Applications should be made into existing vegetative cover, such as cover crops or small grain

crops whenever possible. Established hay and pasture fields may also be used. Vegetative cover shall be maintained as such until March 1.

8. If vegetative cover is not used, manure applications shall be made to land that has a minimum of 30% residue coverage, and is maintained as such until after March 1.

## Stackable manures that are temporarily stockpiled shall be stored under the following guidelines:

Manure should be stockpiled outside and uncovered, only after all available storage is utilized to the fullest extent; this includes the storage of manure on the producing farm if the manure is to be transported off-site.

1. The manure shall be piled and peaked at least eight to ten feet high, and in a manner that will allow it to shed most of the rainfall.
2. The stockpile shall be located:
   a. At least 100 feet from any surface water, drainage ditch, swale or gully; however, if a functioning filter strip or riparian buffer is in place, the setback may be a minimum of 35 feet from any surface water;
   b. At least 100 feet from any public road;
   c. At least 200 feet from any residence or neighboring property;
   d. Above the floodplain of the 25-year, 24-hour storm;
   e. Outside natural drainage ways; and
   f. At least 150 feet from any wells, or 300 feet from a well when the well is located down gradient from the storage area.

# Section I-E1

## utrient Recommendations for Non-Agricultural Land

**Plant Nutrient Recommendations Based on Soil Tests**
**For Turf Maintenance**
**(University of Maryland Cooperative Extension, 1999)**

# PLANT NUTRIENT RECOMMENDATIONS BASED ON SOIL TESTS FOR TURF MAINTENANCE

*Source: University of Maryland Cooperative Extension, March 2003*
*Regulatory Citation: COMAR 15.20.06.04*

## INTRODUCTION

Nutrient management laws passed by the Maryland Legislature in 1998 require that University of Maryland nutrient management guidelines be followed on state property and certain commercially managed turfgrass sites. These laws impacting turfgrass were part of an overall effort to regulate the agricultural industry. Major differences exist between the goals and practices of general agriculture and turfgrass management. The following information is intended to serve as a nutrient management guideline for turfgrass sites in an efficient, effective, and environmentally sound manner.

## WATER QUALITY

Properly managed turfgrass has been shown to be an environmental asset. Turfgrass has significant cooling effects during the summer and traps much of the dust and dirt that is released each year into the atmosphere. Turfgrass absorbs carbon dioxide, ozone, sulfur dioxide, and other gases, while releasing oxygen.

Water runoff is greatly reduced and water infiltration is increased compared to most other agriculture and plant systems. Once turfgrass is established, soil loss from erosion is negligible. Runoff from established turf has compared favorably to forested land. Also, turfgrass is an efficient organic matter producing system. Thus, little nitrogen (N) or phosphorus (P) is lost from turfgrass sites if sound nutrient management practices are followed.

Onsite monitoring and numerous research studies have shown that nutrient loss from turfgrass sites is very small. However, research has also shown that certain types of improper N applications on specific types of sites can result in excessive nitrate ($NO_3$) leaching. This problem is very specific and has occurred as follows:

1. Very high rates of N were applied using soluble $NO_3$-N containing fertilizers (such as ammonium nitrate [$NH_4$-$NO_3$]);
2. The fertilizer was applied to dormant turf (such as bermudagrass during the winter);
3. Soils were predominantly sand; and
4. The sites had high water tables.

A sound turfgrass nutrient management plan shall take into consideration this set of conditions, which can cause a potential problem.

## NITROGEN

Proper nitrogen fertilization is essential in maintaining quality turf that is resistant to pest problems, tolerant of stresses, and able to recover from damage. Current N recommendations are based on extensive research and are dependent on a variety of factors, such as: turfgrass species and cultivars, age of turf, soil type, management practices being used (irrigation, clipping removal, pest control programs), weather conditions, use of area, length of growing season, and the need for recovery from pest damage, adverse environmental conditions, and traffic. The nutrient management specialist shall take into account all of these factors in devising an appropriate N fertilization program. The program may vary from year to year as these conditions change.

Three major factors shall be considered in developing a N fertilization plan for turfgrass sites:

1. What types of N should be applied,
2. How much N needs to be applied annually, and
3. When should N be applied.

Inadequate attention to each of these factors increases the potential for thin turf, which is more prone to pest and stress problems and erosion. It also increases the potential for exposed soil, which is more prone to erosion. Also, the potential for leaching and runoff of N increases if guidelines are not followed.

### Sources of N

A wide range of N-containing fertilizers are available to the turfgrass manager. These fertilizers generally fall into one of two broad categories: 1) fertilizers that contain only soluble, quickly available N; and 2) fertilizers that contain some N in a slowly available form, which is not immediately available for plant use.

Quickly available N fertilizers contain $NO_3$-N or $NH_4$-N, or both. These are soluble and readily available for uptake by turfgrass plants. Turfgrass uptake may occur within a few days with $NO_3$-N fertilizer. Nitrogen uptake may begin within 7-10 days with $NH_4$-N fertilizers, as $NH_4$-N is converted to $NO_3$-N in the soil. Nitrogen uptake by turfgrass roots is predominately in the $NO_3$ form.

Leaching and runoff potential are much higher for $NO_3$-N. Thus, where conditions exist that are conducive to leaching or runoff, fertilizers that contain significant amounts of $NO_3$-N should not be used. These conditions include sandy sites (sands and loamy sands) with high water tables when turf is not actively growing, and sites that are highly sloped. Fertilizers high in $NO_3$-N include $NH_4NO_3$, potassium nitrate, and calcium nitrate. Fertilizers that contain predominantly $NO_3$-N shall only be used on sites not prone to runoff or leaching, sites where very rapid response is essential, and on sites where turf is actively growing.

Soluble N fertilizers that contain $NH_4$-N include: urea ($NH_2$-CO-$NH_2$), ammonium sulfate ($NH_4SO_4$), and ammonium chloride ($NH_4Cl$). These fertilizers can produce excellent quality turf, without leaching or runoff problems, if used properly. Most important is limiting these fertilizers to 1.0 lb. N/1000 $ft^2$ per application. Higher rates per application can result in

excessive growth of turf and can increase the potential for N loss on some sites.

Slow release fertilizers contain significant amounts of N that are not immediately available for plant uptake. Examples of fertilizer sources that contain various amounts of slow release N include: sulfur coated ureas, polymer coated ureas, methylene ureas, ureaformaldehydes, IBDU, natural organics, and various types of sludge. The N in all slow release fertilizers used for turfgrass maintenance is $NH_4$-N based. Slow release fertilizers, while varying considerably in individual characteristics and release patterns, typically provide more even turfgrass response, provide N over a longer period of time, and are less prone to N leaching and runoff, as compared to soluble N fertilizers. Their use should be considered on the aforementioned sites that are prone to leaching or runoff, and when a N application needs to be made to turfgrass that is not in optimum growing conditions.

**Rates of Nitrogen**

When recommending rates of N fertilization, there are two primary issues: 1) how much N can be applied in any one application, and 2) how much total N can be applied annually. The maximum amount of N that should be applied in one application is primarily dependent on the amount of **soluble** N in the fertilizer. No more than 1.0 lb. **soluble** N/1000 $ft^2$ should be made in any single application. For a fertilizer that contains 50% of its N in a soluble form, and 50% in a slow release (water insoluble) form, no more than 2.0 lbs. total N/1000$ft^2$ should thus be applied in any single application (which would result in 1.0 lb. **soluble** N/1000$ft^2$ being applied).

Some fertilizers contain most of their N in a slow release form. For these fertilizers, applying 1.0 lb. soluble N/1000 $ft^2$ would result in very high total N rates. For example, a natural organic fertilizer contains 10% of its N in a soluble form and 90% in slow release form. Applying 1.0 lb. **soluble** N using this fertilizer would result in a total N rate of 10 lbs. N/1000 $ft^2$, which is well in excess of recommended annual rates of N for typical turfgrasses. Thus, for slow release fertilizers with little soluble N, the maximum amount applied in one application shall not exceed the total annual N requirement of the turf.

As previously discussed, the annual turfgrass requirements for N vary considerably, depending on a variety of conditions. Most critical, however, is turfgrass species. The annual N requirements for maintaining established stands of the most common turfgrass species grown in Maryland generally fall within the ranges listed in Table 1.

**Table 1. Nitrogen Recommendations for Commercially Maintained Turfgrass Sites**

| | Total Nitrogen Annually (lbs. N/1000 $ft^2$) | |
|---|---|---|
| | **Years 1-2** | **Subsequent Years** |
| **Cool Season Grasses** | | |
| Kentucky bluegrass | 3.0 – 4.5 | 3.0 – 4.0 |
| Turf-type tall fescue | 3.0 – 4.0 | 2.0 – 3.0 |
| Fine fescue | 1.0 – 3.0 | 0 – 2.0 |
| Perennial Ryegrass | 3.0 – 4.0 | 3.0 – 4.0 |
| | | |
| **Warm Season Grasses** | | |
| Bermudagrass | 3.0 – 4.0 | 3.0 – 4.0 |
| Zoysiagrass | 1.0 – 3.0 | 0 – 2.0 |

Numerous factors influence whether moderate adjustments to these rates may be warranted. For example, if clippings are returned to the site when it is mowed, reductions in the annual N rates (as well as P and K) may be possible. Also, if the site receives little use, and thus, does not need higher growth rates to recover from traffic, lower rates shall be used. Other means of possible reductions in total N requirements include: the use of iron, increasing the height of mowing, and careful selection of cultivars when seeding, overseeding, or sodding.

Conversely, several factors may warrant moderate increases in annual rates. These include: heavily used sites that need high recuperative rates, sites that are mowed lower than typically recommended due to use requirements, and sites that have been damaged from adverse environmental conditions or pests. Also, on sites where pesticide use is not economically feasible or not permitted, somewhat higher N rates can be important in minimizing many pest problems, particularly weeds and diseases.. Rates much higher than those recommended, however, can have the opposite effect.

## Timing of N Applications

The primary potential for N loss from turfgrass sites occurs when excessive rates of N, particularly $NO_3$-N, are applied to turf that is not actively growing. Thus, most of the annual fertilizer requirements should be applied during periods of active shoot (leaf blades, rhizomes, stolons) or root growth (Table 2).

**Table 2. Recommended Periods for N Fertilization of Turf Areas**

| | Recommended Periods | Periods to Avoid |
|---|---|---|
| **Warm Season Grasses** | 1 month before dormancy breaks (mid April in central MD; later in western MD, and earlier on the eastern shore) through September 1st | September 1st through 1 month before dormancy breaks<br><br>During severe or prolonged drought |
| **Cool Season Grasses** | 1 month before top growth starts (last March in central MD) through early June<br><br>Late August through 6 weeks after first killing frost | Mid-June through mid-August<br><br>When turf is dormant due to heat, drought, or cold |

The primary period for growth of warm season grass species (zoysiagrass, bermudagrass, and buffalograss) is from mid-spring, after dormancy has broken, through mid-fall, when the first killing frost is experienced. Thus, N applications to warm season grasses should generally be restricted to these periods. However, fertilizer that primarily contains $NH_4$-N can be applied up to a month before dormancy is typically broken in the spring, so that N is available for plant uptake at this time. Applications after September 1 are generally not recommended, due to the possible enhancement of winterkill, particularly with bermudagrass. However, if bermudagrass has been overseeded with a cool season species, such as perennial ryegrass, up to 1.0 lb. N/1000 $ft^2$ may be applied after September 1, to enhance its performance.

Cool season grasses have a longer growth period. They can exhibit growth at virtually any time during the year, if moisture and temperature conditions are conducive. The prime periods for growth are typically from late winter through early summer, and from late summer through early winter. Research would indicate that ⅔ to ¾ of the total annual N should be applied during the latter period, to maximize cool season turfgrass performance and quality.

Under extended hot and dry periods during mid-summer, cool season grasses may experience a period of dormancy until rainfall occurs. Nitrogen fertilizer should not be applied at this time. If irrigation is available, or if rainfall is adequate throughout the summer, little dormancy will occur and N uptake of cool season grasses will continue. Although not generally needed, applications of ¼ to ½ lb/1000 $ft^2$ can be made to these sites if growth is not adequate to meet the demands of the use of the site.

During the winter months, although top growth may have virtually ceased, root growth and N uptake may still occur during the periods when the ground is not actually frozen, particularly with Kentucky bluegrass. Research has shown that applications of N during this period can

enhance root growth and spring performance of turf. Also, some sites tend to be excessively wet each spring, making fertilization with large equipment difficult. Fertilization earlier, when the ground is firmer, may be the best alternative.

There is minimal risk of runoff or leaching problems from winter application of N if the following guidelines are followed: no more than ½-1.0 lbs. N/1000 $ft^2$ is applied; fertilizers containing significant amounts of $NO_3$-N are not used; and applications are not made to frozen ground if significant rainfall is in the immediate forecast. In most situations, however, mid-winter applications are not necessary, and the guidelines listed in Table 2 should be followed.

## PHOSPHORUS AND POTASSIUM

Phosphorus (P) is critical in the establishment of turfgrass. Inadequate soil P will result in very poor seedling vigor, slow establishment of grass, and a stand with very poor density and root growth. The soil will thus be much more susceptible to erosion. Weed encroachment will also be much more severe due to the lack of competition from the thin turfgrass stand. Thus, it is essential that sufficient P be added to the soil at the time of seeding, if soil levels are inadequate. Although not as critical as during establishment of turfgrass, deficiencies in P in mature turf can result in poor spring greenup, reduced vigor, reduced density, and reduced drought tolerance. Light applications of P are generally sufficient to overcome deficiencies in mature turf.

Potassium (K) is not as critical as N or P during the initial establishment phase of turf. However, K plays an important role in mature turf regarding rhizome production and tolerances to heat, drought, and cold. Thus, sufficient K needs to be available for turfgrass, to ensure that quality turf will be obtained during and after summer or winter stresses. Severe deficiencies in K will result in thin, chlorotic, and unvigorous turf.

Whereas N application recommendations cannot currently be obtained from soil tests, recommendations for application of P and K can be obtained from such tests. A commercial turf maintenance company shall test sites within a year of the initiation of management of the site. Until such time as the first soil test is taken, not more than 1.0 lb. $P_2O_5$ and 2.0 lbs. $K_2O$ per 1000 $ft^2$ shall be applied for maintenance of turf. After the initial soil test, subsequent sampling every 3 years is generally sufficient to monitor soil P and K levels.

Sites having different soil types, sites with different use or management histories, and sites having substantially different fertility levels, as determined by previous soil tests, should be sampled separately. Conversely, sites having similar soil types, having similar use and management histories, and having similar fertility levels, as determined by past soil tests, may be lumped together into one sample. For example, a single sample may be sufficient for an athletic field complex (or townhouse development, etc.) which has had similar management over a period of time and has a relatively uniform soil type.

Current P and K recommendations, based on soil test results for the maintenance of turf sites, are listed in Table 3.

**Table 3. Phosphorus and Potassium Recommendations for Maintenance of Turf Sites Based on Soil Test Results From the University of Maryland.**

| | Soil Test Category | | |
|---|---|---|---|
| | low | medium | optimum---excessive |
| | FIV 0-25 | FIV 26-50 | FIV 51+ |
| | lbs. $P_2O_5$ or $K_2O$/1000 $ft^2$ | | |
| **Phosphorus** | 2.0 | 1.0 | 0 |
| **Potassium** | 2.0 – 4.0 | 1.0 - 2.0 | 0 – 1.0 |

## SOIL REACTION

Maintaining soil pH within an optimum range is important for maximizing the efficiency of nutrient use, and can be important in reducing weed and disease problems. Turfgrass can withstand a rather broad range of soil pH, but 5.8 to 6.2 is generally considered ideal. Wide deviations from this range can result in reduced P and micronutrient availability, and can interfere with soil N metabolism and availability. Depending on turfgrass species, problems in turf may start to occur at soil pH above 7.8 and below 5.4. Thus, to maximize efficiency of nutrient availability and use, soil tests should be taken as recommended previously for soil P and K to determine soil pH.

Recommended limestone applications, to achieve a soil pH of approximately 6.4 are shown in Table 4. If diseases such as take-all patch of bentgrass, summer patch of Kentucky bluegrass, or spring dead spot of bermudagrass are of concern, maintaining lower soil pH (5.4 – 5.7) may be desirable, and reduced or no limestone should be applied to achieve this level. Also, it is recommended, when practical, that limestone be applied approximately 1 month or more before seeding to minimize potential P availability problems and the potential for volatilization loss of applied N.

**Table 4. Limestone Recommendations for Maintenance of Turfgrass (Pounds per Acre)**

| | | | Coastal plain | | Piedmont & Mountain | |
|---|---|---|---|---|---|---|
| soil pH | loamy sands | sandy loams | loams | silt loams and silty clay loams | loams | silt loams and silty clay loams |
| 6.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6.3 | 0 | 0 | 0 | 0 | 545 | 650 |
| 6.2 | 0 | 0 | 545 | 545 | 760 | 1090 |
| 6.1 | 0 | 545 | 650 | 760 | 980 | 1415 |
| 6.0 | 435 | 760 | 870 | 980 | 1195 | 1850 |
| 5.9 | 545 | 870 | 1090 | 1195 | 1415 | 2180 |
| 5.8 | 650 | 1090 | 1195 | 1415 | 1740 | 2505 |
| 5.7 | 760 | 1195 | 1415 | 1630 | 1960 | 2940 |
| 5.6 | 870 | 1305 | 1630 | 1850 | 2180 | 3265 |
| 5.5 | 980 | 1525 | 1850 | 2070 | 2395 | 3590 |
| 5.4 | 1090 | 1630 | 2070 | 2180 | 2720 | 3920 |
| 5.3 | 1195 | 1850 | 2180 | 2395 | 2940 | 4355 |
| 5.2 | 1305 | 1960 | 2285 | 2610 | 3155 | 4355 |
| 5.1 | 1415 | 2070 | 2505 | 2830 | 3375 | 4355 |
| 5.0 | 1525 | 2285 | 2720 | 3050 | 3590 | 4355 |
| 4.9 | 1630 | 2395 | 2940 | 3155 | 3810 | 4355 |
| 4.8 | 1740 | 2505 | 3050 | 3375 | 4135 | 4355 |
| 4.7 | 1850 | 2720 | 3265 | 3590 | 4355 | 4355 |
| 4.6 | 1960 | 2830 | 3375 | 3810 | 4355 | 4355 |
| 4.5 | 2070 | 3050 | 3590 | 4030 | 4355 | 4355 |

1) Divide the above rates by 43.5 to obtain the equivalent rates in pounds per 1000 square feet.
2) Do not apply more than 2,000 pounds per acre for any one maintenance application to turfgrass.

# Section I-E2

## utrient Recommendations for Non-Agricultural Land

**Nutrient Management Guidelines for**
**Commercial Turfgrass Seeding**
**(University of Maryland Cooperative Extension, 2005)**

# NUTRIENT MANAGEMENT GUIDELINES FOR COMMERCIAL TURFGRASS SEEDING

*Source: University of Maryland Cooperative Extension, August 2005*
*Regulatory Citation: COMAR 15.20.06.04*

Nutrient management laws passed by the Maryland Legislature in 1998 require that certain commercial fertilizer applicators adhere to University of Maryland Cooperative Extension guidelines when establishing or maintaining turfgrass sites. This publication is intended to serve as a nutrient management guideline for the establishment of turfgrass by seeding. When establishing a new site by seeding turfgrass, proper fertilization at the time of establishment is essential for obtaining a satisfactory stand of turfgrass for both the short and long-term.

One of the major concerns regarding the health of the Chesapeake Bay is soil erosion and the subsequent movement of nitrogen (N) and particularly phosphorus (P) into the Bay. Thus, the rapid establishment of turfgrass on disturbed soil is environmentally important and can drastically reduce the movement of soil, and thus nutrients, by erosion into sensitive areas. A critical factor in the rapid establishment of turfgrass is providing adequate N and P at the time of establishment. In addition, once turfgrass has been established successfully, soil loss is negligible, water runoff is greatly reduced, and water infiltration is increased. Runoff from established turf has compared favorably to forested land.

**Key Points**

Adequate nitrogen and phosphorus are critical for rapid turf establishment and prevention of soil erosion. Soil tests should be obtained to determine how much P, K and limestone are needed. Long term problems, such as weed encroachment, diseases, and drought susceptibility can be reduced with proper seedbed fertility.

**Phosphorus and Potassium Applications**

Phosphorus is essential for the growth and development of seedling turfgrass. Inadequate P in the seedbed will result in poor initial growth and a stand that rapidly thins, resulting in a site that is prone to soil erosion and weed encroachment. Research has shown that providing adequate P at the time of seeding will reduce long-term weed encroachment problems, reduce soil erosion, and reduce runoff while increasing water infiltration.

Potassium is generally not critical during the establishment phase of turfgrass unless soil levels are particularly low. However, adequate potassium is essential for established turf in improving tolerance to environmental stresses and wear, and may increase the resistance to some diseases. It is recommended that soil K levels be adjusted at the time of seeding so that no deficiencies develop as the turfgrass matures. This is particularly advisable if fertilizer is being incorporated into the soil during soil preparation so that the entire potential root zone can be modified.

Phosphorus (P) and potassium (K) fertilizers shall be applied according to soil test recommendations. Recommendations for P and K are outlined in Tables 1 and 2, respectively. The amounts recommended are a function of initial soil test levels, and whether fertilizer will be surface applied or incorporated into the soil to depths over 2 inches. Occasionally, job contracts or the time during the year when a site will be seeded necessitate immediate seeding before a soil test can be completed. In such cases, a maximum of 2 pounds per 1000 square feet (90 pounds per acre) of $P_2O_5$ and $K_2O$ may be applied to ensure that P and K deficiencies do not

occur, and maximum ground cover is achieved to prevent soil erosion. However, it is strongly recommended that all efforts be made to obtain soil test results before seeding operations begin.

**Table 1. Phosphorus Recommendations for Turfgrass Seeding, Based on Soil Test Results**

| | Soil Test Phosphorus Category | | | |
|---|---|---|---|---|
| | Low (FIV 0-25) | Medium (FIV 26-50) | Optimum* (FIV 51-100) | Excessive (FIV >100) |
| | pounds $P_2O_5$/acre | | | |
| Broadcast or incorporated up to 2 inches | 90 - 175 | 45 - 90 | 0 - 90 | 0 |
| Incorporated over a 2 inch depth | 130 - 220 | 45 - 90 | 0 - 90 | 0 |

* In cool weather, seedbed applications of P may prove beneficial despite soil test results that indicate "optimum" soil phosphorus.

**Table 2. Potassium Recommendations for Turfgrass Seeding, Based on Soil Test Results**

| | Soil Test Potassium Category | | | |
|---|---|---|---|---|
| | Low (FIV 0-25) | Medium (FIV 26-50) | Optimum* (FIV 51-100) | Excessive (FIV >100) |
| | pounds $K_2O$/acre | | | |
| Broadcast or incorporated up to 2 inches | 90 - 175 | 45 - 90 | 0 - 90 | 0 |
| Incorporated over a 2 inch depth | 130 - 220 | 45 - 90 | 0 - 90 | 0 |

**Nitrogen Applications**

Nitrogen has a dramatic impact on root, shoot, rhizome, and stolon growth rates of turfgrass plants. Adequate N is essential in maintaining a dense turfgrass stand that minimizes soil erosion, increases water infiltration, competes against weed encroachment, and recovers from physical or biological damage. However, excessive N may reduce disease resistance and drought tolerance, and could potentially leach if the amounts applied exceed the amount utilized by the turfgrass plant.

A wide range of N-containing fertilizers are available. These fertilizers generally fall into one of two broad categories; 1) fertilizers that contain only soluble, quickly available N, and 2) fertilizers that contain some N in a slowly available form which is not immediately available for plant use. Quickly available N-fertilizers contain $NO_3$-N or $NH_4$-N which are soluble and readily available for uptake by turfgrass plants. Turfgrass uptake may occur within a few days with $NO_3$-N fertilizer. Nitrogen uptake may begin within 7 – 10 days with $NH_4$-N fertilizers, as $NH_4$-N is converted to $NO_3$-N in the soil. Nitrogen uptake by turfgrass roots is predominately in the $NO_3$ form.

Leaching and runoff potential are much higher for $NO_3$-N. Thus, where conditions exist that are conducive to leaching or runoff, fertilizers that contain significant amounts of $NO_3$-N shall not be used. These conditions include sandy sites (sands and loamy sands) with high water tables, and sites that are highly sloped. Also, fertilizer is applied to the seedbed prior to seed germination and turfgrass growth. Thus, fertilizer containing soluble $NH_4$-N is preferable to $NO_3$-N. Fertilizers high in $NO_3$-N include $NH_4NO_3$, potassium $NO_3$, and calcium $NO_3$.

Slow release fertilizers contain significant amounts of N that is not immediately available for plant uptake. Examples of fertilizer sources that contain various amounts of slow release N include; sulfur coated ureas, polymer coated ureas, methylene ureas, ureaformaldehydes, isobutylidenediurea (IBDU), natural organics, and various types of sludge. Slow release fertilizers, while varying considerably in individual characteristics, typically provide more even turfgrass response, provide N over a longer period of time, and are less prone to N leaching and runoff as compared to soluble N fertilizers. The expense of slow release fertilizers makes their widespread use in turfgrass establishment limited. Their use, however, should be considered on the aforementioned sites that are prone to leaching or runoff, or when it is anticipated that follow-up maintenance applications on the site may be missed.

Nitrogen recommendations are not obtained from soil tests; however, extensive research has been conducted to determine rates that are adequate for successful turfgrass culture. Whereas N rates recommended for maintaining turfgrass vary considerably depending on a variety of factors such as turfgrass species, length of growing season, management practices, and use, the N rates recommended for establishing turfgrass from seed are generally uniform. It is recommended that up to 45 lbs. of readily available (soluble) N per acre be applied prior to seeding if fertilizer is broadcast. If fertilizer is incorporated deeper than 2 inches, then up to 90 lbs. readily available N per acre may be applied and incorporated into the soil. If fertilizers are applied containing slow release N (water insoluble N [WIN]), no more should be applied than that which provides the aforementioned rates of readily available N. For example, if a slow release fertilizer contains 50% WIN and the recommended application rate is 45 lbs. N/acre, then no more than 90 lbs. N/acre of this fertilizer should be applied (this would provide 45 lbs. soluble and 45 lbs slow release N.

The slow release N applied to the seedbed should be factored into the first year's maintenance applications of N. Maintenance applications of N should begin after the new turfgrass stand has been mowed at least once. Recommendations for maintenance fertilization of turfgrass can be found in Turfgrass Technical Update #115, "Nutrient Management Guidelines for State Property and Commercially Managed Turfgrass". In addition, organic matter sources such as compost are occasionally incorporated into the seedbed to improve physical characteristics of the soil. These materials contain varying amounts of N and P. The amount of N and P must be determined, and the amount of fertilizer applied reduced by the appropriate amount so that neither the recommended amounts of N and P are not exceeded.

## Soil Reaction

Maintaining soil pH in an optimum range is important for maximizing the efficiency of nutrient use, and can be important in reducing weed and disease problems. Turfgrass can withstand a rather broad range of soil pH, but 5.8 to 6.4 is generally considered ideal. Wide deviations from this range can result in reduced P and micronutrient availability, and can interfere with soil N metabolism and availability. Depending on turfgrass species, problems in turf may start to occur at soil pH above 7.8 and below 5.4 Thus, to maximize efficiency of nutrient availability and use, soil tests should be taken as recommended previously for soil P and K to determine soil pH.

Recommended limestone applications to achieve a soil pH of about 6.4 are shown in Table 3. If diseases such as take-all patch of bentgrass, summer patch of Kentucky bluegrass, or spring dead spot of bermudagrass are of concern, maintaining lower soil pH (5.4 - 5.7) may be desirable, and reduced or no limestone should be applied to achieve this level. Also, it is recommended, when practical, that limestone be applied approximately one month or more before seeding to minimize potential P availability problems and the potential for volatilization loss of applied N.

These recommendations should result in satisfactory establishment in most situations; however, there are many factors that could impact whether modifications of these recommendations are warranted for a specific site.

**Table 3: Limestone Establishment Recommendations (Pounds per Acre)**

| | Coastal Plain | | | | Piedmont & Mountain | |
|---|---|---|---|---|---|---|
| pH | loamy sand | sandy loam | loam | silt loam & silty clay loam | loam | silt loam & silty clay loam |
| 6.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6.3 | 0 | 0 | 0 | 0 | 1090 | 1305 |
| 6.2 | 0 | 0 | 1090 | 1090 | 1525 | 2180 |
| 6.1 | 0 | 1090 | 1305 | 1525 | 1960 | 2830 |
| 6.0 | 870 | 1525 | 1740 | 1960 | 2395 | 3700 |
| 5.9 | 1090 | 1740 | 2180 | 2395 | 2830 | 4355 |
| 5.8 | 1305 | 2180 | 2395 | 2830 | 3485 | 5010 |
| 5.7 | 1525 | 2395 | 2830 | 3265 | 3920 | 5880 |
| 5.6 | 1740 | 2615 | 3265 | 3700 | 4355 | 6535 |
| 5.5 | 1960 | 3050 | 3700 | 4140 | 4790 | 7185 |
| 5.4 | 2180 | 3265 | 4140 | 4355 | 5445 | 7840 |
| 5.3 | 2395 | 3700 | 4355 | 4790 | 5880 | 8710 |
| 5.2 | 2615 | 3920 | 4575 | 5225 | 6315 | 8710 |
| 5.1 | 2830 | 4140 | 5010 | 5665 | 6750 | 8710 |
| 5.0 | 3050 | 4575 | 5445 | 6100 | 7185 | 8710 |
| 4.9 | 3265 | 4790 | 5880 | 6315 | 7625 | 8710 |
| 4.8 | 3485 | 5010 | 6100 | 6750 | 8275 | 8710 |
| 4.7 | 3700 | 5445 | 6535 | 7185 | 8710 | 8710 |
| 4.6 | 3920 | 5665 | 6750 | 7625 | 8710 | 8710 |
| 4.5 | 4140 | 6100 | 7185 | 8060 | 8710 | 8710 |

1) Divide the above rates by 43.5 to obtain the equivalent rates in pounds per 1000 square feet.
2) These rates are for limestone that is tilled into the soil to a 4 to 6 inch depth. Use maintenance rates if not tilled in.
3) Divide the above rates by 2 to obtain maintenance limestone recommendations for turfgrass.
4) Do not apply more than 2,000 pounds per acre for any one maintenance application to turfgrass.

**Dr. Thomas R. Turner, Turfgrass Specialist**
**University of Maryland Department of Natural Resource Sciences & Landscape Architecture**

# Section II-A
## Introduction

# INTRODUCTION

Agricultural operators are required to develop and implement nutrient management plans to prevent and minimize the potential of nutrient impacts to waters of the state. Under COMAR 15.20.08.05E the consultant uses the fertility index value or FIV to make a determination of whether the plan shall use nitrogen or phosphorus as the limiting nutrient. Chapter B in this section, *Determining Fertility Index Value (FIV) from Soil Test Results*, explains how to convert the soil test results from several soil testing laboratories to the fertility index value.

When the FIV is equal to or greater than 150, the consultant shall assess the risk of phosphorus movement. Chapter C in this section, *Phosphorus Site Index for Maryland Agricultural Operations*, provides the factors that shall be evaluated to determine site-specific recommendations for phosphorus management as required under COMAR 15.20.08.05E.

Consultants developing plans for container or out-of-ground agricultural operations shall address the risk of nutrient movement using the *Environmental Risk Assessment for Out-of-Ground Production* in Chapter D. This provides an evaluation tool to determine risk to surface waters as required under COMAR 15.20.08.06D. If risk is determined to be in a medium or high category, management recommendations shall include the use of best management practices to reduce this risk under COMAR 15.20.08.07B. These practices are listed and explained in accordance with what type of management issue they address under Chapter E of this section, *Best Management Practices for Container-Grown Operations*. A consultant and agricultural operator shall select those that are applicable to the site being managed.

# Section II-B

## Converting Among Soil Test Analyses Frequently Used in Maryland

(University of Maryland Cooperative Extension, 2006)

# CONVERTING AMONG SOIL TEST ANALYSES FREQUENTLY USED IN MARYLAND

***Source: University of Maryland Cooperative Extension, August 2006***
***Regulatory Citation: COMAR 15.20.08.05 E***

## What Do Soil Tests Measure?

Soil testing is a useful tool that can help ensure the efficient use of applied plant nutrients. Soil tests provide a means for assessing the fertility status of a soil, but soil tests do not provide a direct measure of the actual quantity of plant available nutrients in the soil. Instead, soil tests measure the quantity of a nutrient element that is extractable from a soil by a particular chemical extracting solution. The measured quantity of extractable nutrient in a soil is then used to predict the crop yield response to application of the nutrient as fertilizer, manure, or other amendment. As soil test levels increase for a particular nutrient, the expected crop yield response to additions of that nutrient decreases.

## Why Are There So Many Different Soil Testing Procedures?

Over the years, many different soil testing procedures and extracting solutions have been evaluated in an effort to identify the method that provides the most reliable prediction of crop yield response to nutrient application. It has been determined that some soil testing procedures are best suited for particular soil types and climatic regions, while other soil testing procedures are better suited for different soil types and climates. Also, we have learned that there are often several alternative soil testing methodologies that generate equally useful predictions of expected crop response for a given region. There are several different soil testing procedures that work well for Maryland soils.

## Why Are There So Many Different Ways to Express Soil Test Results?

The actual numerical soil test values are products of laboratory procedures that determine the concentrations of extractable plant nutrients in the soil. Thus, soil test values are merely arbitrary index numbers, and not measures of the actual quantity of plant available nutrients present in a soil. Historically in Maryland, the numerical soil test values were converted to units of "pounds per acre" of soil test nutrient expressed as a fertilizer equivalent (e.g., $P_2O_5$, $K_2O$). However, pounds per acre of the actual nutrient element (e.g., P, K), concentration of the nutrient element in a given volume of soil (e.g., ppm, $mg/dm^3$), or concentration of the nutrient element in a given weight of soil (e.g., ppm) are all equally valid expressions of soil test results. The numerical soil test values are determined by the units used to express the results.

An alternative method for expressing the relative level of plant available nutrients measured by soil testing uses "fertility index values" or FIV. Soil fertility index values comprise a continuous relative scale that is calculated from the concentration of extractable nutrients measured in the laboratory, where the highest concentration within the "optimum" range is set equal to a FIV of 100. The numerical value of the soil fertility index is not affected by method of soil analysis or the units used to express the soil test results.

## Different Tests Yield Different Results

Different soil testing laboratories use different soil testing procedures. Different soil testing procedures generate different analytical results. Different analytical results may or may not yield different crop nutrient application recommendations. Regardless of the soil testing methods utilized, the analytical results generated must be correlated to crop yield responses under local growing conditions in order to provide reliable nutrient recommendations.

## Who Is In the Soil Testing Business In Maryland?

At one time, soil testing was almost exclusively performed by public (university or state agency) laboratories. The Maryland Cooperative Extension Soil Testing Laboratory provided analyses of farmers' soils from 1954 to 2003. Today, many private-sector soil testing laboratories are providing high-quality soil testing services for our agricultural community. In general, the private-sector laboratories have excellent analytical capabilities and generate reliable analytical results. However, direct application of the analytical results generated by different soil testing laboratories to the crop nutrient recommendations developed by the Maryland Cooperative Extension has been difficult because of the differences in the numerical values and units used in expression of analytical results.

## Converting Among Soil Test Analyses

This publication provides simple factors for converting the analytical results generated by seven regional soil testing laboratories to the FIV scale used by the Maryland Cooperative Extension Soil Testing Laboratory. A list of the seven cooperating regional soil testing laboratories is given in Table 1.

The soil testing conversion factors presented in Table 2 permit the direct application of the crop nutrient recommendations developed in Maryland to soil testing data regardless of how, where, or by whom the soil test was performed.

The conversion indices were intended to be simple and easy to use. The conversions were derived from analysis of 665 Maryland agricultural soils by each of the cooperating regional soil testing laboratories. Conversion of data from the regional soil testing laboratories generates reliable approximations of Maryland soil test FIVs to which the Maryland plant nutrient recommendations may be applied.

Originally prepared by:
Frank J. Coale
Soil Fertility/Nutrient Management Specialist

Revised by:
Joshua McGrath
Soil Fertility/Nutrient Management Specialist

**Table 1.** Participating regional soil testing laboratories, method of soil nutrient extraction used, and instrumentation used to quantify soil nutrient concentrations.

| Laboratory | Address | Nutrient | Extraction Method (extract solution:soil) | Instrumentation |
|---|---|---|---|---|
| A&L [1] | A&L Eastern Agricultural Laboratories<br>7621 Whitepine Rd.<br>Richmond, VA 23237 | P | Mehlich-3 (20 ml:1.7 $cm^3$) | ICP |
| | | K | Mehlich-3 (20 ml:1.7 $cm^3$) | ICP |
| | | Ca | Mehlich-3 (20 ml:1.7 $cm^3$) | ICP |
| | | Mg | Mehlich-3 (20 ml:1.7 $cm^3$) | ICP |
| | | pH | Water (10 ml:8.5 $cm^3$) | Glass Electrode |
| Agri Analysis | Agri Analysis, Inc.<br>P.O. Box 483<br>280 Newport Rd.<br>Leola, PA 17540 | P | Mehlich-3 (20 ml:1.7 $cm^3$) | ICP |
| | | K | Mehlich-3 (20 ml:1.7 $cm^3$) | ICP |
| | | Ca | Mehlich-3 (20 ml:1.7 $cm^3$) | ICP |
| | | Mg | Mehlich-3 (20 ml:1.7 $cm^3$) | ICP |
| | | pH | Water (5 ml:5 $cm^3$) | Glass Electrode |
| Brookside | Brookside Laboratories, Inc.<br>308 East Main St.<br>New Knoxville, OH 45871 | P | Mehlich-3 (20 ml:1.7 $cm^3$) | ICP |
| | | K | Mehlich-3 (20 ml:1.7 $cm^3$) | ICP |
| | | Ca | Mehlich-3 (20 ml:1.7 $cm^3$) | ICP |
| | | Mg | Mehlich-3 (20 ml:1.7 $cm^3$) | ICP |
| | | pH | Water (7 ml:7 $cm^3$) | Glass Electrode |
| Penn State University | Agricultural Analytical Services Laboratory<br>Penn State University<br>University Park, PA 16802 | P | Mehlich-3 (25 ml:2.13 $cm^3$) | IC |
| | | K | Mehlich-3 (25 ml:2.13 $cm^3$) | ICP |
| | | Ca | Mehlich-3 (25 ml:2.13 $cm^3$) | ICP |
| | | Mg | Mehlich-3 (25 ml:2.13 $cm^3$) | ICP |
| | | pH | Water (5 ml:5 g) | Glass Electrode |
| Spectrum Analytic | Spectrum Analytic Inc.<br>P.O. Box 639<br>1087 Jamison Rd.<br>Washington Court House, OH 43160 | P | Mehlich-3 (10 ml:1 $cm^3$) | ICP |
| | | K | Mehlich-3 (10 ml:1 $cm^3$) | ICP |
| | | Ca | Mehlich-3 (10 ml:1 $cm^3$) | ICP |
| | | Mg | Mehlich-3 (10 ml:1 $cm^3$) | ICP |
| | | pH | Water (5 ml:5 $cm^3$) | Glass Electrode |
| University of Delaware [2] | University of Delaware<br>Soil Testing Program<br>149 Townsend Hall<br>University of Delaware<br>Newark, DE 19717-1303 | P | Mehlich-3 (25 ml:2.5 $cm^3$) | ICP |
| | | K | Mehlich-3 (25 ml:2.5 $cm^3$) | ICP |
| | | Ca | Mehlich-3 (25 ml:2.5 $cm^3$) | ICP |
| | | Mg | Mehlich-3 (25 ml:2.5 $cm^3$) | ICP |
| | | pH | Water (10 ml:10 $cm^3$) | Glass Electrode |
| University of Maryland (closed 6/30/03) | University of Maryland<br>Soil Testing Laboratory<br>H.J. Patterson Hall, room 0225<br>College Park, MD 20742 | P | Mehlich-1 (25 ml:5 $cm^3$) | Colorimeter 420nm |
| | | K | Mehlich-1 (25 ml:5 $cm^3$) | Flame Photometer 768nm |
| | | Ca | Mehlich-1 (25 ml:5 $cm^3$) | Flame Photometer 623nm |
| | | Mg | Mehlich-1 (25 ml:5 $cm^3$) | Colorimeter 630nm |
| | | pH | Water (20 ml:20 $cm^3$) | Glass Electrode |
| Waters | Waters Agricultural Laboratories, Inc.<br>257 Newton Highway<br>P.O. Box 382<br>Camille, GA 31730-0382 | P | Mehlich-1 (20 ml:5 $cm^3$) | ICP |
| | | K | Mehlich-1 (20 ml:5 $cm^3$) | ICP |
| | | Ca | Mehlich-1 (20 ml:5 $cm^3$) | ICP |
| | | Mg | Mehlich-1 (20 ml:5 $cm^3$) | ICP |
| | | pH | Water (20 ml:20 $cm^3$) | Glass Electrode |

[1] The use of Bray P1 for P and ammonium acetate for Ca, Mg, and K was discontinued as the standard extraction suite in 9/05.
[2] University of Delaware also uses a 10 ml: 1 $cm^3$ ratio, depending upon the analyses requested.

**Table 2.** Factors for converting from regional soil-testing laboratory report data to Maryland Cooperative Extension Soil Testing Laboratory's fertility index value (FIV) scale.

To determine an equivalent Maryland FIV value for each soil-test nutrient, multiply the regional laboratory reported value, expressed in the units shown, by the value in column A and then add the value in column B.

| | | Soil Test Nutrient | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Phosphorus (P) | | Potassium (K) | | Calcium (Ca) | | Magnesium (Mg) | |
| Regional Soil-Testing Laboratory | Units | A | B | A | B | A | B | A | B |
| A & L (Mehlich 3) | ppm | 1.09 | 2 | 0.65 | 2 | 0.13 | (-27) | 0.76 | 3 |
| A&L (Bray P1 & ammonium acetate K, Ca, and Mg) | ppm | 1.69 | 6 | 0.63 | 0 | 0.13 | (-18) | 0.67 | 21 |
| AgriAnalysis | lbs/a | 0.22[1] | 7 | 0.27 | (-2) | 0.06 | (-21) | 0.23 | 0 |
| Brookside | lb/a | 0.26[2] | 3 | 0.36 | (-3) | 0.07 | (-23) | 0.39 | 12 |
| Brookside | ppm | 1.20[3] | 3 | 0.72 | (-3) | 0.14 | (-22) | 0.79 | 11 |
| Penn State | ppm | 1.11 | 7 | 0.60 | 0 | 0.12 | (-21) | 0.76 | 0 |
| Spectrum | lbs/a | 0.75 | 9 | 0.33 | (-1) | 0.08 | (-16) | 0.43 | 8 |
| Spectrum | ppm | 1.06 | 9 | 0.56 | (-1) | 0.11 | (-16) | 0.75 | 8 |
| U. Delaware | index | 1.01 | 7 | 1.10 | 1 | 1.05 | (-9) | 0.97 | 10 |
| Waters | lbs/a | 1.18 | 4 | 0.38 | (-1) | 0.06 | (-12) | 0.43 | 4 |

[1] For AgriAnalysis, use Phosphate ($P_2O_5$), Potash ($K_2O$), and Magnesium (MgO) values.
[2] For Brookside Laboratories, use Easily Extractable P, lb/a P as $P_2O_5$.
[3] For Brookside Laboratories, use Easily Extractable P, ppm of P.

*Example*: A soil-test report from A & L Laboratories contains the following data:

| | |
|---|---|
| Phosphorus, Bray P1 | 29 ppm |
| Potassium, K | 93 ppm |
| Calcium, Ca | 1210 ppm |
| Magnesium, Mg | 114 ppm |

To determine an equivalent Maryland FIV for each soil-test nutrient:

P, Maryland FIV = (29 * 1.69) + 6 = 55
K, Maryland FIV = (93 * 0.63) + 0 = 59
Ca, Maryland FIV = (1210 * 0.13) – 18 = 139
Mg, Maryland FIV = (114 * 0.67) + 21 = 97

# Section II-C

## Phosphorus Site Index for Maryland

**(University of Maryland Cooperative Extension, 2000)**

# PHOSPHORUS SITE INDEX FOR MARYLAND

***Source: University of Maryland Cooperative Extension, September,2000***
***Regulatory Citation: COMAR 15.20.08.05E***

The nutrient management regulations identify the Phosphorus Site Index (P-index) as the primary tool to be used for evaluating the potential risk for phosphorus movement from agricultural land to state waters. It is used when soil fertility index values are greater than 150 to determine the limiting nutrient and identify required management as delineated by COMAR 15.20.08.04E(3).

## Definition

The Phosphorus Site Index is a tool that can be used to evaluate the potential P soil losses as they relate to certain site characteristics and management practices. This tool provides nutrient management planners and farmers with a method to evaluate their fields and to make management decisions based on the values obtained from the P-index.

## How to Use the P-Index

The P-index evaluates potential P losses in two steps. Part A evaluates potential phosphorus loss due to site and transport characteristics, and Part B evaluates potential phosphorus loss due to management practices.

### Part A: Phosphorus loss potential due to site and transport characteristics

–**Soil Erosion** (estimate tons soil loss /acre/year, using the NRCS Field Office Technical Guide)

–**Soil test P Fertility Index Value** or **FIV** (using the soil test results)

–**Soil Runoff Class**

–**Subsurface Drainage**

–**Leaching Potential** (using the NRCS Field Office Technical Guide)

–**Distance from Edge of Field to Surface water or Drainage** (using the map or site measurement in feet)

–**Priority of Receiving Water**

### Part B: Phosphorus Loss Potential Due to Management Practices

–Soil **Test P**- fertility index value conversion (see "Introconverting Among Soil Test Analyses Frequently Used in Maryland")

–**P Fertilizer Application Rate** (lbs $P_2O_5$/ acre)

–**P Fertilizer Application Method**

–**Organic P Application Rate** (lbs $P_2O_5$/ acre)

–**Organic P Source Application Method**

# PHOSPHORUS SITE INDEX FOR MARYLAND

## Part A: Phosphorus loss potential due to site and transport characteristics

| Characteristic | Phosphorus Loss Rating | | | | | Value |
|---|---|---|---|---|---|---|
| [illegible] | 2 X tons soil loss/acre/year | | | | | |
| [illegible] | Negligible or Very Low 0 | Low 2 | Medium 4 | High 6 | Very High 8 | |
| [illegible] | Very Low 0 | Low 2 | Medium 4 | High 6 | Very High 8 | |
| [illegible] | Low 0 | | Medium 2 | High 4 | | |
| Distance From Edge of Water Channel [illegible] | > 100 feet 0 | < 100 feet AND >50 feet vegetated buffer OR <100 feet AND > 25 feet vegetated buffer AND > 25 feet additional no P application zone 2 | < 100 feet AND > 25 feet vegetated buffer AND < 25 ft additional no P application zone 4 | < 100 feet AND < 25 feet vegetative buffer AND > 25 feet additional no P application zone 6 | < 100 feet AND < 25 feet vegetative buffer AND < 25 ft additional no P application zone 8 | |
| Priority of Receiving Water [illegible] | Category 2 0 | Category 3 1 | Category 3, Selected 2 | Category 1 3 | Category 1, Priority 4 | |

**Sum of Site and Transport Characteristics:** _____

**Scaling Factor:** x 0.02

**Total Site and Transport Value:** _____

## Part B: Phosphorus loss potential due to management practice and source characteristics

| Characteristics | Phosphorus Loss Rating | | | | | Value |
|---|---|---|---|---|---|---|
| Soil Test P Fertility Index Value | 0.2 X FIV | | | | | |
| P Fertilizer Application Rate (lbs $P_2O_5$) | 0.6 X (lbs $P_2O_5$ / acre) | | | | | |
| P Fertilizer Application Method | None applied 0 | Injected/ Banded below surface at least 2" 15 | Incorporated within 5 days of application 30 | Surface applied March through November OR Incorporated more than 5 days after application 45 | Surface applied December through February 60 | |
| Organic P Application Rate (lbs $P_2O_5$) | PAC X (lbs $P_2O_5$ / acre) | | | | | |
| Organic P Application Method | None applied 0 | Injected/banded below surface at least 2" 15 | Incorporated within 5 days of application 30 | Surface applied March through November OR Incorporated more than 5 days after application 45 | Surface applied December through February 60 | |

Total Management and Source Value:_____

# PHOSPHORUS INDEX WORKSHEET

To solve for P loss rating - add all numbers on Part A and all numbers on Part B. Write these numbers on the worksheet. Multiply Part A x Part B. This is your final P loss rating.

Part A: Value:_____

Part B: Value:_____

Multiply A x B = _____ = _____ P Loss Rating

| P Loss Rating | Generalized Interpretation of P Loss Rating |
|---|---|
| 1-50 | **LOW** potential for P movement from this site given current management practices and site characteristics. There is a low probability of an adverse impact to surface waters from P losses from this site. Nitrogen-based nutrient management recommendations are approved for this site. Soil P levels and P loss potential may increase in the future due to N-based nutrient management. |
| 51-75 | **MEDIUM** potential for P movement from this site given current management practices and site characteristics. A nitrogen-based plan may be implemented no more than one year out of three. Phosphorus rates during the other two years shall be limited to the expected amount removed from the field by the crop or plant harvest, or the amount indicated by soil testing in accordance with recommendations described in the Maryland Nutrient Management Manual, whichever is greater. |
| 76-100 | **HIGH** potential for P movement from this site given current management practices and site characteristics. Phosphorus rates shall be limited to *the expected amount removed from the field by the crop or plant harvest*, or the amount indicated by soil testing in accordance with recommendations described in the Maryland Nutrient Management Manual, *whichever is greater*. All practical management practices for reducing P losses by surface runoff, subsurface flow, or erosion shall be implemented. |
| >100 | **VERY HIGH** potential for P movement from this site given current management practices and site characteristics. No phosphorus should be applied to this site. All practical management practices for reducing P losses by surface runoff, subsurface flow, or erosion shall be implemented. |

# TABLE 1: THE SURFACE RUNOFF CLASS

**Table 1**–The Surface Runoff Class site characteristic determined from the relationship of the soil permeability class and field slope. Adapted from the soil survey manual (1993) Table 3-10.

| | Soil Permeability Class* | | | | |
|---|---|---|---|---|---|
| **Slope (%)** | **Very Rapid** | **Moderately Rapid and Rapid** | **Moderately Slow and Moderate** | **Slow** | **Very Slow** |
| **Concave**** | | | | | |
| <1 | | | | | |
| 1-5 | N | M | | | |
| 5-10 | | | | | |
| 10-20 | | | | | |
| >20 | | | | | |

N = Negligible
M = Medium
VL = Very low
L = Low
H = High
VH = Very high

* Permeability class of the least permeable layer within the upper 39 inches (one meter) of the soil profile. Permeability classes for specific soils can be obtained from a published soil survey or from local USDA-NRCS field offices.

Soil permeability Classes in inches per hour (in/hr):
very slow (<0.06 in/hr) slow (0.06 - 0.20 in/hr)
moderately slow (0.20 - 0.60 in/hr) moderate (0.60 - 2.00 in/hr)
moderately rapid (2.00 - 6.00 in/hr)

** Area from which no or very little water escapes by overland flow.

# TABLE 2: SUBSURFACE DRAINAGE POTENTIAL

| Depth to Seasonal High Water Table (feet) | Soil Drainage Class | | | | | | |
|---|---|---|---|---|---|---|---|
| | very poorly drained | poorly drained | somewhat poorly drained | moderately well drained | well-drained soils | somewhat excessively drained | excessively drained |
| 0 - 1 | H | VH | VH | VH | VH | VH | |
| 1 - 3 | M | M | M | M | H | H | H |
| 3 - 6 | L | L | L | L | M | M | M |
| > 6 | | VL | VL | L | L | L | L |
| Artificial Subsurface Drainage (any depth) | H | H | H | H | H | H | H |

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

# TABLE 3: PRIORITY OF RECEIVING WATERS– MARYLAND STATE WATERSHEDS

**Very Low (0)**

| | |
|---|---|
| 02130101 | Atlantic Ocean |
| 02130607 | Christina River |

**Low (1)**

| | |
|---|---|
| 02050301 | Conewago Creek |
| 02130402 | Little Choptank |
| 02130501 | Eastern Bay |
| 02130504 | Kent Narrows |
| 02130605 | Little Elk Creek |
| 02131106 | Middle Patuxent River |
| 02130104 | Sinepuxent Bay |
| 02130403 | Lower Choptank |
| 02130502 | Miles River |
| 02130505 | Lower Chester River |
| 02130705 | Aberdeen Proving Ground |
| 02140301 | Potomac River FR County |

**Medium (2)**

| | |
|---|---|
| 02120203 | Octoraro Creek |
| 02130106 | Chincoteague Bay |
| 02130204 | Diving Creek |
| 02130206 | Tangier Sound |
| 02130302 | Monie Bay |
| 02130306 | Marshyhope Creek |
| 02130401 | Honga River |
| 02130508 | Southeast Creek |
| 02130601 | Lower Elk River |
| 02130606 | Big Elk Creek |
| 02130702 | Lower Winters Run |
| 02130801 | Gunpowder River |
| 02130804 | Little Gunpowder Falls |
| 02130906 | Patapsco River LN |
| 02131001 | Magothy River |
| 02131005 | West Chesapeake Bay |
| 02131108 | Brighton Dam |
| 02140105 | St.Clements Bay |
| 02140108 | Zekiah Swamp |
| 02140202 | Potomac River MO County |
| 02140501 | Potomac River WA County |
| 02140505 | Little Conococheague |
| 02140508 | Potomac River AL County |
| 02141003 | Wills Creek |
| 02120205 | Broad Creek |
| 02130201 | Pocomoke Sound |
| 02130205 | Nassawango Creek |
| 02130207 | Big Annemessex River |
| 02130303 | Wicomico Creek |
| 02130307 | Fishing Bay |
| 02130404 | Upper Choptank |

# TABLE 3: PRIORITY OF RECEIVING WATERS– MARYLAND STATE WATERSHEDS

**Medium (2) ...continued**

| | |
|---|---|
| 02130510 | Upper Chester River |
| 02130602 | Bohemia River |
| 02130609 | Furnace Bay |
| 02130703 | Atkisson Reservoir |
| 02130802 | Lower Gunpowder Falls |
| 02130805 | Loch Raven Reservoir |
| 02130908 | S. Branch Patapsco |
| 02131004 | West River |
| 02131107 | Rocky Gorge Dam |
| 02140101 | Potomac River Lower Tidal |
| 02140106 | Wicomico River |
| 02140201 | Potomac River Upper Tidal |
| 02140304 | Double Pipe Creek |
| 02140503 | Marsh Run |
| 02140506 | Licking Creek |
| 02140509 | Little Tonoloway Creek |
| 05020202 | Little Youghiogheny River |

**High (4)**

| | |
|---|---|
| 02130102 | Assawoman Bay |
| 02130105 | Newport Bay |
| 02130208 | Manokin River |
| 02130304 | Wicomico River Headwaters |
| 02130405 | Tuckahoe River |
| 02130507 | Corsica River |
| 02130511 | Kent Island Bay |
| 02130610 | Sassafras River |
| 02130701 | Bush River |
| 02130706 | Swan Creek |
| 02130807 | Middle River-Browns Creek |
| 02130902 | Bodkin Creek |
| 02130904 | Jones Falls |
| 02131003 | South River |
| 02131103 | Western Branch |
| 02131105 | Little Patuxent River |
| 02140203 | Piscataway Creek |
| 02140205 | Anacostia River |
| 02140207 | Cabin John Creek |
| 02140305 | Catoctin Creek |
| 05020203 | Deep Creek Lake |
| 02130103 | Isle of Wight Bay |
| 02130203 | Upper Pocomoke River |
| 02130301 | Lower Wicomico River |
| 02130308 | Transquaking River |
| 02130506 | Langford Creek |
| 02130509 | Middle Chester River |
| 02130604 | Back Creek |
| 02130611 | Stillpond-Fairlee |

# TABLE 3: PRIORITY OF RECEIVING WATERS– MARYLAND STATE WATERSHEDS

**High (4) ...continued**

| | |
|---|---|
| 02130704 | Bynum Run |
| 02130803 | Bird River |
| 02130901 | Back River |
| 02130903 | Baltimore Harbor |
| 02131002 | Severn River |
| 02131102 | Patuxent River Middle tidal |
| 02131104 | Patuxent River upper |
| 02140104 | Breton Bay |
| 02140204 | Oxon Creek |
| 02140206 | Rock Creek |
| 02140208 | Seneca Creek |
| 02140504 | Conococheague Creek |

**Very High (8)**

| | |
|---|---|
| 02120201 | Lower Susquehana River |
| 02120204 | Conowingo Dam Susq.Run |
| 02130305 | Nanticoke River |
| 02130603 | Upper Elk River |
| 02130806 | Prettyboy Reservoir |
| 02130907 | Liberty Reservoir |
| 02140102 | Potomac River Middle tidal |
| 02140107 | Gilbert Swamp |
| 02140110 | Nanjemoy Creek |
| 02140302 | Lower Monocacy River |
| 02140502 | Antietam Creek |
| 02140510 | Sideling Hill Creek |
| 02140512 | Town Creek |
| 02141002 | Evitts Creek |
| 02141005 | Potomac River Upper N.Br. |
| 05020201 | Youghiogheny River |
| 02120202 | Deer Creek |
| 02130202 | Lower Pocomoke River |
| 02130503 | Wye River |
| 02130608 | Northeast River |
| 02130905 | Gwynns Falls |
| 02131101 | Patuxent River Lower tidal |
| 02140103 | St.Mary's River |
| 02140109 | Port Tobacco River |
| 02140111 | Mattawoman Creek |
| 02140303 | Upper Monocacy River |
| 02140507 | Tonoloway Creek |
| 02140511 | Fifteen Mile Creek |
| 02141001 | Potomac River Lower N.Br. |
| 02141004 | Georges Creek |
| 02141006 | Savage River |
| 05020204 | Casselman River |

# ATTACHMENT 1: REVISED UNIVERSAL SOIL LOSS EQUATION (RUSLE)

***Source: USDA Natural Resources Conservation Service, 1995***

The Revised Universal Soil Loss Equation (RUSLE) is a soil erosion-prediction tool that identifies the factors that are a part of the interaction of rain and soil. While similar to the Universal Soil Loss Equation (USLE), RUSLE adds more specifics to the factors of the equation. These factors are quantified as the equation: **A=RKLSCP**

**A**, the predicted soil loss, is the product of:

| | |
|---|---|
| **R**=rainfall erosivity | } Rain-related factor |
| **K**=soil erodibility<br>**L**=slope length<br>**S**=slope gradient or steepness | } Soil-related factors |
| **C**=cover and management<br>**P**=erosion control practices | } Land Management<br>} Factors |

**Rainfall erosivity factor R** represents the driving force for sheet or rill erosion. It takes into consideration total rainfall, intensity and seasonal distribution of the rain. R is generally the same in the two equations, however RUSLE computes a correction to R to reflect, for flat land, the effect of raindrop impact on water ponded on the surface.

**Soil erodibility factor K** indicates a soil's inherent susceptibility to erosion. Two important soil characteristics influencing erodibility are the infiltration capacity of the soil and the soil's structural stability. RUSLE accounts for seasonal changes in the soil such as freezing, thawing, soil moisture, and soil consolidation.

**Topographic factor LS** reflects the influence of length and steepness of slope on soil erosion. RUSLE refines USLE by assigning new equations based on the ratio of rill to interill erosion and accommodates complex slopes.

**Cover and management factor C** is the ratio of soil loss under the conditions in question to that which would occur under continuously bare soil. C uses the subfactors: prior land use, canopy cover, surface cover and roughness, and soil moisture. RUSLE divides each year in the rotation into 15-day intervals, calculating the soil loss ratio for each time period. It also recalculates a new soil-loss ratio every time a tillage operation changes one of the subfactors.

**Support practice factor P** is the ratio of soil loss with a given support practice (generally a best management practice) to the corresponding loss if there were no support practices. P factor values are based on hydrologic soil groups, slope, row grade, ridge height, and the 10-year single storm erosion index value. RUSLE computes the effect of strip cropping based on the transport capacity of flow in dense strips relative to the amount of sediment reaching the strip. The P factor for conservation planning considers the amount and location of deposition.

# Section II-D

## Environmental Risk Assessment for Out-of-Ground Production

**(Maryland Department of Agriculture, 2000)**

Section II-D

# ENVIRONMENTAL RISK ASSESSMENT FOR OUT-OF-GROUND PRODUCTION

***Source: Maryland Department of Agriculture, 2000***
***Regulatory Citation: COMAR15.20.08.06D***

## Environmental Risk Assessment for Out-of-Ground Production

Environmental Risk Assessment for Out-of-Ground production is a tool used to evaluate practices in order to determine the relative risk of a nursery operation to impact water quality. The risk assessment tool was developed to help non-traditional agricultural practices such as container nurseries assess the environmental impacts of irrigation and nutrient runoff.

The Risk Assessment has 2 parts. Part I evaluates stormwater & runoff management. The risk of runoff in an operation is determined by evaluating water management practices, vegetative cover & management, or methods to capture the used water. Growing areas with containment basins are evaluated separately from those without containment basins. Vegetative cover, growing surface, and containment of water are also used to determine the risk factor by field or management unit.

### Part I: Stormwater and Runoff Management

| | Zero Risk | Low Risk | Medium Risk | High Risk |
|---|---|---|---|---|
| | Risk Factor = 0 | Risk Factor = 1 | Risk Factor = 2 | Risk Factor = 4 |
| A. Growing Areas that Drain to Containment Basins | Growing area is covered: precipitation does not contact substrate, AND growing area is on impervious surfaces, AND there is total capture and recycling of water. (1) | Containment basins sized to hold 90% or more of runoff from maximum daily irrigation; AND some recycling of water from basins OR some provision (diking, containment, wetlands, etc.) for overflow of basins. | Containment basins sized to hold 90% or more of runoff from maximum daily irrigation; AND there is no recycling of water from basins; AND there is no provision for the overflow of containment basins. | Containment basins sized to hold less than 90% of runoff from maximum daily irrigation |

| Growing Areas | | Risk Factor |
|---|---|---|
| ID No. | Acres or Square Feet | 0, 1, 2, or 4 |
| ____ | _____ | _____ |
| ____ | _____ | _____ |
| ____ | _____ | _____ |

| | Risk Factor = 0 | Risk Factor = 1 | Risk Factor = 2 | Risk Factor = 4 |
|---|---|---|---|---|
| B. Growing Areas that do not Drain to Containment Basin(s) | Growing area covered; precipitation does not contact substrate; AND growing area is on impervious surfaces; AND there is total capture and recycling of water (1) | Drainage is spread out to sheet flow AND flows through at least 50 feet of vegetation | Drainage is spread out to sheet flow but flows through less than 50 feet of vegetation | Drainage remains channelized to surface water; OR drainage flows through no vegetation |

| Growing Areas | | Risk Factors |
|---|---|---|
| ID No. | Acres or Square Feet | 0, 1, 2, or 4 |
| ____ | _____ | _____ |
| ____ | _____ | _____ |
| ____ | _____ | _____ |

Complete Part II for growing areas with Risk Factors of 2 (medium) or 4 (high).

# ENVIRONMENTAL RISK ASSESSMENT FOR OUT-OF-GROUND PRODUCTION

Source: Maryland Department of Agriculture, 2000
Regulatory Citation: COMAR 15.20.08.06D

## Environmental Risk Assessment for Out-of-Ground Production

If the risk factor for Part I is medium or high, Part II must also be used for the growing area. Part II takes into account the water application (irrigation) methods for that growing area. Part II has low, medium, or high risk determinations depending on the type of irrigation used & size and spacing of the containers.

When a growing area has a high risk determination, management practices should be changed in order to decrease the amount of runoff and improve nutrient management.

## Part II: Water Application (Irrigation) Methods (2) and (3)

Complete this section only for growing areas with Risk Factors of 2 (medium) or 4 (high) in Part I

| Low Risk | Medium Risk | High Risk |
|---|---|---|
| Microirrigation or subirrigation with less than total capture and recycling of water regardless of contain size<br>OR<br>Overhead irrigation applied to jammed or pot-to-pot containers smaller than 1 gallon (<2492cc container volume) | Overhead irrigation applied to jammed (pot-to-pot) containers 1 to 5 gallons (2492 to 20360 cc container volume)<br>OR<br>Overhead irrigation applied to spaced containers small than 5 gallons (<12860 cc container volume | Overhead irrigation applied to spaced 5 gallon containers 12860-20360 cc container volume<br>OR<br>Overhead irrigation applied to container larger than 5 gallons (>20360 cc container volume) regardless of spacing. |

| Growing Areas | | Risk Assessment |
|---|---|---|
| ID No. | Acres or Square Feet | (Low, Medium, or High) |
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |

**Notes:**

(1) Recycled includes application to agricultural crop(s) other than those which produced the runoff.

(2) Water application refers to irrigation intended to reach plant roots. It does not include the use of water to change environmental conditions around the plant canopy, such as frost protection and cooling.

(3) Container sizes refer to container size categories established by American National Standards of Industry ANSI Z60.1-1996.