

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 (SO₄-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 dm³ 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 (ppm).

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	Nitrogen (N) pounds per acre ^{a,d}	N if no P&K recommended ^{a,d}	Recommended Nutrients Based on Soil Tests								Suggested methods of application
			Soil Phosphorus Index				Soil Potassium Index				
			Low	Medium	Optimum	Excessive	Low	Medium	Optimum	Excessive	
P ₂ O ₅ pounds per acre ^{b,e}				K ₂ O pounds per acre ^{c,f}							
Field Corn for Grain^a											
Yield goal 140 bu/A											
A. Conventional Tillage**											
	140	140	65-135*	30-65*	20-30*	0	110-180*	60-110*	20-60*	0	Total
	30	30	35-95	0-25	0	0	80-140	30-70	0-30	0	Broadcast
	30	0	30-40	30-40	20-30	0	30-40	30-40	20-30	0	Banded with planter
	80	110	0	0	0	0	0	0	0	0	Sidedress
B. No tillage**											
1. Alternating No-tillage/Conventional Tillage											
	140	140	65-135*	30-65*	20-30	0	110-180*	60-110*	20-60*	0	Total
	30	30	35-95	0-25	0	0	80-140	30-70	0-30	0	Broadcast
	30	0	30-40	30-40	20-30	0	30-40	30-40	20-30	0	Banded with planter
	80	110	0	0	0	0	0	0	0	0	Sidedress
2. Continuous No-tillage***											
	140	140	75-180*	30-70*	20-30*	0	110-180*	50-110*	20-50*	0	Total
	30	30	45-140	0-35	0	0	50-110	30-80	0-20	0	Broadcast
	30	0	30-40	30-40	20-30	0	30-40	20-30	20-30	0	Banded with planter
	80	110	0	0	0	0	0	0	0	0	Sidedress
Grain sorghum^d											
Yield goal 100 bu/A											
	75	75	65-135*	30-65*	20-30*	0	80-150*	30-80*	20-30*	0	Total
	45	75	35-95	0-25	0	0	50-110	0-40	0	0	Broadcast
	30	30	30-40	30-40	20-30	0	30-40	30-40	20-30	0	Banded with planter

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.

** 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 sample should be collected from the 0-2 inch depth to monitor surface soil acidity (pH only).

A starter fertilizer 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. If FIV-P is 150 or greater a P Site index calculation may prohibit addition of starter P₂O₅. If FIV-P is less than 100, then P₂O₅ may be applied to meet the total recommended. At sidedressing, subtract any starter N fertilizer already applied from the total recommended for the growing season.

^a 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).

A pre-sidedress soil nitrogen test (PSNT) may be useful in determining whether additional nitrogen is needed for corn crops on fields that have received manure or other organic nutrient sources in the past. See University of Maryland Extension Publication SFM-2 for details.

For conventional-tillage or no-tillage corn:

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

Notes for Table 1 continue on page 4.

Table 1. Notes, continued from page 3.

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

- If phosphorus soil test index is less than 51, increase P₂O₅ 0.6 lb / A for each bushel of expected yield above 140 bushels.
- 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.
- If phosphorus soil test index is greater than 100, no adjustment is necessary.

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

- 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.
- 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.
- If potassium soil test index is greater than 100, no adjustment is necessary.

^dGrain 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:

Where N solution (UAN) is the N source, N rate assumes injection or subsurface band placement.

- If UAN is surface broadcast at planting, increase rate by 15-20%.
- If sidedress UAN is dribbled or streamed on the soil surface, increase rate by 5-10%.
- If sidedress N source is granulated urea, increase rate by 25%.

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

- 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.
- 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.
- If phosphorus soil test index is greater than 100, no adjustment is necessary.

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

- 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.
- 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.
- 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	Nitrogen (N) pounds per acre ^{a,b}	N if no P&K recommended ^{a,b}	Recommended Nutrients Based on Soil Tests								Suggested methods of application	
			Soil Phosphorus Level				Soil Potassium Level					
			Low	Med-ium	Opti-mum	Exces-sive	Low	Medium	Opti-mum	Exces-sive		
			P ₂ O ₅ pounds per acre ^c				K ₂ O pounds per acre ^d					
Corn Silage												
Yield goal 20 tons/A	120	120	55-125*	35-55*	20-35*	0	150-250*	80-150*	20-80*	0	Total	
A. Conventional tillage**												
	30	30	30-85	0	0	0	120-210	60-120	0-50	0	Broadcast	
	20	0	25-40	35-55	20-35	0	30-40	20-30	20-30	0	Banded with planter	
	70	90	0	0	0	0	0	0	0	0	Sidedress	
B. No-tillage**												
1. Alternating no-tillage with conventional Tillage												
	120	120	55-125*	35-55*	20-35*	0	150-250*	80-150*	20-80*	0	Total	
	30	30	30-85	0	0	0	120-210	60-120	0-50	0	Broadcast	
	20	0	25-40	35-55	20-35	0	30-40	20-30	20-30	0	Banded with planter	
	70	90	0	0	0	0	0	0	0	0	Sidedress	
2. Continuous no-tillage***												
	120	120	95-165*	35-95*	20-35*	0	150-250*	80-150*	20-80*	0	Total	
	30	30	55-125	0-55	0	0	120-210	60-120	0-50	0	Broadcast	
	20	0	40	35-40	20-35	0	30-40	20-30	20-30	0	Banded with planter	
	70	90	0	0	0	0	0	0	0	0	Sidedress	

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.
- ** 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).

A starter fertilizer 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. If FIV-P is 150 or greater a P Site index calculation may prohibit addition of starter P₂O₅. If FIV-P is less than 100, then P₂O₅ may be applied to meet the total recommended. At sidedressing, subtract any starter N fertilizer already applied from the total recommended for the growing season.

^a Nitrogen recommendations assume split applications (sidedress or fertigation).

No-tillage corn silage:

Where N solution (UAN) is the N source, N rate assumes injection.

- If sidedress UAN is broadcast after planting using drop nozzles, increase rate by 15%.
- If sidedress UAN is dribbled after planting, increase rate by 5-10%.
- If sidedress N source is granulated urea, increase rate by 25%.

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

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

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

- 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.
- 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.
- If phosphorus soil test index is greater than 100, no adjustment is necessary.

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

- 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.
- 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	Nitrogen (N) pounds per acre ^a	Recommended Nutrients Based on Soil Tests								Suggested methods of application
		Soil Phosphorus Level				Soil Potassium Level				
		Low	Med-ium	Opti-mum	Exces-sive	Low	Med-ium	Opti-mum	Exces-sive	
		P ₂ O ₅ pounds per acre ^{b,d}				K ₂ O pounds per acre ^{c,e}				
Wheat, Barley (fall) Yield goal 100 bu/acre	0-30**	100-140*	80-100*	20-80*	0	100-140*	80-100*	20-80*	0	Broadcast at planting Topdress half at greenup*** and half at Feeke's growth stage 5-6
Wheat, Barley (spring)	100	0	0	0	0	0	0	0	0	
Wheat, Barley - Double Crop Soybeans (fall) Yiled goal 100 bu/A	0-30**	70-165*	45-100*	20-85*	0	75-155*	35-105*	20-85*	0	Broadcast at planting Topdress half at greenup*** and half at Feeke's growth stage 5-6
Wheat, Barley - Double Crop Soybeans (spring)	100	70-100*	40	0	0	70-100*	50	0	0	
Rye, Winter Oats (fall) Rye yield goal 60 bu/A Oats yield goal 70 bu/A	0-30	60-100*	40-60*	20-40*	0	60	100	40-60*	20-40	Broadcast and disk in or drill with seed Topdress at greenup
Rye, Winter Oats (spring)	70-80	0	0	0	0	0	0	0	0	
Rye, Winter Oats - Double Crop Soybeans (fall) Yield goal 100 bu/A	0-30**	70-165*	45-100*	20-85*	0	75-155*	35-105*	20-85*	0	Broadcast or drill in fall
Rye, Winter Oats - Double Crop Soybeans (spring)	70-80	70-100*	40	0	0	70-100*	40	0	0	Topdress at greenup
Spring Oats Yield goal 60-65 bu/A	30-60	60-100*	40-60*	20-40*	0	60-100*	40-60*	20-40*	0	Broadcast and disk in or drill with seed
Small Grain - Legume Interseeded	20-40	75-125*	50-75*	20-50*	0	75-120*	45-75	20-45*	0	Total Broadcast or drill in fall Topdress
	0-20	75-125*	50-75*	20-50*	0	75-120*	45-75*	20-45*	0	
	0-20	0	0	0	0	0	0	0	0	

TABLE 3. NOTES

For small grains: Total nitrogen application rate is 1 lb N per bushel of expected yield.

- * 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.
 - ** Fall nitrogen rate depends upon residual soil nitrate concentration. Nitrogen may not be applied in fall if soil nitrate test is greater than 10 ppm for wheat or greater than 15 ppm for barley. Soil nitrate tests shall be based on sampling to a depth of 8 inches. Organic nutrients, including manure, may be fall-applied in accordance with the Maryland Nutrient Management Manual, Section I-D-1, Section III.C.2.
 - *** Topdress half at 1200 Growing Degree Units (GDU) base 32°F, but no earlier than February 15, and half at Feekes growth stage 5-6 (or 1350 GDD₃₂)
- ^aFor all small grains production systems (conventional-tillage or no-tillage):
- If topdress N solution (UAN) is surface broadcast, increase rate by 15-20%.
 - If topdress UAN is dribbled or streamed on the soil surface, increase rate by 5-10%.
 - If topdress N source is granulated urea, increase rate by 25%.

^bFor wheat & barley yield goals above 100 bu/acre, adjust P₂O₅ as follows:

- If phosphorus soil test index is less than 51, increase P₂O₅ by 1 lb/acre for each bushel of expected yield above 100 bu/acre.
- If phosphorus soil test index is between 51 and 100, increase P₂O₅ by 0.5 lb/acre for each bushel of expected yield above 100 bu/acre.
- If phosphorus soil test index is greater than 100, no adjustment is necessary.

^cFor wheat & barley yield goals above 100 bu/acre, adjust K₂O as follows:

- If potassium soil test index is less than 51, increase K₂O by 1 lb K₂O/acre for each bushel of expected yield above 100 bu/acre.
- If potassium soil test index is between 51 and 100, increase K₂O by 0.5 lb K₂O/acre for each bushel of expected yield above 100 bu/acre.
- If potassium soil test index is greater than 100, no adjustment is necessary.

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

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

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

- If potassium soil test index is less than 51, add 3 lb/acre K₂O for every bushel of expected double-crop soybean yield over 40 bu/acre.
- If potassium soil test index is between 51 and 100, add 1.5 lb/A K₂O for every bushel of expected double-crop soybean yield over 40 bu/acre.
- 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	Nitrogen (N) pounds per acre	Recommended Nutrients Based on Soil Tests								Suggested methods of application
		Soil Phosphorus Level				Soil Potassium Level				
		Low	Med-ium	Opti-mum	Exces sive	Low	Med-ium	Opti-mum	Exces sive	
		P ₂ O ₅ pounds per acre ^{a,c}				K ₂ O pounds per acre ^{b,d}				
Soybean (full season)^{***} (40 bu / A yield goal)	0**	80-120*	45-80*	20-45*	0	80-125*	40-80*	20-40*	0	Broadcast or banded at planting
Canola	70-100*	60-80*	40-60*	20-40*	0	60-80*	40-60*	20-40*	0	Total
	20-40*	60-80*	40-60*	20-40*	0	60-80*	40-60*	20-40*	0	Broadcast
	50-60	0	0	0	0	0	0	0	0	Topdress
Sunflower^e (0.5 ton seed / A yield goal)	50	30	20	0	0	30	20	0	0	Broadcast at planting

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.

** Nitrogen is not needed for soybean production; however, in order to meet crop needs for phosphorous, organic nutrients, including manure, may be applied at up to 50 lb N/acre. The rate may not exceed any phosphorous rate limits imposed by phosphorous site index calculation when FIV-P is 150 or greater.

*** Apply organic nutrients to small grain/double-crop soybean rotations at rates and timings to supply only the recommended nitrogen rate to the small grain crop.

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

- If phosphorus soil test index is less than 51, increase P₂O₅ by 1.5 lb/A for each additional bushel of expected yield over 40 bu/A.
- 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.
- If phosphorus soil test index is greater than 100, no adjustment is necessary.

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

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

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

- 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.
- 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.
- If phosphorus soil test index is greater than 100, no adjustment is necessary.

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

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

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

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

TABLE 5. 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				Soil Test Potassium Category			
			Low	Medium	Optimum	Excessive	Low	Medium	Optimum	Excessive
		lbs N / A	lbs P205 / A				lbs K20 / A			
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 **	Broadcast and disk in	40-60	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
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) lbs N / A	Recommended Nutrients Based on Soil Tests							
			Soil Test Phosphorus Category				Soil Test Potassium Category			
			Low	Medium	Optimum	Excessive	Low	Medium	Optimum	Excessive
ALFALFA & ALFALFA-GRASS MIX (more than 25% alfalfa)			lbs P205 / A				lbs K20 / A			
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)			lbs P205 / A				lbs K20 / A			
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)	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
Yield goal: 4 tons / A	Topdress in late summer	40-50	30-70	0	0	0	50-100	0-50	0	0
FESCUE (less than 25% legumes).	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
Yield goal: 5 tons / A	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 in late April to early May	50	0	0	0	0	0	0	0	0
	Topdress in late May or early June	50	0	0	0	0	0	0	0	0
WARM SEASON PERENNIAL GRASSES** (except Eastern Gammagrass and improved Bermudagrasses)	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
Yield goal: 4 tons / A	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				Soil Test Potassium Category			
			Low	Medium	Optimum	Excessive	Low	Medium	Optimum	Excessive
		lbs N / A	lbs P2O5 / A				lbs K2O / 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 test 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 and Yield Goals for Maryland-Type Tobacco

Crop	Nitrogen (N) pounds per acre	Recommended Nutrients Based on Soil Tests								Suggested methods of application
		Soil Phosphorus Level				Soil Potassium Level				
		Low	Mediu m	Optim um	Excess ive	Low	Mediu m	Optimu m	Exces sive	
		P ₂ O ₅ pounds per acre				K ₂ O pounds per acre				
Maryland-Type Tobacco	60-90	120	80	40	40	200	160	120	120	Total
	40	120	80	40	40	130	100	80	80	Broadcast
	20-50	0	0	0	0	70	60	40	40	Sidedress

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.

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

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

Crop	Nitrogen (N) pounds per acre	Recommended Nutrients Based on Soil Tests								Suggested methods of application
		Soil Phosphorus Level				Soil Potassium Level				
		Low	Medium	Optimum	Excessive	Low	Medium	Optimum	Excessive	
		P ₂ O ₅ pounds per acre				K ₂ O pounds per acre				
Cotton	50-75	80-120	40-80	30-40	0	80-120	40-80	30-40	0	Total Broadcast pre-plant Banded with planter Sidedress
	0	50-80	10-40	0	0	50-80	10-40	0	0	
	20-25	30-40	30-40	30-40	0	30-40	30-40	30-40	0	
	30-50	0	0	0	0	0	0	0	0	

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.

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	If less than 0.7 ppm B	1 pound/A boron plowed down
	Alfalfa	If less than 0.8 ppm B If 0.8-1.2 ppm B If greater than 1.2 ppm B	3 pounds/A boron topdressed or with fertilizer 2 pounds/A boron topdressed or with fertilizer 1 pound/A boron topdressed or with fertilizer
	Red Clover, Ladino Clover	If less than 0.8 ppm B	2 pounds/A boron topdressed or with fertilizer
Zinc (Zn)	Corn	If pH less than 6.8 and P soil test test index less than 100 and soil test zinc less than 0.8 ppm	4 pounds/A zinc in band or 10-12 pounds/A zinc broadcast
Manganese (Mn)	Corn, Soybeans, Small Grains	If less than 10 ppm Mn	6 pounds/A manganese in row or 0.5-1.0 pounds/A manganese, foliar spray @20 gal/A, make two foliar applications two weeks apart
Sulfur (S)	Corn, Soybean, Small Grain, Alfalfa, Cotton	For sand and sandy loam soil: If SO ₄ -S less than 6 ppm in 0-8 inch depth and SO ₄ -S less than 20 ppm in 16-24 inch depth	20 pounds/A SO ₄ -S
		For all other soils: If less than 6 ppm SO ₄ -S	20 pounds/A SO ₄ -S
Copper (Cu)	All Crops	If less than 0.3 ppm Cu and Organic matter less than 3.8% or Organic matter 3.8-5.0% or Organic matter 5.0-10% or Organic matter greater than 10%	2 pounds/A copper 4 pounds/A copper 5 pounds/A copper 6 pounds/A copper