ES00-049

AGR-1

UK COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY—COLLEGE OF AGRICULTURE

2002-2003
Lime and Nutrient Recommendations

Contents

2002-2003 Lime and Nutrient Recommendations

Basis of Nutrient Recommendations

Additions of a recommended nutrient are based on a soil test only when a crop yield or economic response has been measured for that crop under Kentucky soil-climatic conditions. Many field studies have been conducted by the Kentucky Agricultural Experiment Station under Kentucky farm conditions to determine the extent of any primary, secondary, or micronutrient needs. Yield and soil test data from these studies serve as guidelines for establishing recommendations contained in this publication.

Nutrient recommendations in this publication are based on soil test values obtained using testing methods in the laboratories operated as part of the Kentucky Agricultural Experiment Station. This laboratory uses the Mehlich III solution to extract phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and zinc (Zn). Water pH is determined in a 1:1 (v/v) ratio of deionized water:soil, and buffer pH is determined by a modification of the SMP (Shoemaker, McLean, and Pratt) method. These methods are described in Bulletin 190 of the Southern Cooperative Series (November 1984), *Procedures Used by the State Soil Testing Laboratories in the Southern Region of the United States*. The nutrient recommendations in this publication should not be used for soil test results obtained by other testing methods.

The recommendations are based on assumed average climatic and management conditions for Kentucky. Rates should be adjusted upward or downward to reflect any deviations from these assumptions.

The rates recommended are for production of a crop to be grown each year and will increase soil test values slowly for P and K. Using these recommended rates would likely take four years or longer of annual nutrient application at the recommended rates to result in appreciably higher soil test levels of P and K.

CEC and Percent Base Saturation

Values for cation exchange capacity (CEC) and percent base saturation (% BS) are reported for all soil samples analyzed routinely in the University of Kentucky Soil Testing Laboratories. The CEC is an estimate that is calculated according to accepted practices, with a modification to better reflect specific Kentucky conditions.

Reported values for CEC include an estimation of acidity (expressed as hydrogen, H) reflected by the buffer pH measurement and extractable calcium (Ca), magnesium (Mg), and potassium (K) by the Mehlich III extracting. The total CEC is the sum of milliequivalents per 100 grams of soil (me./100 g) of the following cations: H, Ca, Mg, and K. Values for % BS are the sum of the me./100 g of the basic cations (Ca, Mg, and K) expressed as a percentage of the total CEC. The dominant cation in most Kentucky soils with pH above 5.8 is calcium (Ca), and below pH level 5.8 is hydrogen (H). Rarely does the amount of magnesium (Mg) or potassium (K) greatly affect CEC estimation or % BS. The measurements for Ca and H are the dominant values for estimating both CEC and % BS.

While CEC is not used directly in making nutrient recommendations for agronomic crops, this information does affect lime recommendations. The buffer pH is directly related to the acidity or H fraction of the CEC. Values for % BS are good indicators of the relative presence of the basic cations in the soil. Soils with a 70% BS or greater are unlikely to limit agronomic crop growth due to acidity. Agronomic crop yields on soils with a % BS below 50 can be affected by excessive acidity. Other Extension publications or your county Cooperative Extension Service agent should be consulted for soil pH of specific horticultural or agronomic crops for optimal growth and yield.

Sample Accuracy

It is important that the submitted soil sample accurately represent the field or area from which it was taken, in order to get reliable recommendations. Analytical results provided on the soil test report form are for the sample submitted, and the listed recommendations are based on those results. All recommendations are made on the assumption that a representative soil sample was properly taken. If soil sampling procedures are questionable, accurate nutrient and lime recommendations for the sampled field or area cannot be assured.

Sampling Depth and Frequency

For tilled areas, take soil cores to a depth of 6 to 7 inches. With pastures, lawns, no-tilled areas, and turf, take soil cores to a depth of 3 to 4 inches. Each production field should be sampled every three to four years. Annual sampling is preferable for high-value crops, alfalfa, and double-crop silage. Sampling each year after manure application is recommended. See Cooperative Extension Service publication *Taking Soil Test Samples* (AGR-16) for details.

Plant Analysis

A plant analysis may be used to verify a suspected nutrient problem or to evaluate the nutrient status of a crop. Plant analysis is not a substitute for a soil test but should be used along with a soil test. Your county Extension agent has information on plant analysis services available for various crops.

Fertilizer Banding

If soil tests for phosphorus and potassium are low, one-third to one-half the amount recommended for corn can be used if it is banded 2 to 4 inches from the row.

Secondary Nutrients and Micronutrients

Magnesium

Magnesium levels in soils range from very high (in loess-derived soils) to low (some sandstone-derived soils). Only limited crop yield responses have been observed for magnesium fertilization. It is sufficiently important in some areas and in determining CEC that a soil test be offered. Magnesium needs for animals can best be met by direct feeding in the ration rather than through high application rates to soil. Table 3 shows soil test levels and recommended rates for magnesium.

Table 3. Recommendations for magnesium.

Soil Test Level	Lb Mg/A*	Oz Mg/100 Sq Ft**
0 - 6	50	2
7 - 18	45	2
19 - 30	40	2
31 - 42	35	1
43 - 54	30	1
55 - 60	25	1
Above 60	0	0

* These rates may be applied when no lime is needed or where dolomitic lime is not available. When lime is needed, the addition of dolomitic lime is preferred.

** Epsom salts ($MgSO_4.7H_2O$, 10% Mg) is readily available and may be more convenient for applying Mg to small areas.

Iron, Copper, Sulfur, Boron, and Molybdenum

We have neither measured any response to nor observed indications of needs for additional iron, copper, or sulfur. Yield responses to boron and molybdenum have been observed for certain crops under certain conditions. Boron is recommended for topdressing on alfalfa. Consult the sections on tobacco, soybean, alfalfa, and pasture renovation with legumes for molybdenum recommendations.

Zinc and Manganese

Yield responses to zinc applications on corn and to foliar applications of manganese on soybean have been observed in Kentucky. The responses to manganese on soybean have been on a few soils in Daviess, McLean, and Webster counties. After diagnosis of manganese deficiency, responses to foliar applications have been superior to soil-applied manganese at planting. To date, soil testing has not been advantageous in solving any isolated cases in Kentucky soils.

Zinc deficiency in corn is significant in Central and South-Central Kentucky. A soil test for zinc is performed routinely on all samples submitted to the UK Soil Testing Lab. The zinc test results and soil test results for P and soil pH are used in identifying soils that need zinc applications.

Nutrients Removed by Agronomic Crops

Good nutrient management involves effective use of applied nutrients at rates utilized by crops. As a basis to assess long-term soil fertility trends, some may use crop nutrient removal while others may use crop uptake. Crop nutrient removal is the quantity of nutrients removed from a field in the harvested portion of the crop. This should not be confused with crop nutrient uptake values, which are the total amount of nutrients taken up by the entire crop (roots, stems, leaves, and seed) in a field. For quick reference, Table 4 includes crop nutrient removal values, published in Extension publication *Assessment of the Potential for Livestock and Poultry Manure to Provide the Nutrients Removed by Crops and Forages in Kentucky* (IP-56) and in "NRCS Nutrient Management Standard Code 590."

Table 4. Crop nutrient removal values.

Crop	Yield Unit	Nutrients Removed N	P_2O_5	K_2O
from IP-56:		lb/yield unit		
Alfalfa hay	ton	50.00	14.000	55.000
Grass/legume hay	ton	35.00	12.000	53.000
Pasture forage	ton	10.50	3.600	15.900
Corn for grain	bu	0.70	0.400	0.350
Silage corn	ton	7.50	3.500	8.000
Wheat grain	bu	1.20	0.500	0.300
Sorghum grain	bu	0.95	0.410	0.300
Soybean grain	bu	3.00	0.700	1.100
Burley tobacco	lb	0.07	0.011	0.075
Dark air tobacco	lb	0.07	0.006	0.060
Dark fired tobacco	lb	0.07	0.006	0.060
Barley grain	bu	0.90	0.410	0.300
from NRCS Code 590:		lb/yield unit		
Rye grain	bu	1.16	0.330	0.320
Oats grain	bu	0.62	0.250	0.190
Bermuda grass hay	ton	37.60	8.700	33.600
Reed canary hay	ton	27.00	8.200	25.000
Eastern gamma hay	ton	35.00	16.100	31.200
Other warm-season hay	ton	20.00	6.800	25.000

Soil Buffer Test

The pH of the soil is a measurement made from a mixture of soil and water and is reported for all samples. The soil buffer test is performed and used to determine lime requirement of samples with a soil pH of 6.4 or below. In the soil buffer test, a buffer solution is mixed with soil, and the pH of the mixed solution is measured. The result from the buffer test is reported as buffer pH. The buffer pH and the soil pH together can be used to determine lime requirement for changing soil pH to some desired level. Buffer pH is not the same as soil pH.

To determine how much lime is required to raise soil-water pH, refer to the table with your target pH in the heading. Tables

Tobacco

Lime

Limestone should be applied in the fall and thoroughly mixed with the soil one to two years ahead of the crop. If applied in the spring before transplanting, or if more than 4 T/A are applied, plow one-half down and disc in the other half for soils with water pH below 6.0.

Rates—Refer to page 6 and use the appropriate amount for a target pH of 6.6.

Nitrogen

Rates—Nitrogen fertilization rates (see Table 8) depend primarily on the field cropping history. Because losses of fertilizer nitrogen can occur on sandy soils or soils with poor drainage, it is helpful to split nitrogen applications on these soils, applying one-third of the nitrogen before transplanting and the remaining nitrogen two or three weeks after transplanting. See page 4 for soil drainage classes. In years of excessive rainfall, an additional application may be sidedressed.

Table 8. Past cropping history as related to residual N in soil.

	Lb N/A Burley and Dark
Low N levels: problem soils as mentioned above, or first-year tobacco following a poor sod crop	250 - 300
Medium N levels: first-year tobacco following a good grass or grass-legume sod	200 - 250
High N levels: first-year tobacco following good legume sod or legume cover crop	150 - 200

For second- and third-year tobacco following tobacco, consider the type of last sod crop on the field and apply the amount shown in the table above plus an additional 50 lb N/A.

Sources—All commonly available N sources can be used satisfactorily on tobacco, particularly on well-drained soils where a good liming program is followed and soil pH is maintained in the range of 6.0 to 6.6. If soil pH is moderately to strongly acid (pH 6.0 or less) and no lime is applied, using a nonacid-forming source of N (sodium nitrate, calcium nitrate, or sodium-potassium nitrate) will lower the risk of manganese toxicity. Use these sources (or ammonium nitrate or potassium nitrate) for sidedressing, because nitrate is more mobile in soil than ammonium nitrogen. If tobacco is grown on sandy soils or soils that tend to waterlog regardless of pH, using ammonium sources (urea, ammoniumnitrate, ammoniated phosphates, ammonium sulfate, nitrogen solutions) will lower the risk of leaching and denitrification losses.

Time and Method—Currently most nitrogen fertilizer on well-drained soils is applied broadcast up to four weeks before transplanting, with some sidedressed four to five weeks after transplanting. Because Kentucky usually has large rainfall amounts during April and May, applying the broadcast nitrogen as near to transplanting (10 days to two weeks before) as possible will significantly lessen the chances for losses of applied nitrogen. Apply the nitrogen after plowing and disc into the surface soil.

Further efficiencies in nitrogen use, decreased manganese toxicity, and increased early growth can be obtained by banding most of the nitrogen (sidedress) after transplanting. These bands should be applied 10 to 12 inches to the side of the row in either one or two bands and at depths of 4 to 5 inches. The nitrogen should be banded all at 0 to 10 days after transplanting or in two applications, two-thirds at 0 to 10 days and one-third at four or five weeks after transplanting.

Phosphate and Potash

Rates—Phosphorus and potassium fertilizer additions should be determined by soil testing. Based on soil test results, apply the recommended amounts indicated in the tables in the "Tobacco" section. Research indicates that when soil test potassium is below 225 lb per acre, a broadcast application of potassium fertilizer is more effective than banding.

Sources—Research at the University of Kentucky has shown that applications after January 1 of chloride-containing nutrient sources such as muriate of potash at rates greater than 50 lb of chloride per acre lead to excessive levels of chloride in the cured burley tobacco leaf, increased curing and storage problems, decreased combustibility of the leaf, and, ultimately, greatly reduced quality and usability of the cured leaf. Consequently, sulfate of potash should be the major potassium fertilizer used after January 1. Because animal manures contain chloride, applications of dairy and swine manure should not exceed 10 tons per acre. Applications of poultry manure should not exceed 4 tons per acre. Excessive rates of manure or manure used in conjunction with chlorine-containing fertilizers may result in unacceptable chlorine levels in the cured leaf.

Table 9. Phosphate recommendations. *Burley Tobacco*

Category	Lb/A Soil Test P	Lb/A P_2O_5 to Apply
Very High	above 80	0
High	73 - 79	30
	71 - 72	40
	68 - 70	50
	66 - 67	60
	64 - 65	70
	62 - 63	80
	58 - 61	90
Medium	54 - 57	100
	50 - 53	110
	46 - 49	120
	41 - 45	130
	37 - 40	140
	33 - 36	150
	29 - 32	160
Low	25 - 28	170
	22 - 24	180
	18 - 21	190
	14 - 17	200
	11 - 13	210
	7 - 10	220
Very Low	1 - 6	230

Table 12. Potash recommendations. *Dark Tobacco*

Category	Lb/A Soil Test K	Lb/A K_2O to Apply
Very High	above 448	0
High	398 - 448	30
	383 - 397	40
	368 - 382	50
	353 - 367	60
	338 - 352	70
	323 - 337	80
	308 - 322	90
	296 - 307	100
Medium	286 - 295	110
	276 - 285	120
	266 - 275	130
	256 - 265	140
	246 - 255	150
	236 - 245	160
	226 - 235	170
	216 - 225	180
	206 - 215	190
Low	195 - 205	200
	184 - 194	210
	173 - 183	220
	162 - 172	230
	151 - 161	240
	140 - 150	250
	129 - 139	260
	118 - 128	270
	107 - 117	280
	96 - 106	290
Very Low	below 96	300

Molybdenum

Molybdenum (Mo) is recommended for use on burley tobacco either as a broadcast soil application or as a mixture in transplant setter water when the soil pH is below 6.6. Recent research and field trials have shown that setter water applications are equally effective as broadcast applications for supplying molybdenum to the crop. Molybdenum can be purchased in dry solid form or as a liquid. Either source is satisfactory when molybdenum is needed.

Soil Broadcast—Apply at the rate of 1 lb of sodium molybdate (6.4 oz of molybdenum) per acre. Dissolve this amount of dry sodium molybdate (or 2 gallons of 2.5% Mo liquid product) in 20 to 40 gallons of water and spray uniformly over each acre. Apply before transplanting and disc into the soil. Because sodium molybdate is compatible with many herbicides used on tobacco, it can be applied with herbicides normally applied as a spray in water. Combining the two chemicals can result in savings in application costs because only one trip over the field is necessary. It is recommended that not more than 2 lb of sodium molybdate (12.8 oz of molybdenum) per acre be used during a five-year period.

Setter Water—Use 0.25 to 0.50 lb sodium molybdate (1.6 to 3.2 oz of molybdenum) per acre. If dry sodium molybdate is used, divide the total recommended amount (0.25 to 0.50 lb/A) equally among the number of 52-gallon barrels of water used per acre. For example, if 8 barrels of water per acre are used, add one-eighth (0.2 to 0.4 oz sodium molybdate) of the total recommended amount to each barrel, and fill the barrel with water. Adding the dry material before filling the barrel will aid in dissolving and mixing. If a 2.5% liquid source of molybdenum is used with 8 barrels of setter water per acre, add 0.50 pint to 1 pint (1 to 2 cups) of the liquid product per barrel before filling the barrel with water.

Plant Beds

Site Selection—A gentle slope facing south or southeast is preferable. The soil should be high in fertility with a soil pH of 6.0 to 6.6. Rotate with sod crops after one or two years and use a green manure crop between consecutive years.

Fertilizer Rates—Salt damage is often the greatest problem in establishing tobacco seedlings in the plant bed and is commonly caused by excessive use of plant bed fertilizer. Recommendations for plant are shown in Table 13.

Incorporate into the surface 1 to 2 inches before seeding. If additional N is needed later by growing transplants, topdress with 0.5 to 1.0 lb actual N for each 100 sq yd. Nitrogen materials should be evenly broadcast when plants are dry, followed immediately with enough irrigation to remove fertilizer residues from the plant leaves.

Table 13. Plant bed fertilizer rates.

Lime	None if pH is 6.0 or greater. 100-150 lb Aglime per 9-ft-by-100-ft bed if pH is below 6.0.
Nutrient	**lb/9-ft-by-100-ft bed**
N	5
P_2O_5	none if P is above 80. 5-10 if P is below 80.
K_2O	none if K is above 300. 5 if K is below 300.

Fertilization without soil test: 5 lb N, 5 to 10 lb P_2O_5, 5 lb K_2O per 9-ft-x-100-ft bed.

Manure Applications

Animal manures contain chloride, which can reduce the quality of tobacco. Limit rates to 10 tons per acre of cattle or swine manure. Poultry manure should not be applied to land in the year when tobacco will be grown.

Table 16. Potash recommendations. *Corn*

Category	Lb/A Soil Test K	Grain: Lb/A K_2O to Apply	Silage: Lb/A K_2O to Apply
Very High	Above 420	0	0
High	355 - 420	0	30
	336 - 354	0	40
	318 - 335	0	50
	301 - 317	0	60
Medium	282 - 300	30	70
	264 - 281	30	80
	242 - 263	30	90
	226 - 241	40	100
	209 - 225	50	110
	191 - 208	60	120
Low	173 - 190	70	130
	155 - 172	80	140
	136 - 154	90	150
	118 - 135	100	160
	100 - 117	110	170
Very Low	Below 100	120	180

Zinc

Where zinc deficiency of corn is suspected or has previously occurred, a zinc soil test is helpful in determining if zinc should be applied. The following table lists soil test zinc levels at various soil pH ranges and soil test P levels below which a response to zinc fertilization is likely to occur. However, many other factors including weather conditions and cool soil temperatures affect availability of soil zinc to corn, making it difficult to predict a response to added zinc for a specific growing season. When broadcast, zinc should be applied at recommended rates, and when banded, zinc can be applied at one-fifth the recommended broadcast rate.

Table 17. Zinc soil test level.[1] *Corn*

Soil Test P Lb P/A	Soil Water pH: pH 6.0 - 6.4	pH 6.5 - 6.8	pH 6.9 - 7.2	pH 7.3 - 7.6	Lb Broadcast Zn/A Recommended
	Soil Test Zn (Lb/A)				
50	1.1 - 1.8	1.9 - 2.5	2.6 - 3.2	3.3 - 3.9	
100	1.6 - 2.3	2.5 - 3.0	3.2 - 3.7	3.9 - 4.4	10 - 20
150	1.9 - 2.6	2.8 - 3.3	3.5 - 4.0	4.2 - 4.7	
200	2.1 - 2.8	3.0 - 3.5	3.7 - 4.2	4.4 - 5.0	
250	2.3 - 3.0	3.2 - 3.7	3.9 - 4.4	4.6 - 5.1	
300	2.4 - 3.2	3.3 - 3.9	4.0 - 4.6	4.7 - 5.3	
350	2.6 - 3.3	3.4 - 4.0	4.2 - 4.7	4.9 - 5.4	20 - 30
400	2.7 - 3.4	3.6 - 4.1	4.3 - 4.8	5.0 - 5.5	
450	2.8 - 3.5	3.6 - 4.2	4.3 - 4.9	5.1 - 5.6	
500	2.8 - 3.6	3.7 - 4.3	4.4 - 5.0	5.1 - 5.7	

1 Zinc and phosphorus levels shown are from soil extraction by the Mehlich III procedure. To determine if zinc is needed, find the appropriate soil test P level in the left column and read across the table to the appropriate soil pH level. If soil test zinc is less than that shown for the appropriate soil test P level and pH, apply fertilizer zinc as previously explained.

Small Grains

(Barley, Oats, Rye, Wheat, and Triticale)

Lime

Refer to page 6, and use the appropriate amount for a target pH of 6.4.

Nitrogen

Fall Application—Only enough N to provide for good ground cover and to stimulate tillering is necessary. Seedings following tobacco, soybean, or well-fertilized corn will likely have enough carryover N for fall growth. For optimal fertilizer N efficiency, the total fall application should not exceed 40 lb N/A for seedings in fields with insufficient N carryover. Fall-applied N will be of little benefit where little fall growth is expected.

Spring Application—Application from late February to early April is the most effective. Where excessive rainfall occurs in late winter or early spring, split applications of spring-applied N may be justified.

Table 20. Spring nitrogen rates. *Small Grains*

	Lb N/A
Tilled seedbed	60 - 90
No-till seedbed	90 - 120

Sources—Experimental results have shown little difference among nitrogen materials commonly used to supply supplemental N to small grains.

Small Grains for Grazing—Total forage production from small grains can be increased by splitting nitrogen applications between fall and spring. For fall grazing, apply 50 to 60 lb N/A at seeding. A late winter or early spring topdressing of 30 to 50 lb N/A will stimulate early growth for additional grazing.

Intensively Managed Wheat—When managed for high yields (70 to 100 bu/A), wheat should receive higher rates of N in the spring. If spring N is split into two applications (early to mid-February and mid- to late March), yields will be 3 to 5 bu/A higher than if all N is applied in a single application in mid- to late March. The February application should be made at "green-up," and the March application should be made at Feek's growth stage 5 or 6 (just prior to jointing or at jointing). "Green-up" may not occur until March in Central and Northern Kentucky.

Table 21. Spring nitrogen rates (lb/A). *Intensive Wheat*

	February	March	Total
Single application	0	95	95
Split application	30 - 60	75 - 45	105

Table 22. Phosphate recommendations. *Small Grains*

Category	Lb/A Soil Test P	Lb/A P_2O_5 to Apply
High	above 60	0
Medium	48 - 60	30
	45 - 47	40
	41 - 44	50
	38 - 40	60
	34 - 37	70
	31 - 33	80
Low	24 - 30	90
	17 - 23	100
	10 - 16	110
	below 10	120

Table 23. Potash recommendations. *Small Grains*

Category	Lb/A Soil Test K	Lb/A K_2O to Apply
High	above 300	0
Medium	213 - 300	30
	187 - 212	40
Low	159 - 186	50
	132 - 158	60
	104 - 131	70
	below 104	80

Double Cropping of Small Grains and Soybean—The phosphate recommendation should be taken from small grains, and the potash recommendation should be taken from soybean. This recommendation can be applied in the fall before seeding the small grain.

Small Grains for Silage—Small grains harvested for silage remove large amounts of potash from the soil. When double cropping small grains with corn or soybean where the small grain is to be cut for silage, apply recommended rates of potash for small grain at the time of seeding and for corn or soybean at the time of its seeding.

Hay and Pastures

New Seedings

Lime

Refer to page 6 and use the appropriate amount for a target pH of 6.4. For long-term production of alfalfa and alfalfa grass, it is important to raise pH and keep it maintained in the range of 6.5 to 7.0. Refer to page 6 for the amount of lime for a target pH of 6.8.

Nitrogen

Apply 0 to 30 lb N/A at seeding for legumes or grass-legume mixtures and 0 to 50 lb N/A for straight grass. If the field has a history of high N applications, omit N at seeding.

Surface Mine Reclamation

See page 4 for more details.

Molybdenum

If soils are limed to maintain pH values at 6.2 or above, aluminum and manganese toxicities and molybdenum deficiency usually do not occur in forage legumes. However, in soils having pH values below 6.2 at seeding time, molybdenum application to these legumes is recommended. Apply at the rate of 1 lb of sodium molybdate (6.4 oz of molybdenum) per acre. Dissolve this amount of molybdate in 20 to 40 gallons of water, and spray uniformly over each acre. Apply before planting and disc into the soil. It is recommended that not more than 2 lb of sodium molybdate (12.8 oz of molybdenum) per acre be used during a five-year period.

Inoculation

Appropriate good-quality inoculant should be applied to legume seed or in the row at planting. Delays in planting inoculated seed may result in poor root nodulation. Live rhizobia decrease rapidly in inoculum under dry conditions, exposure to sunlight and high temperatures, or when packaged dry with sodium molybdate and fungicides.

Table 27. Phosphate recommendations. *Alfalfa, Alfalfa-Grass, Clover, or Clover-Grass (New Seedings)*

Category	Lb/Acre Soil Test P	Lb/Acre P_2O_5 to Apply
High	above 60	0
Medium	51 - 60	30
	48 - 50	40
	46 - 47	50
	43 - 45	60
	40 - 42	70
	37 - 39	80
	35 - 36	90
	32 - 34	100
	28 - 31	110
Low	23 - 27	120
	19 - 22	130
	14 - 18	140
	9 - 13	150
	below 9	160

Table 28. Potash recommendations. *Alfalfa, Alfalfa-Grass, Clover, or Clover-Grass (New Seedings)*

Category	Lb/Acre Soil Test K	Lb/Acre K_2O to Apply
High	above 300	0
Medium	266 - 300	30
	256 - 265	40
	246 - 255	50
	236 - 245	60
	226 - 235	70
	216 - 225	80
	206 - 215	90
	191 - 205	100
Low	173 - 190	110
	155 - 172	120
	136 - 154	130
	118 - 135	140
	100 - 117	150
	below 100	160

Table 29. Phosphate recommendations. *Cool-Season Grasses (New Seedings)*

Category	Lb/Acre Soil Test P	Lb/Acre P_2O_5 to Apply
High	above 60	0
Medium	48 - 60	30
	45 - 47	40
	41 - 44	50
	38 - 40	60
	34 - 37	70
	31 - 33	80
Low	24 - 30	90
	17 - 23	100
	10 - 16	110
	below 10	120

Table 30. Potash recommendations. *Cool-Season Grasses (New Seedings)*

Category	Lb/A Soil Test K	Lb/A K_2O to Apply
High	above 300	0
Medium	213 - 300	30
	187 - 212	40
Low	159 - 186	50
	132 - 158	60
	104 - 131	70
	below 104	80

Table 33. Potash recommendations.

Category	Lb/A Soil Test K	*Alfalfa or Alfalfa-Grass (Annual Topdressing)* Lb/A K_2O to Apply
High	above 450	0
	363 - 450	30
	338 - 362	40
	313 - 337	50
	297 - 312	60
Medium	291 - 296	70
	285 - 290	80
	279 - 284	90
	272 - 278	100
	266 - 271	110
	260 - 265	120
	254 - 259	130
	247 - 253	140
	241 - 246	150
	235 - 240	160
	229 - 234	170
	222 - 228	180
	216 - 221	190
	210 - 215	200
	204 - 209	210
Low	194 - 203	220
	180 - 193	230
	166 - 179	240
	152 - 165	250
	139 - 151	260
	125 - 138	270
	111 - 124	280
	97 - 110	290
	below 97	300

Table 34. Potash recommendations.

Category	Lb/A Soil Test K	*Clover or Clover-Grass (Annual Topdressing)* Lb/A K_2O to Apply
High	above 300	0
Medium	271 - 300	30
	263 - 270	40
	255 - 262	50
	246 - 254	60
	238 - 245	70
	230 - 237	80
	221 - 229	90
	213 - 220	100
	205 - 212	110
Low	191 - 204	120
	173 - 190	130
	155 - 172	140
	136 - 154	150
	118 - 135	160
	100 - 117	170
	below 100	180

Hay and Pastures and Seed Production

Topdressing Cool-Season Grasses

Cool-season grasses such as tall fescue, bluegrass, timothy, orchardgrass, and bromegrass grow best from early spring into early summer and again in the fall. If moisture and soil test levels of P and K are adequate ($P > 30$, $K > 200$), the use of nitrogen greatly stimulates their growth during these peak production periods. The use of nitrogen should depend on what is expected from the grass. Nitrogen fertilization can help increase total production and protein content and shift seasonality of production. However, unless the increased yields are utilized, there will be no return to the expense of adding N.

Nitrogen Management

Increase Total Production—Research data for a period of years indicate that dry matter can be increased from about a ton per year with no nitrogen up to about 4 tons per year with up to 200 lb N per acre.

Shift Seasonality of Production—Timely nitrogen applications will increase the production of grasses during particular seasons. A topdressing in late winter or early spring just before growth begins will increase growth so that grazing can begin about two weeks ahead of pastures receiving no nitrogen. This effect can be used to lower overwintering feed costs from barnlot feeding. Another topdressing in late spring following a grazedown or hay clipping will increase growth that will carry over into the normally low summer production period. Another topdressing following a grazedown or clipping in late summer will stimulate fall growth, which, if properly utilized, will extend grazing several weeks later into the fall and winter. This is a practical method to lower winter costs from barnlot feeding by keeping animals on pasture longer.

Sources—Research in Kentucky has shown that during late winter and early spring there is little difference among commonly used N sources for topdressing cool-season grasses. After early May, there is a high risk that topdressed urea will not be as effective as other sources. Average values for efficiency of urea-applied topdress after early May ranged from 78% to 51% percent of that of ammonium nitrate, depending largely on the length of time after application before rainfall. For urea to be an economical substitute for ammonium nitrate if applied after early May, the cost per unit of nitrogen from urea probably should be 15% to 20% less than ammonium nitrate. Research indicates that efficiency of liquid nitrogen applied after early May is between that of urea and ammonium nitrate.

Tetany problems with cattle are sometimes encountered on straight grass pastures, particularly with nursing cows where grass pasture is the only source of feed. Tetany in such animals results from an imbalance of magnesium in their blood. Supplemental feeding of magnesium to nursing cows on such fields is recommended as a means of lowering tetany risks. Applying fertilizer containing magnesium is not recommended to offset potential grass tetany problems. There is little guarantee that the plant will take up the additional applied magnesium when soil test levels are adequate. See Extension publication *Grass Tetany in Beef Cattle* (ASC-16) for detailed recommendations.

Grass Seed Production—For pure stands of tall fescue and bluegrass from which seed will be harvested, an additional topdressing of 60 to 70 lb N/A around December 1, after grazedown, will increase seed yields the following year.

Table 37. When to topdress nitrogen.

Date	Lb N/A per Application[1]
Feb. 15 - March 15	up to 100
May 1 - 15	up to 50
Aug. 1 - 15	up to 80

[1] Total amount of N to topdress should depend on how much additional production is needed. If a total of more than 100 lb of N per acre per year is to be used, it should be applied in split applications. Suggested dates and rates for topdressing with N are shown above.

Lime

Refer to page 6 and use the appropriate amount for a target pH of 6.4.

Table 38. Phosphate recommendations. *Annual Topdressing (Cool-Season Grasses)*

Category	Lb/A Soil Test P	Lb/A P_2O_5 to Apply
High	above 60	0
Medium	46 - 60	30
	41 - 45	40
	37 - 40	50
	33 - 36	60
	28 - 32	70
Low	23 - 27	80
	19 - 22	90
	14 - 18	100
	9 - 13	110
	below 9	120

Table 39. Potash recommendations. *Annual Topdressing (Cool-Season Grasses)*

Category	Lb/A Soil Test K	Pasture Lb/A K_2O to Apply	Hay Lb/A K_2O to Apply
Very High	above 420	0	0
High	321 - 420	0	30
	301 - 320	0	40
Medium	267 - 300	30	50
	240 - 266	30	60
	213 - 239	30	70
	187 - 212	40	80
Low	159 - 186	50	90
	132 - 158	60	100
	104 - 131	70	110
	below 104	80	120

Surface Mine Reclamation

See page 4 for more details.

Perennial Warm-Season Crops

Conservation Buffer and Filter Strip—When these crops are used as the primary vegetation in a conservation buffer and/or filter strip, fertilizer or other nutrient sources should not be applied, except for establishment. In these situations, the vegetation is used primarily to remove and immobilize nutrients from the water passing through the vegetative filter. This use may involve mowing with no plant removal so that nutrients in plant residues are recycled back to the soil.

Bermudagrasses

The pH should be maintained in the range of 5.8 to 6.4. If establishing stand, lime to pH 6.4 (see page 6).

Table 42. Nitrogen-Phosphate-Potash. *Bermudagrasses*

Lb/A	Lb/A to Apply Annually					
	For Pasture			For Hay		
Soil Test Level	**N**	**P_2O_5**	**K_2O**	**N**	**P_2O_5**	**K_2O**
High (above 60 P, 300 K)	120 - 240	0	0	120 - 400	0	0
Medium (60-30P, 300-200K)	120 - 240	0 - 65	0 - 90	120 - 400	0 - 95	0 - 180
Low (below 30P, 200K)[1]	120 - 240	65 - 120	90 - 180	120 - 400	95 - 120	180 - 360

1 The maximum P_2O_5 or K_2O rate shown should be used if P is less than 10 or K is less than 100.

When to Apply N—The total amount of N used should be based on the amount of forage needed and whether it is grazed or cut for hay. Nitrogen should be applied in split applications for best results. For top production of hay, apply 100 lb N just before growth starts in the spring and 100 lb N after each clipping except the last one.

For establishing new stands, use only 50 to 60 lb N/A at planting. As ground cover is attained, an additional 30 to 50 lb applied around August 15 can be beneficial in stimulating first-year growth.

Native Warm-Season Grasses

Bluestems, Switchgrass, Indiangrass, Side Oats Grama, Eastern Gamagrass

See the publication *Warm Season Perennial Grasses for Forage in Kentucky* (AGR-145) for more detailed information.

Lime—Soil pH should be in the range of 5.8 to 6.4. When establishing a stand, apply sufficient lime to raise the pH to 6.4.

Nitrogen—Do not apply nitrogen at the time of seeding. A topdressing of 40 to 60 lb N/A can be applied in July of the seeding year to aid establishment. For established stands after the seeding year, apply 40 to 60 lb N/A in April and again following a harvest in June or July for increased yields.

Table 43. Annual phosphate and potash applications for establishment or forage use of native warm-season grasses (lb/A).

	Lb/A to Apply	
Soil Test Level (Lb/A)	**P_2O_5**	**K_2O**
High (above 60 P, 300 K)	0	0
Medium (60-30 P, 300-200 K)	0 - 40	0 - 50
Low* (below 30 P, 200 K)	40 - 80	50 - 100

* The maximum rates should be used if P is less than 6 lb/A or K is less than 90 lb/A.

Conservation and/or Wildlife Use—Native grasses not used as forage (top growth not removed from the field or area) seldom need to be fertilized after establishment. Soil samples should be taken every four or five years, and P and K applied only when soil tests are in the low range. Apply lime when soil test pH levels are below 5.8.

Surface Mine Reclamation

See page 4 for more details.

Tree Fruits, Blackberries, Raspberries, Blueberries, and Grapes

New Plantings

Lime—Limestone should be applied three to six months before planting and worked into the soil. Tree fruits, blackberries, and raspberries are most productive when soil pH is from 6.4 to 6.6. For grape plantings, adjust the soil pH to 6.5 at establishment and maintain pH in the range of 5.5 to 6.0 during production for American and French-American hybrid grapes. European or *Vitis vinifera* grapes perform best at a pH range of 6.0 to 7.0. Refer to page 6 and use the appropriate table for the target pH; apply the amount of recommended lime.

For blueberries, adjust the soil pH to between 4.5 to 5.2. Read Extension publication *Growing Highbush Blueberries in Kentucky* (HO-60) for further information on adjusting soil pH to this range.

Nitrogen—Nitrogen fertilization rates depend on the field cropping history and soil types. Apply no more than 100 lb of nitrogen per acre (3.7 oz nitrogen per 100 sq ft). Nitrogen is most effective when it is applied at planting time.

Table 47. Phosphate and potash. *Tree Fruits, Blackberries, Raspberries, Blueberries, and Grapes*

Soil Test Level (Lb/A)	P_2O_5 Lb/A	P_2O_5 Oz/100 Sq Ft	K_2O Lb/A	K_2O Oz/100 Sq Ft
High (>70 P, >300 K)	0	0	0	0
Medium (70-35 P, 300-200 K)	0 - 80	0 - 3	0 - 80	0 - 3
Low (<35 P, <200 K)	80 - 120	3 - 5	80 - 120	3 - 5

The above recommendations are for establishment only. During subsequent seasons, fertilizer application should be based on the plant growth rate and condition. Tissue analysis is the most accurate method for determining plant nutrient status for commercial plantings. Plant analysis kits can be obtained from your county Cooperative Extension Service agent.

Magnesium—Fruit crops require more magnesium than most agronomic crops. The soil should be adjusted if soil test Mg is less than 120 lb of magnesium per acre prior to planting. Use Table 48 for adjusting Mg levels in the soil based on soil test Mg.

Table 48. Magnesium. *Tree Fruits, Blackberries, Raspberries, Blueberries, and Grapes*

Soil Test Level (Lb/A)	Lb Mg/A
Low (below 60)	80
Medium (61-120)	20 - 80
High (above 120)	0

COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY • COLLEGE OF AGRICULTURE

Taking Soil Test Samples

W.O. Thom, K.L. Wells, and Lloyd Murdock

When you take soil test samples keep in mind that a few ounces of soil are being tested to determine lime and fertilizer needs for what may be several million pounds of soil in the field. It is absolutely necessary to take care to assure that the soil sample you send to the laboratory accurately represents the area sampled.

Soil samples can be collected through much of the year, although fall (September to December) or spring (February to April) are the best times. Fall sampling will often result in a faster return of results and recommendations.

Tools You Need

A soil probe, auger, garden trowel, or a spade and knife are all the tools you need to take the individual cores that will make up the "field" sample (*Figure 1*). You will also need a clean, dry bucket (preferably plastic) to collect and mix the sample cores. Soil sample boxes or bags and information forms for submitting samples are available at all county Extension offices.

The most representative sample can be obtained from a large field by sampling in smaller units on the basis of soil type, cropping history, erosion, or past management practices. More accurate results are obtained when problem areas are sampled separately, especially when "trouble-shooting" in fields during the growing season. In such instances, take a sample both from the poor growing area and adjacent areas of good growth. Designate each sample area with a letter or numbers on a field or area map for record-keeping purposes (*Figure 2*). A sample should represent no more than 20 acres except when soils, past management, and cropping history are quite uniform.

Collect at least 10 soil cores for small areas and up to 30 cores for larger fields. Take the soil cores randomly throughout the area to be sampled and place in the bucket.

Tilled Areas — Take soil cores to the depth of the tillage operation (usually 6 to 8 inches).

Non-Tilled Areas — Take soil cores to a depth of 3 to 4 inches for pastures and no-tillage planting where fertilizer or lime remains on the soil surface or is incorporated only in the surface 1 to 2 inches.

Lawns and Turfgrasses — Collect soil cores to a depth of 3 to 4 inches. Sample problem areas and areas with shrubs or flower beds separate from other turf or lawn areas.

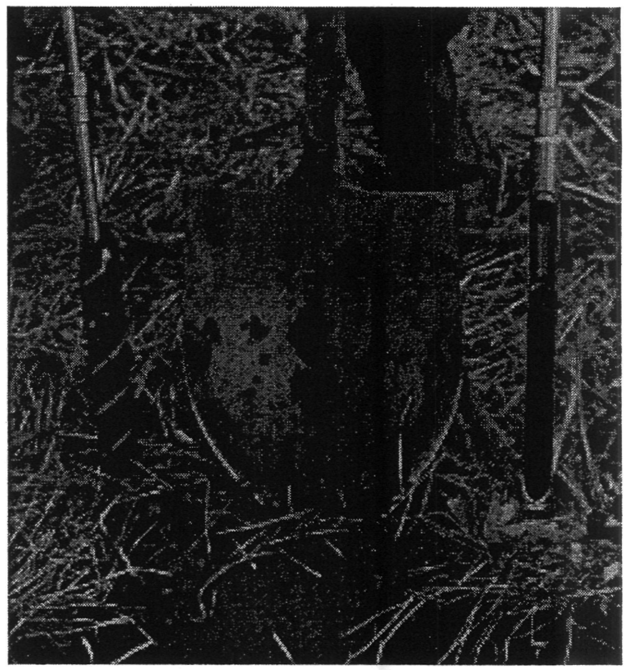


Figure 1. A soil probe, auger, or spade and knife should be used in sampling soils. The spade sample must be trimmed as shown.

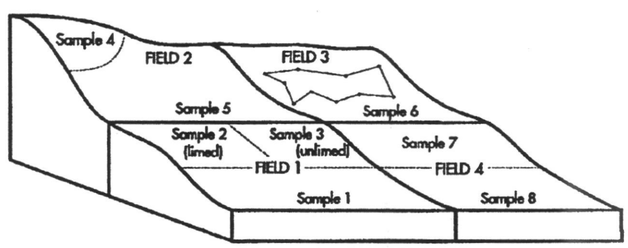


Figure 2. This shows how four fields might require the analyses of 1 to 3 composite samples for determining fertility needs. Each composite must contain 10 or more cores, as shown for sample 6 in field 3.

UNIVERSITY OF KENTUCKY
COLLEGE OF AGRICULTURE
Lexington, Kentucky 40546-0091

COOPERATIVE EXTENSION SERVICE

Department of Agronomy

Soil Science News & Views

Vol. 21, NO. 4, 2000

SOIL TESTING FOR AGRONOMIC AND ENVIRONMENTAL USES

William Thom & Frank Sikora

Soil testing is a program that includes taking samples from a field or site, performing a laboratory analysis, and making recommendations for lime and crop nutrients. Good results from this program depend on several supporting factors: (1) obtaining samples representative of the soil in a field area or site; (2) using good techniques in the laboratory that give accurate indications of the nutrient status of the sampled area; and (3) having an extensive data base for making lime and nutrient recommendations from the analytical results.

Historically, soil testing has been used to assess the need for lime and fertilizer to optimize agronomic crop production. Recently, soil testing has been viewed as a means to predict a soil's ability to retain added nutrients against losses to lakes, rivers, streams and ponds through runoff or leaching. This publication will discuss the agronomic and environmental philosophies of using soil testing and the potential limitations of each philosophy.

Agronomic Soil Testing

Soil testing is a reliable, scientifically based method for assessing nutrient levels of soils relative to crop production. Nutrient recommendations from a soil test result may follow one of several philosophies. The **nutrient sufficiency** philosophy followed by the University of Kentucky recommends enough nutrient to satisfy the annual needs of a crop plus a small amount to gradually increase soil test levels. The **crop removal plus buildup** philosophy recommends nutrient levels to replace those removed by a crop plus a larger amount that more rapidly increases soil test levels. Fewer years are required to reach a high soil test level with this philosophy compared to nutrient sufficiency.

generated from research as has been done for the agronomic critical levels. This research should include investigations on the soil's ability to sorb and retain applied nutrients, the ability of the nutrient to dissolve in water, the soil's ability to remove nutrients from flowing water, and the changes in nutrient forms in water that determine their availability to other organisms (bioavailability). This type of research has just begun at the University of Kentucky and at many other institutions.

Soil studied for this research should be analyzed by different laboratory methods than those that are used for analyzing soils for agronomic purposes. Several different methods have been proposed for environmental soil testing but only a few soils have been studied with these methods at this time. One factor clearly evident from this early research is that soils vary in the amount of nutrients they can retain. Research will need to continue for some time to develop an extensive data base before scientifically-based environmental critical levels can be established across the state. This research will involve laboratory evaluations and field plot research just as was required for agronomic uses.

Initial research from other states has found a positive relationship in some soil-crop landscapes between soil test levels of P and the level of bioavailable P in ground or surface water. Detailed evaluation of soil-crop-landscape combinations will require the use of more specific testing and evaluation methods to assess the potential risk of P reaching undesirable levels in aquatic environments.

Summary

Soil testing for agronomic crop production is a reliable, scientifically based method for predicting crop responses to nutrient applications. Establishment of agronomic critical nutrient levels and nutrient recommendations depends on an extensive research program and accompanying data base.

Even though environmental soil testing is in its infancy, some conclusions can be made about this type of testing. A soil test value alone will not be able to predict a field's impact on water quality, and establishing environmental critical levels will require extensive research. This is because of the many factors that control the release of nutrients from soil into the environment. However, a soil test value may identify fields that require additional evaluation of landscape and management factors to assess the risk they may pose to water quality.

William O. Thom

William O. Thom
Extension Specialist

AGR-146

COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY • COLLEGE OF AGRICULTURE

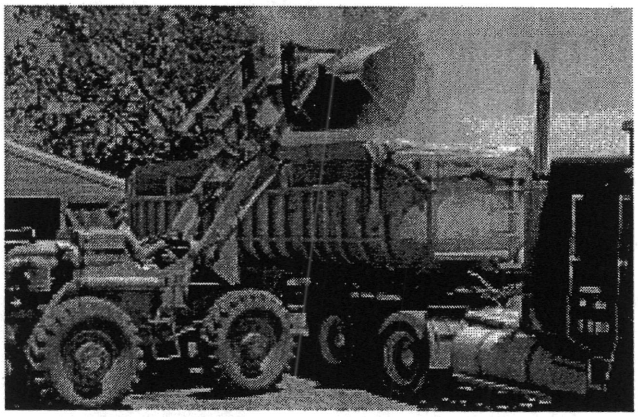
Using Animal Manures as Nutrient Sources

Monroe Rasnake, Bill Thom, and Frank Sikora

Animal manures can be an economical and effective source of crop nutrients. Land application of animal manures is also a Best Management Practice for protecting water quality when it is carried out properly. Correct land application of animal manures depends on the producer knowing:

- the manures' nutrient content.
- best application times and methods.
- availability of manure nutrients to crops.
- how to balance crop nutrient needs using manures, fertilizers, and other nutrient sources.

This publication provides information on proper use of animal manures as nutrient sources for crops.



Dry manures can be transported and used economically some distance from where they are produced, but liquid manures cannot.

Nutrient Content

Nutrient content of manures varies, depending on the:

- type of animal.
- type and amount of bedding used.
- manure's moisture content.
- time and method of storage.

The best way to determine manure's nutrient content is to have manure samples tested as near the time of use as possible. In many cases, however, this is not practical or is nearly impossible to do. However, tabular values for the nutrient concentration of manure or the results of previous testing of similar manures can be used to determine application rates for good crop production and water quality protection.

Table 1 provides a good estimate of nutrient values of some manures available for use in Kentucky. These values should be used unless manure test results are available for the materials actually being used. Manure test data for a particular farm, either current or historical, will allow a more accurate calculation of available nutrients being applied, but Table 1 still should be used as a base reference.

It is often hard to obtain a representative sample of manures, so results that vary significantly from the values in Table 1 should be questioned. For guidelines on taking manure samples, see UK Cooperative Extension Service publication *Livestock Waste Sampling and Testing* (ID-123).

Table 1. Nutrient content of manures commonly used in Kentucky. (All values on an "as-is" moisture basis.)

		N	P_2O_5	K_2O	Moisture (%)
Solid Manures (lb/ton)					
Beef		11	7	10	80
Dairy		11	9	12	80
Swine		9	9	8	82
Broiler	(fresh)	55	55	45	20
	(stockpiled)	40	80	35	20
	(cake)	60	70	40	30
	(pullet)	40	68	40	25
	(breeder)	35	55	30	40
Layer		30	40	30	40
Liquid Manures (lb/1,000 gal)					
Holding Pit	Swine	36	27	22	96
	Dairy	31	15	19	94
Lagoon	Swine	4	2	4	99
	Dairy	4	2	3	98

Availability to Crops

Some manure nutrients are not as readily available to crops as those in commercial fertilizers, especially nitrogen. Its availability to a crop depends on:

- the crop being grown.
- the type of manure used.
- when and how the manure is applied.

Worksheet

Calculations	Example	Your Field
1. Crop to Be Grown	Corn	
2. Fertilizer Recommendation		
a. Nitrogen (lb N/A)	180	
b. Phosphorus (lb P_2O_5/A)	70	
c. Potassium (lb K_2O/A)	125	
3. Preplant Fertilizer		
a. N	0	
b. P_2O_5	0	
c. K_2O	0	
4. Residual N from Manure (Units[a] of manure applied previous year x lb N/unit x availability coefficient—see Table 3)	2T x 55 lb/T x .07 = 8 lb	
5. Net Nutrient Needs		
a. N (2a - 3a - 4)	172 lb	
b. P_2O_5 (2b - 3b)	70	
c. K_2O (2c - 3c)	125	
6. Available Nutrients with As-Is Moisture in Manure (lb/unit)		
a. N (lb N/unit) (Table 1 or test results) x available coefficient (Table 2)	55 x .45 = 25	
b. P_2O_5 (lb P_2O_5/unit [Table 1] x .8)	55 x .8 = 44	
c. K_2O (lb K_2O/unit [Table 1])	45	
7. Application Rate to Supply Priority Nutrient		
a. Priority nutrient	N	
b. Amount needed (5a, b, or c)	172	
c. Manure needed (7b ÷ 6a, b, or c)	172 ÷ 25 = 6.9 T	
8. Nutrients Supplied by 7c		
a. N (7c x 6a)	6.9 x 25 = 172	
b. P_2O_5 (7c x 6b)	6.9 x 44 = 304	
c. K_2O (7c x 6c)	6.9 x 45 = 310	
9. Additional Nutrients Needed[b] (-) = need; (+) = excess		
a. N (8a - 5a)	172 - 172 = 0	
b. P_2O_5 (8b - 5b)	304 - 70 = 234	
c. K_2O (8c - 5c)	310 - 125 = 185	

[a]Units = tons, 1,000 gal, or acre inches, depending on the type of manure used (1 acre inch equals approximately 27,000 gal).
[b]The example calculation shows that 6.9 tons of broiler litter per acre can supply all the nitrogen needed by the crop. However, an excess of 234 pounds of phosphate and 185 pounds of potash per acre is supplied by this much manure. These amounts will result in higher soil test levels of phosphate and potash. Repeated overapplication of phosphate could restrict the amount of manure that can be applied to a field in future years.

ID-123

COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY • COLLEGE OF AGRICULTURE

Livestock Waste Sampling and Testing

Monroe Rasnake, Agronomy; *Doug Overhults,* Agricultural Engineering; *Vern Case,* Regulatory Services

It is estimated that about 25 million tons of animal manure are currently produced on Kentucky farms each year. Most of this is deposited by grazing animals on pastures where the nutrients are recycled. However, an increasing percentage is accumulated in feed lots, barns, poultry houses, lagoons, and other facilities until it can be spread on the land.

Nutrient Value

The nutrient content of manure depends on the animal, the ration, how it is handled and stored, moisture content, and other factors. Data from several studies show there is much variability within and between sources of animal manure. The data in Table 1 illustrate average values for different sources of poultry and dairy manure.

Data from USDA Publication No. URR6. 1979 also show average nutrient contents of fresh manure from other types of animals (calculated as lb N - P_2O_5 - K_2O per ton) as follows: beef (9.1 - 14.2 - 8.4), swine (13.4 - 16.3 - 6.6), sheep (21.9 - 26.8 - 21.8), and turkeys (29.7 - 43.1 - 13.9). Obviously, animal type and source of the manure influence nutrient content. The variability of nutrient content of manures within the same animal type is shown in Table 2. These data illustrate the need for accurate sampling and analysis to determine the nutrient content of each type of manure. Other data in the literature often show differences of two to six times or more for the same nutrient in different samples of the same animal type manure.

Table 1. Average Nutrient Content of Samples as Received in Lab*

Type Manure	Source of Data	Number Samples	Water	N	P_2O_5	K_2O
			%	------	lb/ton	------
POULTRY						
Broiler	Kentucky	47	20.5	48.2	66.8	47.0
Broiler	Alabama	147	19.7	62.6	59.4	40.2
Broiler	USDA	—	—	29.8	44.0	13.7
Layer	Kentucky	15	38.0	36.8	80.2	39.6
Pullet	Kentucky	9	27.8	29.4	45.0	28.0
DAIRY						
Stack pad	Kentucky	14	79.0	9.0	8.2	10.0
Fresh	USDA	—	—	8.2	7.3	9.4
Liquid**	Kentucky	13	—	2.8	1.6	1.8

*Kentucky samples were analyzed by UK Regulatory Services Lab. Alabama data are calculated from AGR-146, Table 1. Fresh data from "Animal Waste Utilization on Cropland and Pastureland," USDA No. URR6. 1979.

**The nutrient content of the Dairy Liquid converts to 158 lb N, 90 lb P_2O_5, and 102 lb K_2O per acre half inch of irrigation (13,577 gallons).

Table 2. Variability of Selected Animal Manure as Received and Analyzed by UK Regulatory Services

Type Manure	Number Samples	Approximate Range in Content Water	N	P_2O_5	K_2O
		%	----------	lb/ton	----------
Broiler	47	<10* - 60	19 - 73	13 - 90	18 - 73
Dairy, solid	14	72 - 85	6 - 13	5 - 10	5 - 20
Dairy, liquid	13	—	0.2 - 7.6	0.2 - 5.4	0.2 - 3.4

*Moisture content was not measured on very dry samples.

When to Sample

To allow time for the analyses to be completed and a decision made on application rates, livestock waste should be sampled about a month before it is to be applied. There are some disadvantages with early sampling. The nutrient content of the manure may change during storage as additional accumulation takes place, such as in beef feeding floors, broiler houses, or stack pads. In the case of lagoons, it is very difficult to take a good sample except when it is being pumped out.

Samples can be taken just before or while spreading the manure. The disadvantage is in not having the analysis to use in determining rates of application. However, nutrient estimates can be used to determine an application rate that is not likely to provide excessive amounts of nutrients. Successive sampling of the same type of manure on one's farm each year can improve these estimates. Additional nutrients can be applied later if the test results show they are needed.

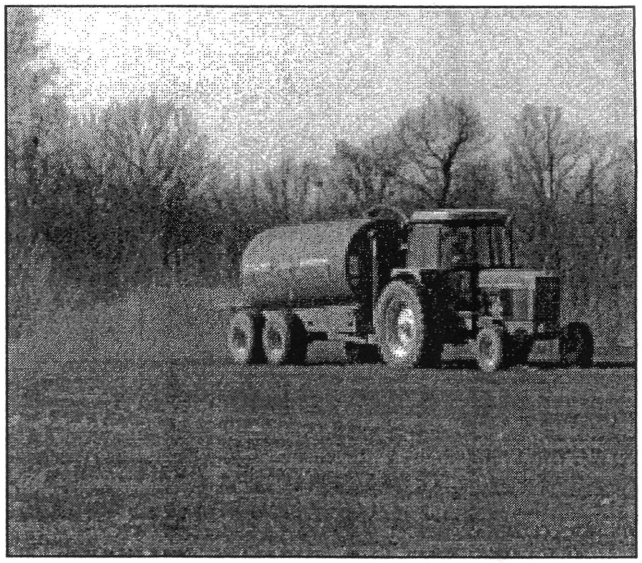
AGR-165

UK COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY—COLLEGE OF AGRICULTURE

The Agronomics of Manure Use for Crop Production

Monroe Rasnake, Extension Specialist—Animal Waste Management

Land application of manures for crop production has in-creased in recent years primarily due to the expansion of the poultry industry in Kentucky. However, regulatory concerns related to water quality are causing some farmers to reconsider their use. This publication will discuss the value of manure in providing nutrients for crop production while minimizing the risk to water quality. Proper agronomic use of animal manures is compatible with most best management practices (BMPs) connected with water quality regulations.



The nutrients in liquid manures are highly available to crops, especially when applied in early spring.

The Agronomic Value of Manures

Animal manures are the digestive by-products of the feed ingested by animals and any associated bedding materials or water used in the animal production operation. Therefore, the nutrient content of manure is closely related to the chemical content of feeds consumed by the animals. During digestion, some of the energy, nutrients, vitamins, and minerals in feed are retained by the animal. However, most of the nutrients pass through the animal in urine or feces. For example, about 75% of nitrogen (N), 80% of phosphorus (P), and 85% of the potassium (K) consumed by cattle is excreted. Undigestible and partially digested organic residues are also excreted. Because of this, animal manure provides:

- nutrients for crop growth, and
- organic material that can increase soil structure, porosity, and water-holding capacity.

Thus, the agronomic value of manure depends on its nutrient and organic matter content.

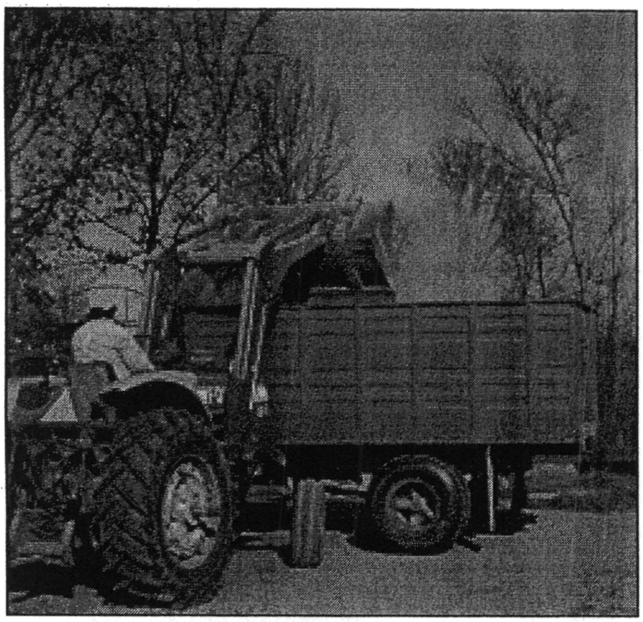
Ability of Manure to Supply Plant Nutrients

How well animal manure performs as a plant nutrient source is determined by the chemical form in which nutrients occur, how the manure is applied, when it is applied, and how much is used. The effects of each of these factors on nutrient availability are discussed below.

Nitrogen Availability

Soluble N (primarily in the form of ammonium) in animal manures ranges from about one-third of the total N in poultry manure to about two-thirds or more in lagoon liquids. This portion has the same availability to plants as N contained in commercial fertilizer. The remaining N is contained in insoluble organic compounds. This N will become available to crops over a period of weeks, months, or even years after the manure is applied to a field. How much of the total N that is actually utilized by the crop depends on the application rate and the length of the growing season. Corn is less efficient in utilizing N than cool-season grass pastures. Corn can utilize N only during three or four months, while the pasture will be growing and taking up N for eight to 10 months.

Substantial amounts of the ammonium and urea-N in manures can be lost through volatilization to the air if left on the soil surface. How much is lost depends on the type of manure and weather conditions at the time of application. High temperatures increase losses, while as little as 1/3 inch of rain can move the inorganic N into the soil and prevent its loss. The organic N is less subject to loss but requires time to become available. Soil incorporation or injection of manure increases availability of both organic and inorganic N.



Poultry manure is portable and can be an economical source of nutrients 50 miles or more from where it is produced.

the N and P needs of one crop (e.g., corn) and the P needs of the next crop in the rotation (e.g., soybeans). Extension publication AGR-146, *Using Animal Manures as Nutrient Sources*, discusses nutrient values of manures and shows how to calculate application rates to supply crop nutrient needs. A computer spreadsheet ("Manure Use 1.2-xls") that calculates application rates is also available through the College of Agriculture .

In addition to environmental risks associated with overapplying manure, there may be agronomic problems as well. Manure rates on tobacco should be limited to 4 T/A of poultry manure or 10 T/A of other manures in order to avoid excess chloride. Poultry manure, for example, contains about 12 lb chloride per ton, and a 4 T/A rate would apply 48 lb/A of chloride, which is about the maximum rate that can safely be used on tobacco.

Another possible problem related to high rates of manure application, particularly if the high rates are repeated for several years, is a "salt" build-up. In this situation, high concentrations of ammonium and soluble salts of potassium, sodium, calcium, and magnesium can accumulate. This can cause poor seed germination, reduced soil water availability, and deterioration of soil structure. This problem with excess salts commonly occurs in soil where manure has been stockpiled. Soil pH in these areas will likely be 7 or above, and nothing will grow there for a year or more.

Uniformity of Manure Application

It is difficult to apply manures uniformly on fields. Spread patterns and application rates of manure spreaders should be checked at least once a year. This can be done by placing sheets of plastic film of uniform size at equal intervals across the path of application and then measuring how much manure is on each. Uniformity of spread can be improved by using lower application rates and going over the field twice with the spreader. The second pass can "split the middle" of the first pass, or run perpendicular to it. For nutrients other than N, this should give adequate uniformity. Uniformity of N from manure is less critical if a portion of the N need of the crop is supplied by fertilizer.

Placement of Manure

The primary concern of manure placement should be the efficiency of N use. Incorporating, or mixing, the manure with the soil, especially during hot weather, will reduce the risk of N loss. This benefit must be weighed against disadvantages such as exposing the soil to erosion or loss of soil moisture. For example, it is seldom worthwhile to sacrifice conservation tillage in order to reduce the risk of N loss from manure.

If liquid manure is injected into the soil in concentrated subsurface bands, especially in poor soil drainage conditions, there will likely be anaerobic decomposition that produces organic compounds toxic enough to stunt or kill plants. This risk can be minimized on soils with restricted water movement by broadcasting the manure and discing it in.

Summary

Animal manures can be used to supply nutrients needed to grow crops. If manures are managed properly, they can save farmers money and be an environmentally safe means of disposal. Application rates should be planned in combination with commercial fertilizer to provide the nutrients recommended for growing a crop. Apply manure close to the time the crop will need the nutrients. Mixing or injecting manure into the soil helps reduce nutrient losses and odor problems. Farmers can visit their local Cooperative Extension Service or Natural Resources Conservation Service office for help in planning for manure use.

UK COOPERATIVE EXTENSION SERVICE
University of Kentucky – College of Agriculture

LEXINGTON, KY 40546

Agronomy notes

Vol. 34, No. 2, 2002

Phosphorus Soil Test Change Following the Addition of Phosphorus Fertilizer to 16 Kentucky Soils

William Thom and James Dollarhide

Introduction

When applying phosphorus to soils it is important to know how much the soil test P changes with the addition of various rates. Soils are different in how they respond to varying rates of application, and only limited information is available for Kentucky soils.

Methods

Sixteen soils representing western and central Kentucky were identified as major soils for agronomic crops. A large amount of A horizon was collected with a shovel and placed into a clean, plastic 5-gallon pail, and covered. Later the soil was spread onto brown paper covered benches, air dried, ground and placed into plastic canisters. Table 1 lists the soil series, mapping unit designation and county from which each soil was obtained.

Laboratory grade ammonium dihydrogen phosphate was dissolved into deionized water to make a stock solution. From this stock solution various volumes were added to 50 grams dry soil resulting in seven rates of P_2O_5 (0, 38, 76, 114, 152, 190 and 228 lbs/ acre). The check treatments had only deionized water added and each treatment was duplicated. The treated soil was placed in a 4-ounce plastic container, mixed thoroughly, moistened to field capacity, then uncapped, and the open containers set on shelves in a closed cabinet. After 4 wk the containers were capped, mixed, re-moistened to field capacity, uncapped and set back on the shelves for an additional 4 wk. At the end of the second 4 wk period (8 weeks total), the samples were sent to the UK Soil Testing Lab to be analyzed for P following extraction with Mehlich III solution.

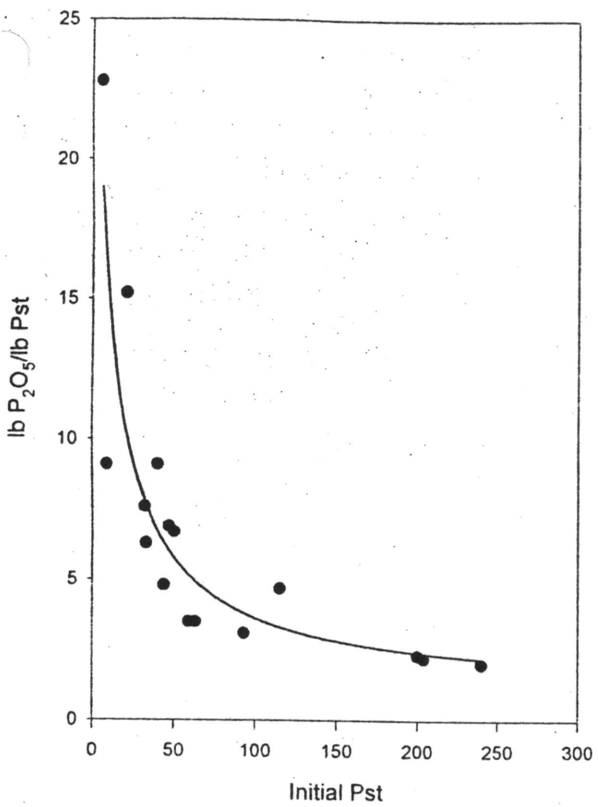


Figure 1. The amount of added P2O5/acre that changed soil test P 1 lb/acre following an 8-wk incubation.

Discussion

Soils with an initially low soil test P value required more P_2O_5 to change soil test P and had the greatest variability in the amount of phosphate needed to change soil test P. This variability could be associated with the each soils's differing ability to adsorb phosphorus. Adsorbed phosphorus would reduce the amount being extracted by the Mehlich III solution for agronomic recommendations.

This study used inorganic phosphorus during the incubation that is closely related to commercial fertilizer sources. With the recent concerns about animal manure containing significant organic P, further studies are needed to determine how this form reacts to change soil test P. Generally, as animal manure is decomposed in the soil, the P would be released to react with the soil except for action delays with decomposition. Most animal manure does contain some inorganic P (ranging from 10 to 30 %) depending on the species and the amount of dicalcium phosphate used in the ration. At this time it is unknown how much organic phosphorus would be extracted by the Mehlich III extractant.

When soil test P levels are below the agronomic critical level of 60 for most crops (80 for tobacco) more phosphate is required to change soil test P which may decrease the economic returns for added phosphate. On the other hand, when soil test P reaches a level of 100 lbs +/acre, considerably less additional phosphate (per unit of soil test) is needed to increase soil test P.

Livestock producers using animal manure at rates based on crop nitrogen needs may find that soil test P changes quite rapidly. Developing alternative cropping or animal manure application strategies resulting from a high priority on phosphorus management will be important. At a soil test P of 200 lbs +/acre, the soil test P may increase l lb/acre for each l lb/acre of actual P added (1 lb P = 2.29 lbs P2O5) in a crop nutrient source.

This study did not determine any long-term affects on soil test change. The 8-wk incubation period was more closely related to what happens during one growing season without plant growth. Removal of P did not occur in the lab but would occur in the field with a growing crop. Also, as part of the soil chemical reactions, there would be some compounds formed that are more difficult to extract. This would reduce the soil test P even though phosphorus had been added to the soil.

Summary

1. Results of a P incubation study with 16 soils indicated that soil test P changed with varying amounts of P_2O_5 based on the initial soil test P as outlined in Table 3.

COMPREHENSIVE NUTRIENT MANAGEMENT PLANNING

TECHNICAL GUIDANCE

DECEMBER 1, 2000

United States Department of Agriculture

Natural Resources Conservation Service

TABLE OF CONTENTS

COMPREHENSIVE NUTRIENT MANAGEMENT PLANNING TECHNICAL GUIDANCE

1.0 INTRODUCTION

USDA's goal is for animal feeding operation (AFO) owners/operators to take voluntary actions to minimize potential water pollutants from confinement facilities and land application of manure and organic by-products. To accomplish this goal, it is a national expectation that all AFOs should develop and implement technically sound, economically feasible, and site-specific Comprehensive Nutrient Management Plans (CNMP)

In general terms, a CNMP identifies management and conservation actions that will be followed to meet clearly defined soil and water conservation goals, including nutrient management, at an agricultural operation. Defining soil and water conservation goals and identifying measures and schedules for attaining the goals are critical to reducing threats to water quality and public health from AFOs. The CNMP should fit within the total resource management objectives of the entire farm/animal feeding operation.

The Comprehensive Nutrient Management Planning Technical Guidance is a document intended for use by those individuals (both public and private) who develop or assist in the development of CNMPs. The purpose of this document is to provide technical guidance for the development of CNMPs, whether they are developed for USDA's voluntary programs or as a means to help satisfy the United States Environmental Protection Agency's (USEPA) National Pollutant Discharge Elimination System (NPDES) permit requirements.

This technical guidance is not intended as a sole-source reference for developing CNMPs. Rather, it is to be used as a tool in support of the conservation planning process (see Appendix A), as contained in the USDA Natural Resources Conservation Service (NRCS) National Planning Procedures Handbook (NPPH) and NRCS Technical References, Handbooks, and Policy Directives (see Appendix B).

2.0 DEFINITION

A CNMP is a conservation system that is unique to animal feeding operations. A CNMP is a grouping of conservation practices and management activities which, when implemented as part of a conservation system, will help to ensure that both production and natural resource protection goals are achieved. It incorporates practices to utilize animal manure and organic by-products as a beneficial resource. A CNMP addresses natural resource concerns dealing with soil erosion, manure, and organic by-products and their potential impacts on water quality, that may derive from a animal feeding operation. A CNMP is developed to assist an AFO owner/operator in meeting all applicable local, tribal, State, and Federal water quality goals or regulations. For nutrient impaired stream segments or water bodies, additional management activities or conservation practices may be required by local, tribal, State, or Federal water quality goals or regulations.

need to be considered by the owner/operator during plan development, and the owner/operators decisions concerning each must be documented):

1) Manure and Wastewater Handling and Storage
2) Land Treatment Practices
3) Nutrient Management
4) Record Keeping
5) Feed Management
6) Other Utilization Activities

- CNMPs will contain actions that address soil erosion and water quality criteria for the feedlot, production area, and land on which the manure and organic by-products will be applied (i.e., as a minimum the plan would address CNMP elements 1, 2, 3, and 4 listed above). For AFO owners/operators who do not land apply any manure or organic by-products, the CNMP would only address the feedlot and production areas (i.e., address CNMP elements 1, 4, and 6 listed above).
- Meet requirements of NRCS Field Office Technical Guide (FOTG) conservation practice standards for practices contained in the CNMP.
- Meet all applicable local, Tribal, State, and Federal regulations.
- When applicable, ensure that USEPA NPDES or State permit requirements (i.e. minimum standards and special conditions) are addressed.

4.2 Element Criteria

Each of the CNMP's elements will address specific criteria. The degree to which these elements are addressed in the development and implementation of a site-specific CNMP is determined by the General Criteria in Section 4.1 and the specific criteria provided for each element. The elements will address the following specific criteria:

4.2.1 Manure and Wastewater Handling and Storage

This element addresses the components and activities associated with the production facility, feedlot, manure and wastewater storage and treatment structures and areas, and any areas used to facilitate transfer of manure and wastewater. In most situations, addressing this element will require a combination of conservation practices and management activities to meet the production needs of the AFO owner/operator and environmental concerns associated with the production facility.

- Operation and maintenance activities that address the collection, storage, treatment and transfer of manure and wastewater, including associated equipment, facilities and structures.
- Nutrient content and volume of manure, if transferred to others.

- An emergency action plan that addresses spills and catastrophic events.

4.2.1.2 Considerations for Manure and Wastewater Handling and Storage

There are additional considerations associated with CNMP development and implementation that should to be addressed. However, NRCS does not have specific technical criteria for these considerations that are required for CNMPs.

Air Quality

AFO operators/owners need to consider the impact of selected conservation practices on air quality during the CNMP development process. Air quality in and around structures, waste storage areas and treatment sites may be impaired by excessive dust, gaseous emissions such as ammonia, and odors. Poor air quality may impact the health of workers, animals and persons living in the surrounding areas. Ammonia emissions from animal operations may be deposited to surface waters, increasing the nutrient load to these regions. Proper siting of structures and waste storage facilities can enhance dispersion and dilution of odorous gases. Enclosing waste storage or treatment facilities can reduce gaseous emissions from AFOs in areas with residential development in the region. Background information on the current state of the knowledge, research gaps, and on-going research projects being carried out on air quality at USDA are provided in Appendix F.

Pathogens

AFO operators/owners need to consider the impact of selected conservation practices on pathogen control during the CNMP development process. Pathogenic organisms occur naturally in animal wastes. Exposure to some pathogens by humans and animals can cause illness, especially for immune-deficient populations. Many of the same conservation practices used to prevent nutrient movement from animal operations, such as leaching, runoff and erosion control are likely to prevent the movement of pathogens. Background information on the current state of the knowledge, research gaps, and on-going research projects being carried out on pathogens at USDA are given in Appendix F.

- *Pest Management* (Code 595)
- *Terrace* (Code 600)

Notes:

The FOTG, Section IV, contains a complete list of NRCS conservation practices and the criteria associated with their design and implementation.

The conservation practice physical effects of individual practices on the natural resources (soil, water, air, plants, and animals) are found in the FOTG, Section V.

- Comply with existing, federal, Tribal, State and Local regulations or ordinances associated with soil erosion and runoff.
- Document the following:
  - Aerial maps of land application areas
  - Individual field maps with marked setbacks, buffers, waterways, and other conservation practices planned
  - Soils information associated with fields (i.e., features, limitations)
  - Design information associated with planned and implemented conservation practices
  - Identification of sensitive areas such as sinkholes, streams, springs, lakes, ponds, wells, gullies, and drinking water sources
- Other site information features of significance, such as property boundaries.
- Identification of operation and maintenance (O&M) practices/activities.

4.2.3 Nutrient Management

This element addresses the requirements for land application of all nutrients and organic by-products (e.g., animal manure, wastewater, commercial fertiiizers, crop residues, legume credits, irrigation water, etc.) that must be evaluated and documented for each CMU.

Land application of manure and organic by-products is the most common method of manure utilization due to the nutrients and organic matter content of the material. Land application procedures must be planned and implemented in a way that minimizes potential adverse impacts to the environment and public health.

4.2.3.1 Criteria for Nutrient Management

- Meet the NRCS Nutrient Management Policy as contained in the NRCS General Manual, Title 190, Part 402, dated May 1999. (See Appendix B)

Salt and Heavy Metals

Build up of salt and heavy metals (i.e., arsenic, selenium, cadmium, molybdenum, zinc) in soils can create a potential for human and animal health problems and threaten soil productivity and crop marketability. Federal and State regulations do not address the heavy metal content associated with agricultural by-products. In developing a CNMP, the build-up of salt and heavy metals should be tracked through soil testing. Additional guidance on salt and heavy metal contamination from manure is available in the following:

NRCS Agricultural Waste Management Field Handbook, Sections 651.1103 and 651.0604(b), deal with the salt content of agricultural waste.

NRCS Agricultural Waste Management Field Handbook, Sections 651.0603(g) and 651.0605(a and b), deal with the heavy metal content of agricultural waste.

USEPA Title 40 Part 503 – Standards for the Use or Disposal of Sewage Sludge, Section 503.13, contains pollutant limits for biosolids heavy metal content and cumulative loading rates. This rule does not address resident levels of metals in the soil.

4.2.4 Record Keeping

It is important that records are kept to effectively document and demonstrate implementation activities associated with CNMPs. Documentation of management and implementation activities associated with a CNMP provides valuable benchmark information for the AFO owner/operator that can be used to adjust his/her CNMP to better meet production objectives. It is the responsibility of AFO owners/operators to maintain records that document the implementation of CNMPs.

Documentation will include:

- Annual manure tests for nutrient contents for each manure storage containment.
- Application records for each application event, including (this also applies to commercial fertilizers that are applied to supplement manure):
    - Containment source or type and form of commercial fertilizer
    - Field(s) where manure or organic by-products are applied
    - Amount applied per acre
    - Time and date of application
    - Weather conditions during nutrient application
    - General soil moisture condition at time of application (i.e., saturated, wet, moist, dry)

"If a dairy cow is fed 0.04 percent above recommended levels of dietary phosphorus she will excrete an additional six pounds of phosphorus annually. For a herd of 500 cows, this is an additional 3,000 pounds of phosphorus per year. In a single cropping system, corn silage is about 0.2 percent phosphorus on a dry matter basis. For a field yielding 30 tons of silage per acre, at 30 percent dry matter, this is 36 pounds of phosphorus in the crop. If an additional 3,000 pounds of phosphorus are recovered in manure it takes considerably more land for application if manure is applied on a phosphorus basis." Dr. Deanne Meyer, Livestock Waste Management Specialist, Cooperative Extension, University of California.

Specific feed management activities to address nutrient reduction in manure may include phase feeding, amino acid supplemented low crude protein diets, and the use of low phytin phosphorus grain and enzymes, such as phytase or other additives.

Feed management can be an effective approach to addressing excess nutrient production and should be encouraged; however, it is also recognized that feed management may not be a viable or acceptable alternative for all AFOs. A professional animal nutritionist should be consulted before making any recommendations associated with feed ration adjustment.

4.2.6 Other Utilization Activities

Using environmentally-safe alternatives to land application of manure and organic by-products could be an integral part of the overall CNMP. Alternative uses are needed for animal manure in areas where nutrient supply exceeds available land and/or where land application would cause significant environmental risk. Manure use for energy production, including burning, methane generation and conversion to other fuels, is being investigated and even commercially tested as a viable source of energy. Methods to reduce the weight, volume, or form of manure, such as composting or pelletizing, can reduce transportation cost, and create a more valuable product. Manure can be mixed or co-composted with industrial or municipal by-products to produce value-added material for specialized uses. Transportation options are needed to move manure from areas of over supply to areas with nutrient deficiencies (i.e., manure brokering).

More efficient and cost-effective methods are needed for manure handling, treatment, and storage. Areas in need of targeting include: (1) improved systems for solids removal from liquid manure; (2) improved manure handling, storage, and treatment methods to reduce ammonia volatilization; (3) treatment systems that transform and/or capture nutrients, trace elements, and pharmaceutically active chemicals from manure; (4) improved composting and other manure stabilization techniques; and, (5) treatment systems to remediate or replace anaerobic lagoons.

As many of these alternatives to conventional manure management activities have not been fully developed or refined, industry standards do not always exist that provide for their consistent implementation. Except for the NRCS conservation practice standard *Composting Facility* (Code 317), NRCS does not have conservation practice standards that address these other utilization options.

It is envisioned that a certified conservation planner, assisting the AFO owner/operator, would facilitate the CNMP development process, with "certified specialists" developing the more detailed specifics associated with the element they are certified to help produce.