Subsection 3D:
Nutrient Recommendations
Forage Crops

Table of Contents

Alfalfa

Management Highlights

- Target pH: **6.8**
- Monitor soil P and K levels. It is more efficient and economical to maintain soil fertility than to re-establish the stand.
- Watch for Mn deficiency, especially when soil test Mn is less than 3.4 lbs/ac.
- Inoculate all seed with fresh, live inoculum just prior to seeding.

Yield Goals

Forage yield of alfalfa is dependent upon many factors: the cultivar selected, seeding date, age of the stand and degree of establishment, stand composition, soil type and water-holding capacity, nutrient and water availability, weed, insect and disease pressure and crop management practices. Table 1 shows typical yield goals for alfalfa at different stages grown on Delaware soils.

Table 1. Alfalfa yield goals as a function of stand age.

Stand Age	Forage Yield
	------- tons / ac -------
Year following fall seeding	4.0 - 5.0
Year of spring seeding	2.0 - 3.5
Subsequent years	5.0 - 7.0

Soil pH and Liming

The target pH for alfalfa on most Delaware soils is **6.8**. ***If the soil pH is 5.5 or lower, soil is too acid for good growth of alfalfa***. For soil pH between **5.1** and **5.5**, apply lime at the recommended rate and plow down prior to seeding the field.

When soil pH is 5.0 or less, the soil is too acid for establishment of alfalfa. Apply lime at the recommended rate and incorporate thoroughly. ***Do not seed immediately.*** Instead, plant another crop and re-test the soil in 6 to 12 months to determine if pH has been adequately corrected.

Soil pH problems are best corrected prior to initial seeding for perennial crops such as alfalfa since tillage, which can increase the effectiveness of liming, is limited for several years once the crop is established.

The lime recommendation for a specific alfalfa field is calculated from the soil pH and buffer pH measurements using the steps outlined in ***Calculating the Lime Requirement -- Chapter 3, Section 3.4***. Avoid overliming to prevent deficiency of micronutrients such as manganese.

In most cases, the lime requirement can be met by either calcitic or dolomitic limestone.

Dolomitic limestone is recommended if:

- soil test Mg is less than 50 FIVs, or
- soil test Mg is between 50 and 100 FIVs ***and less than soil test Ca***.

Calcitic limestone is recommended if:

- soil test Mg is greater than 100 FIVs, or
- soil test Mg is between 50 and 100 FIVs ***and greater than soil test Ca.***

Nitrogen Management

Alfalfa is a leguminous plant and, once established, capable of fixing sufficient nitrogen (N) to meet crop needs. Nitrogen application to alfalfa is, therefore, recommended only at seeding to aid in establishment. ***To ensure that N fixation will be successful, treat the seed with fresh, live inoculum just prior to planting.***

Table 2 gives a summary of recommended N rates for use when seeding alfalfa. Rates are higher for sandier soils to compensate for greater leaching losses.

Table 2. Recommended N rates for seeding alfalfa.

Soil Type	N Rate
	----- lbs / ac -----
Loamy sands, sandy loams	30
All other soil types	20

In subsequent years, the composition of the stand should be evaluated to determine N needs. For stands with more than 25% alfalfa, no N is recommended. When the stand is less than 25% alfalfa, re-seed with alfalfa or interseed a grass crop. If interseeding with grass or if grass is already present, switch to nutrient recommendations for grass-alfalfa mixtures.

Phosphorus Management

Adequate concentrations of soil phosphorus (P) are important for forage production and stand longevity of alfalfa. However, yield-limiting P deficiency is rarely a concern on Delaware soils. Long-term applications of fertilizers and manures have resulted in P accumulations in many soils that are capable of supplying crop needs for several years with no further additions.

To determine whether P fertilization is necessary for a specific field, conduct a routine soil test. University of Delaware P recommendations for alfalfa are dependent upon stand age and soil test P value. A summary of P recommendations for Delaware alfalfa are given in Table 3

Table 3. Broadcast application rates for P for alfalfa.

Stand Status	P Index Value						
	0	**10**	**20**	**30**	**50**	**70**	**90**
	---------- lbs P_2O_5 / ac ----------						
Seeding	210	190	170	150	100	60	20
Subsequent years	150	125	100	80	60	20	0

Seeding

When soil test P is ***Low*** or ***Medium*** (***50 FIVs or less***), P should be broadcast and plowed down prior to seeding. When soil test P is ***Optimum***, (***51 FIVs or greater***), P can either be broadcast and incorporated or topdressed prior to or at planting.

Topdressing Established Stands

When soil test P is ***40 FIVs or greater***, topdressing the recommended rate of P_2O_5 should be effective in meeting crop needs for P.

If soil test P is ***less than 40 FIVs***, satisfactory growth of alfalfa is unlikely. ***Do not attempt to correct the problem by topdressing P_2O_5 or by broadcasting and incorporating P, followed by immediate re-seeding.*** Instead, correct P deficiency by plowing down the field and then broadcasting and incorporating the recommended rate of P_2O_5. Grow a short-season corn or early-maturity soybean cultivar for one season, and then re-seed alfalfa to obtain optimum yields.

Potassium Management

Potassium (K) is very important for alfalfa growth and stand longevity. The need for K fertilization of alfalfa is best determined by the use of a routine soil test. Potassium recommendations are based on crop status (new seeding or established crop) and the soil test K index value. A summary of University of Delaware K recommendations for alfalfa is given in Table 4.

Table 4. Broadcast application rates for K for alfalfa.

Stand Status	K Index Value						
	0	**10**	**20**	**30**	**50**	**70**	**90**
	---------- lbs K_2O / ac ----------						
Seeding	320	280	240	200	110	25	0
Subsequent years	330	290	255	220	150	75	0

Seeding

When establishing a new field, K should be broadcast before or immediately after planting. Incorporation of K by disking or plowing down will de-

crease potential salt effects from higher application rates.

Topdressing Established Stands

If the recommended K rate is ***90 lbs K_2O/ac or less***, potash can be broadcast in a single application either after the first cutting in the spring or after the last cutting in August. When the recommended rate is ***greater than 90 lbs K_2O/ac***, apply K in two applications -- one after the first or second cutting and one after the last cutting in August

Calcium and Magnesium Management

Calcium (Ca) and magnesium (Mg) needs of alfalfa are usually met through routine liming. ***Magnesium application is recommended if the soil test Mg value is less than 38 FIVs.*** If liming has been recommended, use dolomitic limestone to raise soil pH and increase soil Mg. If, however, liming is not necessary but Mg is still indicated, apply Mg as Mg sulfate or Mg chloride to increase soil Mg. Appropriate application rates are given below in Table 5.

Table 5. Application rates for soluble Mg as a function of Mg fertility index value.

Mg Index Value								
0	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**
---------- lbs soluble Mg / ac ----------								
80	70	60	50	40	30	20	10	0

Sulfur Management

Alfalfa should receive sulfur (S) at a rate of **20-40 lbs S/ac** per year to ensure that adequate S is available to meet crop needs. Sulfur should be broadcast prior to seeding and topdressed annually during each subsequent year of production.

Manganese Management

Manganese (Mn) deficiency may occur in alfalfa grown on Delaware soils, most often as a result of overliming soils that are naturally low in Mn. The University of Delaware Soil Testing Program uses an availability index based on the soil test Mn value and soil pH to predict the likelihood of Mn deficiency. That availability index is calculated using the equation:

$$MNAI = 101.7 - (15.2 \times pH) + (2.11 \times ST\text{-}Mn)$$

where:

MNAI = Mn availability index
pH = water pH of the soil
ST-Mn = soil test Mn in lbs/ac.

Table 3-14 in ***Chapter 3, Section 3.5.5.2 (Manganese Management)*** gives a summary of MNAI values for various soil pH-soil test Mn combinations. Interpretations of the index for alfalfa are given in Table 6.

Table 6. Interpretation of Mn availability index for alfalfa.

MnAI Value	Interpretation
Less than 12	Mn deficiency is possible.
Greater than or equal to 12	Mn deficiency is unlikely at this soil pH.

Suspected Mn deficiency can be confirmed by tissue analysis. Confirmed deficiency situations can be corrected in season by foliar applications of Mn of 1-2 lbs/ac of actual Mn as Mn sulfate, Mn oxide or Mn chelate. If deficiency is predicted by the availability index or was observed during the previous growing season, it can be prevented by a broadcast application of 20-30 lbs/ac of actual Mn.

Boron Management

Boron (B) deficiency is occasionally observed in alfalfa grown on Delaware soils. To prevent deficiency, apply **2.0 lbs B/ac** each year. Prior to seeding, apply B in a blended, broadcast fertilizer, or as a soil spray, and incorporate into the soil. On established stands, B can be topdressed in a blended, broadcast fertilizer or applied as a foliar spray.

Caution: Although B is required for maximum yield of alfalfa, even slight over-application of B can be toxic to the crop. When applied as a foliar spray, be certain to apply the correct rate.

Other Nutrients

No other nutrients are known to be limiting to alfalfa production in Delaware.

Additional Information

See Soil Test Notes 1, 3, and 4 (Appendix 7) for additional information concerning fertilization of alfalfa.

Corn Silage

Management Highlights

- Target pH: **6.0**
- Split N applications to increase N use-efficiency. Apply a small amount (20-25%) at planting and the bulk of the N requirement (75-80%) at sidedressing.
- In irrigated corn where fertigation is possible, split N applications to increase N use-efficiency. Apply a small amount (20-25%) at planting and split the remainder into equal increments to be applied with the irrigation water from the 5-6 leaf stage through silking.
- Watch for Mn deficiency, especially when soil test Mn is less than 3.4 lbs/ac.

Yield Goals

Silage yield of corn is influenced by many factors, including the cultivar selected, planting date, soil type and water-holding capacity, nutrient and water availability, weed, insect and disease pressure and crop management practices. Table 1 shows typical yield goals for silage corn grown on Delaware soils.

Table 1. Corn silage yield goals as a function of soil type and irrigation use.

	Non-irrigated		Irrigated
Soil Type	**CT***	**NT****	
	--------- tons / ac -------		
Loamy sands	15	20	30
Sandy loams, loams, black loamy sands, black sandy loams	20	25	30
Silt loams, black loams, black silt loams	25	30	30

*CT = conventional tillage
**NT = no-tillage

As indicated, irrigation use can increase yields significantly. Likewise, since no-tillage production systems favor water conservation and an early planting date, silage corn grown using no-till management often produces higher yields than does silage corn grown conventionally on the same soil type. Use of conservation-tillage practices can be expected to produce yields between the management extremes of conventional- and no-tillage systems.

Soil pH and Liming

The target pH for corn silage grown on most Delaware soils is **6.0**. Soils that are higher in organic matter ("black" soils) have a lower target pH (5.6) because organic matter moderates some of the effects of excessive soil acidity (e.g., aluminum toxicity). The lime recommendation for a specific field is calculated from the soil pH and buffer pH measurements using the steps outlined in ***Calculating the Lime Requirement -- Chapter 3, Section 3.4.*** Use care to avoid overliming in order to prevent micronutrient deficiencies (e.g., manganese or zinc).

In most cases, the lime requirement can be met by either calcitic or dolomitic limestone.

Dolomitic limestone is recommended if:
- soil test Mg is less than 50 FIVs, or
- soil test Mg is between 50 and 100 FIVs ***and less than soil test Ca***.

Calcitic limestone is recommended if:
- soil test Mg is greater than 100 FIVs, or
- soil test Mg is between 50 and 100 FIVs ***and greater than soil test Ca.***

Nitrogen Management

Nitrogen (N) rates for corn silage production are dependent upon a realistic yield goal for the crop and the soil type of the field. A summary of N rates recommended by the University of Delaware are given in Table 2.

Table 2. Recommended N rates for corn silage as a function of yield goal.

Yield Goal	N Rate
----- tons / ac ----	---- lbs N / ac ----
15	100 - 120
20	120 - 150
25	150 - 180
30	180 - 220

The higher rate of N is recommended for management systems utilizing a single application in order to compensate for greater leaching losses. Split applications of N have been shown to increase the efficiency of N use by the crop and thus require less total N to achieve the same yield.

Nitrogen rates also need to be adjusted when planting into a field with a legume cover crop or where manure has been applied. To calculate the N adjustment required, see ***Nitrogen Rate Adjustments -- Chapter 3, Section 3.5.1.2.***

Phosphorus Management

Yield-limiting phosphorus (P) deficiency is rarely a concern on Delaware soils. Long-term applications of fertilizers and manures have resulted in P accumulations in many soils that are capable of supplying crop needs for several years with no further additions.

To determine whether P fertilization is necessary for a specific field, conduct a routine soil test. University of Delaware P recommendations for corn silage are dependent upon yield goal and soil test P value. A summary of P recommendations for corn silage is shown in Table 3.

Table 3. Broadcast application rates of P for corn silage production.

	P Index Value						
Yield	**0**	**10**	**20**	**30**	**40**	**60**	**80**
ton/ac	---------- lbs P_2O_5 / ac ----------						
15	130	114	98	82	66	33	0
20	130	114	98	82	66	33	0
25	160	140	120	100	80	40	0
30	190	166	142	118	94	47	0

Note: These rates are for a broadcast application. If P is to be applied in a fertilizer band, rates should be cut by half.

Potassium Management

The need for potassium (K) fertilization of silage corn is best determined by the use of a routine soil test. As with P, K recommendations are based on expected silage yield and soil test K value. A summary of University of Delaware K recommendations for corn silage production is given in Table 4. Potassium can be broadcast prior to planting or applied in the fertilizer band. ***To avoid salt injury to seedlings, do not band more than 75 lbs K_2O/ acre. If N and K are banded together, total nutrient rate should not exceed 75 lbs/ac.***

Table 4. Potassium recommendations for silage corn.

	K Index Value						
Yield	**0**	**10**	**20**	**30**	**50**	**70**	**90**
bu/ac	---------- lbs K_2O / ac ----------						
15	200	182	164	146	115	85	35
20	200	182	164	146	115	85	35
25	240	220	200	180	140	100	40
30	280	255	230	205	157	111	45

Calcium and Magnesium Management

Calcium (Ca) and magnesium (Mg) needs of corn silage are usually met through routine liming. ***Magnesium application is recommended if the soil test Mg value is less than 38 FIVs.*** If liming has been recommended, use dolomitic limestone to raise soil pH and increase soil Mg. If, however, liming is not necessary but Mg is still indicated,

apply Mg as Mg sulfate or Mg chloride to increase soil Mg. Appropriate application rates are given below in Table 5.

Table 5. Application rates for soluble Mg as a function of Mg fertility index value.

Mg Index Value								
0	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**
---------- lbs soluble Mg / ac ----------								
80	70	60	50	40	30	20	10	0

Manganese Management

Manganese (Mn) deficiency may occur in silage corn grown on Delaware soils, most often as a result of overliming soils that are naturally low in Mn. The University of Delaware Soil Testing Program uses an availability index based on the soil test Mn value and soil pH to predict the likelihood of Mn deficiency. That availability index is calculated using the equation:

$$MNAI = 101.7 - (15.2 \times pH) + (2.11 \times ST\text{-}Mn)$$

where:

MNAI = Mn availability index
pH = water pH of the soil
ST-Mn = soil test Mn in lbs/ac.

Table 3-14 in ***Chapter 3, Section 3.5.5.2 (Manganese Management)*** gives a summary of MNAI values for various soil pH-soil test Mn combinations. Interpretations of the index for corn silage are given below in Table 6.

Suspected Mn deficiency can be confirmed by tissue analysis. Confirmed deficiency situations can be corrected in season by foliar applications of Mn of 1-2 lbs/ac of actual Mn as Mn sulfate, Mn oxide or Mn chelate. If deficiency is predicted by the availability index or was observed during the previous growing season, it can be prevented by an application of 8-10 lbs/ac of actual Mn in the fertilizer band. Band applications of acid-forming fertilizer, which lower soil pH in the area of plant roots, may correct Mn deficiency without the addition of Mn fertilizers.

Table 6. Interpretation of Mn availability index for corn silage.

MnAI Value	Interpretation
Less than 17	Mn deficiency is possible. Monitor the crop for symptoms.
17 or greater	Mn deficiency is unlikely at this soil pH.
Exception: MNAI>17 but ST-Mn is less than 3.4 lbs/ac, pH is less than 6.0 and lime has been recommended.	Mn concentration is adequate at this soil pH. Liming, however, may induce deficiency. Monitor crop for symptoms.

Other Nutrients

No other nutrients are known to be limiting to corn silage production in Delaware.

Additional Information

See Soil Test Notes 1, 2, 4 and 5 (Appendix 7) for additional information concerning fertilization of corn silage.

Grass-Alfalfa Mixtures

Management Highlights

- Target pH: **6.5**
- Monitor soil P and K levels. It is more economical to maintain soil fertility than to re-establish the stand.
- High levels of soil P and K will encourage legume growth in mixed grass and legume pastures.

Yield Goals

Forage yield of grass/alfalfa mixed fields is dependent upon many factors: the cultivars selected, seeding date, age of the stand and degree of establishment, stand composition, soil type and water-holding capacity, nutrient and water availability, weed, insect and disease pressure, crop and grazing management practices. ***On Delaware soils, 3.0-3.5 tons/ac of hay is a realistic yield goal for grass-alfalfa mixed fields in a good to average year.*** When field history data supports the use of a different yield goal, growers should use that information to adjust management decisions and fertility programs accordingly.

Soil pH and Liming

The target pH for grass/alfalfa fields on most Delaware soils is **6.5**. If the soil pH is ***5.3 or lower***, the soil is too acidic for good growth of grass-alfalfa mixtures. Apply the recommended rate of lime and plow down before re-seeding the field. If the soil pH is ***5.4 or higher***, lime can be topdressed.

The lime recommendation for a specific grass-alfalfa field is calculated from the soil pH and buffer pH measurements using the steps outlined in ***Calculating the Lime Requirement -- Chapter 3, Section 3.4.*** Use care to avoid overliming in order to prevent micronutrient deficiencies.

In most cases, the lime requirement can be met by either calcitic or dolomitic limestone.

Dolomitic limestone is recommended if:

- soil test Mg is less than 50 FIVs, or
- soil test Mg is between 50 and 100 FIVs ***and less than soil test Ca***.

Calcitic limestone is recommended if:

- soil test Mg is greater than 100 FIVs, or
- soil test Mg is between 50 and 100 FIVs ***and greater than soil test Ca.***

Nitrogen Management

The nitrogen (N) requirement of grass/alfalfa fields is dependent upon stand composition. Alfalfa is a leguminous plant and capable of fixing sufficient N to meet some or all of the N needed by the crop. Stands containing high percentages of alfalfa require less N once established than those dominated by grass. Overapplication of N to stands high in alfalfa increases the competitiveness of the grass species and will result in loss of the alfalfa from the stand.

Table 1 gives a summary of recommended N rates for grass/alfalfa fields as a function of stand composition. Nitrogen should be applied after each cutting to encourage stand recovery and subsequent growth.

Table 2. Recommended N rates for grass/alfalfa fields.

Stand Composition	N Rate
	----- lbs / ac -----
0 - 25% alfalfa	50/cutting
25 - 50% alfalfa	25/cutting
>50% alfalfa	0/cutting

Phosphorus Management

Yield-limiting phosphorus (P) deficiency is rarely a concern on Delaware soils. Long-term applications of fertilizers and manures have resulted in P accumulations in many soils that are capable of supplying crop needs for many years with no further additions.

Adequate concentrations of soil test P are important to grass/alfalfa hay production and stand longevity. To determine whether P fertilization is necessary for a specific field, conduct a routine soil test. University of Delaware P recommendations for grass/alfalfa fields are dependent upon stand age and soil test P value. A summary of P recommendations for Delaware grass/alfalfa fields are given in Table 3.

Table 3. Phosphorus recommendations for grass/alfalfa fields.

P Index Value						
0	**10**	**20**	**30**	**50**	**70**	**90**
---------- lbs P_2O_5 / ac ----------						
120	104	88	74	50	17	0

If soil test P is Low (less than 25 FIVs), satisfactory growth of grass/alfalfa hay is unlikely. Few, if any, legumes will survive. Grass yield and longevity will be poor. ***Do not attempt to correct the problem by topdressing P. Instead, broadcast the recommended rate of P, plow down and re-seed to obtain optimum yields.***

When soil test P is ***Medium*** or ***Optimum*** (***greater than 25 FIVs***), topdressing the recommended rate of P should be effective in meeting crop needs.

Potassium Management

Potassium (K) is very important to grass/alfalfa growth and stand longevity. The need for K fertilization is best determined by the use of a routine soil test. Recommended K rates are based on the soil test K index value. A summary of K rates for grass/alfalfa hay is given in Table 4.

Table 4. Potassium recommendations for grass/alfalfa fields.

K Index Value						
0	**10**	**20**	**30**	**50**	**70**	**90**
---------- lbs K_2O / ac ----------						
180	165	150	135	105	75	45

If the recommended K rate is ***90 lbs K_2O/ac or less***, potash can be broadcast in a single application. When the recommended rate is ***greater than 90 lbs K_2O/ac***, apply K in two applications: one in June after the first or second cuttings and one after the last cutting in August.

To decrease the potential for grass tetany, avoid K over-fertilization on hay fields that are predominantly grass species. Waiting until after the first cutting to apply K helps to reduce the potential danger.

Calcium and Magnesium Management

Calcium (Ca) and magnesium (Mg) needs of grass /alfalfa fields are usually met through routine liming. ***Magnesium application is recommended if the soil test Mg value is less than 38 FIVs.*** If liming has been recommended, use dolomitic limestone to raise soil pH and increase soil Mg. If, however, liming is not necessary but Mg is still indicated, apply Mg as Mg sulfate or Mg chloride to increase soil Mg. Appropriate application rates are given below in Table 5.

Table 5. Application rates for soluble Mg as a function of Mg fertility index value.

Mg Index Value								
0	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**
---------- lbs soluble Mg / ac ----------								
80	70	60	50	40	30	20	10	0

Boron Management

Hay fields containing legumes such as alfalfa should be fertilized with **0.5 to 1.0 lbs B/ac** each year. Boron can be topdressed in a blended, broad-

cast fertilizer or applied as a foliar spray, generally in late May or June.

Caution: Although B is required for maximum productivity of alfalfa, even slight over-application of B can be toxic to the crop. When applied as a foliar spray, be certain to apply the correct rate.

Manganese Management

Manganese (Mn) deficiency may occur in grass/alfalfa fields on Delaware soils, most often as a result of overliming soils that are naturally low in Mn. The University of Delaware Soil Testing Program uses an availability index based on the soil test Mn value and soil pH to predict the likelihood of Mn deficiency. That availability index is calculated using the equation:

$$MNAI = 101.7 - (15.2 \times pH) + (2.11 \times ST\text{-}Mn)$$

where:

MNAI = Mn availability index
pH = water pH of the soil
ST-Mn = soil test Mn in lbs/ac.

Table 3-14 in ***Chapter 3, Section 3.5.5.2 (Manganese Management)*** gives a summary of MNAI values for various soil pH-soil test Mn combinations. Interpretations of the Mn availability index for grass or grass/clover pastures are given below in Table 6.

Table 6. Interpretation of the Mn availability index for grass/alfalfa fields.

MnAI Value	Interpretation
Less than 12	Mn deficiency is likely at this soil pH and Mn concentration.
12 or greater	Mn deficiency is unlikely.

Suspected Mn deficiency can be confirmed by tissue analysis. Confirmed deficiency situations can be corrected in season by foliar applications of Mn of 1-2 lbs/ac of actual Mn as Mn sulfate, Mn oxide or Mn chelate. If deficiency is predicted by the availability index or was observed during the previous growing season, it can be prevented by a broadcast application of 20-30 lbs/ac of actual Mn in the fertilizer band. Broadcast applications of acid-forming fertilizer, which lower soil pH in the area of plant roots, may correct Mn deficiency without the addition of Mn fertilizer but may be less effective than applications of Mn.

Other Nutrients

No other nutrients are known to be limiting to grass/alfalfa hay production in Delaware.

Additional Information

See Soil Test Notes 1, 3, and 4 (Appendix 7) for additional information concerning fertilization of grass/alfalfa hay.

Grass or Grass / Clover Pastures

Management Highlights

- Target pH: **6.0**
- Monitor soil P and K levels. It is more economical to maintain soil fertility than to re-establish the stand.
- High levels of soil P and K will encourage legume growth in mixed grass and legume pastures.

Yield Goals

Forage yield of grass or grass/clover pasture is dependent upon many factors: the cultivars selected, seeding date, age of the stand and degree of establishment, stand composition, soil type and water-holding capacity, nutrient and water availability, weed, insect and disease pressure, crop and grazing management practices. Table 1 shows typical yield goals for grass or grass/clover pastures grown on Delaware soils.

Table 1. Grass or grass/clover pasture yield goals as a function of stand age.

Stand Age	Forage Yield
	------- tons / ac -------
Year following fall seeding	4.0 - 5.0
Year of spring seeding	2.0 - 3.5
Subsequent years	3.0 - 3.5

Soil pH and Liming

The target pH for grass or grass/clover pastures on most Delaware soils is **6.0**. If the soil pH is ***5.3 or lower***, the soil is too acidic for good growth of grass or grass/clover pastures. Apply the recommended rate of lime and allow the soil pH to increase before attempting to plant.

When seeding over-seeding a field, thorough incorporation of the recommended rate of lime is most effective in correcting soil pH problems.

On established fields, lime can be topdressed although results may be somewhat less effective than those achieved by incorporation of the limestone.

The lime recommendation for a specific grass or grass/clover pasture field is calculated from the soil pH and buffer pH measurements using the steps outlined in ***Calculating the Lime Requirement -- Chapter 3, Section 3.4.*** Use care to avoid overliming in order to prevent micronutrient deficiencies.

In most cases, the lime requirement can be met by either calcitic or dolomitic limestone.

Dolomitic limestone is recommended if:

- soil test Mg is less than 50 FIVs, or
- soil test Mg is between 50 and 100 FIVs ***and less than soil test Ca***.

Calcitic limestone is recommended if:

- soil test Mg is greater than 100 FIVs, or
- soil test Mg is between 50 and 100 FIVs ***and greater than soil test Ca.***

Nitrogen Management

The nitrogen (N) requirement of grass or grass/clover pastures is dependent upon stand age and composition. Clover is a leguminous plant and, once established, capable of fixing sufficient N to meet crop needs. All stands should receive an application of N at seeding to aid in establishment. Seed mixes containing clover should be treated with a suitable inoculum to ensure that N fixation will occur. In subsequent years, stands containing high percentages of clover require less N once established than those dominated by grass. Over application of N to stands high in clover increases the competitiveness of the grass species and will result in loss of the clover.

Table 1 gives a summary of recommended N rates

for grass or grass/clover pasture as a function of stand age and composition. At planting, the higher N rate should be used on sandier soils to compensate for greater leaching losses. That rate can be reduced or eliminated when planting into a legume cover or when manure has been applied prior to planting. To adjust N rates, see ***Nitrogen Rate Adjustments -- Chapter 3, Section 3.5.1.2***. On established stands, N should be applied after each grazing period to encourage stand recovery and subsequent growth.

Table 2. Recommended N rates for grass or grass/clover pastures.

Stand Status	N Rate
	----- lbs / ac -----
Seeding - grass/clover mix	0 - 30
Seeding - grass only	40 - 60
Established stand :	
0 - 25% clover	50/grazing period
25 - 50% clover	25/grazing period
>50% clover	0/grazing period

Phosphorus Management

Yield-limiting phosphorus (P) deficiency is rarely a concern on Delaware soils. Long-term applications of fertilizers and manures have resulted in P accumulations in many soils that are capable of supplying crop needs for many years with no further additions.

Adequate concentrations of soil test P are important to grass or grass/clover pasture production and stand longevity. To determine whether P fertilization is necessary for a specific field, conduct a routine soil test. University of Delaware P recommendations for grass or grass/clover pasture are dependent upon stand age and soil test P value. A summary of P recommendations for Delaware grass or grass/clover pasture are given in Table 3.

Table 3. Phosphorus recommendations for grass or grass/clover pastures.

Stand Status	P Index Value						
	0	**10**	**20**	**30**	**50**	**70**	**90**
	---------- lbs P_2O_5 / ac ----------						
Seeding	120	109	97	86	63	40	13
Subsequent years	120	104	88	74	50	17	0

Seeding

When soil test P is ***Low*** or ***Medium*** (***50 FIVs or less***), P should be broadcast and plowed down prior to seeding. When soil test P is ***Optimum*** (***51 FIVs or greater***), P can either be broadcast and incorporated prior to planting or topdressed prior to or shortly after planting.

Topdressing Established Stands

If soil test P is Low (less than 25 FIVs), satisfactory growth of grass or grass/clover pasture is unlikely. Few, if any, legumes will survive. Grass yield and longevity will be poor. ***Do not attempt to correct the problem by topdressing P. Instead, broadcast the recommended rate of P, plow down and re-seed to obtain optimum yields.***

When soil test P is ***Medium*** or ***Optimum*** (***greater than 25 FIVs***), topdressing the recommended rate of P should be effective in meeting crop needs.

Potassium Management

Potassium (K) is very important to grass or grass/clover pasture growth and stand longevity. The need for K fertilization of grass or grass/clover pasture is best determined by the use of a routine soil test. Potassium recommendations are based on crop status (new seeding or established crop) and the soil test K index value. A summary of University of Delaware K recommendations for grass or grass/clover pasture is given in Table 4.

Table 4. Potassium recommendations for grass or grass/clover pastures.

Stand Status	K Index Value						
	0	10	20	30	50	70	90
	---------- lbs K_2O / ac ----------						
Seeding	180	163	146	129	94	60	20
Subsequent years	180	165	150	135	105	75	45

Seeding

When establishing a new field, K should be broadcast before or immediately after planting. Incorporating K by disking or plowing down will decrease potential salt effects from higher application rates.

Topdressing Established Stands

If the recommended K rate is ***90 lbs K_2O/ac or less***, potash can be broadcast in a single application. When the recommended rate is ***greater than 90 lbs K_2O/ac***, apply K in two applications: one in June after the first or second grazing period and one in August or early September after the late summer grazing period.

To decrease the potential for grass tetany, avoid K overfertilization on pastures that are predominantly grass species. Waiting until after the first grazing period to apply K helps to reduce the potential danger.

Calcium and Magnesium Management

Calcium (Ca) and magnesium (Mg) needs of grass or grass/clover pasture are usually met through routine liming. ***Magnesium application is recommended if the soil test Mg value is less than 38 FIVs.*** If liming has been recommended, use dolomitic limestone to raise soil pH and increase soil Mg. If, however, liming is not necessary but Mg is still indicated, apply Mg as Mg sulfate or Mg chloride to increase soil Mg. Appropriate application rates are given below in Table 5.

Table 5. Application rates for soluble Mg as a function of Mg fertility index value.

Mg Index Value									
0	5	10	15	20	25	30	35	40
---------- lbs soluble Mg / ac ----------								
80	70	60	50	40	30	20	10	0

Boron Management

Pastures containing legumes such as clover should be fertilized with **0.5-1.0 lbs boron (B)/ac** each year. Prior to seeding, apply B in a blended, broadcast fertilizer or as a soil spray and incorporate into the soil. On established stands, B can be topdressed in a blended, broadcast fertilizer or applied as a foliar spray, generally in late May or June.

Caution: Although B is required for maximum productivity of pastures, even slight over-application of B can be toxic to the crop. When applied as a foliar spray, be certain to apply the correct rate.

Manganese Management

Manganese (Mn) deficiency may occur in grass or grass/clover pastures on Delaware soils, most often as a result of overliming soils that are naturally low in Mn. The University of Delaware Soil Testing Program uses an availability index based on the soil test Mn value and soil pH to predict the likelihood of Mn deficiency. That availability index is calculated using the equation:

$$MNAI = 101.7 - (15.2 \times pH) + (2.11 \times ST\text{-}Mn)$$

where:

MNAI = Mn availability index
pH = water pH of the soil
ST-Mn = soil test Mn in lbs/ac.

Table 3-14 in ***Chapter 3, Section 3.5.5.2 (Manganese Management)*** gives a summary of MNAI values for various soil pH-soil test Mn combinations. Interpretations of the Mn availability index for grass or grass/clover pastures are given below in Table 6.

Table 6. Interpretation of the Mn availability index for grass or grass/clover pastures.

MnAI Value	Interpretation
Less than 12	Mn deficiency is likely at this soil pH and Mn concentration.
12 or greater	Mn deficiency is unlikely.

Suspected Mn deficiency can be confirmed by tissue analysis. Confirmed deficiency situations can be corrected in season by foliar applications of Mn of 1-2 lbs/ac of actual Mn as Mn sulfate, Mn oxide or Mn chelate. If deficiency is predicted by the availability index or was observed during the previous growing season, it can be prevented by a broadcast application of 20-30 lbs/ac of actual Mn in the fertilizer band. Broadcast applications of acid-forming fertilizer, which lower soil pH in the area of plant roots, may correct Mn deficiency without the addition of Mn fertilizer but may be less effective than applications of Mn.

Other Nutrients

No other nutrients are known to be limiting to grass or grass/clover pasture production in Delaware.

Additional Information

See Soil Test Notes 1, 3, and 4 (Appendix 7) for additional information concerning fertilization of grass or grass/clover pasture.

Sorghum Silage

Management Highlights

- Target pH: **6.0**
- Split N applications to increase N use-efficiency in sorghum silage production. Apply a small amount at planting and the remainder of the N requirement (75-80%) at the 5th leaf stage.

Yield Goals

Silage yield of sorghum is influenced by many factors, including the cultivar selected, planting date, winter weather, soil type and water-holding capacity, nutrient and water availability, weed, insect and disease pressure and crop management practices. ***On Delaware soils, 10 - 15 tons/ac is a realistic yield goal for sorghum silage production in a good to average year***. When field history supports the use of a different yield goal, growers should use that information to adjust management decisions and fertility programs accordingly.

Soil pH and Liming

The target pH for sorghum on most Delaware soils is **6.0**. Soils that are higher in organic matter ("black" soils) have a lower target pH (5.6) because organic matter moderates some of the effects of excessive soil acidity (e.g., aluminum toxicity). The lime recommendation for a specific field is calculated from the soil pH and buffer pH measurements using the steps outlined in ***Calculating the Lime Requirement -- Chapter 3, Section 3.4.*** Avoid overliming in order to prevent deficiency of micronutrients such as manganese.

In most cases, the lime requirement can be met by either calcitic or dolomitic limestone.

Dolomitic limestone is recommended if:

- soil test Mg is less than 50 FIVs, or
- soil test Mg is between 50 and 100 FIVs ***and less than soil test Ca***.

Calcitic limestone is recommended if:

- soil test Mg is greater than 100 FIVs, or
- soil test Mg is between 50 and 100 FIVs ***and greater than soil test Ca.***

Nitrogen Management

The University of Delaware recommends a nitrogen (N) rate of **160-180 lbs N/ac** for sorghum silage production on Delaware soils. Nitrogen use will be most efficient when applied in a spilt application. A small amount of the N (approximately 25%) should be applied at or just prior to planting. The remainder of the N requirement should be applied at the **5th** leaf stage. When a single application is planned, N should be applied as close to planting as possible to reduce the potential loss of N prior to crop uptake.

Application rates for N should be reduced when planting into legume cover or when manure has been applied. To determine the N adjustment, see ***Nitrogen Rate Adjustments -- Chapter 3, Section 3.5.1.2***.

CAUTION: To avoid ***nitrate toxicity*** in the crop which could be dangerous when used as feed for livestock, be cautious when harvesting silage after a drought or if a recent application of N was followed by cool, wet weather. Both situations can result in nitrate-N accumulation in the plant.

Phosphorus Management

Yield-limiting phosphorus (P) deficiency is rarely a concern on Delaware soils. Long-term applications of fertilizers and manures have resulted in P accumulations in many soils that are capable of supplying crop needs for several years with no further additions.

To determine whether P fertilization is necessary for a specific field, conduct a routine soil test. University of Delaware P recommendations for sorghum silage are dependent upon the soil test P value. A summary of those P recommendations are given in Table 1 below.

Table 1. Broadcast application rates for P for sorghum silage production.

P Index Value						
0	**10**	**20**	**30**	**40**	**60**	**80**
---------- lbs P_2O_5 / ac ----------						
140	120	100	90	80	40	0

Note: These rates are for a broadcast application. If P is to be applied in a fertilizer band, rates should be cut by half.

Potassium Management

The need for potassium (K) fertilization of sorghum silage is best determined by the use of a routine soil test. Potassium recommendations are based on the the soil test K value and the K needs of the crop. A summary of University of Delaware K recommendations for sorghum silage is given in Table 2. Potassium can be broadcast prior to planting or applied in the fertilizer band. ***To avoid salt injury to seedlings, do not band more than 75 lbs K_2O/ ac.***

Table 2. Potassium fertilizer recommendations for sorghum silage.

K Index Value						
0	**10**	**20**	**30**	**50**	**70**	**90**
---------- lbs K_2O / ac ----------						
200	183	167	150	117	84	50

Calcium and Magnesium Management

Calcium (Ca) and magnesium (Mg) needs of sorghum silage are usually met through routine liming. ***Magnesium application is recommended if the soil test Mg value is less than 38 FIVs.*** If liming has been recommended, use dolomitic limestone to raise soil pH and increase soil Mg. If, however, liming is not necessary but Mg is still indicated, apply Mg as Mg sulfate or Mg chloride to increase soil Mg. Appropriate application rates are given below in Table 3.

Table 3. Application rates for soluble Mg as a function of Mg fertility index value.

Mg Index Value								
0	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**
---------- lbs soluble Mg / ac ----------								
80	70	60	50	40	30	20	10	0

Manganese Management

Manganese (Mn) deficiency may occur in silage sorghum grown on Delaware soils, most often as a result of overliming soils that are naturally low in Mn. The University of Delaware Soil Testing Program uses an availability index based on the soil test Mn value and soil pH to predict the likelihood of Mn deficiency. That availability index is calculated using the equation:

$$MNAI = 101.7 - (15.2 \times pH) + (2.11 \times ST\text{-}Mn)$$

where:

MNAI = Mn availability index
pH = water pH of the soil
ST-Mn = soil test Mn in lbs/ac.

Table 3-14 in ***Chapter 3, Section 3.5.5.2 (Manganese Management)*** gives a summary of MNAI values for various soil pH-soil test Mn combinations. Interpretations of the Mn availability index for sorghum silage are given below in Table 4.

Table 4. Interpretation of the Mn availability index for silage sorghum.

MnAI Value	Interpretation
Less than 17	Mn deficiency is likely at this soil pH and Mn concentration.
17 to 25	Mn deficiency is possible at this soil pH and soil Mn concentration. Monitor crop for deficiency symptoms.
Greater than 25	Mn deficiency is unlikely.

Suspected Mn deficiency can be confirmed by tissue analysis. Confirmed deficiency situations can be corrected in season by foliar applications of Mn of 1-2 lbs/ac of actual Mn as Mn sulfate, Mn oxide or Mn chelate. If deficiency is predicted by the availability index or was observed during the previous growing season, it can be prevented by an application of 8-10 lbs/ac of actual Mn in the fertilizer band. Band applications of acid-forming fertilizer, which lower soil pH in the area of plant roots, may correct Mn deficiency without the addition of Mn fertilizer.

Other Nutrients

No other nutrients are known to be limiting to sorghum silage production in Delaware.

Additional Information

See Soil Test Notes 1, 2, 4 and 5 (Appendix 7) for additional information concerning nutrient management of sorghum silage.

Sudan or Millet Hay

Management Highlights

- Target pH: **6.0**.
- Apply N at planting to aid in establishment and after the 2nd and 3rd cuttings to encourage stand recovery and subsequent growth.

Yield Goals

Forage yield of sudan - millet hay production is dependent upon many factors: the cultivars selected, seeding date, stand composition, soil type and water-holding capacity, nutrient and water availability, weed, insect and disease pressure and crop management practices. ***On Delaware soils, 3.0 to 5.0 tons/ac of hay is a realistic forage yield for a sudan - millet hay field in a good to average year.*** When field history supports the use of a different yield goal, the grower should adjust management decisions and the fertility program accordingly.

Soil pH and Liming

The target pH for sudan - millet hay fields on most Delaware soils is **6.0**. ***If the soil pH is 5.3 or lower, soil is too acid for good growth of sudan-millet hay***. Surface applications of limestone will not be effective in correcting soil pH. Apply lime at the recommended rate and plow down prior to seeding the field.

The lime recommendation for a specific field is calculated from the soil pH and buffer pH measurements using the steps outlined in ***Calculating the Lime Requirement -- Chapter 3, Section 3.4.*** Use care to avoid overliming in order to prevent micronutrient deficiencies (e.g., manganese).

In most cases, the lime requirement can be met by either calcitic or dolomitic limestone.

Dolomitic limestone is recommended if:

- soil test Mg is less than 50 FIVs, or
- soil test Mg is between 50 and 100 FIVs ***and less than soil test Ca***.

Calcitic limestone is recommended if:

- soil test Mg is greater than 100 FIVs, or
- soil test Mg is between 50 and 100 FIVs ***and greater than soil test Ca.***

Nitrogen Management

The University of Delaware recommends a total nitrogen (N) application of **140-160 lbs N/ac** per growing season for sudan - millet hay fields. ***At seeding, apply 40-60 lbs N/ac*** to aid in establishment of the crop. The higher N rate should be used on sandier soils to compensate for greater leaching losses. ***Apply an additional 50 lbs N/ac after both the second and third cuttings*** to encourage recovery and subsequent growth of the plants.

Nitrogen applications should be reduced when seeding a field where manure has been applied prior to planting or a legume cover crop has been produced. To calculate the necessary adjustment, see ***Nitrogen Rate Adjustements -- Chapter 3, Section 3.5.1.2***.

CAUTION: To avoid ***nitrate toxicity*** in the crop which could be dangerous when used as feed for livestock, be cautious when cutting hay or grazing the field during or after a drought or if a recent application of N was followed by cool, wet weather. Both situations can result in nitrate-N accumulation in the plant.

Phosphorus Management

Yield-limiting P deficiency is rarely a concern on Delaware soils. Long-term applications of fertilizers and manures have resulted in P accumulations in many soils that are capable of supplying crop

needs for several years with no further additions.

Adequate concentrations of soil test P are important to sudan-millet hay production. To determine whether P fertilization is necessary for a specific field, conduct a routine soil test. University of Delaware P recommendations for sudan-millet hay production are dependent upon soil test P value. A summary of those P recommendations is given in Table 1.

If soil test P is ***Low or Medium*** (***e.g., 50 FIVs or less***), P should be broadcast and plowed down prior to seeding. If soil test P is ***Optimum*** (***e.g., greater than 50 FIVs***), P can be broadcast and incorporated prior to planting or surface broadcast at planting.

Table 1. Phosphorus fertilizer recommendations for sudan-millet hay production.

P Index Value									
0	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**
---------- lbs P_2O_5 / ac ----------									
120	108	96	84	72	60	48	36	24	12

Potassium Management

Potassium (K) is very important to sudan-millet hay production. The need for K fertilization is best determined by the use of a routine soil test. Potassium recommendations are based on the soil test K index value. A summary of University of Delaware K recommendations for sudan-millet hay production is given in Table 2.

Applications of K should be broadcast prior to or shortly after planting. Incorporating K by disking or plowing down will decrease potential salt effects from higher application rates.

Table 2. Potassium fertilizer recommendations for sudan-millet hay production.

K Index Value									
0	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**
---------- lbs K_2O / ac ----------									
120	108	96	84	72	60	48	36	24	12

Calcium and Magnesium Management

Calcium (Ca) and magnesium (Mg) needs of sudan-millet hay production are usually met through routine liming. ***Magnesium application is recommended if the soil test Mg value is less than 38 FIVs.*** If liming has been recommended, use dolomitic limestone to raise soil pH and increase soil Mg. If, however, liming is not necessary but Mg is still indicated, apply Mg as Mg sulfate or Mg chloride to increase soil Mg. Appropriate application rates are given below in Table 3.

Table 3. Application rates for soluble Mg as a function of Mg fertility index value.

Mg Index Value								
0	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**
---------- lbs soluble Mg / ac ----------								
80	70	60	50	40	30	20	10	0

Manganese Management

Manganese (Mn) deficiency may occur in sudan-millet hay fields on Delaware soils, most often as a result of overliming soils that are naturally low in Mn. The University of Delaware Soil Testing Program uses an availability index based on the soil test Mn value and soil pH to predict the likelihood of Mn deficiency. That availability index is calculated using the equation:

$$MNAI = 101.7 - (15.2 \times pH) + (2.11 \times ST\text{-}Mn)$$

where:

MNAI = Mn availability index
pH = water pH of the soil
ST-Mn = soil test Mn in lbs/ac.

Table 3-14 in ***Chapter 3, Section 3.5.5.2 (Manganese Management)*** gives a summary of MNAI values for various soil pH-soil test Mn combinations. Interpretations of the Mn availability index for sudan-millet hay fields are given below in Table 4.

Table 4. Interpretation of the Mn availability index for sudan-millet hay fields.

MnAI Value	Interpretation
Less than 12	Mn deficiency is likely at this soil pH and Mn concentration.
12 or greater	Mn deficiency is unlikely.

Suspected Mn deficiency can be confirmed by tissue analysis. Confirmed deficiency situations can be corrected in season by foliar applications of Mn of 1-2 lbs/ac of actual Mn as Mn sulfate, Mn oxide or Mn chelate. If deficiency is predicted by the availability index or was observed during the previous growing season, it can be prevented by a broadcast application of 20-30 lbs/ac of actual Mn in the fertilizer band. Broadcast applications of acid-forming fertilizer, which lower soil pH in the area of plant roots, may correct Mn deficiency without the addition of Mn fertilizer but may be less effective than applications of Mn.

Other Nutrients

No other nutrients are known to be limiting to sudan-millet hay production in Delaware.

Additional Information

See Soil Test Notes 1, 3, and 4 (Appendix 7) for additional information concerning fertilization of sudan-millet hay fields.

White Clover - Bluegrass Pastures

Management Highlights

- Target pH: **6.5**
- Monitor soil P and K levels. It is more cost- effective to maintain soil fertility than to re-establish the stand.

Yield Goals

Forage yield of white clover-bluegrass pasture is dependent upon many factors: the cultivars selected, seeding date, age of the stand and degree of establishment, stand composition, soil type and water-holding capacity, nutrient and water availability, weed, insect and disease pressure and crop management practices. ***On Delaware soils, 2.0 tons/ac hay or equivalent is a realistic forage yield for an established white clover-bluegrass pasture in a good to average year.*** When field history supports the use of a different yield goal, growers should adjust management decisions accordingly.

Soil pH and Liming

The target pH for white clover-bluegrass pastures on most Delaware soils is **6.5**. If the soil pH is ***5.3 or lower***, the soil is too acidic for good growth of white clover and bluegrass. Apply the recommended rate of lime and allow the soil pH to increase before attempting to plant.

When seeding or re-seeding a pasture, thorough incorporation of the recommended rate of lime is most effective in correcting soil pH problems. On established pastures, lime can be topdressed although results may be somewhat less effective than those achieved by incorporation of the limestone.

The lime recommendation for a specific white clover/bluegrass pasture is calculated from the soil pH and buffer pH measurements using the steps outlined in ***Calculating the Lime Requirement -- Chapter 3, Section 3.4.*** Avoid overliming in order to prevent micronutrient deficiencies.

In most cases, the lime requirement can be met by either calcitic or dolomitic limestone.

Dolomitic limestone is recommended if:

- soil test Mg is less than 50 FIVs, or
- soil test Mg is between 50 and 100 FIVs ***and less than soil test Ca***.

Calcitic limestone is recommended if:

- soil test Mg is greater than 100 FIVs, or
- soil test Mg is between 50 and 100 FIVs ***and greater than soil test Ca.***

Nitrogen Management

The nitrogen (N) requirement of white clover/ blugrass pastures is dependent upon stand age and composition. Clover is a leguminous plant and, once established, capable of fixing sufficient N to meet crop needs. All stands should receive an application of N at seeding to aid in establishment. Seed mixes containing clover should be treated with a suitable inoculum to ensure that N fixation will occur. In subsequent years, stands containing high percentages of white clover require less N than those dominated by bluegrass. Over-application of N to stands high in clover increases the competitiveness of the bluegrass and will result in loss of the clover.

Table 1 gives a summary of recommended N rates for white clover-bluegrass pastures as a function of stand age and composition. At planting, the higher N rate should be used on sandier soils to compensate for greater leaching losses. That rate can be reduced or eliminated when planting into a legume cover or when manure has been applied prior to planting. To adjust N rates, see ***Nitrogen Rate Adjustements -- Chapter 3, Section 3.5.1.2***. On established stands, N should be applied after each grazing period to encourage stand recovery and subsequent growth.

Table 1. Recommended N rates for white clover-bluegrass pastures.

Stand Status	N Rate
	----- lbs / ac -----
Seeding - grass/clover mix	0 - 30
Established stand :	
0 - 25% clover	50/grazing period
25 - 50% clover	25/grazing period
>50% clover	0/grazing period

Phosphorus Management

Yield-limiting phosphorus (P) deficiency is rarely a concern on Delaware soils. Long-term applications of fertilizers and manures have resulted in P accumulations in many soils that are capable of supplying crop needs for many years with no further additions.

Adequate concentrations of soil test P are important to white clover-bluegrass pastures for forage production and stand longetivity. To determine whether P fertilization is necessary for a specific field, conduct a routine soil test. University of Delaware P recommendations for white clover-bluegrass pastures are dependent upon stand age and soil test P value. A summary of P recommendations for Delaware white clover-bluegrass pastures are given in Table 2.

Table 2. Phosphorus recommendations for white clover-bluegrass pastures.

Stand Status	P Index Value						
	0	**10**	**20**	**30**	**50**	**70**	**90**
	---------- lbs P_2O_5 / ac ----------						
Seeding	120	109	97	86	63	40	13
Subsequent years	120	104	88	74	50	17	0

Seeding

When soil test P is ***Low*** or ***Medium*** (***50 FIVs or less***), P should be broadcast and plowed down prior to seeding. When soil test P is ***Optimum*** (***51 FIVs or greater***), P can either be broadcast and incorporated prior to planting or topdressed prior to or shortly after planting..

Topdressing Established Stands

If soil test P is Low (less than 25 FIVs), satisfactory growth on white clover-bluegrass pastures is unlikely. Few, if any, legumes will survive. Grass yield and longetivity will be poor. ***Do not attempt to correct the problem by topdressing P. Instead, broadcast the recommended rate of P, plow down and re-seed to obtain optimum yields.***

When soil test P is ***Medium*** or ***Optimum*** (***greater than 25 FIVs***), topdressing the recommended rate of P should be effective in meeting crop needs.

Potassium Management

Potassium (K) is very important to white clover-bluegrass pasture forage growth and stand longetivity. The need for K fertilization of white clover-bluegrass pastures is best determined by the use of a routine soil test. Potassium recommendations are based on crop status (new seeding or established crop) and the soil test K index value. A summary of University of Delaware K recommendations for white clover-bluegrass pastures is given in Table 3.

Table 3. Potassium recommendations for white clover-bluegrass pastures.

Stand Status	K Index Value						
	0	**10**	**20**	**30**	**50**	**70**	**90**
	---------- lbs K_2O / ac ----------						
Seeding	180	163	146	129	94	60	20
Subsequent years	180	165	150	135	105	75	45

Seeding

When establishing a new field, K should be broadcast before or immediately after planting. Incorporating K by disking or plowing down will decrease potential salt effects from higher application rates.

Topdressing Established Stands

If the recommended K rate is ***90 lbs K_2O/ac or less***,

potash can be broadcast in a single application in the early spring. When the recommended rate is ***greater than 90 lbs K_2O/ac***, apply K in two applications: one in early spring and one in August or early September after the late summer grazing period.

To decrease the potential for grass tetany, avoid K overfertilization on pastures that are predominantly grass species. Waiting until after the first grazing period to apply K helps to reduce the potential danger.

Calcium and Magnesium Management

Calcium (Ca) and magnesium (Mg) needs of white clover-bluegrass pastures are usually met through routine liming. ***Magnesium application is recommended if the soil test Mg value is less than 38 FIVs.*** If liming has been recommended, use dolomitic limestone to raise soil pH and increase soil Mg. If, however, liming is not necessary but Mg is still indicated, apply Mg as Mg sulfate or Mg chloride to increase soil Mg. Appropriate application rates are given below in Table 4.

Table 4. Application rates for soluble Mg as a function of Mg fertility index value.

Mg Index Value								
0	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**
---------- lbs soluble Mg / ac ----------								
80	70	60	50	40	30	20	10	0

Boron Management

Pastures containing legumes such as clover should be fertilized with **0.5 to 1.0 lbs boron (B)/ac** each year. Prior to seeding, apply B in a blended, broadcast fertilizer or as a soil spray and incorporate into the soil. On established stands, B can be topdressed in a blended, broadcast fertilizer or applied as a foliar spray, generally in late May or June.

Caution: Although B is required for maximum productivity of pastures, even slight over-application of B can be toxic to the crop. When applied as a foliar spray, be certain to apply the correct rate.

Manganese Management

Manganese (Mn) deficiency may occur in white-clover-bluegrass pastures on Delaware soils, most often as a result of overliming soils that are naturally low in Mn. The University of Delaware Soil Testing Program uses an availability index based on the soil test Mn value and soil pH to predict the likelihood of Mn deficiency. That availability index is calculated using the equation:

$$MNAI = 101.7 - (15.2 \times pH) + (2.11 \times ST\text{-}Mn)$$

where:

MNAI = Mn availability index
pH = water pH of the soil
ST-Mn = soil test Mn in lbs/ac.

Table 3-14 in ***Chapter 3, Section 3.5.5.2 (Manganese Management)*** gives a summary of MNAI values for various soil pH-soil test Mn combinations. Interpretations of the Mn availability index for white clover-bluegrass pastures are given in Table 5.

Table 5. Interpretation of the Mn availability index for white clover-bluegrass pastures.

MnAI Value	Interpretation
Less than 12	Mn deficiency is likely at this soil pH and Mn concentration.
12 or greater	Mn deficiency is unlikely.

Suspected Mn deficiency can be confirmed by tissue analysis. Confirmed deficiency situations can be corrected in season by foliar applications of Mn of 1-2 lbs/ac of actual Mn as Mn sulfate, Mn oxide or Mn chelate. If deficiency is predicted by the availability index or was observed during the previous growing season, it can be prevented by a broadcast application of 20-30 lbs/ac of actual Mn in the fertilizer band. Broadcast applications of acid-forming fertilizer, which lower soil pH in the area of plant roots, may correct Mn deficiency without the addition of Mn fertilizer but may be less effective than applications of Mn.

Other Nutrients

No other nutrients are known to be limiting to white clover-bluegrass pasture production in

Delaware.

Additional Information

See Soil Test Notes 1, 3, and 4 (Appendix 7) for additional information concerning fertilization of white clover-bluegrass pastures.