

Golf Turf - Cool Season Grass Maintenance

Crop Highlights

- Target pH: 6.5
- Follow these guidelines for maintenance of cool season grasses on golf courses with sand-based or native soils. Do not use these recommendations for fine fescue or putting greens.
- Enhanced efficiency nitrogen (N) sources (>50% slow release or water insoluble) are recommended for use during maintenance to prevent N losses.
- Fall is the preferred time for N fertilizer applications to promote root development.
- Scheduling and applying N prior to cultural practices, such as aerification and verticutting, can reduce healing time and promote new tillering.
- Facilities managed under a Delaware Nutrient Management General Permit are prohibited from applying phosphorus (P) fertilizers at a rate that exceeds 2 lb/1000 ft² of P₂O₅.
- Potassium levels should be near optimal prior to summer stress period to maximize soil water utilization.

Management Notes

These recommendations are valid for maintenance of cool season turfgrasses on golf courses with sand-based or native soils. Use these recommendations for Kentucky bluegrass, tall fescue, bentgrass, or perennial ryegrass that was planted more than 12 weeks prior to soil testing or fertilization. Do not use these recommendations for areas planted in fine fescue or putting greens.

Soil pH and Liming

Target pH: 6.5

Turfgrass species can withstand a rather large range of pH (5.4 to 7.8), but they perform best when soil pH is near the target pH of 6.5. The lime recommendation for a specific site is calculated from the soil pH and Adam-Evans buffer pH measurements using the steps outlined in the UD Extension Fact Sheet [Calculating the Lime Requirement Using the Adams-Evans Soil Buffer](#). Avoid over-liming to prevent deficiency of micronutrients such as iron (Fe).

The recommended liming source is dependent upon Mehlich-3 (M3) soil test calcium (Ca) and magnesium (Mg) reported in University of Delaware fertility index value (FIV) and can be determined using Table 1.

Table 1. Recommended type of lime as a function of Mehlich-3 soil test calcium and magnesium concentrations.

| Soil Test Levels | Recommended Lime Type |
|---|-----------------------|
| M3-Mg is less than 50 FIV | Dolomitic |
| M3-Mg between 50 and 100 FIV AND M3-Mg is less than M3-Ca | Dolomitic |
| M3-Mg greater than 100 FIV | Calcitic |
| M3-Mg is greater than 50 FIV AND M3-Mg is greater than M3-Ca | Calcitic |

Nitrogen

The University of Delaware recommends the use of enhanced efficiency nitrogen (N) fertilizers (e.g., urea formaldehyde, polyon) over water soluble forms (e.g., ammonium sulfate, urea) whenever possible for the maintenance of cool season golf turf. Enhanced efficiency fertilizers typically contain at least 30% of the total N in a slow release or water insoluble form. If preferred, water soluble N sources can be applied through the irrigation system (fertigation) or a sprayer to increase nutrient use efficiency and decrease the potential for nitrogen loss to the environment. Water soluble N sources should be applied more frequently at lower rates than enhanced efficiency soil.

Recommended total annual nitrogen (N) rates for common cool season species under standard and high maintenance are listed in Table 2. **NOTE: Annual N applications may not exceed 2 lb/1000 ft² for standard maintenance and 3 lb/1000 ft² for high maintenance areas without written approval of a certified nutrient consultant.** When possible, maintenance N applications should be split into two or more applications.

Table 2. Annual N regulatory limits for the turf general permit for common cool season golf turf species grown in Delaware based on maintenance level.

| Turf Species | Annual Nitrogen Rate (lb/1000ft ²) | |
|--------------------|--|------------------|
| | Standard Maintenance | High Maintenance |
| Creeping Bentgrass | 3 | 4-5 |
| Perennial Ryegrass | 2 | 4-5 |
| Kentucky Bluegrass | 2 | 4-5 |
| Poa Annua | 3-4 | 5-6 |
| Tall Fescue | 2 | 3-4 |

For maintenance of cool season golf turf, with the exception of areas planted in fine fescue or putting greens:

1. A small amount of N can be applied in the spring to aid turf recovery. Apply 0.5 to 1.0 lb N/1000 ft² (20 to 40 lb N/ac) of enhanced efficiency fertilizers. Water soluble N fertilizers can be applied in two applications at a rate of 0.25 to 0.5 lb N/1000 ft² (20 lb N/ac) in April and May.
2. If applying water soluble N sources (>70% water soluble N), split into three applications of 0.5 to 1.0 lb N/1000 ft² (20 to 40 lb/ac) in September, October, and November. Single applications of water-soluble N sources should not exceed 1 lb N/1000 ft².

- If applying enhanced efficiency N fertilizers (>50% water insoluble N), apply N at a rate of 1.0 lb to 2.0 lb/1000 ft² (40 to 80 lb/ac) in September and again in October. Single applications of enhanced efficiency N fertilizers should not exceed 2 lb N/1000 ft².

Phosphorus

Phosphorus (P) fertilization is based on the results of a Mehlich 3 (M3) routine soil test (Table 3). Soil test results are reported as a Fertility Index Value (FIV). Phosphorus fertilizers are best applied prior to planting when it can be incorporated into the soil.

Table 3. Recommended broadcast phosphorus application rates for maintenance of cool season golf turf based on results of a M3 routine soil test.

| | M3-P (UD-FIV) | | | |
|--|---------------|----------------|------------------|------------------|
| | Low (0-25) | Medium (26-50) | Optimum (51-100) | Excessive (>100) |
| lb P ₂ O ₅ /1000 ft ² | 2-3 | 1-2 | 0-1 | 0 |

- Within each M3 soil test phosphorus (M3-P) category, choose the higher rate when M3-P is at the lower side of the range and the lower rate at the higher side of the range.
- If M3-P is “Low” (e.g., 25 FIV or less) and P fertilizer is incorporated to a depth greater than 2 inches, the P₂O₅ application rate can be increased to 3 to 4 lb/1000 ft².
- If M3-P is “Excessive” (e.g., greater than 100 FIV), the application of phosphorus fertilizers is **NOT RECOMMENDED**.
- Facilities managed under a Delaware Nutrient Management General Permit are prohibited from applying P at a rate that exceeds 2 lb/1000 ft² P₂O₅, regardless of M3-P concentration. Higher P₂O₅ rates (>2 lb/1000 ft²) are restricted to those facilities managed under a nutrient management plan with written justification by a certified nutrient consultant.

Potassium

The need for potassium (K) fertilization is determined by a routine soil test (Table 4). Potassium fertilizers are best applied prior to planting when it can be incorporated into the soil.

Table 4. Recommended broadcast potassium application rates for maintenance of cool season golf turf based on results of a M3 routine soil test.

| | M3-K (UD-FIV) | | | |
|--|---------------|----------------|------------------|------------------|
| | Low (0-25) | Medium (26-50) | Optimum (51-100) | Excessive (>100) |
| lb K ₂ O/1000 ft ² | 2-3 | 1-2 | 0-2 | 0 |

- Within each M3 soil test potassium (M3-K) category, choose the higher rate when M3-K is at the lower side of the range and the lower rate at the higher side of the range.
- If M3-K is “Low” (e.g., 25 FIV or less) and K fertilizer is incorporated to a depth greater than 2 inches, the application rate can be increased to 3 to 5 lb K₂O/1000 ft².

Calcium and Magnesium

Calcium (Ca) and magnesium (Mg) needs for establishment of golf turf are usually met through liming. See above for guidance on liming.

Table 4. Recommended application rates of soluble magnesium as a function of soil test (M3) magnesium.

| | M3-Mg (FIV) | | | |
|-------------------------------------|-------------|----------------|------------------|------------------|
| | Low (0-25) | Medium (26-50) | Optimum (51-100) | Excessive (>100) |
| lb soluble Mg /1000 ft ² | 1-2 | 0.25-1 | 0 | 0 |

1. Magnesium (Mg) is recommended when M3 soil test Mg (M3-Mg) is less than 50 FIV.
2. Within each M3-Mg category, choose the higher rate when M3-Mg is at the lower side of the range and the lower rate at the higher side of the range.
3. If M3-Mg is less than 50 FIV and lime is recommended, use dolomitic limestone.
4. If M3-Mg is less than 50 FIV and lime is not needed, apply soluble Mg (Mg sulfate or Mg chloride) according to the rates in Table 4.

Golf Turf - Fine Fescue Maintenance

Crop Highlights

- Target pH: 6.5
- Follow these guidelines for maintenance of fine fescue on golf courses with native soils.
- Enhanced efficiency nitrogen (N) sources (>50% slow release or water insoluble) are recommended for use during maintenance to prevent N losses.
- Fall is the preferred time for N fertilizer applications to promote shoot and root development.
- Facilities managed under a Delaware Nutrient Management General Permit are prohibited from applying phosphorus (P) fertilizers at a rate that exceeds 2 lb/1000 ft² of P₂O₅.
- "No-mow" fine fescue native areas are great buffers for nutrient and pesticide sequestration.

Management Notes

These recommendations are valid for maintenance of fine fescue native areas that are on native soils and have a bi-yearly mowing schedule. Use these recommendations for fine fescue that was planted more than 12 weeks prior to soil sampling or fertilization.

Soil pH and Liming

Target pH: 6.5

Turfgrass species can withstand a rather large range of pH (5.4 to 7.8), but they perform best when soil pH is near the target pH of 6.5. The lime recommendation for a specific site is calculated from the soil pH and Adam-Evans buffer pH measurements using the steps outlined in the UD Extension Fact Sheet [Calculating the Lime Requirement Using the Adams-Evans Soil Buffer](#). Avoid over-liming to prevent deficiency of micronutrients such as iron (Fe).

The recommended liming source is dependent upon Mehlich-3 (M3) soil test calcium (Ca) and magnesium (Mg) reported in University of Delaware fertility index value (FIV) and can be determined using Table 1.

Table 1. Recommended type of lime as a function of Mehlich-3 soil test calcium and magnesium concentrations.

| Soil Test Levels | Recommended Lime Type |
|---|-----------------------|
| M3-Mg is less than 50 FIV | Dolomitic |
| M3-Mg between 50 and 100 FIV AND M3-Mg is less than M3-Ca | Dolomitic |
| M3-Mg greater than 100 FIV | Calcitic |
| M3-Mg is greater than 50 FIV AND M3-Mg is greater than M3-Ca | Calcitic |

Nitrogen

The University of Delaware recommends the use of enhanced efficiency nitrogen (N) fertilizers (e.g., urea formaldehyde, polyon) over water soluble forms (e.g., ammonium sulfate, urea) whenever possible for the maintenance of cool season golf turf - fine fescue. Enhanced efficiency fertilizers typically contain at least 30% of the total N in a slow release or water insoluble form. If preferred, water soluble N sources can be applied through the irrigation system (fertigation) or a sprayer to increase nutrient use efficiency and decrease the potential for nitrogen loss to the environment. Water soluble N sources should be applied more frequently at lower rates than enhanced efficiency soil.

Recommended total annual nitrogen (N) rates for common cool season species under standard and high maintenance are listed in Table 2. **NOTE: Annual N applications may not exceed 2 lb/1000 ft² for standard maintenance and 3 lb/1000 ft² for high maintenance areas without written approval of a certified nutrient consultant.** When possible, maintenance N applications should be split into two or more applications.

Table 2. Annual N regulatory limits for the turf general permit for fine fescue golf turf grown in Delaware based on maintenance level.

| Turf Species | Annual Nitrogen Rate (lb/1000ft ²) | |
|--------------|--|------------------|
| | Standard Maintenance | High Maintenance |
| Fine Fescue | 2 | 3-4 |

For maintenance of fine fescue golf turf:

1. Fine fescue is typically used in native areas on golf courses. The goal is to avoid excessive succulent growth in the spring to maintain the speed of play by making it easier to find golf balls. Spring N applications are not recommended, unless applying a small amount of N to aid turf recovery and growth. Apply 0.5 to 1.0 lb N/1000 ft² (20 to 40 lb N/ac) of enhanced efficiency fertilizers in March or April. Water soluble N fertilizers should be avoided if possible.
2. If applying water soluble N sources (>70% water soluble N), split into two to three applications of 0.5 to 1.0 lb N/1000 ft² (20 to 40 lb/ac) in September, October, and/or November. Single applications of water soluble N sources should not exceed 1 lb N/1000 ft².
3. If applying enhanced efficiency N fertilizers (>50% water insoluble N), apply N rate of 1.0 lb to 2.0 lb/1000 ft² (40 to 80 lb/ac) in September and again in October. Single applications of enhanced efficiency N fertilizers should not exceed 2 lb N/1000 ft².
4. Annual recommended N rates for fine fescue used for no-mow native areas is 0-1 lb N/1000ft².

Phosphorus

Phosphorus (P) fertilization is based on the results of a Mehlich 3 (M3) routine soil test (Table 3). Soil test results are reported as a Fertility Index Value (FIV). Phosphorus fertilizers are best applied prior to planting when it can be incorporated into the soil.

Table 3. Recommended broadcast phosphorus application rates for maintenance of cool season golf turf - fine fescue based on results of a M3 routine soil test.

| | M3-P (UD-FIV) | | | |
|--|---------------|----------------|------------------|------------------|
| | Low (0-25) | Medium (26-50) | Optimum (51-100) | Excessive (>100) |
| lb P ₂ O ₅ /1000 ft ² | 2-3 | 1-2 | 0-1 | 0 |

1. Within each M3 soil test phosphorus (M3-P) category, choose the higher rate when M3-P is at the lower side of the range and the lower rate at the higher side of the range.
2. If M3-P is “Low” (e.g., 25 FIV or less) and P fertilizer is incorporated to a depth greater than 2 inches, the P₂O₅ application rate can be increased to 3 to 4 lb/1000 ft².
3. If M3-P is “Excessive” (e.g., greater than 100 FIV), the application of phosphorus fertilizers is NOT RECOMMENDED.
4. Facilities managed under a Delaware Nutrient Management General Permit are prohibited from applying P at a rate that exceeds 2 lb/1000 ft² P₂O₅, regardless of M3-P concentration. Higher P₂O₅ rates (>2 lb/1000 ft²) are restricted to those facilities managed under a nutrient management plan with written justification by a certified nutrient consultant.

Potassium

The need for potassium (K) fertilization is determined by a routine soil test (Table 4). Potassium fertilizers are best applied prior to planting when it can be incorporated into the soil.

Table 4. Recommended broadcast potassium application rates for maintenance of cool season golf turf - fine fescue based on results of a M3 routine soil test.

| | M3-K (UD-FIV) | | | |
|--|---------------|----------------|------------------|------------------|
| | Low (0-25) | Medium (26-50) | Optimum (51-100) | Excessive (>100) |
| lb K ₂ O/1000 ft ² | 2-3 | 1-2 | 0-2 | 0 |

1. Within each M3 soil test potassium (M3-K) category, choose the higher rate when M3-K is at the lower side of the range and the lower rate at the higher side of the range.
2. If M3-K is “Low” (e.g., 25 FIV or less) and K fertilizer is incorporated to a depth greater than 2 inches, the application rate can be increased to 3 to 5 lb K₂O/1000 ft².

Calcium and Magnesium

Calcium (Ca) and magnesium (Mg) needs for establishment of golf turf are usually met through liming. See above for guidance on liming.

Table 4. Recommended application rates of soluble magnesium as a function of soil test (M3) magnesium.

| | M3-Mg (FIV) | | | |
|-------------------------------------|-------------|----------------|------------------|------------------|
| | Low (0-25) | Medium (26-50) | Optimum (51-100) | Excessive (>100) |
| lb soluble Mg /1000 ft ² | 1-2 | 0.25-1 | 0 | 0 |

1. Magnesium (Mg) is recommended when M3 soil test Mg (M3-Mg) is less than 50 FIV.
2. Within each M3-Mg category, choose the higher rate when M3-Mg is at the lower side of the range and the lower rate at the higher side of the range.
3. If M3-Mg is less than 50 FIV and lime is recommended, use dolomitic limestone.
4. If M3-Mg is less than 50 FIV and lime is not needed, apply soluble Mg (Mg sulfate or Mg chloride) according to the rates in Table 4.

Golf Turf - Warm Season Grass Management (Without Overseeding)

Crop Highlights

- Target pH: 6.5
- Follow these guidelines for maintenance of warm season grasses (without overseeding) on golf courses with sand-based or native soils.
- Enhanced efficiency nitrogen (N) sources (>50% slow release or water insoluble) are recommended for use during maintenance to prevent N losses.
- Spring to late summer is the preferred time for N applications to promote root and shoot development.
- Scheduling and applying N prior to cultural practices, such as aerification and verticutting, can reduce healing time and promote new tillering.
- Facilities managed under a Delaware Nutrient Management General Permit are prohibited from applying phosphorus (P) fertilizers at a rate that exceeds 2 lb/1000 ft² of P₂O₅.
- If potassium levels are not optimal, pre-dormancy applications of potassium (K) can promote carbohydrate storage via root mass increases and help promote hardier plants before the winter dormancy period. Deficient K can lead to increased spring dead spot activity.
- **For Zoysia only:** New research suggests that early season N applications may help suppress zoysia patch disease rather than increase it. More research is needed before we can make specific recommendations for earlier N applications on zoysia.

Management Notes

These recommendations are valid for maintenance of warm season turfgrasses on golf courses with sand-based or native soils. Use these recommendations for bermudagrass or zoysia that was planted more than 12 weeks prior to soil sampling or fertilization. Do not use these recommendations if overseeding.

Soil pH and Liming

Target pH: 6.5

Turfgrass species can withstand a rather large range of pH (5.4 to 7.8), but they perform best when soil pH is near the target pH of 6.5. The lime recommendation for a specific site is calculated from the soil pH and Adam-Evans buffer pH measurements using the steps outlined in the UD Extension Fact Sheet [Calculating the Lime Requirement Using the Adams-Evans Soil Buffer](#). Avoid over-liming to prevent deficiency of micronutrients such as iron (Fe).

The recommended liming source is dependent upon Mehlich-3 (M3) soil test calcium (Ca) and magnesium (Mg) reported in University of Delaware fertility index value (FIV) and can be determined using Table 1.

Table 1. Recommended type of lime as a function of Mehlich-3 soil test calcium and magnesium concentrations.

| Soil Test Levels | Recommended Lime Type |
|---|-----------------------|
| M3-Mg is less than 50 FIV | Dolomitic |
| M3-Mg between 50 and 100 FIV AND M3-Mg is less than M3-Ca | Dolomitic |
| M3-Mg greater than 100 FIV | Calcitic |
| M3-Mg is greater than 50 FIV AND M3-Mg is greater than M3-Ca | Calcitic |

Nitrogen

The University of Delaware recommends the use of enhanced efficiency nitrogen (N) fertilizers (e.g., urea formaldehyde, polyon) over water soluble forms (e.g., ammonium sulfate, urea) whenever possible for the maintenance of warm season golf turf. Enhanced efficiency fertilizers typically contain at least 30% of the total N in a slow release or water insoluble form. If preferred, water soluble N sources can be applied through the irrigation system (fertigation) or a sprayer to increase nutrient use efficiency and decrease the potential for nitrogen loss to the environment. Water soluble N sources should be applied more frequently at lower rates than enhanced efficiency soil.

Recommended total annual nitrogen (N) rates for common cool season species under standard and high maintenance are listed in Table 2. **NOTE: Annual N applications may not exceed 2 lb/1000 ft² for standard maintenance and 3 lb/1000 ft² for high maintenance areas without written approval of a certified nutrient consultant.** When possible, maintenance N applications should be split into two or more applications.

Table 2. Annual N regulatory limits for the turf general permit for common warm season golf turf species grown in Delaware based on maintenance level.

| Turf Species | Annual Nitrogen Rate (lb/1000ft ²) | |
|--------------|--|------------------|
| | Standard Maintenance | High Maintenance |
| Bermudagrass | 3-4 | 4-6 |
| Zoysiagrass | 1-2 | 2-3 |

For maintenance of warm season golf turf:

1. The first applications of N should not begin until the plant has broken dormancy and is actively growing, which is typically in mid- to late-May.
2. If applying water soluble N sources (>70% water soluble N), split into three applications of 0.5 to 1.0 lb N/1000 ft² (20 to 40 lb/ac) in June, July, and August. Single applications of water-soluble N sources should not exceed 1 lb N/1000 ft².
3. If applying enhanced efficiency N fertilizers (>50% water insoluble N), apply N at a rate of 1.0 lb to 2.0 lb/1000 ft² (40 to 80 lb/ac) in mid- to late- May and again in late July to early August. Single applications of enhanced efficiency N fertilizers should not exceed 2 lb N/1000 ft².
4. Nitrogen applications should be timed so that soil N supply has been exhausted before dormancy.

Phosphorus

Phosphorus (P) fertilization is based on the results of a Mehlich 3 (M3) routine soil test (Table 3). Soil test results are reported as a Fertility Index Value (FIV). Phosphorus fertilizers are best applied prior to planting when it can be incorporated into the soil.

Table 3. Recommended broadcast phosphorus application rates for maintenance of warm season golf turf based on results of a M3 routine soil test.

| | M3-P (UD-FIV) | | | |
|--|---------------|----------------|------------------|------------------|
| | Low (0-25) | Medium (26-50) | Optimum (51-100) | Excessive (>100) |
| lb P ₂ O ₅ /1000 ft ² | 2-3 | 1-2 | 0-1 | 0 |

1. Within each M3 soil test phosphorus (M3-P) category, choose the higher rate when M3-P is at the lower side of the range and the lower rate at the higher side of the range.
2. If M3-P is “Low” (e.g., 25 FIV or less) and P fertilizer is incorporated to a depth greater than 2 inches, the P₂O₅ application rate can be increased to 3 to 4 lb/1000 ft².
3. If M3-P is “Excessive” (e.g., greater than 100 FIV), the application of phosphorus fertilizers is NOT RECOMMENDED.
4. Facilities managed under a Delaware Nutrient Management General Permit are prohibited from applying P at a rate that exceeds 2 lb/1000 ft² P₂O₅, regardless of M3-P concentration. Higher P₂O₅ rates (>2 lb/1000 ft²) are restricted to those facilities managed under a nutrient management plan with written justification by a certified nutrient consultant.

Potassium

The need for potassium (K) fertilization is determined by a routine soil test (Table 4). Potassium fertilizers are best applied prior to planting when it can be incorporated into the soil.

Table 4. Recommended broadcast potassium application rates for maintenance of warm season golf turf based on results of a M3 routine soil test.

| | M3-K (UD-FIV) | | | |
|--|---------------|----------------|------------------|------------------|
| | Low (0-25) | Medium (26-50) | Optimum (51-100) | Excessive (>100) |
| lb K ₂ O/1000 ft ² | 2-3 | 1-2 | 0-2 | 0 |

1. Within each M3 soil test potassium (M3-K) category, choose the higher rate when M3-K is at the lower side of the range and the lower rate at the higher side of the range.
2. If M3-K is “Low” (e.g., 25 FIV or less) and K fertilizer is incorporated to a depth greater than 2 inches, the application rate can be increased to 3 to 5 lb K₂O/1000 ft².

Calcium and Magnesium

Calcium (Ca) and magnesium (Mg) needs of for establishment of golf turf are usually met through liming. See above for guidance on liming.

Table 4. Recommended application rates of soluble magnesium as a function of soil test (M3) magnesium.

| | M3-Mg (FIV) | | | |
|-------------------------------------|--------------------|-----------------------|-------------------------|----------------------------|
| | Low (0-25) | Medium (26-50) | Optimum (51-100) | Excessive (>100) |
| lb soluble Mg /1000 ft ² | 1-2 | 0.25-1 | 0 | 0 |

1. Magnesium (Mg) is recommended when M3 soil test Mg (M3-Mg) is less than 50 FIV.
2. Within each M3-Mg category, choose the higher rate when M3-Mg is at the lower side of the range and the lower rate at the higher side of the range.
3. If M3-Mg is less than 50 FIV and lime is recommended, use dolomitic limestone.
4. If M3-Mg is less than 50 FIV and lime is not needed, apply soluble Mg (Mg sulfate or Mg chloride) according to the rates in Table 4.

Athletic Turf - Cool Season Grass Maintenance

Crop Highlights

- Target pH: 6.5
- Follow these guidelines for maintenance of cool season grasses on athletic fields with sand-based or native soils.
- Enhanced efficiency nitrogen (N) sources (>50% slow release or water insoluble) are recommended for use during maintenance to prevent N losses.
- Fall is the preferred time for N fertilizer applications to promote shoot and root development.
- Scheduling and applying N prior to cultural practices, such as aerification and verticutting, can reduce healing time and promote new tillering.
- Facilities managed under a Delaware Nutrient Management General Permit are prohibited from applying phosphorus (P) fertilizers at a rate that exceeds 2 lb/1000 ft² of P₂O₅.
- Potassium levels should be near optimal prior to summer stress period to maximize soil water utilization, and photosynthesis.

Management Notes

These recommendations are valid for maintenance of cool season turfgrasses on athletic fields with sand-based or native soils. Use these recommendations for Kentucky bluegrass, tall fescue, or perennial ryegrass that was planted more than 12 weeks prior to soil testing or fertilization.

Soil pH and Liming

Target pH: 6.5

Turfgrass species can withstand a rather large range of pH (5.4 to 7.8), but they perform best when soil pH is near the target pH of 6.5. The lime recommendation for a specific site is calculated from the soil pH and Adam-Evans buffer pH measurements using the steps outlined in the UD Extension Fact Sheet [Calculating the Lime Requirement Using the Adams-Evans Soil Buffer](#). Avoid over-liming to prevent deficiency of micronutrients such as iron (Fe).

The recommended liming source is dependent upon Mehlich-3 (M3) soil test calcium (Ca) and magnesium (Mg) reported in University of Delaware fertility index value (FIV) and can be determined using Table 1.

Table 1. Recommended type of lime as a function of Mehlich-3 soil test calcium and magnesium concentrations.

| Soil Test Levels | Recommended Lime Type |
|--|-----------------------|
| M3-Mg is less than 50 FIV | Dolomitic |
| M3-Mg between 50 and 100 FIV AND M3-Mg is less than M3-Ca | Dolomitic |
| M3-Mg greater than 100 FIV | Calcitic |
| M3-Mg is greater than 50 FIV AND M3-Mg is greater than M3-Ca | Calcitic |

Nitrogen

The University of Delaware recommends the use of enhanced efficiency nitrogen (N) fertilizers (e.g., urea formaldehyde, IBDU, polyon) over water soluble forms (e.g., ammonium sulfate, urea) whenever possible for the maintenance of cool season athletic turf. Enhanced efficiency fertilizers typically contain at least 30% of the total N in a slow release or water insoluble form. If preferred, water soluble N sources can be applied through the irrigation system (fertigation) or a sprayer to increase nutrient use efficiency and decrease the potential for nitrogen loss to the environment. Water soluble N sources should be applied more frequently at lower rates than enhanced efficiency soil.

Recommended total annual nitrogen (N) rates for common cool season species under standard and high maintenance are listed in Table 2. **NOTE: Annual N applications may not exceed 2 lb/1000 ft² for standard maintenance and 3 lb/1000 ft² for high maintenance areas without written approval of a certified nutrient consultant.** When possible, maintenance N applications should be split into two or more applications.

Table 2. Annual N regulatory limits for the turf general permit for common cool season athletic turf species grown in Delaware based on maintenance level.

| Turf Species | Annual Nitrogen Rate (lb/1000ft ²) | |
|--------------------|--|------------------|
| | Standard Maintenance | High Maintenance |
| Creeping Bentgrass | 3 | 4-5 |
| Perennial Ryegrass | 2 | 4-5 |
| Kentucky Bluegrass | 2 | 4-5 |
| Poa Annua | 3-4 | 5-6 |
| Tall Fescue | 2 | 3-4 |
| Fine Fescue | 2 | 3-4 |

For maintenance of cool season athletic turf:

1. A small amount of N can be applied in the spring to aid turf recovery. Apply 0.5 to 1.0 lb N/1000 ft² (20 to 40 lb N/ac) of enhanced efficiency fertilizers. Water soluble N fertilizers can be applied in two applications at a rate of 0.25 to 0.5 lb N/1000 ft² (20 lb N/ac) in April and May.

2. If applying water soluble N sources (>70% water soluble N), split into three applications of 0.5 to 1.0 lb N/1000 ft² (20 to 40 lb/ac) in June, July, and August. Single applications of water-soluble N sources should not exceed 1 lb N/1000 ft².
3. If applying enhanced efficiency N fertilizers (>50% water insoluble N), apply N rate of 1.0 lb to 2.0 lb/1000 ft² (40 to 80 lb/ac) in September and again in October. Single applications of enhanced efficiency N fertilizers should not exceed 2 lb N/1000 ft².
4. If turf use is continued into the fall, small applications of water-soluble N (0.10 to 0.25 lb N/1000ft²) may be necessary to sustain plant growth and traffic recovery. Foliar applications are highly recommended to avoid extended growth into dormancy.

Phosphorus

Phosphorus (P) fertilization is based on the results of a Mehlich 3 (M3) routine soil test (Table 3). Soil test results are reported as a Fertility Index Value (FIV). Phosphorus fertilizers are best applied prior to planting when it can be incorporated into the soil.

Table 3. Recommended broadcast phosphorus application rates for maintenance of cool season athletic turf based on results of a M3 routine soil test.

| | M3-P (UD-FIV) | | | |
|--|---------------|----------------|------------------|------------------|
| | Low (0-25) | Medium (26-50) | Optimum (51-100) | Excessive (>100) |
| lb P ₂ O ₅ /1000 ft ² | 2-3 | 1-2 | 0-1 | 0 |

1. Within each M3 soil test phosphorus (M3-P) category, choose the higher rate when M3-P is at the lower side of the range and the lower rate at the higher side of the range.
2. If M3-P is “Low” (e.g., 25 FIV or less) and P fertilizer is incorporated to a depth greater than 2 inches, the P₂O₅ application rate can be increased to 3 to 4 lb/1000 ft².
3. If M3-P is “Excessive” (e.g., greater than 100 FIV), the application of phosphorus fertilizers is NOT RECOMMENDED.
4. Facilities managed under a Delaware Nutrient Management General Permit are prohibited from applying P at a rate that exceeds 2 lb/1000 ft² P₂O₅, regardless of M3-P concentration. Higher P₂O₅ rates (>2 lb/1000 ft²) are restricted to those facilities managed under a nutrient management plan with written justification by a certified nutrient consultant.

Potassium

The need for potassium (K) fertilization is determined by a routine soil test (Table 4). Potassium fertilizers are best applied prior to planting when it can be incorporated into the soil.

Table 4. Recommended broadcast potassium application rates for maintenance of cool season athletic turf based on results of a M3 routine soil test.

| | M3-K (UD-FIV) | | | |
|--|---------------|----------------|------------------|------------------|
| | Low (0-25) | Medium (26-50) | Optimum (51-100) | Excessive (>100) |
| lb K ₂ O/1000 ft ² | 2-3 | 1-2 | 0-2 | 0 |

1. Within each M3 soil test potassium (M3-K) category, choose the higher rate when M3-K is at the lower side of the range and the lower rate at the higher side of the range.
2. If M3-K is “Low” (e.g., 25 FIV or less) and K fertilizer is incorporated to a depth greater than 2 inches, the application rate can be increased to 3 to 5 lb K₂O/1000 ft²

Calcium and Magnesium

Calcium (Ca) and magnesium (Mg) needs of for establishment of golf turf are usually met through liming. See above for guidance on liming.

Table 4. Recommended application rates of soluble magnesium as a function of soil test (M3) magnesium.

| | M3-Mg (FIV) | | | |
|-------------------------------------|-------------|----------------|------------------|------------------|
| | Low (0-25) | Medium (26-50) | Optimum (51-100) | Excessive (>100) |
| lb soluble Mg /1000 ft ² | 1-2 | 0.25-1 | 0 | 0 |

1. Magnesium (Mg) is recommended when M3 soil test Mg (M3-Mg) is less than 50 FIV.
2. Within each M3-Mg category, choose the higher rate when M3-Mg is at the lower side of the range and the lower rate at the higher side of the range.
3. If M3-Mg is less than 50 FIV and lime is recommended, use dolomitic limestone.
4. If M3-Mg is less than 50 FIV and lime is not needed, apply soluble Mg (Mg sulfate or Mg chloride) according to the rates in Table 4.

Athletic Turf - Bermudagrass Management (Without Overseeding)**Crop Highlights**

- Target pH: 6.5
- Follow these guidelines for maintenance of bermudagrass athletic turf (without overseeding) on athletic fields with sand-based or native soils.
- Enhanced efficiency nitrogen (N) sources (>50% slow release or water insoluble) are recommended for use during maintenance to prevent N losses.
- Spring to late summer is the preferred time for N applications to promote root development.
- Scheduling and applying N prior to cultural practices, such as aerification and verticutting, can reduce healing time and promote new tillering.
- Facilities managed under a Delaware Nutrient Management General Permit are prohibited from applying phosphorus (P) fertilizers at a rate that exceeds 2 lb/1000 ft² of P₂O₅.
- If potassium levels are low, pre-dormancy applications of potassium (K) can promote carbohydrate storage via root mass increases and help promote hardier plants before the winter dormancy period. Deficient K can lead to increased spring dead spot activity.

Management Notes

These recommendations are valid for maintenance of bermudagrass turf on athletic fields with sand-based or native soils. Use these recommendations for bermudagrass that was planted more than 12 weeks prior to soil sampling or fertilization. Do not use these recommendations if overseeding.

Soil pH and Liming**Target pH: 6.5**

Turfgrass species can withstand a rather large range of pH (5.4 to 7.8), but they perform best when soil pH is near the target pH of 6.5. The lime recommendation for a specific site is calculated from the soil pH and Adam-Evans buffer pH measurements using the steps outlined in the UD Extension Fact Sheet [Calculating the Lime Requirement Using the Adams-Evans Soil Buffer](#). Avoid over-liming to prevent deficiency of micronutrients such as iron (Fe).

The recommended liming source is dependent upon Mehlich-3 (M3) soil test calcium (Ca) and magnesium (Mg) reported in University of Delaware fertility index value (FIV) and can be determined using Table 1.

Table 1. Recommended type of lime as a function of Mehlich-3 soil test calcium and magnesium concentrations.

| Soil Test Levels | Recommended Lime Type |
|---|-----------------------|
| M3-Mg is less than 50 FIV | Dolomitic |
| M3-Mg between 50 and 100 FIV AND M3-Mg is less than M3-Ca | Dolomitic |
| M3-Mg greater than 100 FIV | Calcitic |
| M3-Mg is greater than 50 FIV AND M3-Mg is greater than M3-Ca | Calcitic |

Nitrogen

The University of Delaware recommends the use of enhanced efficiency nitrogen (N) fertilizers (e.g., urea formaldehyde, IBDU, polyon) over water soluble forms (e.g., ammonium sulfate, urea) whenever possible for the maintenance of warm season athletic turf. Enhanced efficiency fertilizers typically contain at least 30% of the total N in a slow release or water insoluble form. If preferred, water soluble N sources can be applied through the irrigation system (fertigation) or a sprayer to increase nutrient use efficiency and decrease the potential for nitrogen loss to the environment. Water soluble N sources should be applied more frequently at lower rates than enhanced efficiency soil.

Recommended total annual nitrogen (N) rates for common cool season species under standard and high maintenance are listed in Table 2. **NOTE: Annual N applications may not exceed 2 lb/1000 ft² for standard maintenance and 3 lb/1000 ft² for high maintenance areas without written approval of a certified nutrient consultant.** When possible, maintenance N applications should be split into two or more applications.

Table 2. Annual N regulatory limits for the turf general permit for bermudagrass athletic turf grown in Delaware based on maintenance level.

| Turf Species | Annual Nitrogen Rate (lb/1000ft ²) | |
|--------------|--|------------------|
| | Standard Maintenance | High Maintenance |
| Bermudagrass | 3-4 | 4-6 |

For maintenance of warm season athletic turf:

1. The first applications of N should not begin until the plant has broken dormancy and is actively growing, which is typically in mid- to late-May.
2. If applying water soluble N sources (>70% water soluble N), split into three applications of 0.5 to 1.0 lb N/1000 ft² (20 to 40 lb/ac) in June, July, and August. Single applications of water-soluble N sources should not exceed 1 lb N/1000 ft².
3. If applying enhanced efficiency N fertilizers (>50% water insoluble N), apply N at a rate of 1.0 lb to 2.0 lb/1000 ft² (40 to 80 lb/ac) in mid- to late- May and again in late July to early August. Single applications of enhanced efficiency N fertilizers should not exceed 2 lb N/1000 ft².
4. If bermuda use is continued into the fall, small applications of water-soluble N (0.10 to 0.25 lb N/1000ft²) may be necessary to sustain plant growth and traffic recovery. Foliar applications are highly recommended to avoid extended growth into dormancy

Phosphorus

Phosphorus (P) fertilization is based on the results of a Mehlich 3 (M3) routine soil test (Table 3). Soil test results are reported as a Fertility Index Value (FIV). Phosphorus fertilizers are best applied prior to planting when it can be incorporated into the soil.

Table 3. Recommended broadcast phosphorus application rates for maintenance of warm season athletic turf based on results of a M3 routine soil test.

| | M3-P (UD-FIV) | | | |
|--|---------------|----------------|------------------|------------------|
| | Low (0-25) | Medium (26-50) | Optimum (51-100) | Excessive (>100) |
| lb P ₂ O ₅ /1000 ft ² | 2-3 | 1-2 | 0-1 | 0 |

1. Within each M3 soil test phosphorus (M3-P) category, choose the higher rate when M3-P is at the lower side of the range and the lower rate at the higher side of the range.
2. If M3-P is "Low" (e.g., 25 FIV or less) and P fertilizer is incorporated to a depth greater than 2 inches, the P₂O₅ application rate can be increased to 3 to 4 lb/1000 ft².
3. If M3-P is "Excessive" (e.g., greater than 100 FIV), the application of phosphorus fertilizers is NOT RECOMMENDED.
4. Facilities managed under a Delaware Nutrient Management General Permit are prohibited from applying P at a rate that exceeds 2 lb/1000 ft² P₂O₅, regardless of M3-P concentration. Higher P₂O₅ rates (>2 lb/1000 ft²) are restricted to those facilities managed under a nutrient management plan with written justification by a certified nutrient consultant.

Potassium

The need for potassium (K) fertilization is determined by a routine soil test (Table 4). Potassium fertilizers are best applied prior to planting when it can be incorporated into the soil.

Table 4. Recommended broadcast potassium application rates for maintenance of warm season athletic turf based on results of a M3 routine soil test.

| | M3-K (UD-FIV) | | | |
|--|---------------|----------------|------------------|------------------|
| | Low (0-25) | Medium (26-50) | Optimum (51-100) | Excessive (>100) |
| lb K ₂ O/1000 ft ² | 2-3 | 1-2 | 0-2 | 0 |

1. Within each M3 soil test potassium (M3-K) category, choose the higher rate when M3-K is at the lower side of the range and the lower rate at the higher side of the range.
2. If M3-K is "Low" (e.g., 25 FIV or less) and K fertilizer is incorporated to a depth greater than 2 inches, the application rate can be increased to 3 to 5 lb K₂O/1000 ft².

Calcium and Magnesium

Calcium (Ca) and magnesium (Mg) needs of for establishment of golf turf are usually met through liming. See above for guidance on liming.

Table 4. Recommended application rates of soluble magnesium as a function of soil test (M3) magnesium.

| | M3-Mg (FIV) | | | |
|-------------------------------------|-------------|----------------|------------------|------------------|
| | Low (0-25) | Medium (26-50) | Optimum (51-100) | Excessive (>100) |
| lb soluble Mg /1000 ft ² | 1-2 | 0.25-1 | 0 | 0 |

1. Magnesium (Mg) is recommended when M3 soil test Mg (M3-Mg) is less than 50 FIV.
2. Within each M3-Mg category, choose the higher rate when M3-Mg is at the lower side of the range and the lower rate at the higher side of the range.
3. If M3-Mg is less than 50 FIV and lime is recommended, use dolomitic limestone.
4. If M3-Mg is less than 50 FIV and lime is not needed, apply soluble Mg (Mg sulfate or Mg chloride) according to the rates in Table 4.