Improving Nitrogen Use Efficiency in Bermudagrass

by Malay C. Saha, Ph.D., Professor, Grass Genomics | mcsaha@noble.org

Warm-season perennial grasses are essential components of pasture systems in the southern U.S., where beef and forage production are the largest contributors to agricultural income. Bermudagrass is the most prevalent warm-season perennial grass species in the region. It is also a predominant turf grass. Bermudagrass produces lush green forage and/or ground cover during summer months and remains dormant during fall-winter. However, standing or stockpiled bermudagrass can be grazed in fall and early winter. Overseeding of bermudagrass pastures with cool-season annual grasses (such as rye or ryegrass) and legumes (such as clovers) can be practiced for late winter and spring grazing.

Bermudagrass can be adapted in a variety of soil types. It has excellent grazing tolerance and can produce a high amount of good quality forage when soil nutrients are not restricted. Most traditional bermudagrass varieties are open pollinated and are usually propagated by seed. However, hybrid bermudagrass varieties were developed starting in the 1940s. Hybrid varieties can produce more than twice as much forage compared to common bermudagrass at moderate fertility levels and are usually propagated by sprigs. Water and nitrogen (N) fertilizer are the two most limiting factors for bermudagrass forage production. It is very responsive to N fertilizer and needs a lot of N to grow, develop and produce high biomass (Figure 1). However, plants can uptake and utilize only a part of the applied N fertilizer. Improving N use efficiency (NUE) is a common target in many crop improvement programs.

WHAT IS NUE?
NUE is defined as the fraction of applied N that is absorbed and used by the plant to produce forage, grain and other products.

WHY IMPROVE NUE?
Application of N fertilizers enable growers to maximize biomass yield. However, NUE in the major crop species is low (30-70%) and even lower in grass species (less than 40%). Globally, up to 64% (an average of 18%) of applied N was lost via ammonia volatilization, and the losses significantly increased with higher N application rates. Another part of N applied is lost by nitrate leaching, which is also a major worldwide cause of groundwater pollution. Surface runoff of N fertilizer to rivers and ocean causes the death of fish and aquatic organisms. A crop that demands large amounts of N fertilizer to reach full production implies large agronomic, economic and energetic inefficiencies, as well as a large potential for excess N to be lost from crop fields and to cause environmental pollution.

Plant NUE is generally composed of both N uptake and N utilization efficiencies. Nitrogen uptake efficiency is defined as total shoot N relative to the amount of N applied to the soil, while N utilization efficiency is defined as total crop yield relative to total shoot N content. Thus, to improve NUE, attention needs to be paid to both N uptake and N use efficiencies.
and its utilization. Increased N uptake and utilization efficiency may allow growers to maximize yield under a moderate rate of N fertilization instead of the traditional high rate of applications.

**IMPROVING NUE IN BERMUDAGRASS**
We have collected bermudagrass germplasms and its relatives from Germplasm Resources Information Network and other breeding programs and evaluated those in greenhouse and hoop house experiments to evaluate their NUE. The NUE of these accessions was compared with the commercial cultivars commonly cultivated in the region. The addition of N fertilizer had a distinct positive effect for all the studied traits. Average leaf length was increased by 46%, leaf width by 30% and internode length by 13%. A threefold difference in NUE (from 1.72 g.g\(^{-1}\) to 5.21 g.g\(^{-1}\)) was observed among the accessions. We have identified at least 20 accessions, which have higher NUE than the best commercial cultivar, Tifton 85 (Figure 1). These accessions have been planted in the field to evaluate their NUE, biomass yield potential and other characteristics suitable for forage (Figure 2). The best accessions from this selection will be used as parents to develop synthetic and hybrid populations.

**INFLUENCE OF NUE ON FORAGE YIELD AND CRUDE PROTEIN**
N fertilization strongly affects biomass production with significant increments as more N was applied. The highest relative increment in biomass was obtained when the first dose of N was applied, and biomass tended to be stabilized at higher N rates. NUE had a strong positive correlation with dry biomass production. This relationship got even stronger with increased application of N fertilizer. No significant interaction between bermudagrass accessions and N rates was observed for NUE, indicating that N use efficient accessions performed similar in low and high N rates. On average, NUE drastically decreased as more N was added to the plants. Lower NUE at higher N rates implies that plants cannot absorb and/or utilize all the N added or that the N losses exceeded the rate of plant uptake.

Along with biomass yield, forage quality is an important parameter that determines the effectiveness of bermudagrass as a forage. Crude protein (CP) is an important quality characteristics of bermudagrass. It was observed that, in N limiting conditions, bermudagrass showed a trade-off between dry biomass production and CP content. Application of N fertilizer improved both forage yield and CP content. However, at the beginning, most of the applied N was utilized for biomass production. When N is abundant, the crop gives priority to improve CP over biomass production.

Figure 2: Field screening of bermudagrass accessions for nitrogen use efficiency. Accessions with higher NUE compared to commonly used control cultivars have been identified.