Considerations for Matching Soils and Forages

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Pasture fertilization is one of the most important management decisions that can affect pasture productivity and sustainability. Most soils may contain insufficient concentrations of one or more essential plant nutrient resulting in decreased plant growth or deficiencies; therefore, required nutrients must be supplied in appropriate amounts to optimize the biological and resultant economic benefits of fertilizer application. Because the fate of fertilizers applied to pastures is extremely complex, crop response can be affected by several factors including application rate and timing, fertilizer source, and soil and environmental characteristics. It is critical to implement fertilization strategies that integrate all the factors that affect fertilizer efficiency and ultimately the economic return associated with this management practice.

Forage crops require different soil fertility conditions and target pH varies according to the forage species. Bahiagrass (*Paspalum notatum*) is, in general, more tolerant to poor soil fertility conditions than more productive species such as bermudagrass *(Cynodon spp.)* and limpograss (*Hemarthria altissima*). In general, warm-season grasses are more tolerant to soil acidity than legumes. The optimum soil pH for the majority of the forage grasses growing in Florida is ~ 5.5, while legumes typically require soil pH ~ 6.0. Liming frequency as well as application rates will depend on the soil's characteristics and management practices. For instance, N fertilization rate and source and decomposition of organic materials may contribute to soil acidity.

Soils in Florida are often exhibit low pH and are considered "acidic" and lime is frequently applied to raise soil pH. Lime also serves as a primary source of Ca and Mg to pastures. By raising the soil pH, macronutrient availability is typically increased. However, at excessively high soil pH, micronutrients become less available and forage production can be affected. Bahiagrass is particularly sensitive to high soil pH conditions. Repeated applications of biosolids or sludges, especially the calcium-stabilized materials can excessively increase soil pH and reduce forage yields. Maintenance of adequate soil pH is an important step in soil fertility programs for forage crops. Soil pH controls nutrient availability to plants, root development, and fertilizer use efficiency. Optimum soil pH promotes better root growth, which, in turn, results in more efficient fertilizer and water utilization by the plants. Research has shown that N, P, and K fertilization efficiency may be increased considerably when soil pH is within the adequate range (Belesky and Wilkinson, 1983)

Nitrogen is often a limiting nutrient in grassland systems and is typically applied to pastures as commercial fertilizer, animal manure, or organic amendments. Biological fixation of atmospheric N by forage legumes can also provide adequate amounts of N to sustain forage and livestock production.

In most soils, forage response to P fertilization is relatively smaller than N and K because of the lower crop P requirement as compared to the other primary macronutrients (Robinson, 1996). Current fertilizer management strategies for forage crops are aimed at balancing agronomic requirement of crops while reducing the risks of nutrient accumulation and subsequent transport to the environment.

Forage crops require similar amounts of K as compared to N. Low K availability is often associated with stand mortality and increase incidence of pest and diseases (Matocha and Smith, 1980; Richardson and Croughan, 1989). Intensively-managed hay production systems require application of K removed in the forage in order to sustain crop yields. Conversely, because tissue K concentration is typically greater than animal requirements, a large proportion of K in grazed pastures is returned as animal excreta. A field study currently being conducted at Ona demonstrated that lack of K in mechanically-harvested production systems can reduce Jiggs bermudagrass yields by as much as 50% compared to treatments receiving K fertilization. Similarly, 2 years without K application reduced limpograss yields by ~ 30%. In addition to reduced yields, this study also demonstrated that both Jiggs bermudagrass and limpograss stands decreased (18 to 69%) during the 2-yr period when K was not applied.

Calcium and Mg are usually supplied to forage crops through liming. Sulfur is often associated with N and P fertilizers (i.e., ammonium sulfate and triple superphosphate). Because forages generally have relatively low S requirements, soil reserves are often sufficient to supply adequate amounts of S to the crops. Sulfur fertilization is seldom needed in grazed systems. Similarly, micronutrients are typically present in adequate amounts in the soil and are seldom applied to grazed pastures.

Importance of soil and tissue testing

From both agronomic and environmental perspectives, it is important to understand the amounts and forms of nutrients present in the soil. Soil testing is still the best management tool to monitor soil fertility levels. Based on soil test results, cost-effective fertilization programs can be developed to meet forage nutrient requirements and minimize production costs. In addition to soil tests, tissue analysis has been recently incorporated into soil fertility programs of major forage crops in the United States. In Florida, for instance, the critical tissue P concentration established bahiagrass was identified as being 0.15% (Silveira et al., 2011). Mondart et al. (1974) suggested that 90% of maximum bermudagrass yields were obtained when average tissue P concentration was 0.2%. Similarly to bahiagrass P fertilization work, future research is being designed to identify critical tissue concentrations for other forage crops and nutrients. When used in conjunction with soil testing, tissue analysis has potential to be a useful diagnostic tool for developing nutrient management programs that predict when crops need additional nutrients.

Fertility management for harvested versus grazed pastures

Fertility management of warm-season grasses depends on the goals and objectives of the dry matter production and costs of fertilizer. Harvested forages including hay, green chop, silage, and grain crop residue have similar fertility management as row crops. Because the majority of the crop residue is exported with harvested forage, large nutrient removal rates occur in these systems and relatively high fertilizer inputs are often necessary to maintain forage productivity. Nutrient removal rates vary considerably depending on the soil nutrient availability, crop species, stage of maturity, harvest procedure, and number of harvests.

In grazed systems, a large proportion of nutrients, particularly K and P, is returned to the soil via animal excreta, therefore, grazing management can have significant impacts on soil fertility status. Significant amounts of N, P, Ca, Mg, and micronutrients can be recycled to the soil via animal feces and urine deposition. Animal excreta returns to the soil an estimated 60 to 99% of the P and K ingested (Rouquette et al., 1973; Mathews et al., 1986). Similarly, only 5 to 30% of ingested N is used by livestock for meat and milk production (Russelle, 1996). Therefore, fertilizer requirements of grazed pastures can be considerably lower than in harvested forage systems. However, because grazing animals tend to defecate and urinate near to water, shade and feeding areas, excreted minerals are not evenly distributed which provides a major challenge.

Grazing management is important for improving nutrient distribution and availability in grazed pastures. Rotational stocking with short grazing intervals often results in more uniform nutrient distribution than continuously stocked pastures (Haynes and Williams, 1993; Dubeux et al., 2007, 2009). Research has also shown that intensifying pasture use by increasing stocking rates significantly affects excreta distribution, nutrient cycling, and redistribution in soils (Rouquette et al., 1973; Forbes and Rouquette, 2007; Silveira et al., 2013). Increased stocking rate may also lead to excessive nutrient accumulation in certain areas of the pasture. Additionally, environmental factors such as daily temperature and animal type may also affect animal grazing behavior and, consequently, nutrient redistribution in pastures.

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