

# The Benefits of Forage Legumes Go Beyond Nitrogen Fixation

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**W**hy are Legumes & Nutrient Cycling Important? Nutrient cycling is vital for sustaining the productivity of pasture systems. Biochemical processes change the structure and biological activity of nutrients, resulting in the formation of “nutrient pools.” In pasture systems, nutrient pools include soil minerals, organic matter, dead plant material, excreta, and the atmosphere. In recent years, carbon (C) sequestration has become an increasingly important topic, as our atmosphere’s concentration of CO<sub>2</sub> is rapidly increasing. Therefore, finding ways to capture C is highly important for minimizing adverse effects. The good news is perennial grasslands can be net C sinks, indicating they can store greater C quantities than they emit. The not-so-good news is C sequestration is a slow process – not something occurring overnight. Nutrient cycling is an important component for C sequestration in pasture systems. However, nitrogen (N) is also important, and to increase soil C sequestration, we must also increase N sequestration.



The use of forage legumes is an alternative to N fertilizer in pasture systems. Legumes have the capacity to associate with microbes to reduce N gas (N<sub>2</sub>) from the atmosphere, which is important since atmospheric N<sub>2</sub> is unavailable for plants. The N amount fixed by legumes is dependent on several factors, including legume species, proportion of legume present in the pasture, legume productivity, and all other factors affecting plant growth including rainfall, temperature, soil nutrient status, pH, light, and grazing management. An example of these species’ combinations is shown in Table 1, where annual ryegrass was grown with different annual clovers, and all showed differences in terms of productivity. One thing to note is adding clovers improved the productivity of the ryegrass, but the extent to which improvement was made differed, with crimson clover showing the best response of the four clover types in the trial.

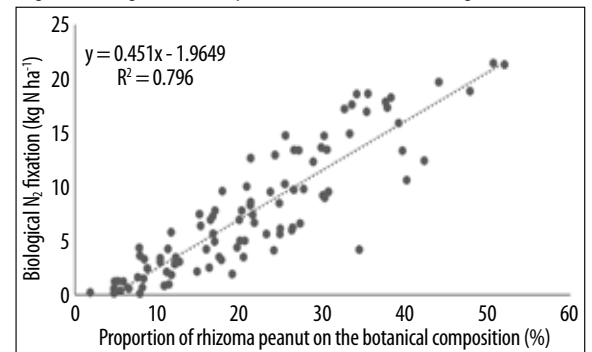
**Table 1.** Forage accumulation of the total plot, and clover or ryegrass components in the mixtures.

Treatments	Forage Accumulation, lbs/ac		
	Total	Clover	Ryegrass
Ryegrass-Balansa Clover	1,550 <sup>b</sup>	420 <sup>b</sup>	1,040 <sup>b</sup>
Ryegrass-Ball Clover	2,090 <sup>b</sup>	540 <sup>b</sup>	1,490 <sup>b</sup>
Ryegrass-Berseem Clover	2,030 <sup>b</sup>	1,530 <sup>a</sup>	1,480 <sup>b</sup>
Ryegrass-Crimson Clover	4,090 <sup>a</sup>	1,990 <sup>a</sup>	1,960 <sup>a</sup>
Unfertilized Ryegrass	870 <sup>c</sup>	---	850 <sup>b</sup>
SEM	247	201	173
P-value	<0.001	<0.001	0.0006

<sup>a,b,c</sup>Means in a column with different superscripts differ, P<0.05. Source: (Santos et al., 2015).

The proportion of legume in a pasture is important for reaping benefits of biological N<sub>2</sub>-fixation. These benefits are maximized with increasing proportions of legume in the pasture. Increasing the proportion of rhizoma peanut (a perennial legume found in the southeastern U.S.) improved the N amount fixed in these systems (Figure 1). Similar observations can be made with most legumes in pasture systems. Generally, ideal grass-legume mixtures contain ≥30% of the pasture botanical composition in legumes.

**Figure 1.** Proportion of rhizoma peanut on the botanical composition of ungrazed bahiagrass-rhizoma peanut mixtures and their biological N<sub>2</sub>-fixation.



Source: (Queiroz, 2021).

**How Does N Transfer from Legume to Grass?** Nitrogen transfer from legume to grass is a dynamic process occurring in several ways. In grazed pastures, 80-90% of ingested N from grazing is returned to pasture through feces and urine, where a limited amount of N is retained by the animal. Where the legume is not grazed, N contained within the plant will return to the system as the plant decomposes and becomes litter material. In both scenarios, N returned to the pasture will be available for companion grasses. Belowground structures (e.g., roots, rhizomes) make up a large component of plant biomass in pasture systems. These are highly important in mixed grass-legume pastures since N can be shared from legume to grasses through direct root contact and other microorganisms, such as mycorrhizal fungi (Queiroz, 2021). Decay and root turnover also provide an important mechanism for belowground N transfer in grazing systems.

**Beyond N Fixation.** Beyond biological N fixation, legumes provide a wide range of benefits in pastures. Two of these aspects are the effects on pollinators and changes in soil microbial composition.

- **Providing habitat for pollinators.** Pollinators are a diverse group of animals, dominated by insects, which are largely responsible for pollinating >35% of global crops, with bees being the most recognized. Land-use changes, agricultural intensification, pesticide application, and environmental pollution all contribute to bee population declines. Including legumes in pastures can enhance the flowering period and add diversity to the flowering structures found within a given land area. These factors contribute to creating positive habitats that nurture and sustain populations of bees and other pollinator species. Recent studies by Garcia (2019) showed increased abundance of flowers, and the extended flowering period, resulted in greater pollinator species diversity in grazing systems managed with legumes. This indicates the benefits of including legumes extend beyond N fixation, since harboring pollinator habitat is so important to our food systems and the environment.
- **Altering soil microbial composition.** Microorganisms found within the root zone are critical members of the plant microbiome. Soil bacterial communities are strongly influenced by soil N, and, therefore, plant species composition within a pasture system can affect the types of soil bacterial communities present. Recent advancements in DNA sequencing technologies have improved our ability to understand the soil microbiome, and we have just begun to scratch the surface! Guerra et al. (2022) showed increasing species diversity in grazing systems did not result in increased soil bacterial diversity. Instead, the authors observed grazing systems containing legumes had greater proportions of *Bradyrhizobium* spp., a genus of bacteria associated with biological N<sub>2</sub>-fixation and N cycling, whereas grazing systems relying on N fertilizer had greater abundance of soil bacteria associated with soil C and nutrient cycling. These studies are important for further understanding belowground processes and linking pasture management practices to soil bacterial communities.

**Take Home Message.** Forage legumes are important components of pasture systems, especially since they can be alternatives for reducing N fertilizer use, but the benefits go well beyond N fixation. Plenty of work remains to further evaluate ways in which legume use can be incorporated in grazing systems and how to best obtain these benefits, as well as to quantify the various benefits obtained when legumes are used in pastures. In the near future, our research efforts will be directed at quantifying how much N is fixed in grazing systems, quantifying animal gains, as well as quantifying nutrient returns in grazing systems when legumes are included.

**References:**

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