Legumes Provide Nitrogen to Pastures

Fertilizer nitrogen is the most reliable way to maximize yields in grass pastures and hay fields. However, many Missouri producers can match or exceed their current forage yields using legumes as the nitrogen source instead of nitrogen fertilizer. This guide outlines when legumes are a good option as your primary nitrogen source and situations where they are less effective as a nitrogen fertilizer for grass.

How much nitrogen do legumes fix?

Legumes, such as red clover, lespedeza, birdsfoot trefoil, and alfalfa, are capable of "fixing" nitrogen from the atmosphere and using it to increase forage growth. Rhizobacteria on legume roots provide nitrogen to their legume host. Some of that fixed nitrogen is then transferred to the grasses in the forage mix. The amounts of nitrogen fixed are highly variable depending on the type of legume and local conditions (Table 1). The amounts of nitrogen transferred to an inter-seeded grass are comparatively small, often no more than 10 to 20 percent of nitrogen fixed by the legume (Table 1).

However, from the perspective of the grass, the legume nitrogen represents up to 65 percent of the nitrogen in the grass (e.g. Fig. 1). The contribution of legume to the inter-seeded grass will also vary year to year (Figure 1). Weather conditions and stand age both can play a role.

Table 1. Annual amounts of nitrogen (N) fixed by legume species and the amount of fixed nitrogen transferred to inter-seeded grasses.

Legume species	Biological N Fixed	Biological N Transferred
	pounds per acre	
Alfalfa	46 - 252	3 – 24
Birdsfoot trefoil	18 - 70	5 - 25
Red clover	5 - 333	2 - 38
White clover	74 - 252	10 - 91

Sources: Burity et al., 1989; Ta and Farris., 1987; Hardarson et al., 1988; Heichel and Henjum, 1991; Boller and Nosberger., 1987; Ledgard, 1991.

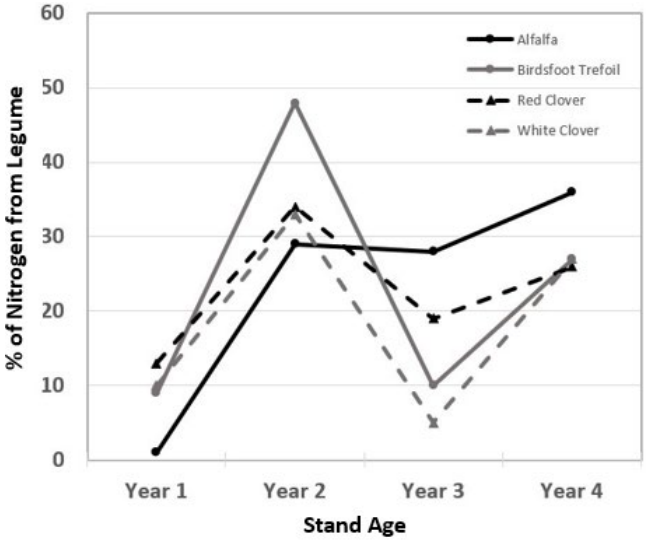

Figure 1. Annual variation in percent nitrogen in inter-seeded grass from four legumes.

Understanding when legumes can match or exceed fertilizer yields.

Sixty pounds per acre of nitrogen is a common spring rate for Missouri tall fescue stands. Figure 2 summarizes a two-year study where yield of tall fescue inter-seeded with birdsfoot trefoil matched or exceeded yield of tall fescue with fertilizer nitrogen.

A comparison of full-season yields of tall fescue with and without fertilizer compared to tall fescue interseeded with three different legumes emphasizes both the benefits of legume nitrogen its limits (Fig. 3). Summer yields (June and August) of legume mixes exceeded yields of fescue with fertilizer. But spring and stockpile yields were consistantly lower when relying on legumes.

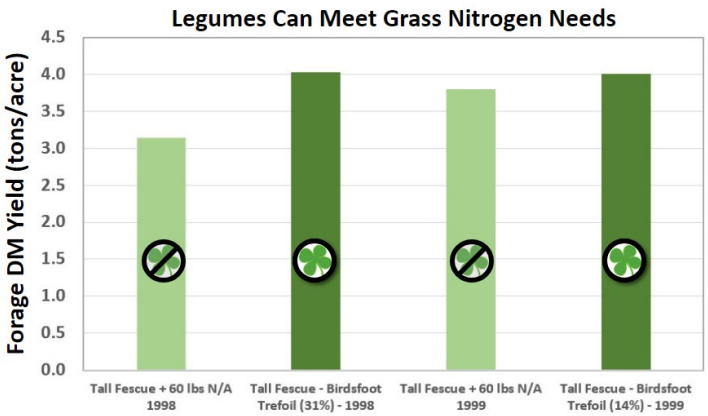

Figure 1. Spring yields grazing tall fescue in Missouri. (Wen et al., 2002).

Figure 2. Full-season yield response of tall fescue to nitrogen versus legume nitrogen in Columbia MO. (Matches et al., 1971).

The inability of legume nitrogen to maximize stockpile yields is well researched as represented by a four-year study at Linneus Missouri (Figs. 3 and 4). Fescue yield with red clover and no fertilizer was low compared to yield potential with nitrogen fertilizer. The limited value of legumes in fall reflects limited legume growth potential in the cool fall conditions where tall fescue thrives.

The cost of high nitrogen rates of fall-applied nitrogen to the legume is clear in Fig. 4; high nitrogen rates eliminated fescue from the stand. Additionally, high nitrogen rates were associated with doubling the toxicity of toxic endophyte tall fescue used in the study.

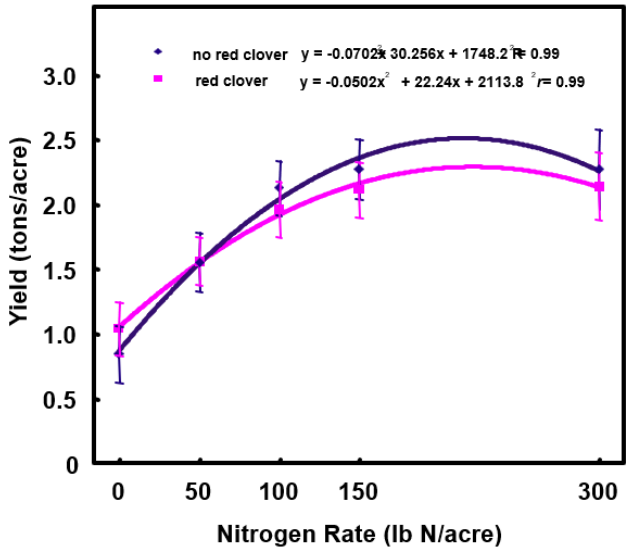

Figure 3. Effect of August fertilizer nitrogen rate on fall-stockpile tall fescue yield with and without red clover. (Kallenbach et al. 2017).

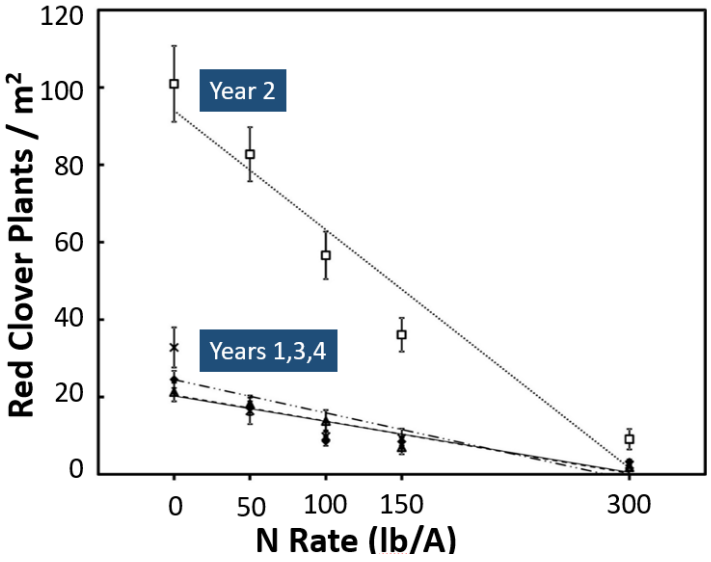

Figure 4. Effect of August fertilizer nitrogen rate on spring red clover density. (Kallenbach et al. 2017)

How to manage nitrogen in legume-grass mixes.

Legumes and fertilizer nitrogen are not a good mix. There is extensive data documenting that any nitrogen application to legume-nitrogen mixes reduces legume component of the stand. Grasses that rely solely on legumes can meet or exceed yields in grass-only yields in late spring and summer with the added benefit that

the legume component will improve forage quality. This is particularly pronounced in toxic tall fescue stands where the legume component also dilutes the toxic fescue. Legumes are better adapted to summer conditions than cool season grasses, contributing to their ability to successfully increase summer forage quantity and quality.

However, fields reliant solely on legume nitrogen will be slower to initiate rapid growth in the spring and under-perform fertilized pastures in the fall. Under these cool conditions, reduced nitrogen production by the legume and cool soil conditions limit the ability of legume nitrogen to meet cool-season grass growth rates. This is a particular challenge for stockpile management.

Keys to success with legume-nitrogen mixes include:

1. Avoid applying fertilizer nitrogen to fields with a good legume component – typically assumed to be greater than 25% legume.
2. If you do apply fertilizer nitrogen, limit the amount applied to less than 60 pounds nitrogen per acre. If applying phosphorus fertilizer blends, limit the amount of nitrogen in the blend to less than 60 lbs.
3. If you are applying fertilizer to a grass-legume mix apply in the fall or perhaps early spring so the nitrogen enhances yield at a time when legumes perform poorly.

In Missouri fields, where toxic fescue is prevalent, there is high incentive to use legumes to meet nitrogen need of the pasture. Legume-grasses increase yield during the summer slump while improving forage quality and animal performance.

If maximum productivity is the goal, fertilizer nitrogen will result in higher spring and fall yields. If your goal is to maximize yield with fertilizer, replacing toxic fescue with a novel endophyte tall fescue or other cool season grass is highly recommended given the high potential for animal health issues from high nitrogen rates on toxic tall fescue.

Selected References

Heichel, G. H., & Henjum, K. I. (1991). Dinitrogen fixation, nitrogen transfer, and productivity of forage legume-grass communities. *Crop Science*, **31**, 202–208. doi: 10.2135/cropsci1991.0011183X003100010045x.

Kallenbach, R., C. Roberts, J. Lory, and S. Hamilton. 2017. Nitrogen fertilization rates influence stockpiled tall fescue forage through winter. Crop Sci. 57:1732-1741. doi:10.2135/cropsci2016.02.0097/

Ledgard, S. and Steele, K. (1992) Biological Nitrogen Fixation in Mixed Legume/Grass Pastures. Plant and Soil, 141, 137-153. doi: 10.1007/BF00011314

Wen, et al., 2002

West, C.P., and Mallarino, A.P., 1996, *In Nutrient Cycling in Forage Systems*,pp. 167–175, (Joost, R.E., and Roberts, C.A., eds.), Potash and Phosphate Institute and Foundation for Agronomic Research, Manhattan, Kansas.