Agriculture

extension.usu.edu

June 2018 AG/Forage/2018-02pr

Alternative Legume Species Can Reduce the Environmental Impacts of Cattle

Elizabeth K. Stewart, Graduate Research Assistant, Wildland Resources
Jennifer W. MacAdam, Professor, Plants, Soils, and Climate
Juan J. Villalba, Professor, Wildland Resources

Cattle are inefficient with regard to utilizing the protein that is provided to them in their diets, leading to large amounts of the nitrogen they consume being wasted and excreted in the urine. The excreted nitrogen can then be lost as environmentally harmful compounds, including large amounts of ammonia and nitrate, and smaller amounts of nitrous oxide (Watson and Atkinson, 1999). The environmental impacts from these compounds differ but can include ground and surface water pollution and algal blooms from the leaching of nitrates, odors and air pollution from ammonia, and greenhouse warming from nitrous oxide. In fact, nitrous oxide has a global warming potential that is approximately 298 times greater than that of carbon dioxide (Fig. 1). Additionally, ammonia can contribute to acid rain or can be redeposited onto the soil and subsequently be transformed into nitrous oxide.

Cattle also produce large amounts of enteric (digestive) methane as a result of normal rumen function during the digestion process. Methane is considered to be a greenhouse gas with a global warming potential that is approximately 32 times greater than that of carbon dioxide (Fig. 1).

Grass vs. Legumes as Livestock Forage

Pastures are usually seeded with grasses or mixtures of grasses and legumes and, in the West, alfalfa is usually grown for hay. However, there are less commonly grown alternative forage species that not only help to reduce the nitrogen and enteric methane losses from beef production systems, but also improve animal productivity.

The benefits of grasses include a fibrous root system, which provides for greater protection to the soil from erosion and adds more organic matter to the soil than the taproot typical of legume species (Fig. 2). The leaves of grasses, however, have greater concentrations of fiber than legume leaves

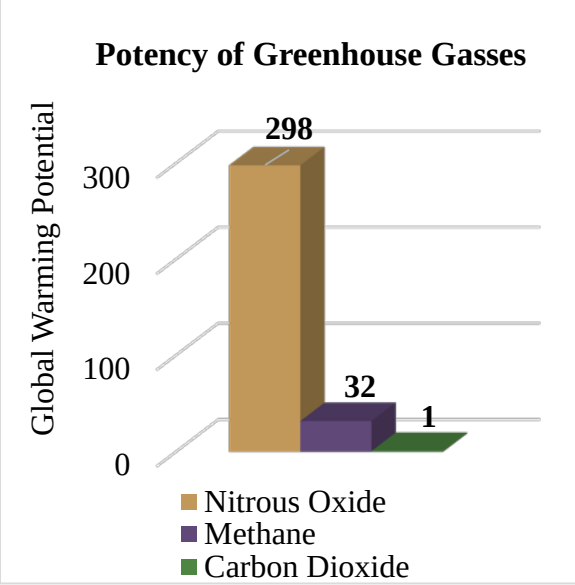

Figure 1. Nitrous oxide and methane have much higher global warming potentials than carbon dioxide (EPA, 2017).

(Wen et al., 2002) so they are digested more slowly. Greater fiber concentrations also lead to larger volumes of methane production by cattle.

Perennial legume forages help to promote environmental health because they have the ability to fix their own nitrogen as needed through symbiosis with soil microorganisms, so they do not need external inputs of nitrogen fertilization. Nitrogen fertilizers are the primary source of atmospheric nitrous oxide from agricultural production (Stackhouse-Lawson et al., 2012), and the most potent greenhouse gas by-product of agricultural production. Therefore, reducing the nitrogen fertilizer applied for forage production could significantly decrease the negative environmental impacts of animal agriculture.

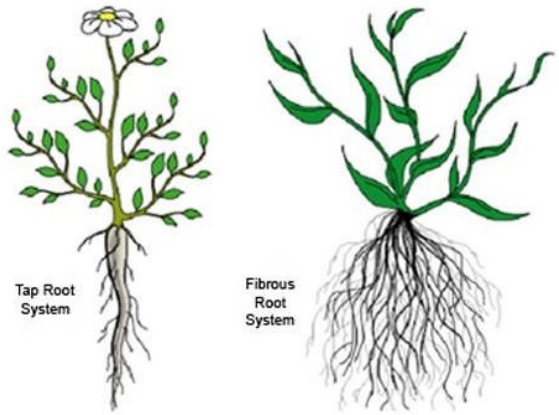

Figure 2. Grasses have a fibrous root system while legumes have a taproot system. Image courtesy of Peter Carroll (http://slideplayer.com/slide/8989227/).

Benefits of Legumes for Cattle

The use of alternative legume forages instead of alfalfa or grasses for cattle production can have positive effects on the environment. We will describe two legume species that are well-suited to the soil pH and climate of the Intermountain West region of the United States. Both are non-bloating and are capable of fixing the nitrogen they need for growth. When grown in mixtures with grasses, this nitrogen would be shared with the grass component, eliminating the need for nitrogen fertilization of mixtures.

Birdsfoot Trefoil

Birdsfoot trefoil (Fig. 3) contains condensed tannins, a plant secondary compound, which at concentrations present in the plant (1 – 3%) do not reduce voluntary forage intake (Barry and McNabb, 1999). These condensed tannins mitigate the problem of bloating that is associated with alfalfa and most true (e.g., white, red) clovers (Jones and Lyttleton, 1971). Tannins can also reduce enteric methane production and nitrogen excreted in the urine (Woodward et al., 2004). The condensed tannins found in birdfoot trefoil have also been shown to increase beef and dairy production (Waghorn and McNabb, 2003).

Figure 3. Birdsfoot trefoil is easily identifiable by its bright yellow flowers. Image courtesy of David Cappaert (http://articles.extension.org/pages/65812/lotus-corniculatus-birdsfoot-trefoil).

Sainfoin

Sainfoin (Fig. 4) is another condensed tannin-containing legume species. Sainfoin has been shown to reduce both enteric methane emissions and urinary nitrogen emissions (Chung et al., 2013). However, sainfoin contains concentrations of condensed tannins as high as 6 – 8%, which is

Figure 4. Sainfoin flowers. Image courtesy of Ralph Pearce (https://www.country-guide.ca/2015/05/20/sainfoin-a-new-forage-legume-for-ontario-livestock-producers/46694/).

greater than concentrations found in birdsfoot trefoil. While this does not seem to reduce its palatability (Scharenberg et al., 2007), this legume can benefit ruminants by reducing or inhibiting internal parasites in livestock (Hoste et al., 2006). Additionally, sainfoin has been shown to reduce the negative effects of the fungal endophyte on animals consuming endophyte-infected tall fescue (Catanese et al., 2014).

Producer Concerns

Choosing to feed an alternative forage legume species in lieu of better known species, such as grasses or alfalfa, may seem daunting to many producers. However, in addition to the environmental benefits these species have to offer, their greater nutritive value and more rapid digestion result in beef daily weight gains greater than grass (Pitcher, 2015) and alfalfa (Fig. 5; Marten et al., 1986), and meat that is more juicy and tender than grass-finished beef (Chail, et al., 2016). A recent study showed that ribeye steaks from cattle finished on birdsfoot trefoil were comparable to grain-finished beef and preferred over steaks from cattle finished on grass (Chail et al., 2016); these steaks also retained their color after cutting better than steaks from grass-finished beef (Legako et al., 2018). Compared to grain-finished beef, steaks from cattle finished on both grass and birdsfoot trefoil have elevated concentrations of unsaturated fatty acids in ribeye steaks (Chail et al., 2016).

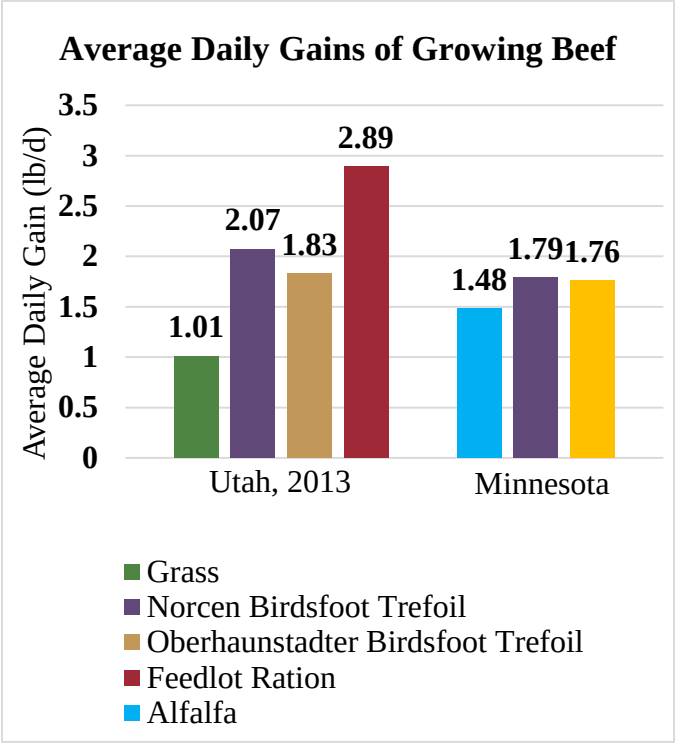

Figure 5. Average daily gains of growing beef cattle consuming grass, alfalfa, birdsfoot trefoil, sainfoin, or feedlot diets in Minnesota (MN, Marten et al., 1987) or Utah (UT, J. W. MacAdam, Pers. Comm., 2018).

References

Barry, T. N., and W. C. McNabb. 1999. The implications of condensed tannins on the nutritive value of temperate forages fed to ruminants. Br. J. Nutr. 81:263-272.

Catanese, F., R. A. Distel, and J. J. Villalba. 2014. Effects of supplementing endophyte-infected tall fescue with sainfoin and polyethylene glycol on the physiology and ingestive behavior of sheep. J. Anim. Sci. 92:744-757. doi:10.2527/jas.2013-6713

Chail, A., J. F. Legako, L. R. Pitcher, T. C. Griggs, R. E. Ward, S. Martini, and J. W. MacAdam. 2016. Legume finishing provides beef with positive human dietary fatty acid ratios and consumer preference comparable with grain-finished beef. J. Anim. Sci. 94:2184-2197.

Chung, Y. H., E. J. Geough, S. Acharya, T. A. McAllister, S. M. McGinn, O. M. Harstad, and K. A. Beauchemin. 2013. Enteric methane emission, diet digestibility, and nitrogen excretion from beef heifers fed sainfoin or alfalfa. J. Anim. Sci. 91:486-4874. doi:10.2527/jas.2013-6498

Dahlberg, E. M., M. D. Stern, and F. R. Ehle. 1988. Effects of forage source on ruminal microbial nitrogen metabolism and carbohydrate digestion in continuous culture. J. Anim. Sci. 66:2071-2083.

EPA. 2017. Understanding global warming potentials. https://www.epa.gov/ghgemissions/understanding-global-warming-potentials (Accessed 7 February 2018.)

Legako, J. F., T. Cramer, K. Yardley, T. J. Murphy, T. Gardner, A. Chail, L. R> Pitcher, and J. W. MacAdam. 2018. Retail stability of three beef muscles from grass-, legume- and feedlot-finished cattle. J. Anim. Sci. in press.

Marten, G. C., F. R. Ehle, and E. A. Ristau. 1987. Performance and photosensitization of cattle related to forage quality of four legumes. Crop Sci. 27:138-145.

Pitcher, L. R. 2015. Beef average daily gain and enteric methane emissions on birdsfoot trefoil, cicer milkvetch and meadow brome pastures. Master's thesis. (Accessed 30 March 2018). https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=5028&context=etd

Stackhouse-Lawson, K. R., C. A. Rotz, J. W. Oltjen, and F. M. Mitloehner. 2012. Carbon footprint and ammonia emissions of California beef production systems. J. Anim. Sci. 90:4641-4655. doi:10.2527/jas.2011-4653.

Waghorn, G. C., and W. C. McNabb. 2003. Consequences of plant phenolic compounds for productivity and health of ruminants. Proc. Nutr. Soc. 62:383-392.

Watson, C. A., and D. Atkinson. 1999. Using nitrogen budgets to indicate nitrogen use efficiency and losses from whole farm systems: a comparison of three methodological approaches. Nutr Cycling Agroecosystems. 53:259-267.

Wen, L., R. L. Kallenback, J. E. Williams, C. A. Roberts, P. R. Beuselinck, R. L. McGraw, and H. R. Benedict. 2002. Performance of steers grazing rhizomatous and nonrhizomatous birdsfoot trefoil in pure stands and in tall fescue mixture. J. Anim. Sci. 80:1970-1976.

Woodward, S. L., G. C. Waghorn, and P. G. Laboyrie. 2004. Condensed tannins in birdsfoot trefoil (*Lotis corniculatus*) reduce methane emissions from dairy cows. Proc. N. Z. Soc. Anim. Prod. 64:160-164.