Animal and Forage Performance of Integrated Crop-Livestock Systems

Dillard, S.L.*
* Dept. of Animal Sciences, Auburn University

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Abstract
Grazing of cool-season cover crops has been shown to be a viable tool for extending the grazing season while mitigating environmental risks associated with row-crop farming systems. Grazing cover crops is not novel, but most recent information available on this practice focuses on soil health as opposed to forage production and animal performance. Research has shown that forage quality of cool-season annual cover crops is sufficient to maintain an average daily gain of at least 1 kg/d and as high as 1.5 kg/d. Forage species selection plays an important role in the success of an integrated crop-livestock system. Grasses typically dominate the stand with over 75% of the mixture, however, other species such as clovers and brassicas provide improved forage quality and ecosystem services such as reduced enteric methane emissions. However, multiple studies have shown that increased fiber fractions have the greatest impact on animal performance and enteric methane emissions, regardless of species in the forage mixture. Grazed cover crop systems allow for grazing of land that otherwise would be void of any livestock and would be out of production for 3-6 months each year. The use of grazed cover crops increases efficiency of land use and greater production output per hectare for producers as a result of cattle income potential. However, cattle performance and effects on the agroecosystem are variable within each system and each grazing system based on cover crop mixture, grazing management, and forage maturity and quality.

Introduction

Cover crops have been used as a management tool in row cropping systems for centuries. Interest in cover crops has increased in the last 40 years as a result of increased knowledge into the importance of ground cover and plant diversity on the productivity of intensively managed row cropped fields. Cover crops provide many environmental benefits such as reducing erosion (Langdale et al. 1990), nutrient leaching and runoff (Li et al.2006), inhibiting insect and weed encroachment (Creamer and Baldwin 2000), and increasing soil fertility (Cavigelli and Thien 2003). However, adoption of cover crops has been slow due to the economic investment and lack of immediate economic returns on these systems. Integration of crop and livestock systems can be a valuable management strategy that allows for coupling of two complementary enterprises. Cover crops often use plant species that can be used as forage species. These forages are typically nutrient-dense, providing adequate CP and energy for all classes of cattle (NRC 2016).

Results and Discussion

Cover Crop and Forage Performance

Plant species that can be used as cool-season annual forage and for cover crop production include small grains [wheat (*Triticum aestivum* L.), oat (*Avena sativa* L.), and cereal rye (S*ecale cereal* L.)], annual ryegrass (*Lolium multiflourm* Lam.), clovers (*Trifolium* spp.), and brassicas (*Brassica* spp.). These forages are often used for stocker cattle production in the Southeast US. Multiple studies from this region have demonstrated that grazing of cool-season annuals can be advantageous for stocker gains and total production per land unit (Beck et al. 2014; Mullenix et al. 2014; Marchant et al. 2019). Research in South Alabama has shown that when cattle are allowed to graze a cool-season annual cover crop for 30, 60, or 90 d, seasonal forage biomass was 40, 54, and 52% greater in the non-grazed paddocks, respectively (Carrell 2022). However, during the three-year trial, no differences were found among grazed treatments. This resulted in no differences among grazed treatments for forage allowance, grazing days per hectare, or stocking density. Furthermore, the botanical composition of the cover crop did not change based on the presence of animals or throughout the season. Grasses represented 76% of the sward (oat and cereal rye), crimson

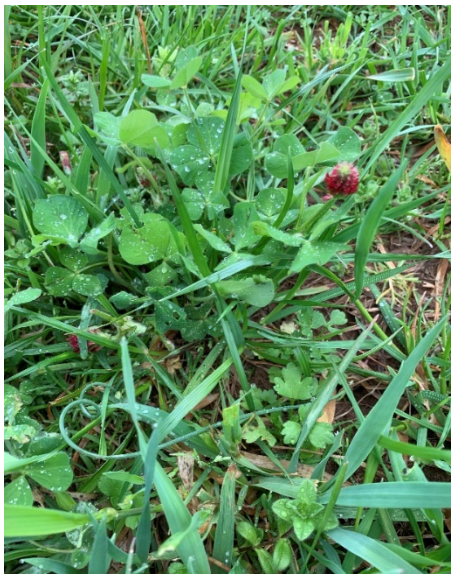

Figure 1. Cool-season annual cover crop mixture on producer farm in Marshall County, AL.

clover (*Trifolium incarnatum* L.) 13%, and a turnip × rapeseed hybrid (*Brassica rapa* L. × *B. napus* L.) only contributed 11% to the sward composition (Carrell 2022).

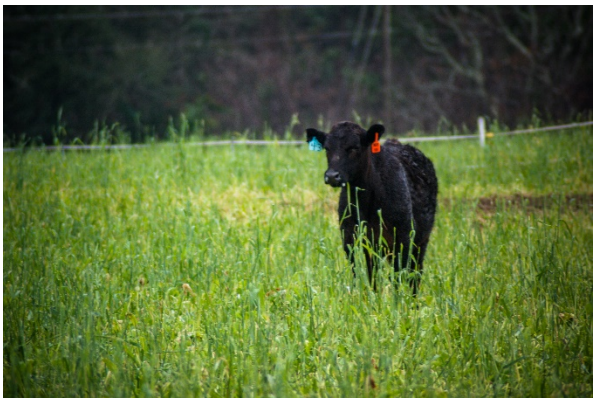

Figure 2. Steer grazing cool-season annual cover crop at the Wiregrass Research and Extension Center in Headland, AL.

Beef Cattle Performance

The presence of cattle on cover crops provides ecosystem services to cropland through plant defoliation that would otherwise be conducted through various chemical applications. However, recommendations on proper grazing management of a multi-species cover crop are unclear. Although forages used in cover crop mixtures can serve as effective grazing crops, it is not well understood how specific plant species will respond to grazing pressure and subsequent potential beef production per hectare using these mixtures. Grazing management for traditional annual forage systems places emphasis on increased forage utilization throughout a grazing season; however, research on grazing management to ensure cover crops continue to provide ecosystem services to the cropping system are needed. Research at Auburn University has shown that when managed under a put-and-take system, yearling steers grazing cover crop of cereal rye, oat, crimson clover, and turnip × rapeseed hybrid can maintain an average daily gain of 1.1 – 1.3 kg/d (Carrell 2022). Total body weight gain per hectare was 388 – 466 kg/ha. Previous research at Auburn University has that monocultures of annual ryegrass, triticale [× *Triticosecale* Wittm. ex A. Camus (Secale × Triticum)], and wheat provided cattle average daily gains of 1.23 – 1.51 kg/d, greater than Carrell (2022). This difference is likely due to the length of the grazing season in cover cropping systems that attempt to provide ground cover prior to row crop establishment late in the growing season, thus requiring early removal of grazing animals such as in Carrell (2022), compared to longer season grazing to remove all ground cover, such as in Mullenix et al. (2014). Additionally, forage quality was superior in Mullenix et al. (2014), likely a result of forage species selection. Previous research has also shown that due to its early-season maturity, forage quality of mixtures including cereal rye are lower than those included other cool-season annual grass species (Pereira 2009; Marchant et al. 2019). Multiple stepwise regression conducted by Carrell (2022) and Mullenix et al. (2014) indicated that neutral detergent fiber and acid detergent fiber had a negative causative relationship with cattle average daily gain, having a 0.48 and 0.22 partial r^2, respectively.

Ecosystem Services

Integrated crop-livestock systems have become a more commonly used practice to increase land use efficiency during cash crop off-seasons (Franzluebbers 2007). The incorporation of grazing livestock such as cattle onto cropland can provide many ecosystem services that would otherwise be provided via synthetic products such as chemical fertilizer. Studies have reported that grazing of cover crops has minimal to no effect on soil quality parameters such as bulk density, water holding capacity, nitrogen (N) cycling, and soil organic matter (SOM) (Franzluebbers and Steudemann 2008; Tracy and Zhang 2008) or subsequent cash crop yields (Balbinot et al. 2011; Kelly et al. 2021). Inclusion of specific forage species have also been shown to reduce enteric methane emissions. Dillard et al. (2018) showed when used in a continuous culture fermenter system, cattle diets containing *Brassica* spp. had a lower methane production per day, per gram of digestible organic matter fed, and per gram of digestible neutral detergent fiber fed. Multiple stepwise regression indicated that neutral detergent fiber was responsible for 75% of the variation in methane production among dietary treatments. Recent research has shown that enteric methane production conducted in vitro was less in January than in February, March, or April grown forage diets (Carrell 2022). This study also reported a greater acetate to butyrate ratio in samples with lower methane production.

Economic Considerations

The impact of grazing cover crops on economic sustainability of integrated crop-livestock systems has not been greatly investigated. DeLaune et al. (2020) found that including both monoculture and mixed-sward cover crops consisting of Austrian winter pea (*Pisum sativum*), hairy vetch (*Vicia villosa*), crimson clover, wheat, or a multi-species mixture increased seed costs but had no effect on net return in cotton systems in North Texas. The authors concluded that although no direct economic incentive was present, the use of cover crops provided environmental advantages to continuous-cropping systems without affecting the economic return. Poffenbarger et al. (2017) found that including cattle grazing into a crop rotation resulted in similar returns

($370-$1200/ha) as that of traditional cropping systems, this is because of the added infrastructure and labor needed to manage livestock. These data suggest that adding cattle production to a farming operation may not produce greater net returns.

Conclusions and/or Implications

Grazed cover crops can be a useful management tool for row crop and livestock producers when properly managed. This system allows for grazing of land that otherwise would be void of any livestock. The use of grazed cover crops increases efficiency of land use and greater production output per hectare for producers as a result of cattle income potential. Specific management considerations should be made when grazing cover crops, however. Cover crops typically consist of high-quality forages that are suitable for continuous grazing of stocker cattle. However, cattle performance and effects on the agroecosystem are variable within each system and each grazing system based on cover crop mixture, grazing management, and forage maturity and quality.

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References

Balbinot Junior, A. A., Veiga, M. D., Moraes, A. D., Pelissari, A., Mafra, Á. L. and Piccolla, C. D. 2011. Winter pasture and cover crops and their effects on soil and summer grain crops. *Pesquisa Agropecuária Brasileira*, 46:1357-1363.

Beck, P., Hess, T., Hubbell, D., Hufstedler, G. D., Fieser, B. and Caldwell, J. 2014. Additive effects of growth promoting technologies on performance of grazing steers and economics of the wheat pasture enterprise. *J. Ani. Sci.*, 92(3):1219-1227.

Carrell, R. 2022. Evaluation of Cover Crops as an Alternative Forage Source for Beef Cattle. Dissertation. Auburn University, Auburn, AL.

Cavigelli, M. A. and Thien, S. J. 2003. Phosphorus bioavailability following incorporation of green manure crops. *Soil Sci. Soc. Am. J.*, 67(4):1186-1194.

Creamer, N. G. and Baldwin, K. R. 2000. An evaluation of summer cover crops for use in vegetable production systems in North Carolina. *Hort. Sci.*, 35(4):600-603.

DeLaune, P. B., P. Mubvumba, Y. Fan, and S. Bevers. 2020. Agronomic and economic impacts of cover crops in Texas rolling plains cotton. *Agrosystems, Geosci. & Enviro.,* 3(1):e20027.

Dillard, S. L., Roca-Fernández, A. I., Rubano, M. D., Elkin, K. R. and Soder, K. J. 2018. Enteric methane production and ruminal fermentation of forage brassica diets fed in continuous culture. *J. An. Sci.*, 96(4):1362-1374.

Franzluebbers, A. J. 2007. Integrated crop–livestock systems in the southeastern USA. *Agron. J.,* 99:361-372.

Franzluebbers, A. J. and Stuedemann, J. A. 2008. Early response of soil organic fractions to tillage and integrated crop–livestock production. *Soil Sci. Soc. Am. J.*, 72(3):613-625.

Kelly, C., Schipanski, M. E., Tucker, A., Trujillo, W., Holman, J. D., Obour, A. K. and Fonte, S. J. 2021. Dryland cover crop soil health benefits are maintained with grazing in the US High and Central Plains. *Agric., Ecosys. & Enviro*., 313:107358.

Langdale, G. W., Bruce, R. R. and Wilson Jr, R. L. 1990. Cropping frequencies to sustain long-term conservation tillage systems. *Soil Sc. Soc. Am. J*., 54(1):193-198.

Li, C., Farahbakhshazad, N., Jaynes, D. B., Dinnes, D. L., Salas, W. and McLaughlin, D. 2006. Modeling nitrate leaching with a biogeochemical model modified based on observations in a row-crop field in Iowa. *Ecolog. Modelling, 196(1-*2):116-130.

Marchant, K. B., Dillard, S. L., Holland, C. E., Gamble, B. E. and Muntifering, R. B. 2019. Stocker cattle performance from grazed mixtures of triticale and wheat with annual ryegrass. *Applied Ani.Sci.*, *35*(2):199-208.

Mullenix, M. K., Dillard, S. L., Lin, J. C., Gamble, B. E. and Muntifering, R. B. 2014. Evaluation of wheat and triticale forage for stocker production in the Gulf Coast region. *The Prof. Ani. Sci.*, 30(3):296-304.

National Academies of Sciences, E., and Medicine. 2016. Nutrient requirements of beef cattle. National Academies Press, Washington, D.C.

Pereira Jr, A. C. 2009. Performance of forage-finished beef cattle grazing ryegrass, rye or oats, and forage quality measured by a high-throughput procedure. Dissertation. Auburn University, Auburn, AL.

Poffenbarger, H., G. Artz, G. Dahlke, W. Edwards, M. Hanna, J. Russell, H. Sellers, and M. Liebman. 2017. An economic analysis of integrated crop-livestock systems in Iowa, USA. *Agric. Sys*., 157:51-69.

Tracy, B. F. and Zhang, Y. 2008. Soil compaction, corn yield response, and soil nutrient pool dynamics within an integrated crop-livestock system in Illinois. *Crop Sci.*, 48(3):1211-1218.