The effects of grazing cover crops on animal performance and soybean production

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Abstract. Grazing cover crops has the potential to offset costs incurred with cover crop establishment, thus incentivizing management adoption. Information regarding cover crop species in combination with grazing and their subsequent effects on soybean production is limited. A field trial was conducted in Newton, MS from 2019 to 2021 to assess these effects. Cover crop treatments included oats (O), O + crimson clover (OC), and OC + radish (OCR) were applied in a randomized complete block design with three replications. Cover crops differed in nutritive analysis; O had significantly lower mean CP, but greater total daily nutrients (TDN). Weaned beef steers grazing cover crops had lower ADG in the OCR treatment (3.03 lb hd^{-1} d^{-1}), compared to O (3.52 lb hd^{-1} d^{-1}) and OC (3.55 lb hd^{-1} d^{-1}). No significant difference was observed in soybean grain yield between cover crop treatments. Mean yields were 51.1, 46.1, and 38.7 bu ac^{-1} for the O, OC, and OCR treatments, respectively. Total net returns for grazing plus soybean production were significantly lower in the OCR ($817.51 ac^{-1}), compared to the O ($1,107.03 ac^{-1}) and OC ($1,071.15 ac^{-1}) treatments. These returns suggest that grazing provides an added value to cover crop establishment and provides incentives for increased revenue for producers willing to combine livestock and row crop enterprises.

Introduction

Integrated crop-livestock systems (ICLS) have been utilized in agricultural settings dating back to early civilizations. These systems were designed to produce a wide variety of products that helped sustain human and livestock nutritional demands (Russelle *et al*., 2007). In general, ICLS are a form of sustainable intensification of agricultural production that relies on synergistic relationships between plants and animals which bolster critical agroecosystem processes (Peterson et al., 2020). Grazing of cover crops in the southeastern United States has the potential to alleviate economic concerns of cover crop establishment (Franzluebbers and Stuedemann, 2004), and is a highly adaptable ICLS model that can be adopted throughout several production systems. These southern ICLS systems are designed to capitalize on animal performance on cool-season forage species, such as oats (*Avena sativa*), crimson clover (*Triticum aestivum* L.) and radish (*Raphanus sativus* L.).

Methods

A field trial was conducted over two full cropping system rotations (2019-2020 and 2020-2021) in a randomized complete block design with three treatments and three replications at the Coastal Plain Branch Experiment Station (CPBES) in Newton, MS (32º20’05.11” N, 89º05’09.60” W). Treatments included three cover crop systems: oats (O); O + crimson clover (OC); and OC + radish (OCR). The study site consisted of an 18-ac pasture subdivided into nine (2.0 ± 0.1 ac) paddocks. In the fall of each year, one of the three cover crop treatments was randomly assigned to each paddock and was no-till seeded. Following seeding, all O paddocks were fertilized with 50 lb N ac^{-1} and OC and OCR paddocks received 25 lb N ac^{-1} using urea ammonium sulfate (33-0-0-11S). Cover crop data collection included forage mass (FM) and nutritive analysis (CP – crude protein; TDN – total digestible nutrients). Nine sub-samples were taken within each paddock at the beginning and end of each grazing period, and every two weeks throughout the grazing season. All samples were dried, ground, and analyzed using near-infrared spectroscopy (NIRS) and the 2018 mixed hay grass equation (NIRS Forage and Feed Testing Consortium; Berea, KY).

In each year of the trial, 36 weaned, predominantly Angus crossbred steers were used to graze cover crops. Mean steer weights were 568 and 739 lb hd^{-1} for the 2019-2020 and 2020-2021 grazing seasons, respectively. Four steers were randomly assigned to each experimental paddock (approximately 1,200 lb ac^{-1}). No additional animals were added to any paddock. Steer performance data included animal days (AD), average daily gain (ADG), and total gain per acre (GAIN). Animal days were determined as the sum of the number of days animals remained on each paddock, multiplied by the number of animals, and divided by the paddock size. Average daily gain was calculated by dividing total animal gain by the number of days of grazing for each animal. Total GAIN was calculated by dividing weight gain by the actual size of the paddock.

Following the end of each grazing season, soybeans (*Glycine max*) were no-till planted in each paddock. Soybean variety 'A4618X' with a 4.6 maturity and Roundup Ready 2 Extend technology was used in both seasons of the trial. Soybeans were planted using a no-till vacuum planter on 30-in row spacing with a target plant population of 120,000 plants ac^{-1}. Soybean stand counts were taken from each paddock. Total grain yield was measured by harvesting two, 6-row by 30-ft plots within each paddock.

Expected profitability for each of the three cover crop systems was determined by calculating the expected revenues and costs associated with each production practice for each system. Costs included fertilizer, seed, establishment, herbicide, insecticide, custom application rates, and opportunity costs for capital. Revenue for the cover crop was calculated for cattle in each cover crop grazing season as the difference between the end value of cattle and the beginning value of cattle divided by the total GAIN. Soybean revenue was the average yield multiplied by the expected value of soybean based on Mississippi averages from 2020 and 2021. Costs and rates were used from the Mississippi Forage Planning Budget, 2022, and the Mississippi Soybean Planning Budget, 2022.

Statistical analysis was conducted using ANOVA in SAS. Cover crop treatment was considered fixed, while replication and growing season were considered random. Mean separations were based on Tukey's protected least significant difference (LSD) and differences were considered significant at 0.95 probability level.

Results and Discussion

Cover crop production, animal performance, and economic analysis can be found in **Table 1**. No differences were observed between cover crop treatments for mean FM. Oat had lower mean CP (15.6%) than the other two treatments but had greater mean TDN (58.5%). As for animal performance, AD were similar among treatments, however, OCR had lower ADG (3.03 lb hd^{-1} d^{-1}) and GAIN (346 lb ac^{-1}) than the other two treatments. For soybean production, no differences were observed in stand counts or grain yield. Mean grain yield was 51.1, 46.1, and 38.7 bu ac^{-1} for the O, OC, and OCR treatments, respectively. Total production costs for each cover crop and soybean system, including interest, were $330.56, $335.09, and $347.13 ac^{-1}, for the O, OC, and OCR treatments, respectively. Total revenue and net return was lower for the OCR treatment ($1,1163.40 and $817.51, respectively) compared to the other two cover crop systems.

Table 1. Cover crop, animal, soybean, and economic analysis for oats (O), oats + crimson clover (OC), and oats + crimson clover + radish (ORC) cover crop treatments; Newton, MS (2019-2021).

Variable	System		
	O	OC	OCR
Cover crop			
FM† (lb DM ac^{-1})	1810	1695	1656
CP† (%)	15.6 b‡	17.2 a	17.0 a
TDN† (%)	58.5 a	57.2 b	56.5 c
Animal			
AD† (d yr^{-1})	47	48	48
ADG† (lb hd^{-1} d^{-1})	3.52 a	3.55 a	3.03 b
GAIN† (lb ac^{-1})	430 a	441 a	346 b
Soybean			
Stand counts (plants 1/1000 ac^{-1})	105	103	100
Yield (bu ac^{-1})	51.1	46.1	38.7
Economics			
Total production cost			
Cover crop ($ ac^{-1})	81.42	85.64	96.84
Soybean ($ ac^{-1})	226.08	226.08	226.08

Interest on operating capital§ ($ ac^{-1})	23.06	23.37	24.21
Total production cost ($ ac^{-1})	330.56	335.09	347.13
Revenue			
Cover crop ($ ac^{-1})	799.45	823.43	680.56
Soybean ($ ac^{-1})	637.12	575.21	482.83
Total revenue ($ ac^{-1})	1436.58 a	1398.65 a	1163.40 b
Net return ($ ac^{-1})	1107.03 a	1071.15 a	817.51 b

†FM, forage mass; CP, crude protein; TDN, total digestible nutrients; AD, animal days; ADG, average daily gain; GAIN, gain per acre.
‡Lowercase letters denote significant differences at $\alpha = 0.05$.
§7.5% annual percentage rate (APR).

Conclusions and/or Implications

Results from this research comparing cover crop treatments indicate that grazing oats or a combination of oats and crimson clover as a cover crop with subsequent soybean production can significantly increase net profit for livestock/row crop producers. By combining these enterprises, the opportunity for generating greater revenue nearly doubled than by producing each respective commodity alone. In certain areas of the southeastern USA, there exists ample opportunities to develop partnerships where both enterprises can capitalize off one another. However, there is a need to continue evaluating ICLS, specifically the impacts grazing has on soil compaction, nutrient cycling, and pest cycles. Developing long-term management plans that address these potential impacts should be considered.

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References

Franzluebbers, A.J., and J.A. Stuedemann. 2004. Crop management and animal production in yearly rotation under inversion and no tillage. p. 231–238. *In* Franzluebbers, A. 2007. Integrated crop-livestock systems in the south-eastern USA. *Agronomy Journal*., 99:361-372.

Peterson, C.A., L.W. Bell, P.F. Carvalho, and C.M. Gaudin. 2020. Resilience of an integrated crop-livestock system to climate change: A simulation analysis of cover crop grazing in Southern Brazil. Front. Sustain. Food Syst. 4:604099.

Russelle, M.P., M.H. Entz, and A.J. Franzluebbers. 2007. Reconsidering integrated crop-livestock systems in North America. *Agronomy Journal*., 99(2):325-334.