Management Intensive Grazing of Cover Crops for Soil Health and Profitability

Divya Pant (M.S. Student in Agronomy at Penn State
Email: dzp5431@psu.edu
Sjoerd W. Duiker (Penn State Soil Management Specialist and Divya's advisor)
Email: sduiker@psu.edu, mobile 814-4042605.

There is renewed interest in integration of grazing of cover crops after main crop harvest as a way to add economic value to cover crops. There is concern about soil compaction by the animals, but the animals may also affect soil health positively by depositing manure and urine and their grazing action. The results of an on-farm Pennsylvania study looking into this are presented here.

Management Intensive grazing of cover crops in continuous no-tillage systems is an opportunity to realize mutual benefits of cover crops for improving soil health while providing forage to livestock, but there are also concerns that animals could cause undesirable soil compaction. In this study we evaluate the effect of grazing cover crops planted after small grain or corn silage harvest on soil physical and biological properties, forage production, and economic returns. This project is a combination of technical and financial assistance by grazing specialists to install grazing infrastructure and develop a grazing plan, and research to evaluate forage production and soil health effects of grazing cover crops. Funding for this research was provided by The National Fish and Wildlife Foundation under a subcontract from Capital RC&D Council. An important part of this project is the technical advice and grazing plan provided by USDA-NRCS Grazing Specialists, while the research is performed by Penn State University with support of USDA-ARS. This research takes place on four farms in Adams and Franklin Counties, Pennsylvania. The comparisons entail grazed versus un-grazed cover crops planted after corn silage or grazed cover crops versus double cropped soybeans after small grain harvest. Grazing of cover crop follows Management Intensive Grazing practices.

Objectives

The objectives of the study are to:

1. Evaluate the effects of grazing cover crops on soil biological and physical properties (active carbon, respiration rate, bulk density, porosity, aggregate stability, and infiltration rate).
2. Evaluate the effectiveness of biological activity to alleviate soil compaction after grazing.
3. Study and compare economic returns of alternative scenarios.
4. Documentation of case studies of innovative cover crop grazing and dissemination of the information through pasture walks, in-door presentations, a fact sheet and articles, video case studies, and podcasts.

Methodology

The study started in the fall of 2019 and continues in 2020 and 2021. The results presented here are from the fall of 2019 and spring of 2020. With support from USDA-NRCS the farmers were assisted to set up fencing and watering systems in their fields. Exterior permanent fence was installed on the outside of fields while portable electrified fences are used by the farmers to create small paddocks to obtain desired stocking density of animals. Water infrastructure was installed to provide water in each paddock. Typically, following Management Intensive Grazing principles, animals were allowed to graze in a designated paddock for 1 to 2 days after which they were moved to the next paddock while the previously grazed paddock was rested for a period of time (typically at 2-3 weeks) before re-grazing. During the resting period the plants recover and produce new growth. Visual observation of cover crop regrowth is important to determine time of re-entry for effective utilization of the forage in the paddock. After grazing soil samples were taken from 0-10 cm depth because past research has shown that the effect of grazing on the soil is usually found to be limited to the surface 10-12 cm. We also measured cover crop standing and grazed biomass. Results presented here include water stable aggregation (of 1-2 mm size aggregates), infiltration rate (in the field using 10 cm rings with automated SATURO dual head infiltrometers), bulk density (core method, 3”x3” rings), **s**oil respiration (CO_2 burst test in lab), and grazed forage dry matter yield (using 0.5 sq meter frames).

Results and Discussion

Wet aggregate stability

The data for wet aggregate stability (WAS) from fall and spring 2019/20 is summarized in Table 1. Aggregate stability in 0-10 cm depth ranged between 73%- 94%. Grazing cover crop did not negatively impact aggregate stability significantly in three of the farms (Adams-2, Franklin-1 and Franklin-2), but for Adams-1 grazing cover crops significantly improved WAS in the field that was grazed weeks earlier (82%) as compared to cover crop un-grazed (74%) and grazed recently (73%). We are not able to explain why WAS after soybeans was greater than that in the ungrazed cover crop. Greater aggregate stability is suggestive of soil physical properties less prone to damage and more resistant to action of grazing.

Table 1. Wet aggregate stability (0-10 cm depth) as influenced by grazing cover crops on 4 southern Pennsylvania farms in 2019/20.

Wet aggregate stability %							
Description			**Treatment**				
Farm	Cover crops grazed	Date	Un-grazed	Grazed recently	Grazed weeks earlier	After soybean	AOV P>fr
Franklin1 Fall	Radish, cowpea, Sudan grass, Sunflower after wheat	Sep-19	75 [b]	76 [ab]	91 [ab]	94 [a]	**0.073**
Franklin1 Spring	Triticale after corn silage	Apr-20	88	87	84	_	0.14
Adams1	Wheat after corn silage	May-20	74 [b]	73 [b]	82 [a]	_	**0.036 ***
Adams2	Wheat after oats	Jun-20	88	89	88	_	0.81
Franklin2	Crimson clover and annual ryegrass after corn silage	Jun-20	84	87	_	_	0.66

Mean values followed by different lower letters between each treatment represent significant differences.

Infiltration rate

Data for infiltration rate (IR) is summarized in Table 2. Grazing treatments did not significantly affect IR at any of the sites, but trends could be observed. Across the farms the highest IR was observed in un-grazed cover crop scenarios except for Adams-2, where the highest infiltration was observed for cover crop that was grazed weeks earlier. IR was numerically (though not statistically) reduced in recently grazed cover crop vs ungrazed cover crop, but showed a consistent pattern of recovery a few weeks after grazing in most cases. The trend of non-significant impact of cover crop grazing treatment on infiltration rate was similar on all the farms.

Table 2. Infiltration rate as influenced by grazing cover crops on 4 southern Pennsylvania farms in 2019/20.

Infiltration Rate							
Inch/hour							
Description			Treatment				
Farm	Cover crops grazed	Date	Un-grazed	Grazed recently	Grazed weeks earlier	Double crop soybean	AOV P>fr
Franklin1 Fall	Radish, cowpea, Sudan grass, Sunflower after wheat	Sep-19	27	9	21	15	0.17
Franklin1 Spring	Triticale after corn silage	Apr-20	21	8	10	_	0.1
Adams1	Wheat after corn silage	May-20	5	3	3	_	0.62
Adams2	Wheat after oats	Jun-20	8	4	16	_	0.19
Franklin2	Crimson clover and annual ryegrass after corn silage	Jun-20	7	6	_	_	0.6834

Mean values followed by different lower letters between each treatment represent significant differences.

Bulk density

The data for bulk density is summarized in Table 3. Grazing did not have a significant impact on bulk density except for one farm scenario. For Adams-1 grazing significantly increased the bulk density in the recently grazed cover crops (1.60 g cm^{-3}) while the un-grazed (1.36 g cm^{-3}) and cover crop grazed weeks earlier (1.40 g cm^{-3}) were similar. The numerical values for the bulk density in most of the cases were non-restrictive for root growth for silt loam soils i.e, less than

1.6 g cm^{-3}, Except for Adams1 where bulk density was 1.60 g cm^{-3}, above which root growth may be restricted (USDA, 1999). For Franklin-1, 2 and Adams-2, we found a decrease in the bulk density in cover crop grazed weeks earlier scenario as compared to un-grazed cover crop, though it was not significant. This could imply that with the herbivory action, addition of manure from the animal and subsequent action of micro-organism and soil fauna, the soil structure improved with time. Similar results of small or non-existent increases in bulk density of grazing cover crops were reported by researchers in the southeastern United States.

Table 3. Bulk density as influenced by grazing cover crops on 4 southern Pennsylvania farms in 2019/20.

			Bulk density					
			g cm^{-3}					
Description			**Treatment**					
Farm	Cover crops grazed	Date	Un-grazed	Grazed recently	Grazed weeks earlier	Double crop soybean	AOV P>fr
Franklin1 Fall	Radish, cowpea, Sudan grass, Sunflower after wheat	Sep-19	1.17	1.2	1.11	1.19	0.15
Franklin1 Spring	Triticale after corn silage	Apr-20	1.1	1.04	1.08	_	0.62
Adams1	Wheat after corn silage	May-20	1.36 [b]	1.60 [a]	1.44 [a]	_	**0.01 ***
Adams2	Wheat after oats	Jun-20	1.3	1.25	1.23	_	0.26
Franklin2	Crimson clover and annual ryegrass after corn silage	Jun-20	0.99	0.98	_	_	0.89

Mean values followed by different lower letters between each treatment represent significant differences.

Soil respiration measured as CO_2 burst

A consistent trend of increased numerical value for soil respiration, measured as CO_2 burst, for cover crops grazed weeks earlier was observed when compared to un-grazed and recently grazed cover crops on all the farms except Adams-2 and this observation was found to be significant for two farms: Franklin1 spring and fall observations and Adams-1. In Adams-1 grazing increased soil CO_2 burst by 291.4 % when measured a few weeks after grazing (1550 mg of CO_2/ kg soil) as compared to un-grazed cover crop (396 mg of CO_2/ kg soil), which indicates the thriving microbial activity possibly from the addition of residue, animal manure and root decomposition and regrowth. Increased soil CO_2 burst is an indicator of increased microbial activity and aerobic microbial decomposition of SOM which is one component of soil capacity to support crops and soil fauna.

Table 4. Soil respiration measured as CO_2 burst as influenced by grazing cover crops on 4 southern Pennsylvania farms in 2019/20.

Soil respiration measured as CO^2 burst							
Mg of CO_2/ kg soil							
Description			**Treatment**				
Farm	Cover crops grazed	Date	Un-grazed	Grazed recently	Grazed weeks earlier	Double crop soybean	AOV P>fr
Franklin1 Fall	Radish, cowpea, Sudan grass, Sunflower after wheat	Sep-19	699 ^{c}	778 ^{bc}	908 ^{ab}	958 ^{a}	0.033 *
Franklin1 Spring	Triticale after corn silage	Apr-20	256 ^{b}	319 ^{ab}	447 ^{a}	_	0.031 *
Adams1	Wheat after corn silage	May-20	396 ^{b}	555 ^{b}	1550 ^{a}	_	0.007 **
Adams2	Wheat after oats	Jun-20	2088	1788	1637	_	0.49
Franklin2	Crimson clover and annual ryegrass after corn silage	Jun-20	600	1226	_	_	0.0796.

Mean values followed by different lower letters between each treatment represent significant differences.

Cover crop dry matter and grazed yield

Across different farms different types of cover crops were planted for grazing. With the management intensive grazing comprising of movement of animals from one paddock to another every one or two days, the cover crops provided 1273-2318 lb/acre of forage dry matter to the livestock. Farmers implemented grazing in a way that they always managed to leave more than 50 % (1368- 5993 lb/acre) of cover crop residue for soil protection and promotion of soil health.

Table 5: Calculation of forage dry matter from sample collected from four different farms from 2019/20.

Forage dry matter calculation						
lb/acre						
Farm	Animal description	Total live weight of animal	Cover crop grazed	Pre-grazing forage DM lb//acre	Post-grazing forage DM lb/acre	Total forage DM consumed lb/ acre
Franklin1-Fall	4 heifers/800lbs 10 heifers/300lbs	6200 lbs	Ray's Crazy Summer Mix	4098 (100%)	2216 (54%)	1883 (46%)
Franklin1-Spring	16 steers/650 lbs	10,400 lbs	Triticale	4371 (100%)	2490 (56%)	1880 (44%)
Franklin2	18 Cows /1000 lbs 4 heifers /600lbs 9calves /600lbs	25,800 lbs	Wheat	2641 (100%)	1368 (51%)	1273 (49%)
Adams1	25 dry cows/ 1000lbs 1 bull/2000 lbs	27,000 lbs	Wheat	3857 (100%)	1969 (51%)	1889 (49%)
Adams-2	40 animals with average weight of 570 lbs	22,800 lbs	Annual ryegrass/crimson clover	8311 (100%)	5993 (73%)	2318 (27%)

Conclusion

These preliminary results indicate that, similar to other studies, if cover crops are grazed with management intensive grazing methods in no-till systems, bulk density was not negatively impacted except for one occasion. Several weeks after grazing, bulk density was never higher than in un-grazed control, suggesting porosity recovered probably by biological mechanisms. We did measure a non-significant reduction in water infiltration immediately after grazing, but again, this property also seemed to recover over a time period of a few weeks after grazing. On the other hand, we observed an increase in CO_2 burst and improved wet aggregate stability in samples obtained from cover crop grazed several weeks earlier, suggesting improvement in soil biological activity. By careful management, the animals left approximately 50% of cover crop residue in the field while animals consumed the rest of the cover crop biomass, which amounted to 1200-2318 lb A^{-1} DM per grazing.

The findings so far suggest that grazing cover crops with proper management can benefit the farmers without causing detrimental soil compaction, while boosting soil biological activity.

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