Pasture Project
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TECHNICAL BULLETIN:

BENEFITS OF PLANTING AND GRAZING DIVERSE COVER CROPS

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FIELD PARTNERS:

Practical Farmers of Iowa – working together, always learning

Land Stewardship Project

Sustainable Farming Association – Farmer-to-Farmer Network

IN A NUTSHELL

- Integrating cattle grazing on winter cover crops can provide significant soil health and on-farm economic benefits, particularly when cover crop mixes are diverse and combined with adaptive high-stock density grazing practices.
- This project studied three years of cover crop and livestock integration on 8 cooperating farms in Minnesota and Iowa.

KEY FINDINGS:

BUILDING SOIL HEALTH
Seven of eight farms experienced higher total living microbial biomass in the grazing cover crops plots compared to plots without cover or grazing, an early indicator of positive soil carbon changes

OFFSETTING COSTS
Cooperating farms had an average cover crop management cost of $83/acre/year but had an average forage benefit of $123/acre/year.

PROVIDING LONG TERM BENEFITS
When adding in long-term benefits such as reduction in soil erosion, soil fertility, and increased water storage to the forage benefit, cooperating farms had an average net benefit of $135/acre/year.

BACKGROUND & PROJECT DESCRIPTION

Cover crops are effective at improving water quality, reducing field nitrogen losses by 31% and phosphorus loads by 50%.[1] Cover crops also provide significant on-farm benefits such as improved water infiltration and retention, reduced erosion and runoff, mineral cycling, and increases in soil organic matter. However, cover crops have been adopted slowly across the Upper Mississippi River Basin, partially due to high cost and low short-term return on investment. Coupling diverse cover crop mixes with livestock grazing, particularly cattle, can provide positive soil health and water quality impacts while producing economic benefits for the producer, such as winter forage value, that offset implementation costs. In addition, by employing adaptive grazing management practices such as high stock density, short duration grazing, and frequent movement between paddocks can further optimize these benefits. Using these principles, a single day's graze on an acre of cover crops by 100 cows weighing an average of 1000 lbs each can result in the application of approximately 23 lbs N, 15 lbs, P, and 52 lbs K to an acre, thereby making the practice more financially viable and sustainable.[2]

The Pasture Project, Sustainable Farming Association, Practical Farmers of Iowa, and Land Stewardship Project partnered on a 3-year USDA Conservation Innovation Grant to demonstrate the economic and soil health benefits of livestock grazing on cover crops using adaptive management practices. This project has completed three years comparing the use of cover crops and livestock integration in cash crop production (treatment) to plots that were conventionally managed without cover crops or livestock grazing impact (control) on 8 cooperating farms in Minnesota and Iowa. This project used annual soil tests (S3M, Phospholipid Fatty Acid (PLFA), and soil carbon), the NRCS Cover Crop Economic Version 2.1 tool, and the Revised Universal Soil Loss Equation 2 (RUSLE2) to examine impacts of grazing cover crops on soil health and farm economics. For full methods and results, see the project's final report.

RESULTS

SOIL HEALTH RESULTS

During the trial period, subtle to distinct differences were noted in the treatment plots compared to the control plots in seven out of the eight farms. As with most field trials conducted on cooperating farms, there were differences in management practices applied and location of the farms. All farms planted a diverse cover crop (at least two brassica species, two legume species, and two grass species), and integrated grazing as cover crop forage was available, but stocking densities, timing of cover crops, and cultivation practices varied. However, even with these differences, this trial noted positive changes on most of the participating farms.

Table 1. Soil Mineral Data – Control (Con) vs. Treatment (TRT) in PPM. Overall Farm Means.

Plot	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
Con	43	157	3379	388	78	1.13	1.63	112	93	4.1
Trt	51	184	3745	460	194	1.34	1.89	103	99	3.8

1 Iowa Nutrient Reduction Strategy. (2016). Iowa Department of Agriculture and Land Stewardship, Iowa Department of Natural Resources, and Iowa State University College of Agriculture and Life Sciences. http://www.nutrientstrategy.iastate.edu/sites/default/files/documents/INRSfull-161001.pdf

2 The exact amount of nutrients excreted daily will vary depending on cow size, stage of lactation or gestation, and forage DM consumption. Citations: Energy Aspects of Manure Management. (1998). University of Illinois Extension. http://livestocktrail.illinois.edu/dairynet/paperDisplay.cfm?ContentID=274. and How Much N, P, and K Does a Dairy Cow Excrete? (2001). Midwest Plan Service, Iowa State University. https://articles.extension.org/mediawiki/files/9/93/L12_sec3.pdf

Evident from the analysis was that the farms optimizing the factors of cover crop species mix diversity, timing of planting, grazing impact, and cultivation had the greatest overall improvement in soil physical, chemical, and biological characteristics. Timing of planting was critical to achieving a successful stand of cover crops to support grazing through the fall, winter, and spring harvest and planting of cash crops. Farms which used higher stocking densities and were able to fit in both fall and winter grazing showed more positive results, likely due to higher manure application, as did farms that practiced minimal till or no-till.

Overall farm means for soil fertility are presented in Table 1. The results over the three-year trial period show slight favorable increases in P, K, Ca, Mg, S, B, Cu, and Mn for the treatment plots across all farms compared to the control plots. For the 10 nutrients profiled in the test panel, five of the eight farms showed slight to significant advantages in at least 5 of the 10 nutrient profiles in the treatment plots compared to the control plots. Three farms showed an advantage in the treatment nutrient profile for 7 or more of the 10 total nutrients measured.

Overall farm means for soil pH, organic matter (OM), and Cation Exchange Capacity (CEC) were similar to the control means, with no significant difference between treatment and control for soil pH, a slight 0.11% difference in soil OM with the treatment slightly greater, and a 2.63 difference in CEC with the treatment slightly greater than the control (Table 2).

Table 2. Soil pH, Organic Matter, CEC and Ratios. Overall Farm Means.

Plot	pH	OM	CEC	K/Mg	Ca/Mg
Con	6.51	3.86	22.13	0.15	5.30
Trt	6.54	3.97	24.76	0.16	4.77

Table 3. Total Organic Carbon (TOC), Inorganic Carbon (IC), and Total Carbon (TC) (PPM). Overall Means.

Plot	TOC	IC	TC
Con	275	12.4	289
Trt	307	30.2	338

Soil carbon means for all farms combined over the three-year trial period favored the Treatment plots vs the control plots in Total Organic Carbon (TOC), Inorganic Carbon (IC), and Total Carbon (TC) (Table 3). These data, taken together, indicate that adaptive grazing of cover crops may improve soil fertility for the future cash crop.

Soil biological parameters were measured over the three-year trial period using the PLFA test and results are presented in Table 4. Overall combined means for the participating farms over the three-year trial period show that the use of cover crops combined with grazing (treatment plots) allowed the farms to build more Total Living Microbial Biomass (TLMB), Total Bacteria (TBB), Gram + bacteria (G+), Actinobacteria (Act), Rhizobial bacteria (Rhiz), Gram- bacteria (G-), Total Fungi (TF), Arbuscular Mycorrhizal Fungi (AMF), Saprophytic Fungi (SF), and Protozoa (Prot) when compared to the control plots (no covers and no grazing). In comparing the three-year means for each of the 11 variables measured, seven out of the eight farms showed slight to significant advantages for the treatment plots in 7 or more of the 11 variables. This is quite significant as increased microbial population biomass and diversity enhances plant mineral availability, formation of soil aggregates, water infiltration rates and retention, phosphorus solubilization, plant phytohormone function, and mineral cycling.[3]

Table 4. PLFA Data – Control vs Treatment (ng/g). Overall Means.

Plot	TLMB	GD	TBB	G+	Act	Rhiz	G-	TF	AMF	SF	Prot
Con	2537	1.39	1328	875	293	33	489	223	68	154	15
Trt	3071	1.41	1670	1064	352	36	606	296	98	198	26

3 Brussaard, L., de Ruiter, P.C., and Brown, G.G. (2007). Soil Biodiversity for Agricultural Sustainability. Agriculture, Ecosystems, and Environment 121 (3). 233-244.

ECONOMIC RESULTS

This analysis used the NRCS Cover Crop Economic Version 2.1 tool. This tool calculates both the short-term and long-term costs and benefits associated with implementing a farm management practice that utilizes crop crops and grazing. The short-term economic costs related to the cover crop include seed, planting, fertilizer, termination and management, plus those of grazing including fencing, watering, haying or baling and management time needed to move cattle. The short-term cover crop benefits are related to reductions in chemical and-or fertilizer usage for the cash crop planted the economic benefits due to reductions in erosion. Related short-term benefits from grazing are directly attributable to the value of the forage produced from the cover crop.

For long-term analysis, the cover crop and grazing tool is designed to take multiple assumptions and factors in consideration:

- A 15-year life-cycle of the cover crop and grazing practices.
- A 1% increase in soil carbon every 5 years (during the 15-year period) using adaptive grazing of cover crops.
- The short-term costs and benefits associated with grazing a cover crop, amortized at 3% over fifteen years.
- The increased amount and value of nitrogen, phosphorus, potassium, sulfur and carbon from increasing SOM by 1%.
- The water storage benefit from increasing SOM by 1%.

Data are presented in Table 5.

Table 5. Long Term Economic Benefits from Cover Crop and Livestock Impact.

	Average Annual Costs ($/a/yr)	Average Grazing Benefit ($/a/yr)	Average Soil Erosion Benefit ($/a/yr)	Average Soil Fertility Benefit ($/a/yr)	Average Water Storage Benefit ($/a/yr)	Total Benefit ($/a/yr)[4]	Net Benefit ($/a/yr)
Farm 1	$63.81	$36.44	$3.06	$53.93	$46.90	$140.33	$76.52
Farm 2	$113.70	$15.56	$20.40	$53.93	$46.90	$139.48	$25.78
Farm 3	$142.97	$207.67	$1.07	$53.93	$46.90	$309.57	$166.60
Farm 4	$77.45	$65.95	$1.43	$53.93	$46.90	$168.21	$90.76
Farm 5	$63.28	$9.33	$1.53	$53.93	$46.90	$118.08	$54.78
Farm 6	$67.04	$133.70	$1.53	$53.93	$53.93	$243.09	$169.02
Farm 7	$53.47	$84.13	$0.51	$53.93	$46.90	$185.47	$132.00
Farm 8	$55.32	$318.93	$0.51	$53.93	$46.90	$420.27	$364.94
Average	**$82.87**	**$123.06**	**$3.76**	**$53.93**	**$46.90**	**$215.56**	**$135.05**

IMPACT

This project shows that the integration of cattle into cover cropping systems offers a win-win scenario, providing simultaneous soil health improvements and net profits. The incorporation of complex cover crops and adaptive livestock grazing resulted in incremental improvements in soil fertility, soil biological characteristics, and soil physical parameters. Through increases in soil microbial populations, the mineral cycle was enhanced, resulting in greater realized soil fertility. In addition, the soil physical characteristics were improved as total soil carbon, inorganic carbon, and total organic carbon all were positively influenced using cover crops and adaptive grazing with cattle. Cooperating producers also experienced positive benefits in annual operating costs, grazing revenue, reduced soil erosion, soil fertility, and water storage. This resulted in better overall gross margins and net margins.

4 Total benefit also includes slight yield benefit on one farm and slight herbicide reduction benefit on one farm. Most farms did not experience changes in yield or herbicide application throughout the three-year project.

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