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SOIL HEALTH 2020

RESEARCH REPORT

Regeneration of fallow fields for vegetable production

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IN A NUTSHELL

Eric compared five methods of preparing fallow land for vegetable production with respect to soil regeneration and cost to implement.

- Cover crops with micronutrient amendments increased active carbon, a sensitive indicator of soil health and soil regeneration potential.
- Micronutrient amendment alone did not increase active carbon; and Eric saw no added benefit with respect to soil health of adding chicken manure or woody compost with cover crops.
- Balancing cost and soil health benefits, Eric will focus on micronutrient application and full season cover crops in areas that require regeneration.

MOTIVATION

Because land cost is high and land access is difficult, many vegetable growers have to start growing on degraded soil. Before they can start growing vegetables profitably, therefore, they need to raise soil organic matter and balance nutrient status.

One relatively fast way to regenerate degraded land for production is to add micronutrient amendments and bring in sufficient amounts of compost. Depending on the scale, however, this method is costly such that and the task of regeneration is often a balance of speed of regeneration vs cost to implement.

Eric has a 1-acre field in a perfect location for intensive vegetable production. It has sandy, well drained soil that warms up well in the spring with good road and water access. However, the topsoil was stripped by a previous owner and the organic matter is very low. To expand his vegetable operation, Eric would like to assess different methods for regenerating the field while balancing cost to implement.

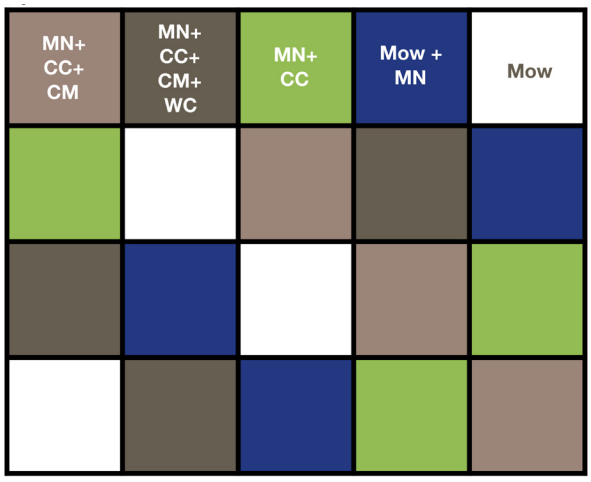

Figure 1. Experimental layout of Eric's trial. He divided a 1-acre field into 20 30'x30' plots. In each row of 5 plots, he randomly assigned one of 5 treatments. Treatment acronyms are defined in the text below.

DESIGN

Treatments

1. Mow (control;●)
2. Mow + micronutrients (Mow + MN;●)
3. Mow + micronutrients + cover crops (Mow + MN + CC;●)
4. Mow + micronutrients + cover crops + chicken manure (Mow+MN+CC+CM;●)
5. Mow + micronutrients + cover crops + chicken manure + woody compost (Mow+MN+CC+CM+WC;○)

On Eric's 1-acre field, he set-up a randomized complete block design with 5 replicates and randomly assigned one of five treatments to each row in the grid, as shown in **Figure 1**.

Amendment details

Micronutrients: Eric applied 50 lb per acre sulfur equivalent and 200 lb per acre Mg-K-Sulp based on soil tests and consultation with Ken Laing. He used a surface application with shallow incorporation for Treatment 2, and he used tillage to incorporate the micronutrients for Treatments 3-5.

Cover crops: Mix of rye 9 (5), oat (5), vetch (5), phacelia (5), pea (11), crimson clover (4), radish (3), fava (7), sunflower (1), sorghum sudangrass (5), flax (2). Numbers in parentheses are in lbs/acre equivalent; recipe based on mix 20 from reference 1. Eric seeded by drilling for larger seeds and broadcasting for the smaller seeds.

Chicken manure: 100 lb N/acre equivalent granulated chicken manure from Acti-Sol.

Woody compost: 10 ton/acre equivalent high-C compost for treatments with woody compost that he made on-farm using wood chips, straw and well aged horse manure.

Active Carbon

Eric used active carbon to assess soil health under the different treatments. Active carbon is an indicator of the small portion of organic matter (OM) that is a readily available (i.e. labile) food and energy source for the soil microbial community.

In April 2020, Eric took three baseline soil samples across the entire experimental area. He prepared and seeded the plots at the end of May **(Photo 1a)**, and in October he took soil samples from all 20 plots **(Photo 1c)**. He used a shovel to take multiple slices (1" wide x 8" deep) per plot, which he mixed thoroughly in a plastic bucket.

Within 1 day of sampling, he sent 1-cup samples from each plot to A&L Canada Laboratories Inc. for their analysis of permanganate ($KMnO_4$) oxidizable carbon (active carbon; **Photo 2)**.

FINDINGS

Cost

Averaging across all plots, Eric found the cost (total cost, labour cost, material cost and tractor time) of implementing the treatments increased from the control (treatment 1) to the most comprehensive treatment (treatment 5), as shown in **Table 1**. He did not track cost on a plot level so we were unable to run statistics.

Soil Health

To evaluate the effects on active carbon, an indicator of soil health, we used a statistical model called analysis of variance (ANOVA) with a 95% confidence level to calculate the least significant difference (LSD) needed to see among treatments in order to call them "statistically different".

Using this approach, Eric found that active carbon was highest in plots with the diverse mix of cover crops (Treatments 3-5). As a food source for the soil microbial community, more active carbon reflects greater potential to build soil organic matter and regenerate soil health (reference 4).

Photos 1. Progression of Eric's experimental plots throughout the season (top to bottom) **(a)** Seeding the plots on May 19; **(b)** late-summer growth on August 28; **(c)** fall growth on October 19.

This effect was reflected in the absolute value of active carbon (LSD = 97 ppm) and the difference in active carbon from April to October (LSD 92 ppm), as shown in **Figure 2.** Among the treatments with the cover crop, Eric also observed increasing active carbon from least labour intensive/expensive method (Treatment 3) to most labour intensive/expensive method (Treatment 5), but the difference was less than the LSD and, therefore, not statistically significant. See More on Statistics at the end of the report.

Table 1. Cost breakdown of the five treatments to regenerate a fallow field for vegetable production.
Eric mowed all plots twice.

	Per 4 replicate plots combined				Per acre
	Labour hours	Tractor hours*	Material cost	Total cost	Total cost
1. Mow (control)	0.0	0.3	$0.00	$12.60	$152.46
2. Micronutrients (surface application) + mow as needed	0.5	0.5	$52.50	$85.64	$1,036.26
3. Micronutrients + cover crops	1.8	1.1	$52.50	$142.98	$1,730.00
4. Micronutrients + cover crops + chicken manure	2.3	1.1	$80.00	$183.81	$2,224.08
5. Micronutrients + cover crops + chicken manure + woody compost	2.7	2.4	$80.00	$248.14	$3,002.51

*Tractor hours = fuel, depreciation and maintenance. Cost of tractor hours calculated at $42/hour.

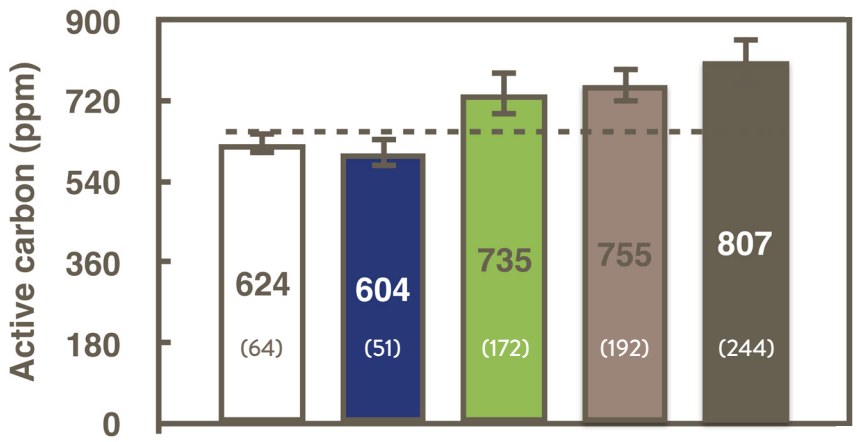

Figure 2. Active carbon in each of the five soil regeneration treatments. Bars represent means and lines represent standard error. Numbers in the middle of the bars are the average active carbon values for each treatment; numbers in brackets below are the difference in active carbon from spring to fall. The LSD needed to detect a difference in active carbon was 97 ppm, as denoted by the dashed line separating the treatments with cover crops from the treatments without cover crops. The LSD needed to detect a difference in active carbon between fall and spring was 92 ppm.

General Observations

- The dry weather wiped out some of the components of the cover crop mix, which makes a good case for using a diverse mix. The sorghum sudangrass and radish did the best in the dry weather **(Photo 1b)**.
- Overall, the cover crop mix did a great job of providing growth and cover over a very long season (through to November).
- Cover crop management (i.e. preparing a seedbed, establishment and mowing) was about what Eric expected, given that he uses similar mixes elsewhere on the farm.
- The areas amended with additional manure and compost were more lush throughout the growing season.
- Eric compared cover crop growth in the trial to cover crop growth in other areas of the farm with amended soil. Even in the best trial plots, the cover crops did not compare to areas where he had amended for vegetables and grown vegetables and cover crops for years.

TAKE HOME MESSAGE

Even with the tillage passes required to amend the soil and establish the cover, cover crops played an important part in regenerating Eric's fallow field by promoting active carbon belowground and, in turn, presumably building soil.

These findings support previous research that shows that cover crops sustain soil quality and productivity by enhancing soil C, N, and microbial biomass (reference 5) and increase active carbon and soil organic matter relative to continuous corn (references 6); and that active carbon is a sensitive indicator of soil health (references 3, 7).

Balancing cost and soil health benefits, Eric will focus on micronutrient application and full season cover crops in areas that require regeneration; but he will use compost and heavy amendments to continue regeneration when the land is in production.

"You can't just bootstrap to healthy soil in one year": Even with gains in active carbon, production areas in other parts of the farm that have had nutrient balancing and organic amendments over years looked better than the highest input treatment he compared.

NEXT STEPS

As a follow-up, Eric is curious about the effectiveness of cover crops without micronutrients, since it is interesting that the treatment of adding micronutrients and mowing (Treatment 2) resulted in a good stand of weeds, but not concomitant increase in active carbon.

He also wonders if a sustained program of micronutrient balancing would lead to more vigorous species dominating the field over many years?

In November, the cool season grasses in the cover crop mix have exploded and the cover crop plots all look great compared to the others. For this reason, Eric is interested in re-measuring active carbon in the spring of 2021.

Photo 2. Soil samples ready to mail. Eric packaged up 1-cup samples from each of the 20 plots and sent them to the lab for active carbon analysis.

MORE ON STATISTICS

Using a 95% confidence level means:

- When we measure a difference in active carbon between any two treatments that is greater than the calculated least significant difference (LSD), we expect this difference would occur 95 times out of 100 and, therefore, consider it a reliable difference.
- When we measure a difference in active carbon between any two treatments that is less than the calculated LSD, we consider these treatments unreliably different and not statistically different.

ACKNOWLEDGEMENTS

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