Consultant Training Program

Final Report

Sweet Corn Plantation

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Student Statement

There are some local organic farmers here in the U.K. who are doing a marvelous job but are struggling with adverse weather conditions. While taking soil samples for them, I saw the absent soil structure, which made me wonder how they've made it this far. Therefore, I would like to help them restore the diversity in their soils.

A change in the soil would mean the viability of growing a crop that would otherwise be scrubland. A healthy soil food web would bring resilience to the crop. Pests wouldn't be interested in the crop, weeds wouldn't be rushing to take over and return it to wild scrubland. Watering would not be an issue due to relying on rain harvesting. Eventually, once the soil food web is established, growing a crop each year will be easier and healthier.

My project was only a short one of 4 months and even though I knew it would take time to get the soil food web established, especially with the nature of this particular trial project, I hoped to be able to make a difference in the first growing season. I have made a difference, even if it is a small one. This project has given me confidence and experience. I now know that I should quite easily be able to up-scale and help others as the ecological, societal, and health benefits on any scale would be enormous. Healthy soil, abundance in wildlife, no nasty chemical runoff, and healthy plants lead to healthy happy people eating the produce and reducing stress and disease.

Project Summary

The project was to grow a crop of sweetcorn in the middle of some scrubland using the soil food web approach to change dirt to soil. I planned to clear the area, lay cardboard, and make some plots using a permaculture method of layering material in a kind of lasagna and adding a topsoil of 3 inches. The idea was to use only biological liquid amendments in the form of teas and extracts on the treatment plots and water for the control plots. I measured the soil biology fortnightly. I also measured the plant heights weekly, plant yield, and nutrient content at the end of the harvest. The results showed a

noticeable difference of the treatment doing better than the control in yield, growth rate, nutrient content and soil biology. My conclusion is that the soil food web is there and if the project had been longer the difference would have been greater.

Introduction

The location is mainly characterized by scrubland of hawthorn, blackthorn, brambles, and gorse bushes which invade if left alone for any time. The soil on top of bedrock is typically sandy. For every bucket of soil, you can expect three buckets of rock or more, so very little topsoil is available. Vegetables were grown on the site in the 70’s, and pesticides were used minimally. No crops have been grown since then, and the land has been left for grazing. The grazing stopped in the 90’s and the land became overgrown until I started to clear it some years ago.

The site receives all-day sun but is exposed to wind, mainly from the west. Since the plots will be randomized, any negative impact and pollution distribution should be equal throughout the plots. Sometimes, in the U.K, we have drought for 6-12 weeks, and it can start at any point in spring or later in summer. It seems to be different each year. Last year, we had a drought from May until the end of July, and then it pretty much rained until the beginning of September. There is very little topsoil on the site as it sits on bedrock. The limitation in topsoil is why I have chosen these no-till deep beds for my project as this will add loads of organic matter and help the plants thrive in adverse weather conditions. This project aimed to use the soil food web approach combined with permaculture to build structure into the soil to best help the crop.

Project Site and Plot Layout

The total area for this project measured 7m x 6.5m, with each plot measuring 1.5m x 2.5m. The photos below show the new space created and the crop beds that were prepared using the permaculture method of adding layers to form deeper beds. The layers included rotted manure, straw, fresh grass clippings and some seaweed. Soil (dirt) was added to the top at a level of 3 inches. All the crop beds received exactly the same materials.

Figure 1. Property map before the area was cleared. The crop area is outlined in red.

Figure 2. The crop beds are ready for planting.

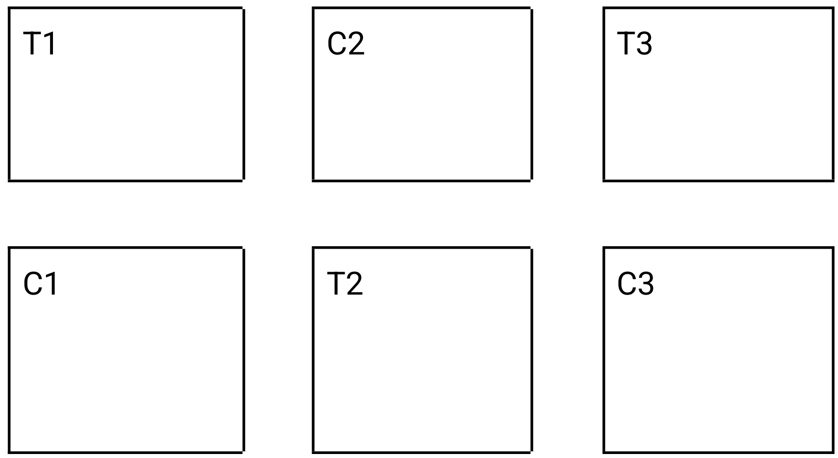

Figure 3. The site layout. T=Treatment beds, C=Control beds. The total area for this project measured 7m x 6.5m.

Methods

Agricultural practices

Land Preparation

To create these crop beds, I first had to clear the area using a strimmer and hedge trimmer. Next, some nice thick cardboard was laid down. I then made some short wire mesh enclosures for each of the beds, gave a meter buffer between beds, and filled this buffer with wood chips. The beds were then layered with equal measures of manure, straw, grass clippings, and seaweed. Finally, 3 inches of topsoil with 5% organic compost were added on top.

Pre-treatment of the crop

I used organic seeds for the crop and the understory plants. These were sown in modules and grown in the greenhouse until they were between 4-6 inches in height and all risk of frost had passed. I prepared the site and crop beds while the seeds were growing.

Figure 4. These are the control seedlings in modules, with the treatment seedlings on the bench in the background. There were 21 plants for each bed in total

Application

Treatment

The first treatment applied was a biologically complete tea, in which the seeds were soaked for 5 minutes before sowing wet. I used about a cup full of compost tea for all of the seeds. I prepared the understory cover crop in exactly the same way as for treatment and control.

The second application was a biologically complete extract applied when the seedlings were planted in the crop beds. I used about 1.5 gallons per plot. Then, it was applied fortnightly as a soil drench and then into the root system later with a backpack soil injector.

Applications of biologically complete tea were sprayed onto the leaf surface fortnightly using a handheld sprayer at first to spray 1L of tea per treatment plot when the seedlings were tiny and then when the seedlings were bigger, I sprayed 1.5 gallons of tea per treatment plot using a backpack sprayer.

Control

The control seeds were soaked in water for 5 minutes before sowing, and then, water was applied to the soil surface every time a liquid amendment was used for the treatment. I used the same amount of “liquid” as for the treatment with 1 cup of water for the seeds, followed by 1 Liter of water per plot. Then, 1.5 gallons of water per plot as the plants got bigger.

Response variables

Crop yield:

This gives evidence and comparability in how a crop has performed overall during its growth cycle by counting the ears of corn for each treatment and control trial by weighing the total harvest from each plot. These were measured in grams at the end of the harvest. Some ears were picked and weighed a week before the others because they had matured earlier. This variable measures overall crop performance by comparing crop yield with or without biology added (i.e. control and treatment). At the end of the harvest, the total ears of corn per plot were added and weighed in grams.

Soil Biology

A full soil biology assessment was carried out fortnightly for the control and treatment plots. This variable was measured to determine whether added biology was a determinant factor that affects crop yield, growth rate, and nutrient content. A sample was taken from each crop bed using an apple corer. Three cores were taken from 3 random plants in each plot and then analyzed using a compound microscope.

Plant height

Plant height was measured weekly from 3 random plants in each plot. The same plant was used each time for consistency. The height was measured using a tape measure and counted in cms. Plant height was one of the variables measured that may help to predict yield differences due to water stress, evapotranspiration rate, and other crop stresses. It is also correlated with life span, seed mass, and time to maturity, and is a major determinant of a species' ability to compete for light.

Nutrient content

Nutrient content is measured by brix, and shows how densely packed the sap of a plant is with biological compounds that aid the plant to defend itself against pests and diseases. A plant with a high brix reading will be more resistant to various stress factors due to the extra resources stored in the sap.
This measurement was taken at the end of the harvest using 3 randomly selected plants from each bed. Two measurements were taken from each plant; one from the kernels of the corn and the other from the leaves. The sap was squeezed from the leaves and kernels using something like a garlic press and dropped onto the refractometer which reads the brix content. Brix measurements were taken from 3 individual plants, randomly chosen from each plot.

Timeline

Date	Action
04/21/2024	Sowed seeds in pre-treatment of tea and water for control.
05/24/2024	Prepared ground for plots and made the lasagna beds
05/15/2024	Sprayed biological tea on first true leaves of treatment leaves

05/28/2024	Planted crop and understory. Treatment received extract at planting . Water for control
02/06/2024	Initial soil assessment for all plots. Application biological tea on foliage for treatment and water for control.
05/06/2024	Application of biological extract on soil surface for treatment. Water for control beds.
04/06/2024	Started to measure growth rates and height weekly.
06/12/2024	Application of biological tea for treatment, water for control
06/21/2024	Soil assessment of all plots
06/18/2024	Application biological extract on soil surface for treatment. Water for control beds.
06/19/2024	Application of biological tea sprayed onto foliage of treatment, water for control
06/26/2024	Mulched all crop beds with seaweed.
06/26/2024	Application of biological extract onto soil surface and water for control.
06/27/2024	Application of biological tea to foliage of treatment and water for control beds.
07/09/2024	Soil assessment of all plots
07/03/2024	Application biological extract applied by soil injection down into the root system 6 inches depth to treatment and water for control.
07/10/2024	Application biological extract applied by soil injection down into the root system 3-4 inches depth to treatment and water for control.
07/19/2024	Application biological extract applied by soil injection down into the root system 3-4 inches depth to treatment and water for control.
07/23/2024	Soil assessment of all plots
07/24/2024	Application of biological tea to foliage of treatment and water for control beds.
07/29/2024	Application biological extract applied by soil injection down into the root system 6 inches depth to treatment and water for control
08/01/2024	Application of biological tea to foliage of treatment and water for control beds.
08/05/2024	Application biological extract applied by soil injection down into the root system 6 inches depth to treatment and water for control

08/09/2024	Application of biological tea to foliage of treatment and water for control beds.
08/11/2024	Soil assessment for all plots
08/26/2024	All cobs harvested and yield measured and weighed.
08/26/2024	Measured brix from leaves and from kernels for each plot.
08/27/2024	Last soil assessment

Results

Crop yield

The plants were planted into the ground on May 28th, 2024. It had been very dry and there were a few days' rain forecast so it was an optimal time to plant. Although, during the growing season, the plants appeared at quite similar stages, the data shows a clear difference in crop yield. The unseasonably cold wet windy weather we experienced in Cornwall affected all of the plants and they were slow to get off the ground.

However, in Figure 4 we can see the total weight of yield in Control was 11,940kg, while Treatment yielded 17,980kg, increasing 34% over Control.

In Figure 5, we can see the average number of cobs per plot, Control yielded an average of 17 cobs, while Treatment yielded an average of 21 cobs per plot making an increase of 21% over the Control.

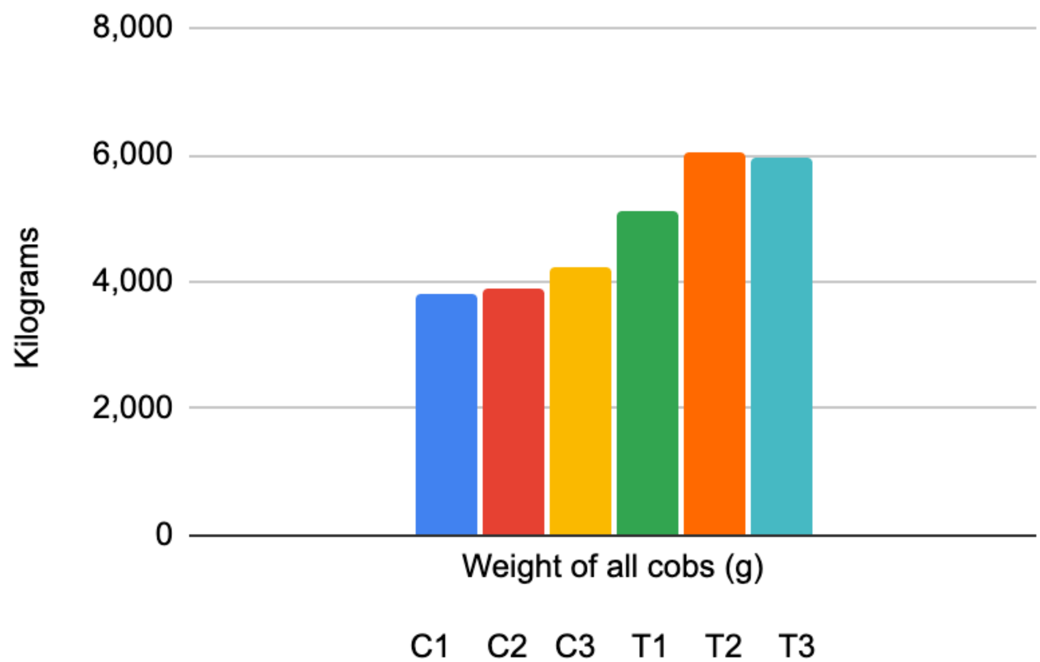

Figure 4. Total weight of ears of corn in each plot.

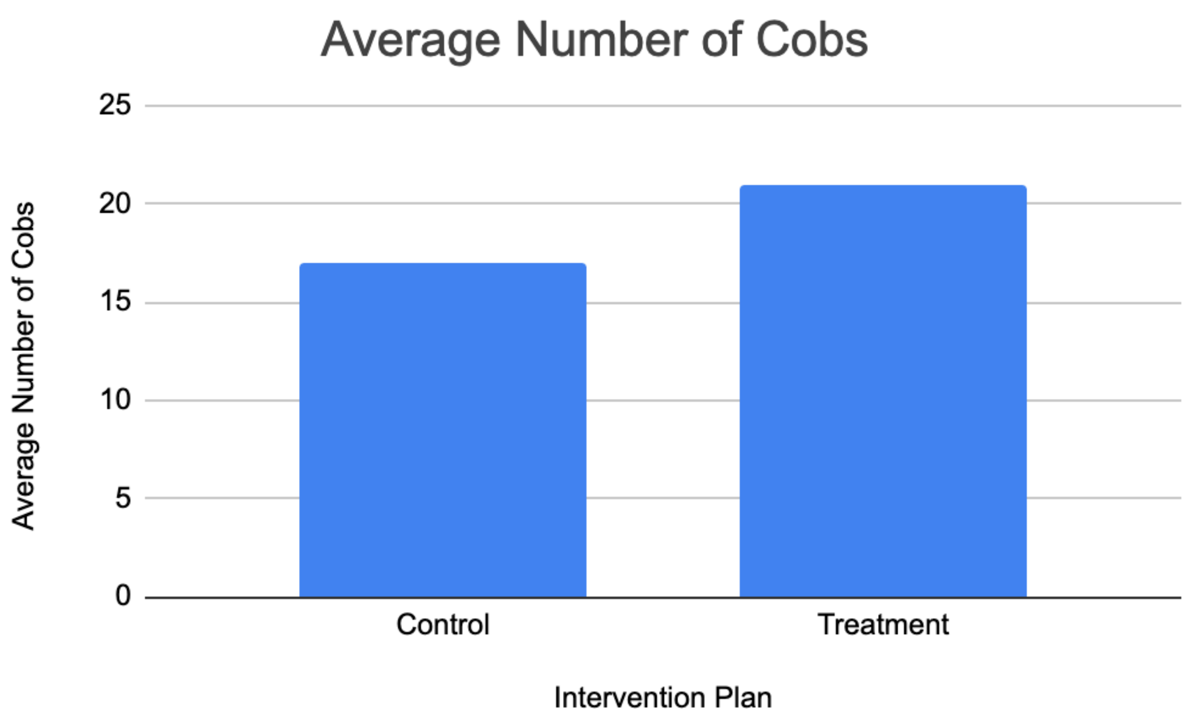

Figure 5. Average number of cobs per plot.

Plant height

The plants were slow to start, and I believe this was due to the weather. June was very cold with ambient temperatures between 46-60°F (8 -15°C). There were also some very strong winds making conditions even colder. Ideal temperatures for growing sweetcorn are between 65-70°F (17-25 °C), However, there was a height difference between treatment and control right from the start, an increase of 8.75%, which could be attributed to the soil food web, since everything else in the system was the same for both.

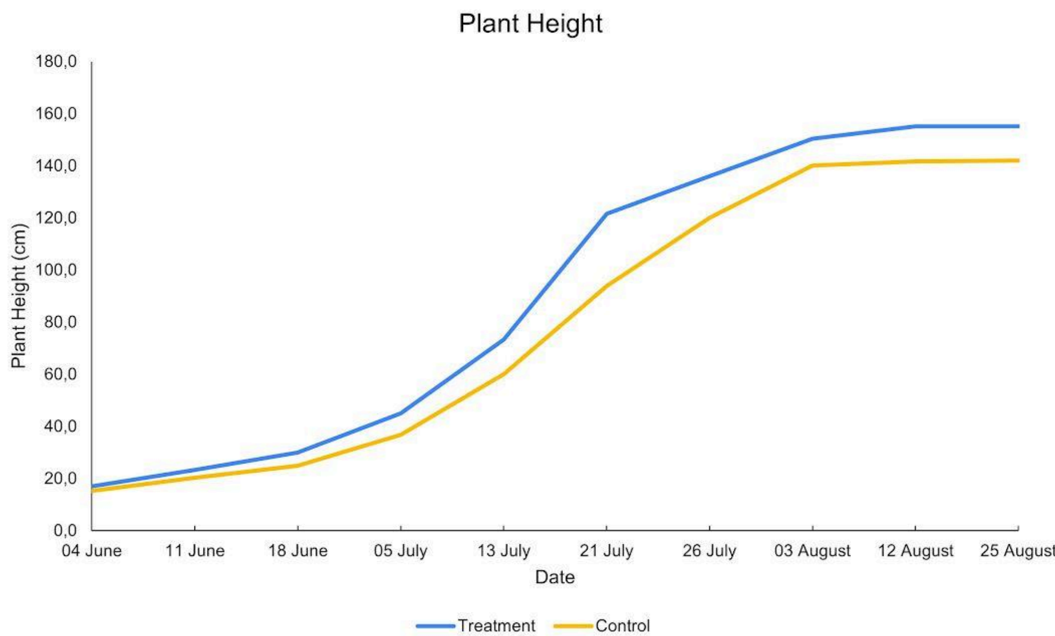

Figure 6. Plant height was measured weekly.

Soil Biology

The data shows that biology was present in greater numbers in the treatment plots than in the control plots. It also shows that the biology applied was up and down. Looking through the graphs, you can see that overall the biology in the treatment plots were at its highest in July when the plant needed it most, before it's crucial reproductive stage and then started to drop off after fruiting, while the control plots stayed more or less the same over the growth stages as no biology was added. Therefore, the importance of measuring biology over time gives a clearer picture of what's going on in the soil and how that can help the plant during its growth cycle. Control, where nothing was added apart from water and treatment where biology was added, so having the comparison, shows you that adding biology can really help your crop.

So, although it was a short project and only a longer project could provide more consistency, the tendency was there.

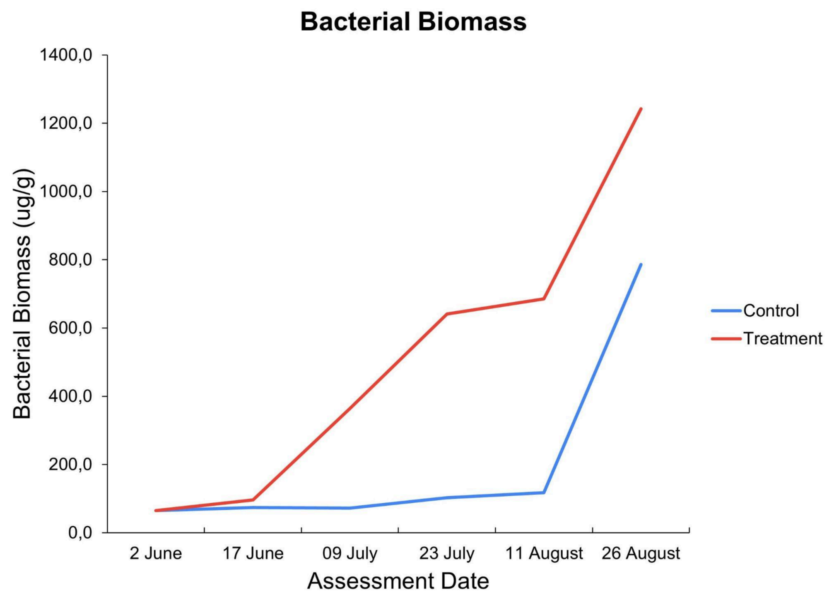

Figure 7. Bacterial biomass. The data show an increase in bacteria biomass throughout the growing season.

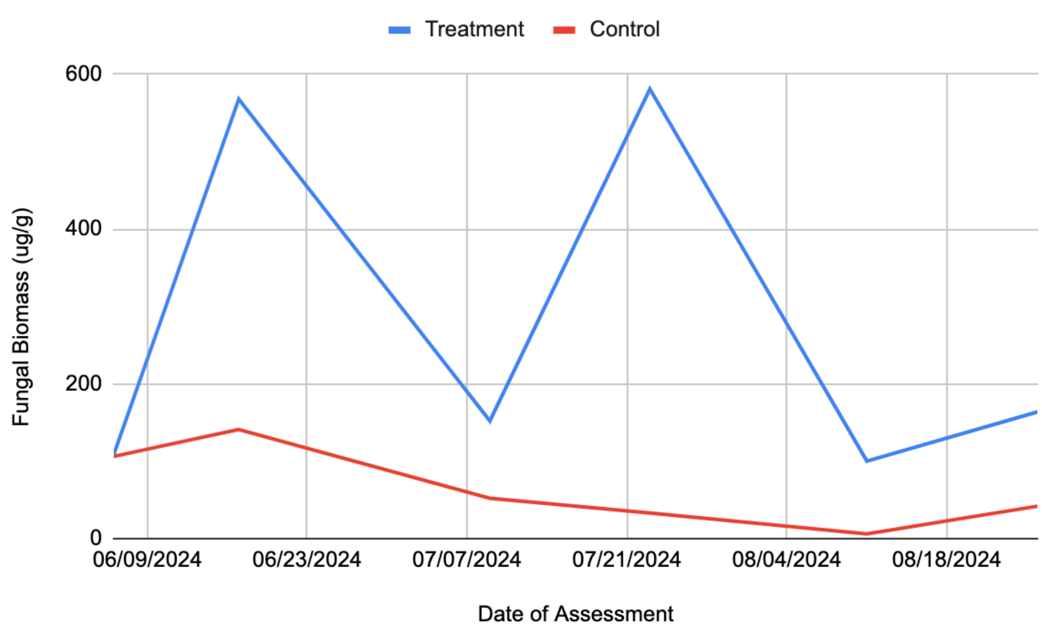

Figure 8. Fungal biomass. There is an increase in growth in July when the plant has a greater uptake.

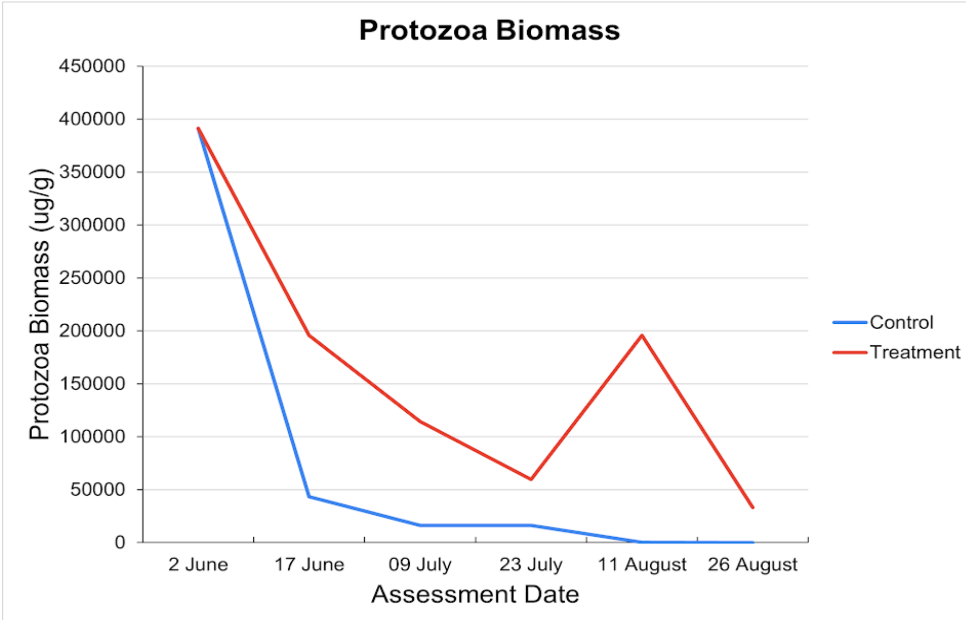

Figure 9. Protozoa in the system starts to increase in July and then decreases towards the end of the project.

Why do I care about Biology? Having a balanced soil food web in place, (bacteria, fungi, nematodes, protozoa), means that plants can control the nutrient cycling that's happening in the root zone by investing some of the sugars and carbohydrates they produce captured from the sun and air in order to feed bacteria and fungi, which causes these organisms to multiply around the rootzone, then they get busy harvesting nutrients from organic matter and parent material in the sands, silts, and clays which they absorb into their bodies, this attracts predatory microbes, protozoa, nematodes, which consume bacteria and fungi. The wastes left behind from these predators contain an abundance of nutrients in a plant-available form that the plant can take up. This results in well-nourished, resilient plants that produce nourishing food for us.

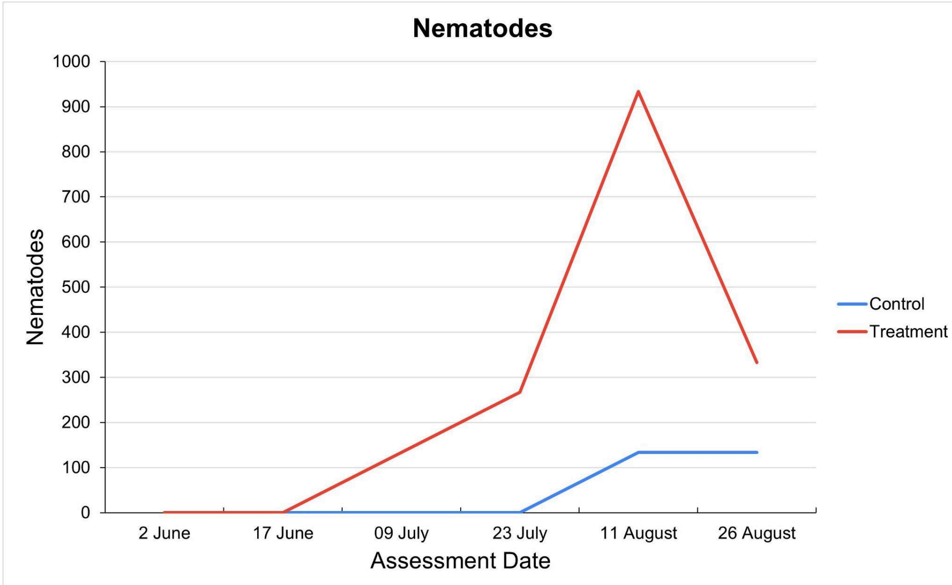

Figure 10. Nematodes in the system, again the same as the protozoa, go up in population in July and then decrease toward the end of the project.

Nutrient content

The average brix reading for treatment and control shows a marginal difference. The range for treatment kernels was between 9.8 and 14. For the control kernels it was between 7.0 and 13.5. For leaves, the treatment ranged between 9.2 and 11.0 whereas the control ranged between 7.0 and 10.5 (Figure 11).

Ideally, we would want the brix reading above 13 to protect the plant from insect attacks. The crop beds were within their first growing season so I think they did well to get above 10. If the project had been longer,I think there would have been more of a significant difference between treatment and control.

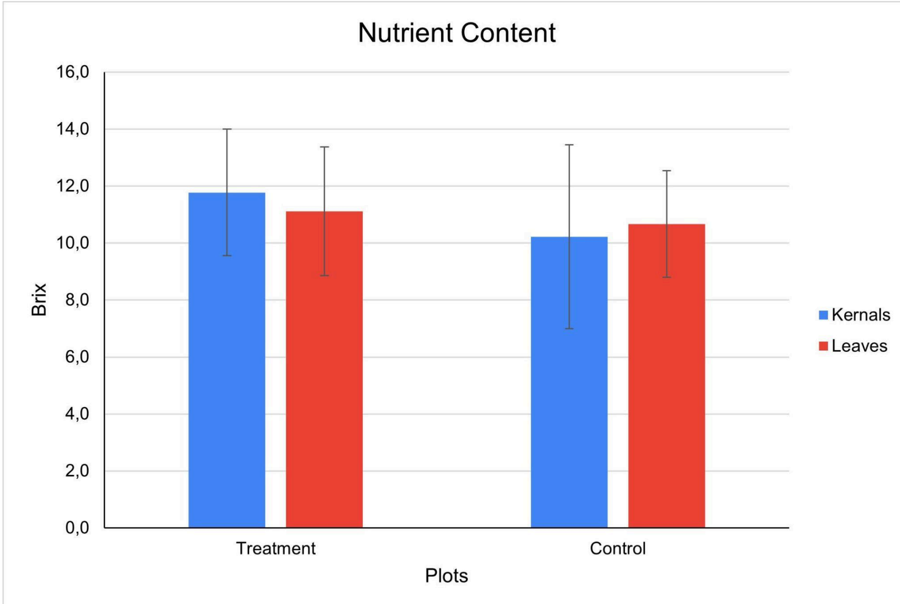

Figure 11. Brix with the ranges are not significantly different, but it looks like treatment had marginally more nutrient content than the control in both kernels and leaves.

Figure 12. The photo shows the early stages of planting. May 30th.

Figure 13. Plants at 4 weeks in the ground. June 29th

Figure 14. Plants at 7 weeks in the ground. July 25th

Figure 15. Plants at 9 weeks in the ground. August 1st

Figure 16. Almost harvest time. August 15th

Figure 17. Harvested cobs from T2 treatment plot.

Conclusions

For this 3-months trial project of converting dirt into soil and growing a crop using only soil biology through liquid amendments, the overall data shows that the biology did make a difference in crop yield, plant height and nutrient content. The average height and growth stage of the crop in the treatment plots were slightly taller /quicker than the control plots making the treatment plot an average of 8.75% taller. The overall yield of the crop was greater in the treatment plots as compared to control plots. A greater number of ears of sweetcorn were harvested at 21% more cobs. On average they weighed 34% heavier. Soil biology, however, was up and down for the treatment plots and can be said to be normal in the first growing season, as biology can be slow to take hold, but you could see activity at the crucial times. The last soil biology assessment revealed that bacteria and fungi were present in the minimum numbers with the SD as a percentage of mean lower, presenting more accurate data. Beneficial nematodes were present in good numbers in all the treatment plots. The nutrient content did not reveal any significant difference between treatment and control. However, a long-term crop might show up more consistent results.

But I believe the dirt is turning into soil, and if the project had been longer, we would see more distinction in the results. Soil biology would have become more stable, grown in numbers more consistently, and been more advantageous to the crop.

Table 1. Soil Assessment Results at the start and end of the experiment.

Plot number:	**Initial Assessment**	**Treatment**	**Control**
Assessment Date:	**02/06/2024**	**26/08/2024**	**26/08/2024**
Bacterial Biomass (µg/g)	65	1242	786
SD as % of Mean	38.00%	15.80%	19%
Actinobacterial Biomass (µg/g)	0	0.189	0.662
SD as % of Mean	0.00%	223.60%	223.60%
Fungal Biomass (µg/g)	106	164	61.6
SD as % of Mean	223.60%	60.70%	153.45%
F:B ratio	**0.265**	**0.132**	**0.104**
Total Beneficial Protozoa (number/g)	**391296**	**20768**	0
SD as % of Mean Total Beneficial Protozoa	71.30%	143.70%	0.00%
Beneficial nematodes (number/g)	0	333.3	133
Oomycetes Biomass (µg/g)	0	0	0
SD as % of Mean	0.00%	0.00%	0.00%
Ciliates (number/g)	0	0	7763
SD as % of Mean	0.00%	0.00%	223%%
Root-feeding Nematodes (number/g)	0	0	0

Figure 16. I was very happy having just unpacked and assembled the soil injector.

Other Observations

At the end of the growing season, I observed less weeds in the treatment plots as compared to the control plots. There were pests during the growing season, particularly during the crop's early and reproductive stages. They were mainly slugs, but these seemed to be less in the treatment plots as compared to the control plots in as much as maybe one slug would be eating the silks of a plant in the treatment plot but in control there may have been multiple on a single plant silk at any one time.

At the end of harvest, I also observed that the materials added for the lasagna bed were fully broken down in the treatment beds as compared to the control beds, where you could still identify straw and grass in the system and some of the material was very hard and dry.

There were numerous benefits of growing in the lasagna bed. First, it enabled a crop to grow in an otherwise poor dry sandy soil of low depth. Second, it added copious amounts of organic matter. Third, the lasagna beds held on to water well. With the added biology on top, it helped break down and feed the organisms while starting to colonize around the crop's root system.

The cover crop ‘dwarf french beans’ were first to be attacked and fully consumed by high levels of slugs and snails at the start of the growing season in all plots, perhaps this helped the sweetcorn to get established. The dirt was very dry and as time went on during June I felt the biology added by way of extracts using a watering can was not having much effect and I decided to mulch with seaweed which I obtained from the beach and washed before spreading around the plants. I also acquired a soil injector to use with a backpack and so by the beginning of July I made weekly extracts which I delivered to the treatment plots via the soil injector which then I think made a difference especially with the mulch layer above ground.

Recommendations for the future

For future experiments, I would recommend making the lasagna beds at least 3 months before growing the crop. This would give the material time to break down. I would also add more organic matter to the soil level and I would mulch around the plants at the beginning. I would also get some cover plants established earlier, maybe multiple perennial varieties.

Appendix

Treatment plan in more detail

Data for Timeline
https://docs.google.com/spreadsheets/d/1Cr908Mx6UtEmK_8QJxt6L897oUIgEfNm82RW3_DKW4s/edit?gid=1031618253#gid=1031618253

Data for Extract
https://docs.google.com/spreadsheets/d/1Cr908Mx6UtEmK_8QJxt6L897oUIgEfNm82RW3_DKW4s/edit?gid=1969241913#gid=1969241913

Data for Teas
https://docs.google.com/spreadsheets/d/1Cr908Mx6UtEmK_8QJxt6L897oUIgEfNm82RW3_DKW4s/edit?gid=1932984815#gid=1932984815

Data for Yield
https://docs.google.com/spreadsheets/d/1Cr908Mx6UtEmK_8QJxt6L897oUIgEfNm82RW3_DKW4s/edit?gid=1293493421#gid=1293493421

Data for Plant Height
https://docs.google.com/spreadsheets/d/1Cr908Mx6UtEmK_8QJxt6L897oUIgEfNm82RW3_DKW4s/edit?gid=868910192#gid=868910192

Data for Soil Biology “Control”
https://docs.google.com/spreadsheets/d/1Cr908Mx6UtEmK_8QJxt6L897oUIgEfNm82RW3_DKW4s/edit?gid=1983860074#gid=1983860074

Data for Soil Biology “Treatment”
https://docs.google.com/spreadsheets/d/1Cr908Mx6UtEmK_8QJxt6L897oUIgEfNm82RW3_DKW4s/edit?gid=2047429843#gid=2047429843

Data for Nutrient Content
https://docs.google.com/spreadsheets/d/1Cr908Mx6UtEmK_8QJxt6L897oUIgEfNm82RW3_DKW4s/edit?gid=690847493#gid=690847493