Pineapple Estate: 2022 Interim Report

Arbuscular Mycorrhizal Fungi. Farm Trial

Objective: The objective of this report is to set out the hypothesis, methodology and limitations of the trial. Finishing with the trial's benchmark results.

Contents

1) Hypothesis

This farm trial is being conducted to determine if encouraging Arbuscular Mycorrhizal Fungi (AMF), can help increase carbon sequestration in the soil. Our hypothesis is, encouraging native AMF could be used as a mechanism to speed up carbon sequestration in depleted soil.

The chosen inoculation technique outlined in this trial aims to encourage native AMF via an inoculant created on the farm. This mixture will include compost, also made on the farm. There is a risk that the effectiveness of AMF, as a carbon sequestration mechanism, is overestimated due to the compost increasing SOM. To overcome this risk, both compost with and without AMF inoculum will be tested.

1a. Reasoning behind the hypothesis

Mycorrhizal fungi form a mutually beneficial relationship with plants, whereby the plant feeds the fungi sugar (in the form of carbon) and the fungi feed the plant nutrients and water.

Mycorrhiza comes from the Greek word "Mykes" which means fungus and rhiza, coined to describe an association between a plant and fungi. Whilst Arbuscular signifies that the type of mycorrhizal fungi we're researching are Endomycorrhiza and therefore, penetrates the plant root. This is opposed to Ectomycorrhiza that attach to the outside of the root.

This mutualist relationship has been going on for a long time; Fossilised plant roots from 450 million years ago have been found with mycorrhizae fungi on the root systems. Scientists seem in agreement that the evolution of plants from the water to the land, would not have been possible without fungi. The mycorrhizae fungi were effectively plant roots, whilst the plants focused on creating energy via photosynthesis. Over time, plants have evolved to create their own root systems however, hyphae have had longer to evolve for optimal efficiency. As a result, they are thinner and longer, meaning they have greater contact with the soil, making them more effective at nutrient and water collection. In return, plants can harvest the suns energy, something fungi cannot. The result being, the plant transfers between 4 – 20% of net photosynthate to the fungus. The hypothesis for this trial is based on the concept that by increasing fungi populations (in this case AMF), you are increasing the transfer of carbon from plants to fungi. In turn, fixing more carbon into the soil via their exudates and eventual breakdown.

This symbiotic relationship is prevalent, with an estimated 95% of terrestrial plants forming this connection with mycorrhizal fungi. AMF has been specifically targeted in this trial as an estimated 85% - 90% of terrestrial plants specifically benefit from AMF, thus, making them a more common partner for plants. Furthermore, AMF forms a symbiotic relationship with many grasses and legumes. As the parcels included in this trial are in grass, legume and wildflower mixes, the application of AMF inoculum should hold more benefit compared to other types of mycorrhizal fungi.

The table below indicates the lays included in this trial.

Field Name	Mix
Horse Hill & Home Ground	Ryegrass
	Meadow Fescue Pardus
	Timothy Comer
	Kentucky Bluegrass
	Strong CRF Maxima
	Red Clover Rozeta
	Sainfoin Esparsette
	Lecerne Neptune
	Birdsfood Trefoil Leo
	Sheeps Burnet
	Ribwort Plantain Diversity
	Yarrow
	Oxeye Daisy
	Sheeps Sorrel
Lower Cowlease	Toddington
	Pardus Meadow
	Timothy Comer
	Evora
	Maxima
	Red Clover Essex
	Esparsette Sainfoin
	Plato Lucerne
	Bull Birdsfoot Trefoil
	Sheeps Burnet
	Ribwort Plantain
	Yarrow
	Oxeye Daisy
	Sheeps Sorrel
Higher Cowlease	Ryegrass

1b. Why is this trial useful?

I. Mitigation against climate change

The soil is estimated to hold 2400gt of carbon to a 2-meter depth. That's more than the atmosphere (800 gt) and above-ground plants (550gt) combined. Meaning the soil is a fantastic asset for storing carbon. However, whilst the carbon cycle previously operated at a perfect equilibrium, human activity has pushed it out of kilter. It is estimated we are creating 6gt of excess Co2 per year. Furthermore, 52% of agricultural lands are medium to severely degraded. Impairing the soil's ability to hold carbon. These two factors in combination mean we need a mechanism to absorb excess carbon but we have prohibited the soils ability to do so.

It is clear that soil is an essential and prominent carbon sink. Second only to the ocean. However, it's role in reversing climate change is a widely debated topic. More research and understanding is needed to give clarity to farmers and land managers on how to manage their soils. This trial will help us to form a deeper understanding on how to manage our soils and if successful, others too.

II. Limited research

It's clear the carbon cycle funnels through plants and consequently into the soil. However, research into the impact AMF has on soil carbon stocks is minimal. The number of field trials are limited but vitally important, largely because AMF has been found to behave vastly differently under lab conditions compared to the natural world. There are also many different types of AMF and it's unknown if different ecosystems behave in different ways. Therefore, a small scale local trial could be beneficial in understanding if AMF inoculation is a viable option for the West Dorset region.

III. Farming techniques impact on AMF.

AMF is thought to be significantly reduced due to conventional farming practices. Disturbing the soil in various ways, such as tilling, tears through the AMF. If disturbance happens too frequently, the hyphae will not have time to recover and the fungi will deplete. Phosphorus and Nitrogen input has also been found to reduce AMF. Potentially due to the plant not relying on the fungi as a nutrient source. Another technique found to reduce AMF is the application of fungicides as they cannot decipher symbiotic fungi and pathogenetic fungi.

The impact conventional farming has on AMF will be considered in this trial. With 3 of the 4 parcels having been in wheat, maize, grass rotation with till, muck spreading and pesticide spray management techniques. Whilst the 4th parcel has remained as permanent pasture for over 8 years. In 2022/23, all 4 parcels were put to permanent pasture for 5 years with minimal, to no, artificial input. Meaning, this trial will give some insight into the impact AMF inoculation has on soil that have and have not recently been under conventional farming practises.

2) Methodology

This trial will test three variables, across 4 land parcels. Resulting in 12 different test areas, as indicated on the table below.

Parcel Name	Treatments	
Lower Cowlease	Control	1
	Soil treated with compost	2
	Soil treated with compost & AMF inoculation	3
Home Ground	Control	4
	Soil treated with compost	5
	Soil treated with compost & AMF inoculation	6
Higher Cowlease	Control	7
	Soil treated with compost	8
	Soil treated with compost & AMF inoculation	9
Horse Hill	Control	10
	Soil treated with compost	11
	Soil treated with compost & AMF inoculation	12

The control data will be collected via walking a W shape, avoiding gate ways and water troughs. Whilst two 1 meter square areas will be chosen in each field for the compost treatment, with and without the AMF inoculation. All sample points will be recorded on a QGIS map system, to enable the same point to be sampled each year with accuracy.

The AMF inoculant will be created as per the process set out by the Rondale Institute. However, some small alterations have been made to fit the trial. The table below outlines the steps to form the inoculation. The main alteration being the use of Phacelia instead of a grass. This plant has been selected as the host plant due legumes, or grasses possible spreading pathogens due to the soil sample and test area both including these plant families. This is a compromise as legumes such as vetch would have been more desirable due to their strong association with AMF. However, if the test area was contaminated with a pathogen, the results run risk of being negatively impacted.

Month	Action	Step
March	Cover area of grass with plastic sheet, to prevent weeds growing in the inoculum mixture. Chosen area is away from land that is sprayed with pesticides or fungicides.	1
	Mix 1:4 compost to vermiculite into 7 gallon grow bag.	2
	Add 100cm3 of field soil from 5 soil samples. Using soil from the farm that has not been spray with fungicide or pesticide for 5 + years	3
	Plant 10 Phacelia seeds per grow bag	4
April	Thin to 5 plants per bag	5
AYR	Water and weed as needed.	6
November	Frost may kill off most of the annual. Cut down if needed and discard.	7
April	Shake compost from the root ball and cut roots into 1cm lengths. Mix the bag together.	8
	Apply to the test area, in each parcel.	9
	April 2024 only. Sprinkle seeds of the same lay mix, on top of the inoculum to enable germination.	10

Each September soil and root samples will be taken for carbon and AMF inoculation testing. Soil samples will be taken 30cm deep and sent to the lab for a soil carbon audit.

Trial Location: Pineapple Estate, West Dorset. Hannah Dyke
Part funded by FiPL Dorset AONB

The following equation will allow SOC comparison.

SOC stock has been calculated = % SOC measured content x soil bulk density x soil depth

2a. Trial Timeline

Year		Action	Complete
Year 0. 1st January 2021 – 31st December 2021	18th October 2021	Carbon soil samples taken: Soil Carbon Audit conducted by NRM *Technically not part of the study. However, carbon soil samples were undertaken in the same way as Year 1. Therefore, the data has been included in this report as a means to expand our understanding.*	Y
Year 1. 1st January 2022 – 31st December 2022	13th Sept 2022	Carbon soil samples taken: Soil Carbon Audit conducted by NRM.	Y
	23rd Nov 2022	AMF inoculation sample taken: Completed via BioLabs.	Y
	28th Feb 2023	2022 Interim Report.	Y
Year 2. 1st January 2023 – 31st December 2023	1st March 2023	Start inoculum production year 1.	In progress
	13th Sept 2023	Carbon soil samples taken: Soil Carbon Audit via lab.	
	13th Sept 2023	AMF inoculation sample taken: To be completed by Hannah, via microscope.	
	31st Dec 2023	2023 Interim Report.	
Year 3. 1st January 2024 – 31st December 2024	1st March 2023	Start inoculum production year 2.	
	1st April 2024	Apply year 1 inoculum and compost treatment.	
	13th Sept 2024	Carbon soil samples taken: Soil Carbon Audit via lab.	
	13th Sept 2024	AMF inoculation sample taken: To be completed by Hannah, via microscope.	
	31st Dec 2024	2024 Interim report.	
Year 4. 1st January 2025 – 31st December 2025	1st March 2025	Start year 3 inoculum production.	
	1st April 2025	Apply year 2 inoculum and compost treatment.	
	13th Sept 2025	Carbon soil samples taken: Soil Carbon Audit via lab.	
	13th Sept 2025	AMF inoculation sample taken: To be completed by Hannah, via microscope.	
Year 5. 1st January 2026 – 31st December 2026	1st April 2026	Apply year 3 inoculum and compost.	
	13th Sept 2026	Carbon soil samples taken: Soil Carbon Audit via lab.	
	13th Sept 2026	AMF inoculation sample taken: To be completed by Hannah, via microscope.	
	1st Dec 2026	2026 final report.	

3) Limitations

This research project was formed out of interest and little knowledge in soil science. This past year has been spent researching the subject as knowledge has increased, the methodology behind the trial has changed in the aim to answer the hypothesis more effectively. It has been a learning curve and we can only hope this learning continues. As we are not experts on this subject, we appreciate that there could be knowledge gaps in the study.

Soil and carbon sequestration is also a young sector and at times, information and research contradict each other, depending on the source. For example, currently there is a prominent debate around how to measure soil carbon. We have chosen to conduct the soil sample using the most widely used methods; walking a W in the field, and taking multiple 30cm depth samples. Followed by testing via dry combustion for bulk density and SOC % to give you one carbon stock result per field. However, other systems include; taking samples at 30cm – 1m, with each soil sample being individually tested. The result being 15 – 45 combustion tests and results given per field. Although we see the benefits of this, the cost associated was not feasible at the time of testing. New technologies are also emerging, with another company developing NIRS systems to monitor soil carbon stocks.

To conclude, a limitation of this trial is that, in much in the same way we are learning, so is the industry. It is possible new and better ways to monitor soil carbon and health will be created during the trial. However, to enable us to readily compare our data year on year, we will aim to conduct our soil samples the same way throughout the trial.

4) 2022 Results: benchmarking for the trial

Soil Carbon Stock Data				
	Years without disturbance or input.	2021 Organic Carbon Stock t/ha	2022 Organic Carbon Stock t/ha	Difference t/ha
Lower Cowlease	1	62	68	6
Home Ground	0	75	79	4
Higher Cowlease	8+	75	85	10
Horse Hill	1	71	80	9

Mycorrhizal inoculation Data			
	Years without disturbance or input.	2022 Ectomycorrhiza Mycorrhizal Colonisation %	2022 AMF Mycorrhizal Colonisation %
Lower Cowlease	1	0%	36%
Home Ground	0	0%	25%
Higher Cowlease	8+	0%	27%
Horse Hill	1	0%	23%

5) References

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