Annual Project Report
January 2019 to January 2020

Project title	Fostering populations of arbuscular mycorrhizal fungi through cover crop choices and soil management		
Project number	21140024		
Start date	08/01/2018	**End date**	07/01/2021

Project aim and objectives

The overall aim of this project is to quantify how cover crops influence colonisation and diversity of arbuscular mycorrhizal (AM) fungi and how this interaction influences crop growth and yield in field conditions. The study will utilise field-scale trials, as well as glasshouse experiments, to address the following project aims:

1. To assess the impact of cover crop species on soil health, including the diversity and abundance of AM fungi.

2. To quantify the effect of increased diversity and abundance of AM fungal species on crop yield, under a range of soil, inoculation and physico-chemical conditions.

3. To consider the impact of common farm practices, such as cultivation, nutrient application and use of herbicides, on AM fungal diversity and abundance.

Key messages emerging from the project

A UK-wide assessment of AM fungal diversity (in collaboration with Fera's Big Soil Community) has shown that different farming practices, including crop species, cultivation choice and fungicide applications can influence diversity of AM fungi in the soil. This work has set the scene for further experimental work, including two fully replicated trials (Bawburgh and Morley) in Norfolk.

Bawburgh trial

The trial at Bawburgh investigates cover crop mixtures, grown with and without a five-species AM fungal inoculum (sourced from our industry partner, Plantworks). Confocal microscopy of cover crop roots suggests that these cover crop species may host distinct AM fungi, but this is almost impossible to confirm without molecular analysis, which will take place in 2020. Root length colonisation (RLC) of the following barley crop was not influenced by cover crop or AM fungi inoculation, nor was biomass or yield. However, there were some differences in grain size.

Morley (New Farming Systems – NFS) trial

At Morley, a legume mix or oat and radish cover crop has been grown as part of a long-term rotation since 2007. Here, both of the cover crop treatments increased the RLC of barley, which could suggest either soil type specificity or that multiple iterations of cover crops are required before quantitative benefits are observable. At this trial site, growth of cover crops decreased barley yield at the full and 50% nitrogen (N) doses, but the leguminous cover crop increased yields in the zero N application plots. This is likely to be due to increased soil N fixed by rhizobia associating with legume root nodules, as barley RLC was not a significant predictor of yield in this trial.

Innovative Farmers trial

Applying these findings to the farm scale, an Innovative Farmers (IF) trial investigated the use of anaerobic digestate (AD) and cover crops at four sites, ahead of maize. The impact of the treatments on soil characteristics was recorded, with soil type differences apparent. Generally, application of AD increased available N in the soil profile. However, N appeared to leach to the 30–60cm and 60–90cm horizons. Cover crops reduced N leaching into the lower soil horizons, except at North Moor farm, where the cover crop treatment had the highest soil N. This was thought to be due to the site being waterlogged and did not represent an accurate treatment effect. Neither cover crops, nor application of AD influenced RLC or biomass of maize in this experiment, further suggesting the importance of multiple cover crops to achieve a quantitative benefit.

Summary of results from the reporting year

Commonly used ITS primers were unable to detect AM fungi in the Fera Big Soil Community project. This led to the dissemination that AM fungi could not be important in arable systems. However, AM fungal-specific primers have confirmed that 87 AM fungal taxa were present in the soil samples submitted. This is likely to be due to the relative numbers of AM fungal DNA sequences being low in comparison to other fungi, such as saprophytes, and AM may have been amplified, if soil DNA had been diluted by 10–100 fold. Even then, the ITS region is highly conserved in AM fungi. Therefore, ITS primers would not have been able to detect the true diversity of AM fungi that was achieved with the use of AM-specific primers.

Results show that fungicide use (as a whole) affects the AM fungal community recovered from soils. Specific fungicides also differentially influence AM fungal diversity, with taxa known to be more beneficial being significantly less abundant at the sites using fungicides. Similarly, deep cultivations were shown to both decrease the total numbers of AM fungal species found in soil samples, and these cultivations also influenced AM species composition. There was weak clustering of AM fungal communities found in similar crop species, as shown by NMDS analysis. This suggests that there are AM fungi that may be more likely to associate with individual crops or groups of crops.

CEREALS & OILSEEDS

Considering these results, it is clear that different farming practices have a strong influence on AM fungal diversity, and this is likely to influence crop growth, resilience and yield. This experiment also provides a fantastic background to the replicated trials at Bawburgh and Morley, to identify AM taxa that may be nationally rare in agriculture, or to identify 'beneficial' taxa which have been promoted by certain experimental conditions.

At the Bawburgh site, neither cover crop species, nor inoculation by AM fungi have influenced RLC, biomass, or yield of Laureate spring barley. Winter oats have been drilled into these plots to explore whether oats are more responsive to the inoculum, which should still be present in the soil. This will be confirmed by molecular approaches in 2020 to quantify the diversity of AM fungi colonising cover crop, barley and oat roots, both under natural and applied inoculum conditions. Similar to the 2019 barley crop, the 2020 oat crop will also be assessed for RLC, biomass, and yield.

Key issues to be addressed in the next year

In the next year, winter oats from Bawburgh wil be sampled ahead of a second round of molecular analysis. This analysis will span the Bawburgh, NFS, and IF trials, and will provide data on whether experimental conditions such as cover crop, AM inoculation, application of N/digestate influence AM fungal diversity, and whether diversity *per se* or specific species of AM fungi are able to influence crop growth and yield.

Lead partner	University of Cambridge
Scientific partners	NIAB
Industry partners	PlantWorks
Co-sponsor	AgriFood Charities Partnership

Has your project featured in any of the following in the last year?	
Events	***Press articles***
Cambridge Science Festival (16/03/19) Cereals (12/6/18) Royal Norfolk Show – Poster (25/6/18 - 26/6/18) Agritech East week (4/11/18- 8/11/18)	NIAB Landmark Magazine – April 2019
Conference presentations, papers or posters	***Scientific papers***
AHDB Maxicrop (09/01/19) – Presentation	

Norfolk Farming Conference (07/02/19) – Presentation MENTOR Agronomists meeting (11/02/19) – Poster AFCP East of England Meeting (05/03/19) – Presentation AFCP Student Forum (11/04/19) – Poster Morley Innovation Day (20/06/19) – Poster AHDB Agronomist's Conference (03/12/19) – Presentation Sainsbury Laboratory Endosymbiosis Seminar (17/12/19) – Presentation AHDB Student Conference (29/10/20-30/01/20) - Poster	
Other	
Innovative Farmers Field Lab partners meeting (14/01/19) – Presentation NIAB EMR Root Group (10/05/19) – Presentation NIAB Research Seminar (23/05/19) – Presentation Innovative Farmers Field Lab partners meeting (06/06/19) Innovative Farmers Field Lab partners meeting (12/09/19)	