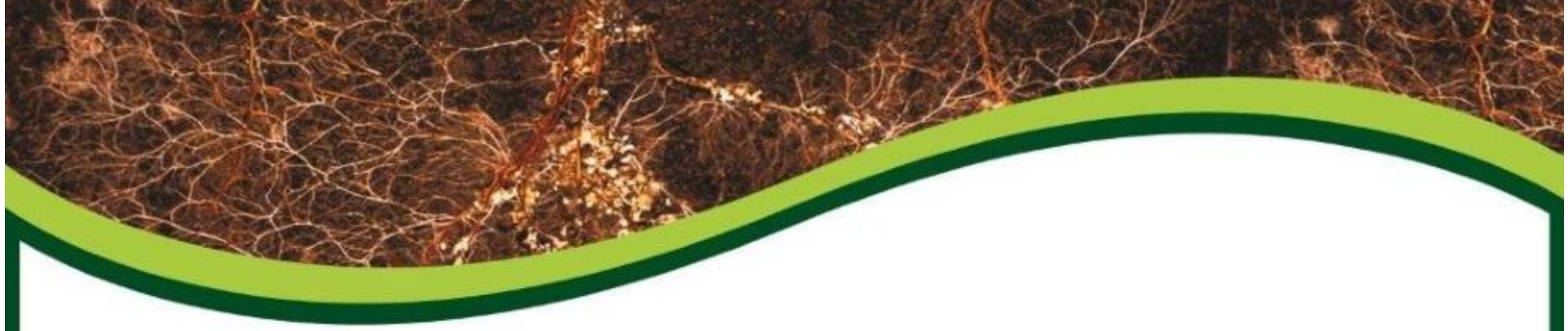


Jamie Stotzka

Mycorrhizal Fungi

Production and Application in Agriculture

Overview

- Why beneficial microbes?
- An introduction to mycorrhizae
- Who are PlantWorks
- The use of mycorrhizal fungi in agriculture
- Products and the PlantWorks Soil Hub

The Need for Change

- Sustainability – Economical, environmental, future
- Healthy soils are the foundation of all farming
- Legislative changes – Arsenal of available chemicals declining, need for alternatives

Basic Principles

- Minimal Soil disturbance
- Continuous soil cover (living plants)
- Good crop diversity

All of these principles create ideal conditions for the application and maintenance of soil biology

The Food security challenge

*"To produce more food between 2000-2050 than we did between 1500-2000 AD" – **Food security challenge***

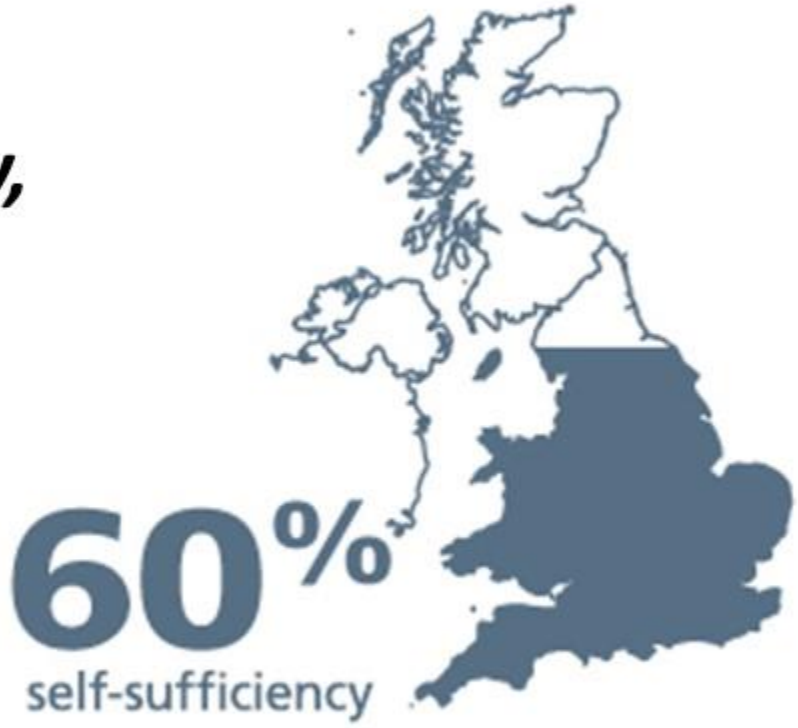
Crop yields worldwide are not increasing quickly enough to support this

Food production in developing countries needs to almost double by 2050

The British Farming challenge

Produce more, sustainably, for the long term

- Maintain crop yields at healthy profit margins
- Minimise environmental impact
- Maintain resources - legacy



Mycology in the UK

Mycology *is the branch of biology concerned with the study of fungi*

Soil quality is a function of <u>three</u> factors:

1. Soil **chemistry**
2. Soil **physics**
3. Soil **MICROBIOLOGY**

The last domain of intervention

Mycology in the UK

YORK
University

JAMES HUTTON
INSTITUE

Sheffield
University

CAMBRIDGE
University

BRISTOL
University

2016

ROYAL
HOLLOWAY
University

NIAB

EAST MALLING
RESEARCH

WARWICK
University

ABERDEEN
University

LEEDS
University

OXFORD
University

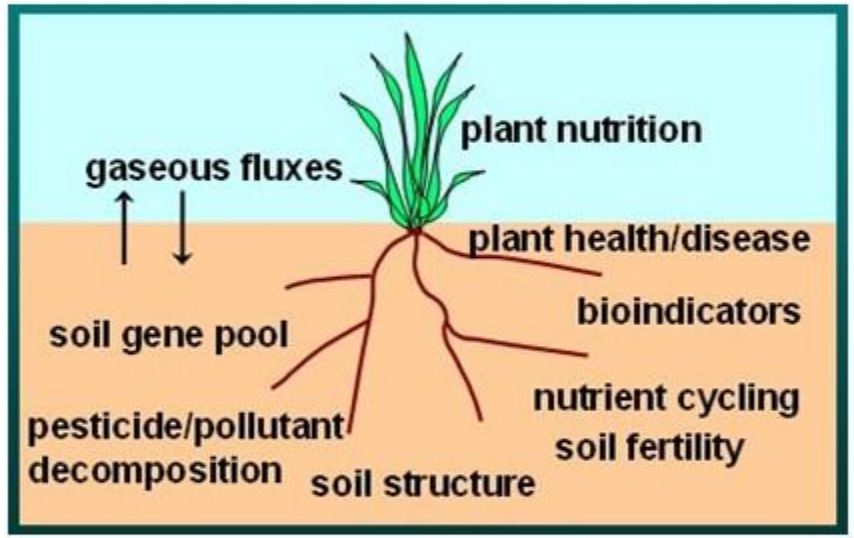
MANCHESTER
Met. University

Plant Works

Soil Microorganisms

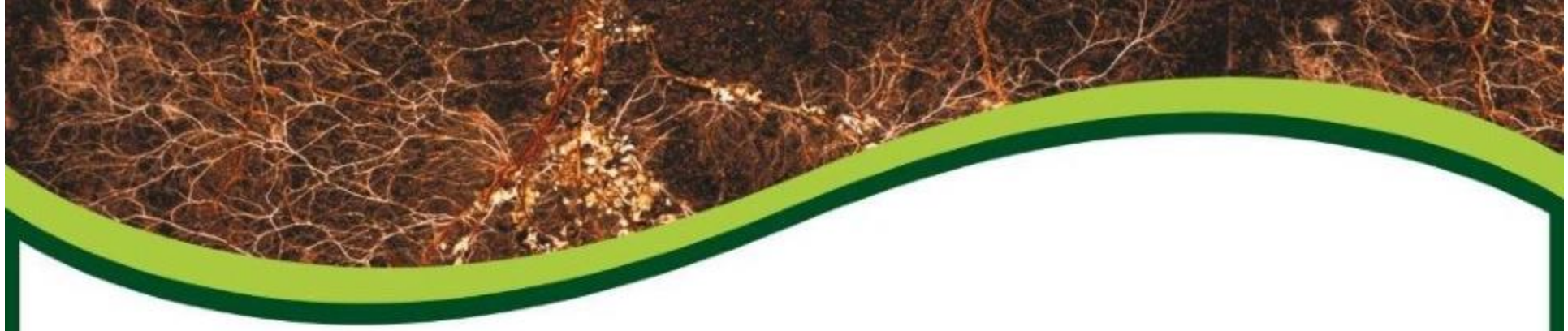
Essential for the maintenance of soil fertility

- Cycling/mineralisation of nutrients
- Improvement of soil structure
- Support of healthy plant growth
- Degradation of organic pollutants



Rothamsted Research, 2016

Fungi, Bacteria, Actinomycetes, Algae and Protozoa



Arbuscular Mycorrhizal Fungi

What are Mycorrhizae

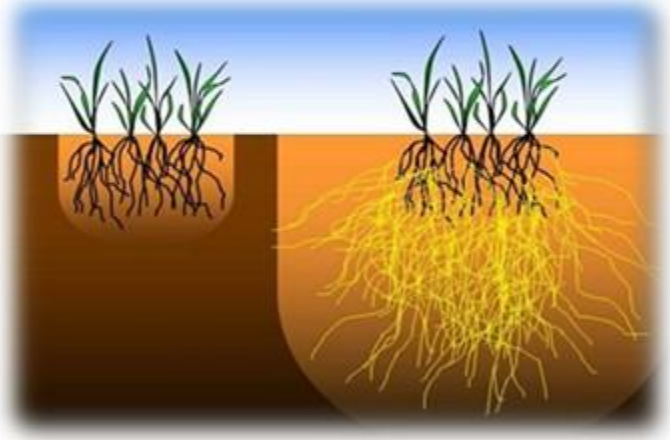
Symbiotic association between a fungus and the roots of a plant

Obligate mutualistic symbiosis with >80% vascular plant families

Plant Works

Mycorrhizal fungi

'The majority of plants, strictly speaking, do not have roots; they have mycorrhizas'



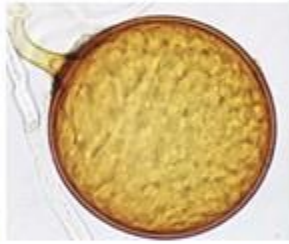
'Mycor' = Fungus

'Rhiza' = Root

Root uptake surface increased up to 700 times

Types of Mycorrhiza

Ectomycorrhiza - Host specific for tree species (e.g. Conifers)

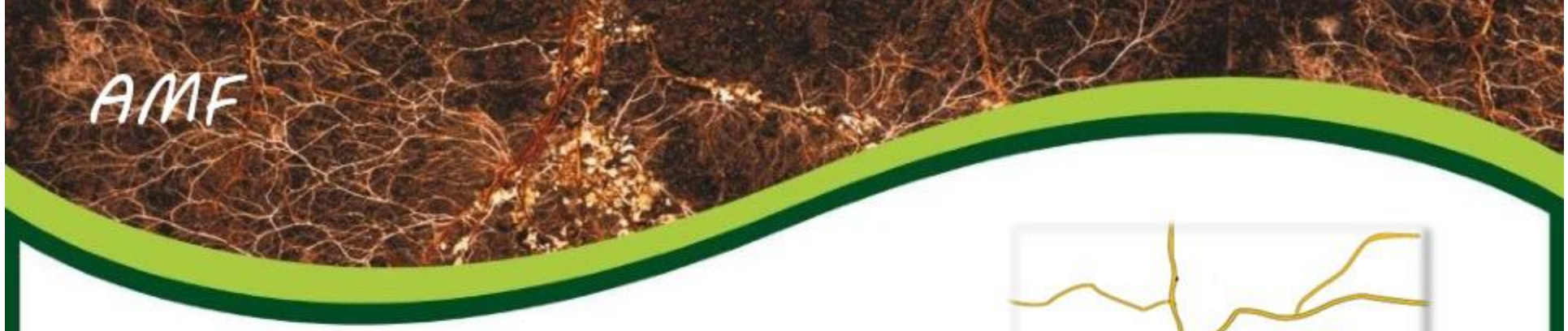


Arbuscular mycorrhiza - most plant species, including trees

Orchid Mycorrhiza - orchids

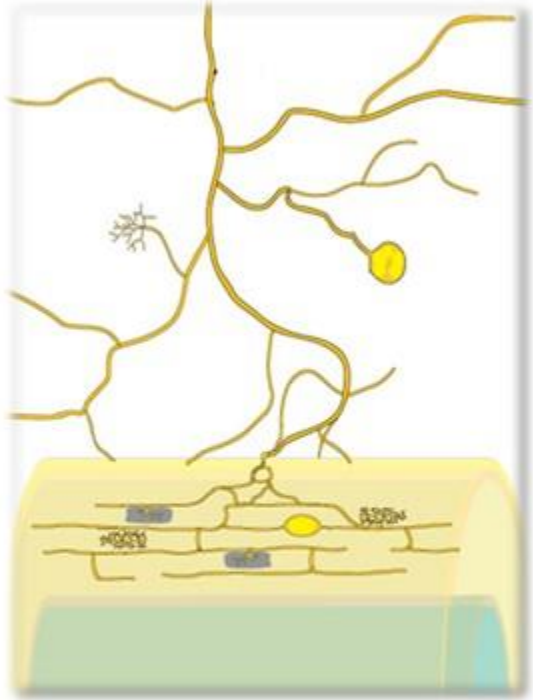
Ericoid Mycorrhiza -Heathers, Rhododendrons, Blueberries

Non-mycorrhizal plants – Brassicaceae, Amaranthaceae



Arbuscular mycorrhizal fungi:

- Ancient asexual organisms
- Hyphae penetrate the roots
- Form arbuscules, vesicles and spores, lack fruiting bodies

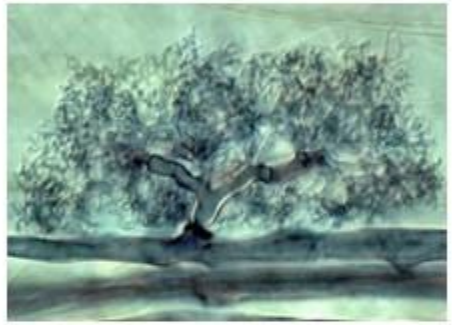


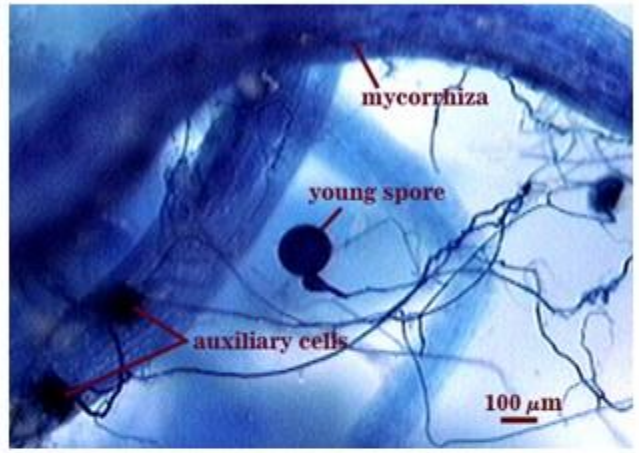
Mineral nutrients and water extracted from the soil

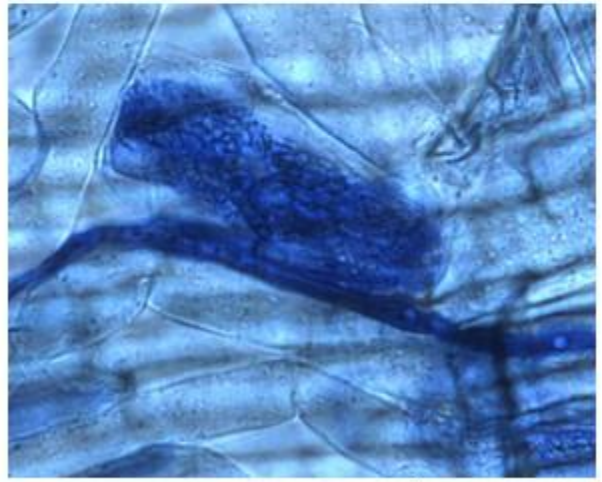
Organic carbon compounds transferred to fungus

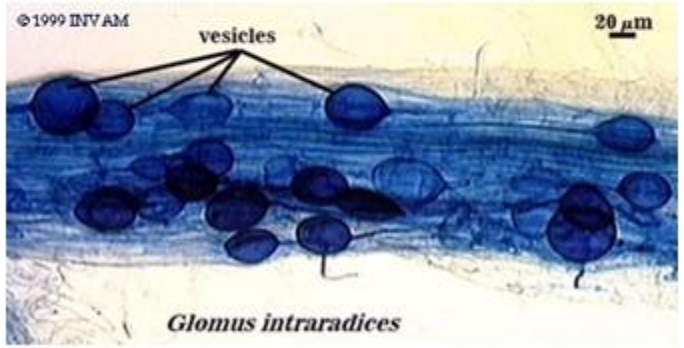
Plant Works

AMF



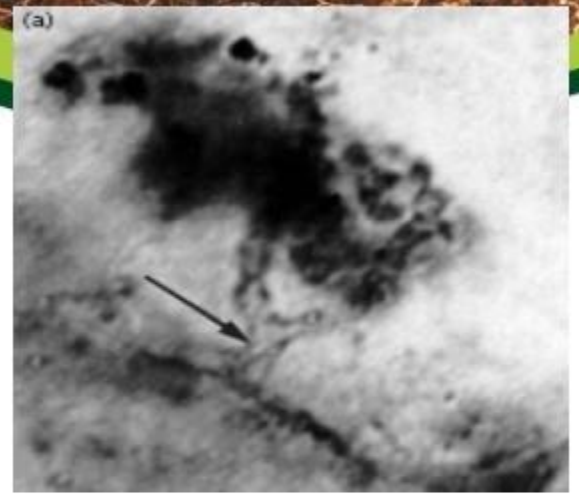




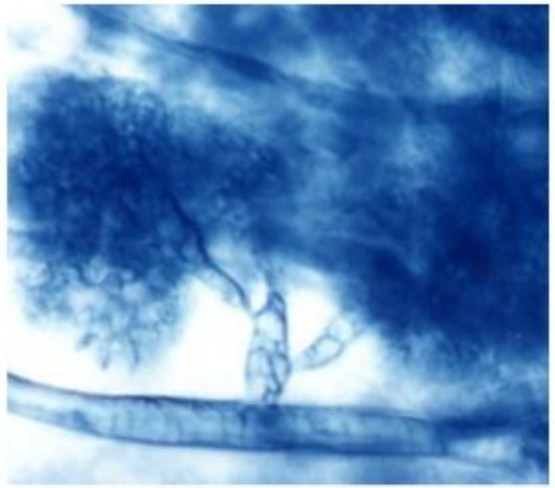


Plant Works

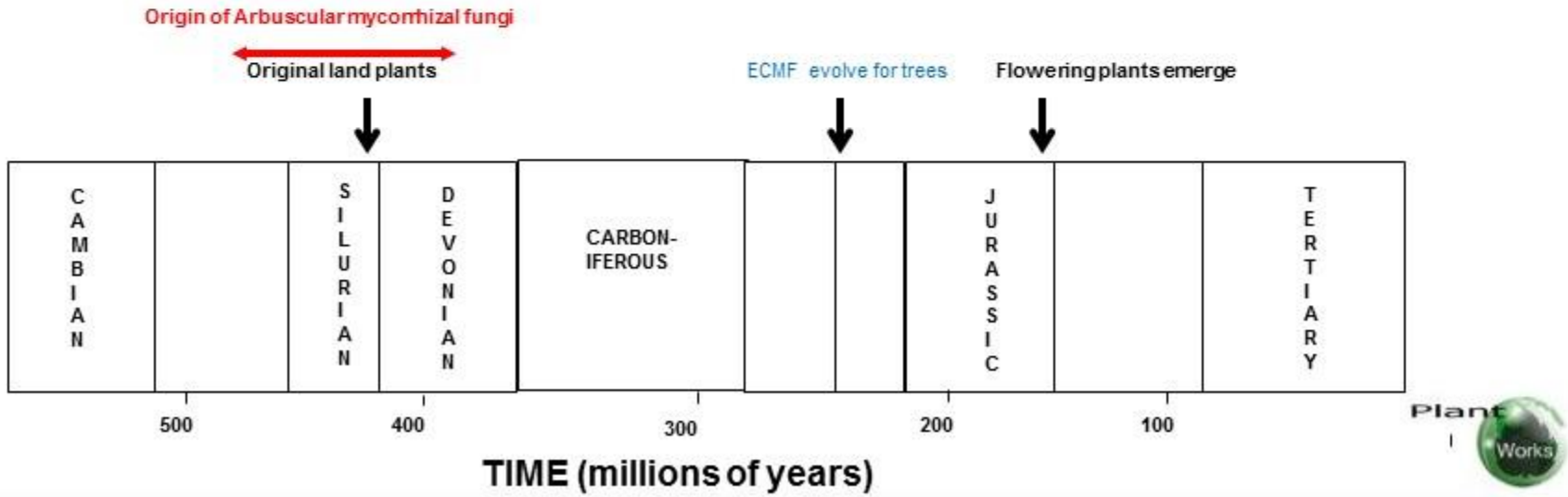
Fossil record



460 million year old fossil



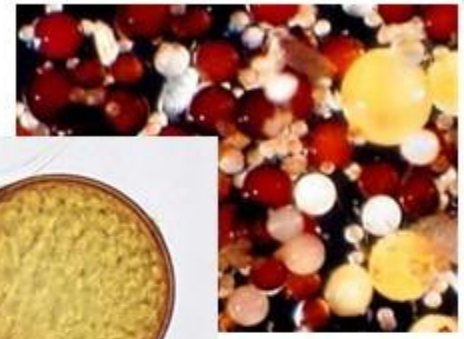
Present Day stain



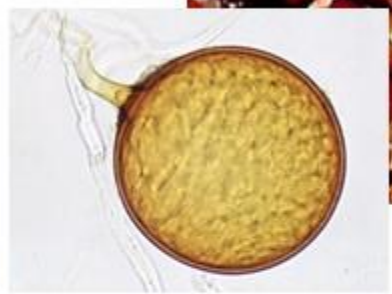
AMF

Plant root system, uptake of water and nutrients to the plant

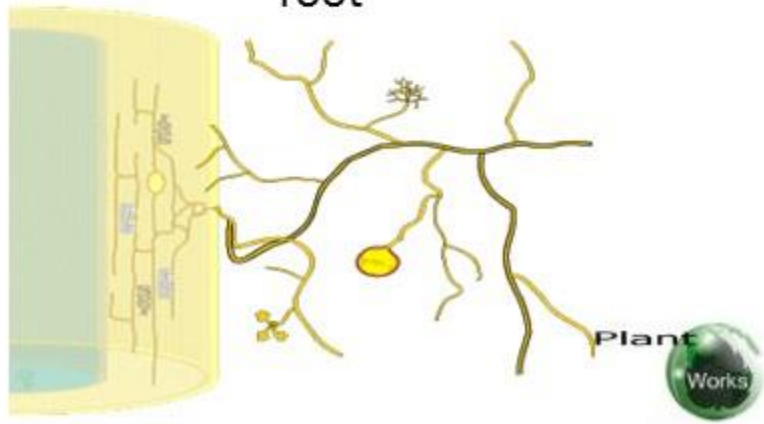
Plant, undergoes photo-synthesis, providing carbon



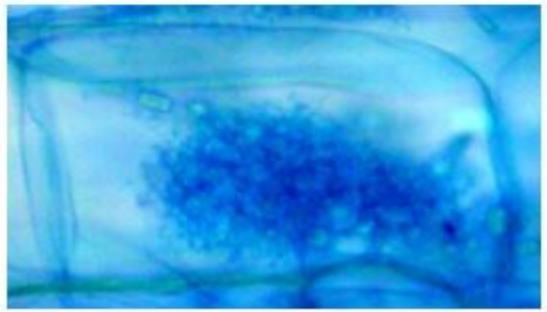
Spores, (seeds) can germinate to form hyphae



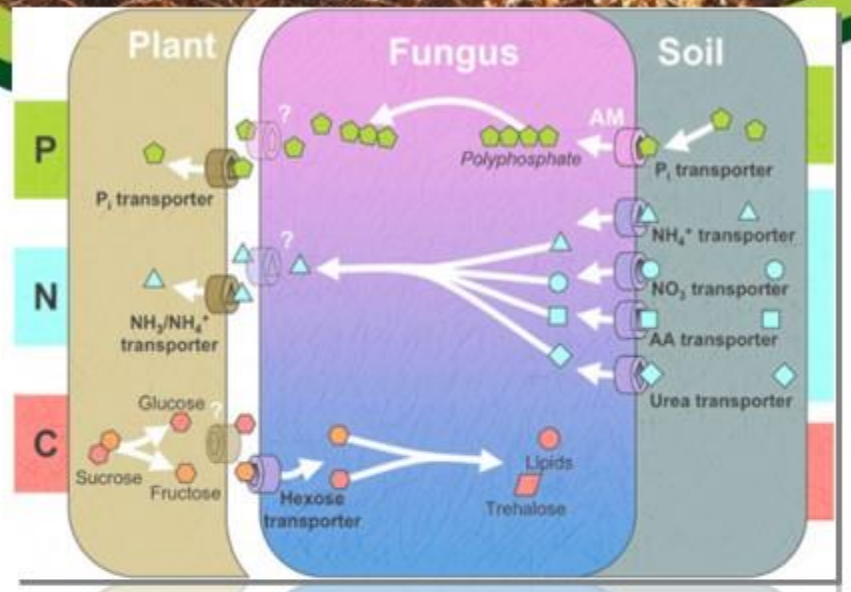
Fungal hyphae, network that penetrates the soil, and colonises root

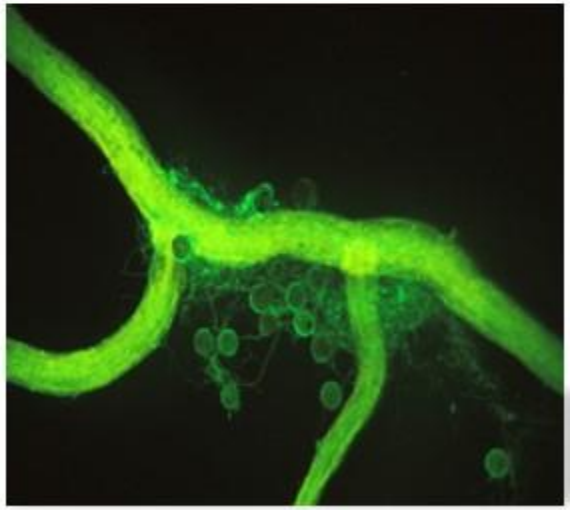


Arbuscules, site of transfer for nutrients

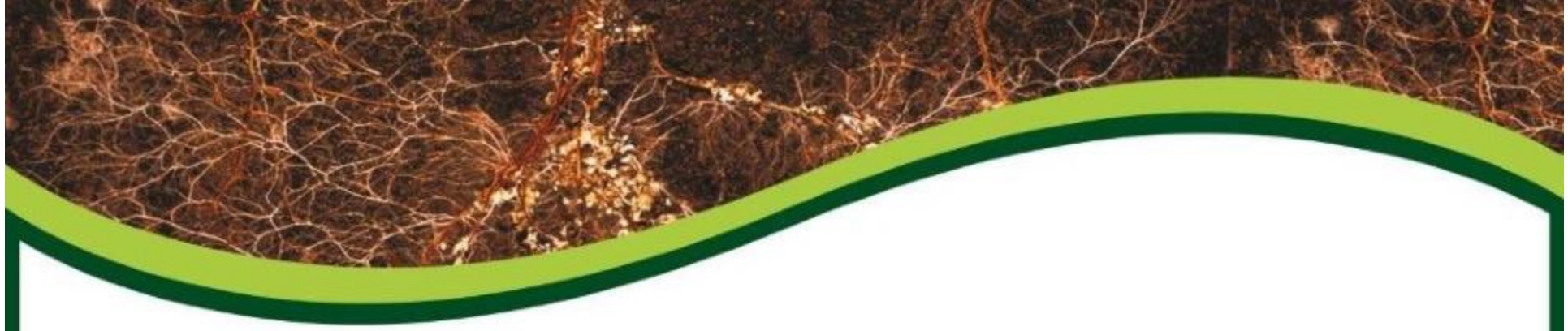


Role of Mycorrhiza:





- Nutrient uptake primarily P, N and Zn
- Protection from biotic stress
  - pathogens and herbivores
- Protection from abiotic stress
  - drought, heavy metal tolerance
- Soil stabilisation (glomalin)



PlantWorks
AMF Production

PlantWorks Ltd.

PlantWorks Ltd is one of Europe's largest manufacturers of mycorrhizal fungi and the UK's only producer. The company operates from **Kent Science Park (KSP)** and **East Malling Research (EMR)**.

PlantWorks Ltd.

- Formed in 2000 as a **spin out** of the International Institute of Biotechnology
- Established **production** in the UK in 2006
- **Science team** of six including PhDs in mycology, bacteriology and degrees plant science, horticulture and soil sciences.
- Launched **farming** proposition 2014
- Produce **100 tonnes** of Mycorrhizal Fungi each year

Market Sectors

RGPRO HORTI

Horticulture

RGPRO AGRI

Agriculture

PlantWorks Ltd

empathy
the biological choice

Retail

Licensing

Plant Works

Production and QA

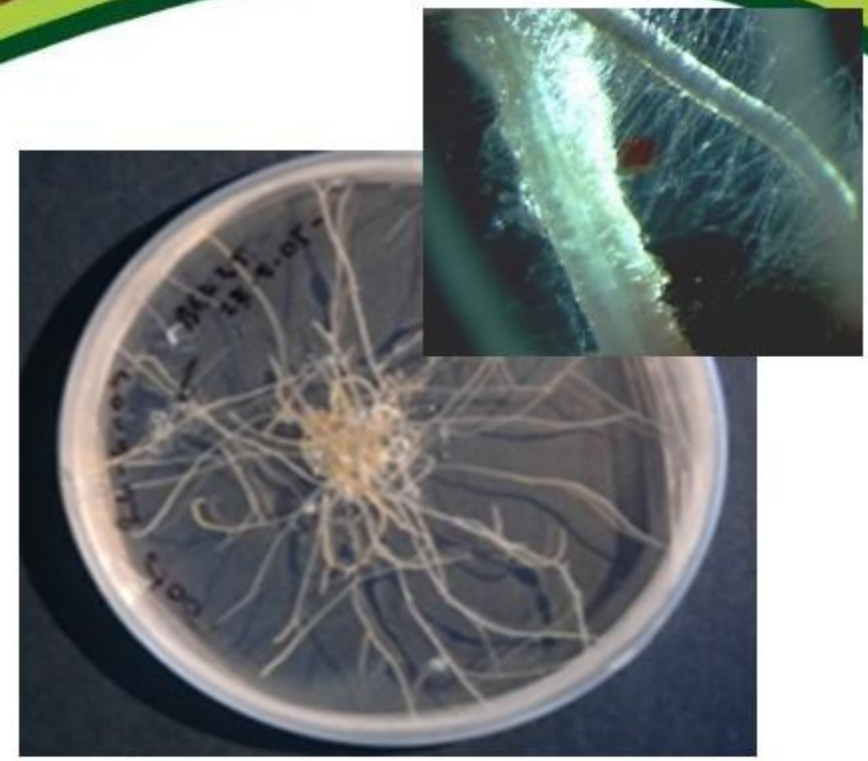
Current production:

- **100 tonnes** per annum (*in vivo*)
- **5 species** in bulk pure culture
- Blended ex production to min **500,000 MPN**
- **Coarse and fine grade** substrates (1-3mm, 0.5-1mm)

Production and QA

in vivo AMF production

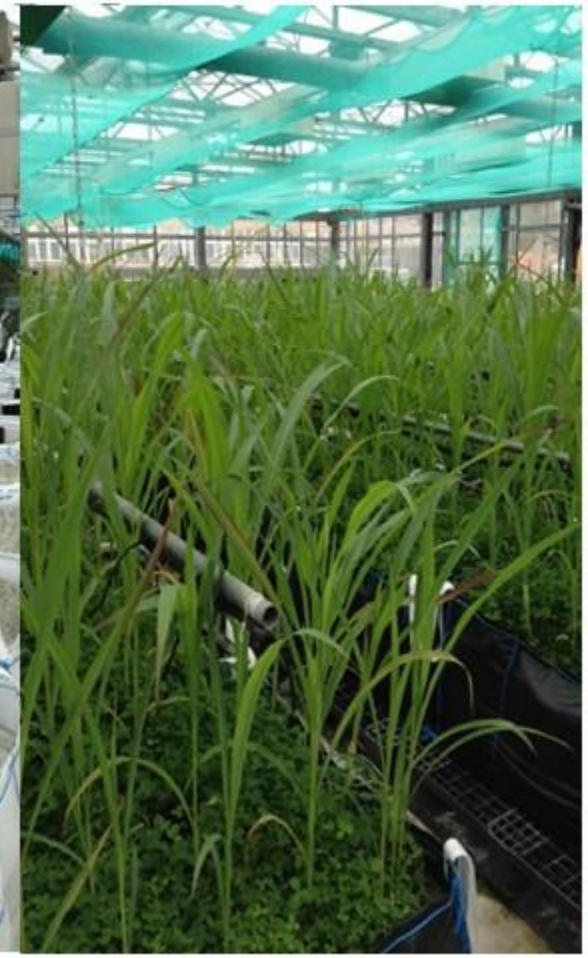
High species biodiversity, grown on inert substrates using host plants



in vitro AMF production

Potentially high spore yield but lower species biodiversity – suited to mono-crop application

Production and QA

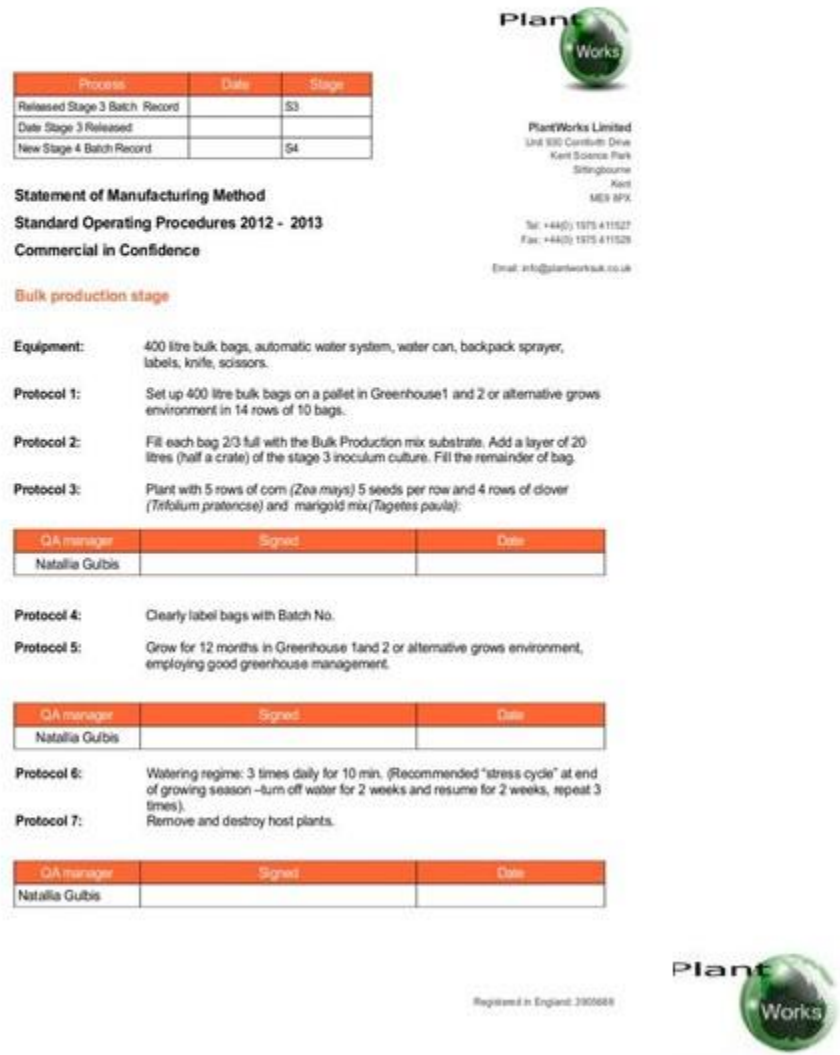


Production and QA

Quality Assurance

All production stages are defined under SOP designed in accord for GLP. All stages are signed off.

- RLC testing
- Spore Count
- MPN testing



Process	Date	Stage
Released Stage 3 Batch Record		S3
Date Stage 3 Released		
New Stage 4 Batch Record		S4

Statement of Manufacturing Method
Standard Operating Procedures 2012 - 2013
Commercial in Confidence

Bulk production stage

Equipment: 400 litre bulk bags, automatic water system, water can, backpack sprayer, labels, knife, scissors.

Protocol 1: Set up 400 litre bulk bags on a pallet in Greenhouse1 and 2 or alternative grows environment in 14 rows of 10 bags.

Protocol 2: Fill each bag 2/3 full with the Bulk Production mix substrate. Add a layer of 20 litres (half a crate) of the stage 3 inoculum culture. Fill the remainder of bag.

Protocol 3: Plant with 5 rows of corn *(Zea mays)* 5 seeds per row and 4 rows of clover *(Trifolium pratencse)* and marigold mix*(Tagetes paula)*:

QA manager	Signed	Date
Natallia Gulbis		

Protocol 4: Clearly label bags with Batch No.

Protocol 5: Grow for 12 months in Greenhouse 1and 2 or alternative grows environment, employing good greenhouse management.

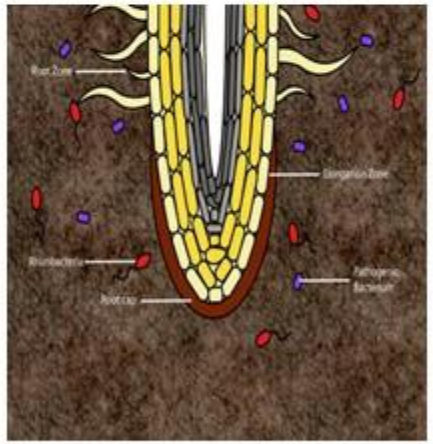
QA manager	Signed	Date
Natallia Gulbis		

Protocol 6: Watering regime: 3 times daily for 10 min. (Recommended "stress cycle" at end of growing season –turn off water for 2 weeks and resume for 2 weeks, repeat 3 times).

Protocol 7: Remove and destroy host plants.

QA manager	Signed	Date
Natallia Gulbis		

Plant Growth Promoting Rhizobacteria (PGPR):

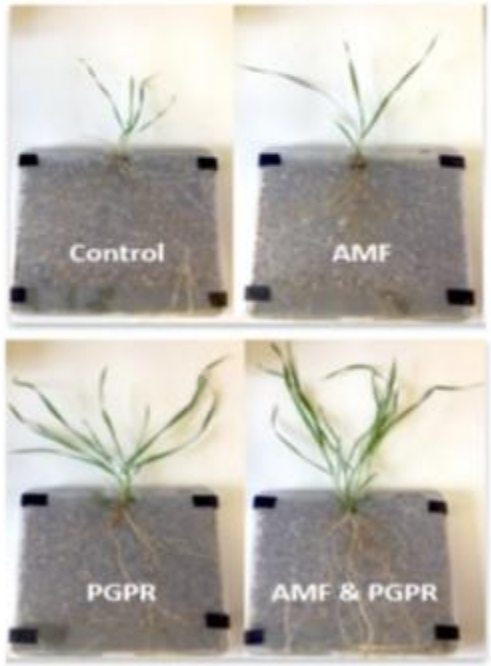


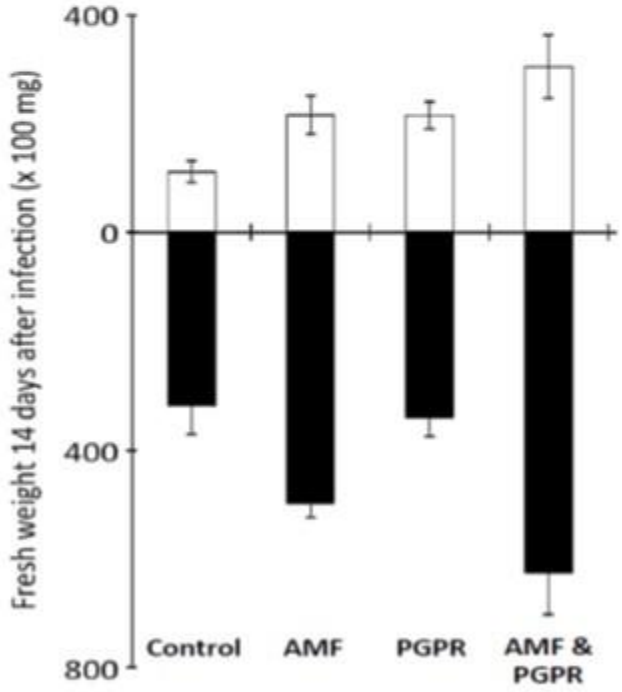
Plant Works

AMF + PGPR
- microorganisms in Synergy

Additive effects of Plant Growth Promoting Rhizobacteria (PGPR) and arbuscular mycorrhizas on host biomass

The University Of Sheffield.



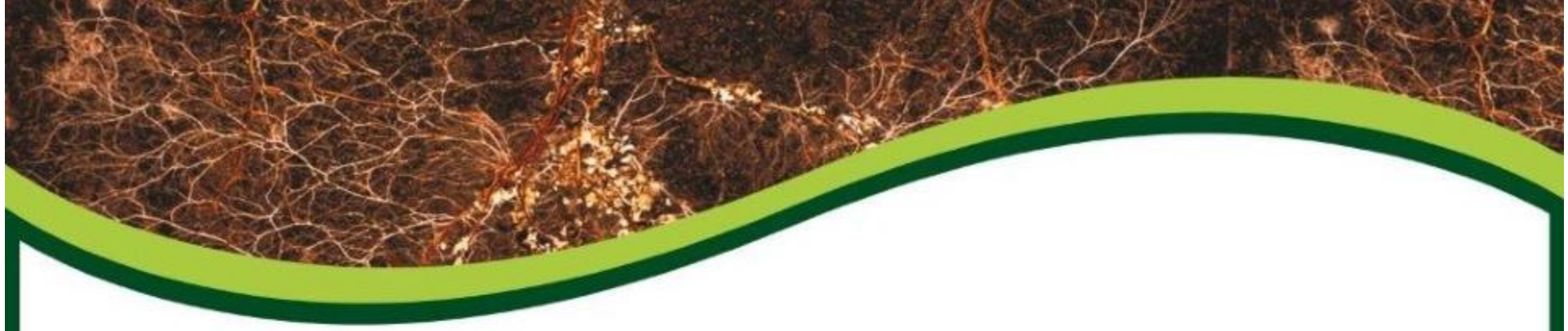


Plant Works

BIOLOGY IN ACTION

Inoculation conditions

1. No inoculation – negative control
2. *sterilised* rootgrow
3. PGPR granule
4. Rootgrow
5. Rootgrow & PGPR



Practical application of AMF

Agriculture

Trials 2015/16

John Cherry, Non-till farmer in Hertfordshire

- Observed increased yield on potato 2015

Simon Chiles, Non-till farmer in Kent:

- Observed increased yield in triticale 2015

Parrish Farms, Bedfordshire

- Long term rotation trial set up in 2016
- Monitor benefits of microbial application together with conservation techniques
- Onion trial *Fusarium* with AMF and PGPR

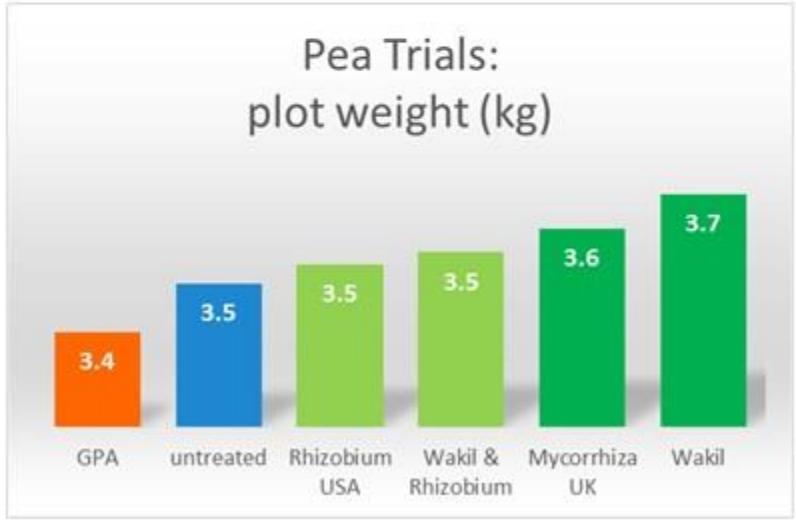
Procam UK

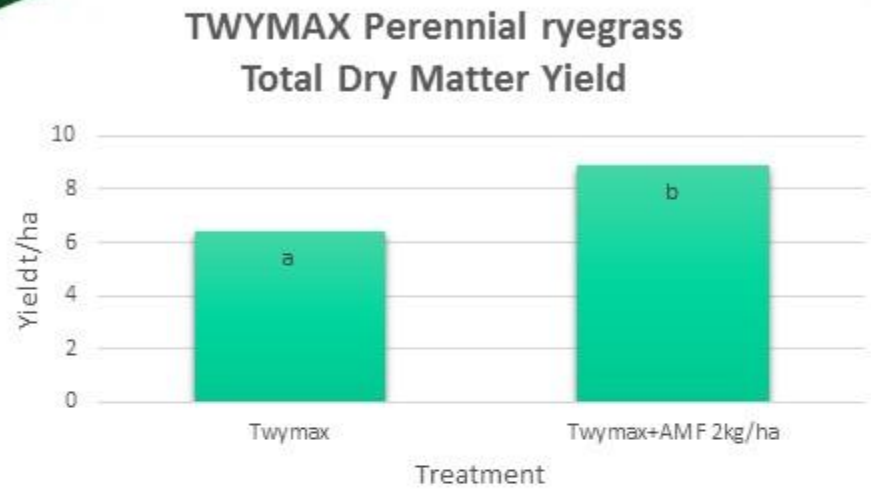
- Sweetcorn trial set up 2016
- Brassica trial with PGPR planned for summer 2016

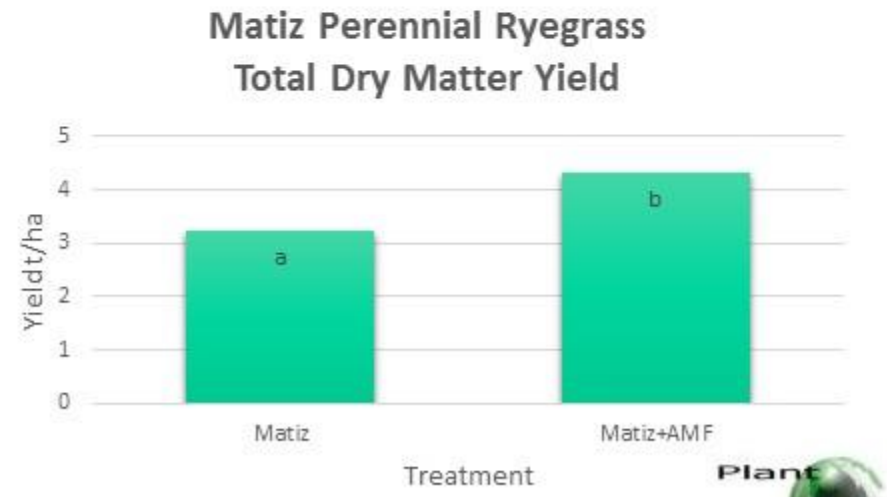
Trials 2015/16

Limagrain UK:

- Fodder grass and maize trials 2015
- Increased yields on grass
- Repeats on both crops in 2016
- Pea trials 2015: Increased yield







Plant Works

Challenges

- Farm Practices
  - Pesticides
  - Fertiliser regime
  - Application – Seed drills and machinery
- Interaction between AMF and specific plant cultivars
- Economy/Profit margins

Challenges

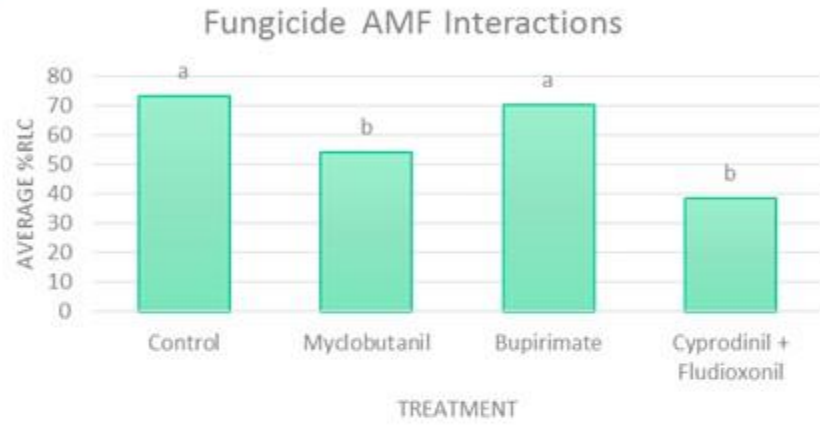
Application

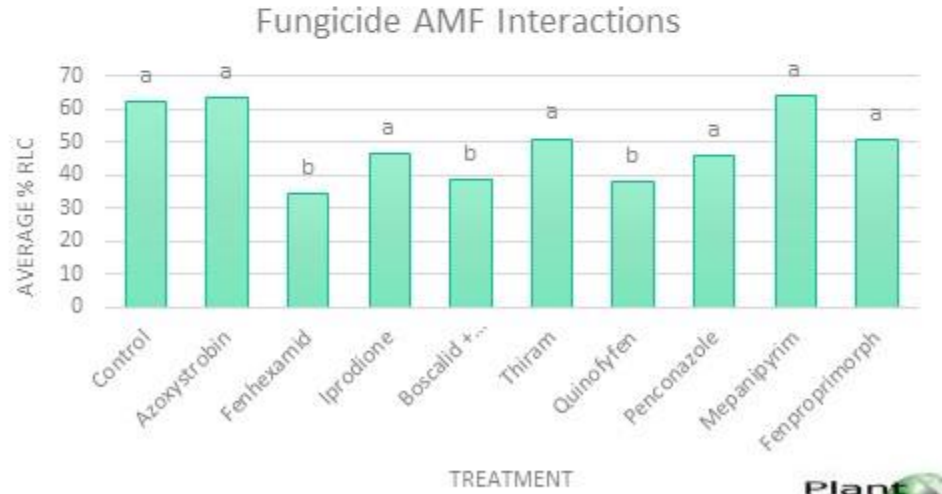
- Seed Drills

Challenges

Pesticides

- Detailed review of all Pesticides used in trials
- Correlation reviews of literature/lists of chemicals harmful to AMF
- Trials started October 2015

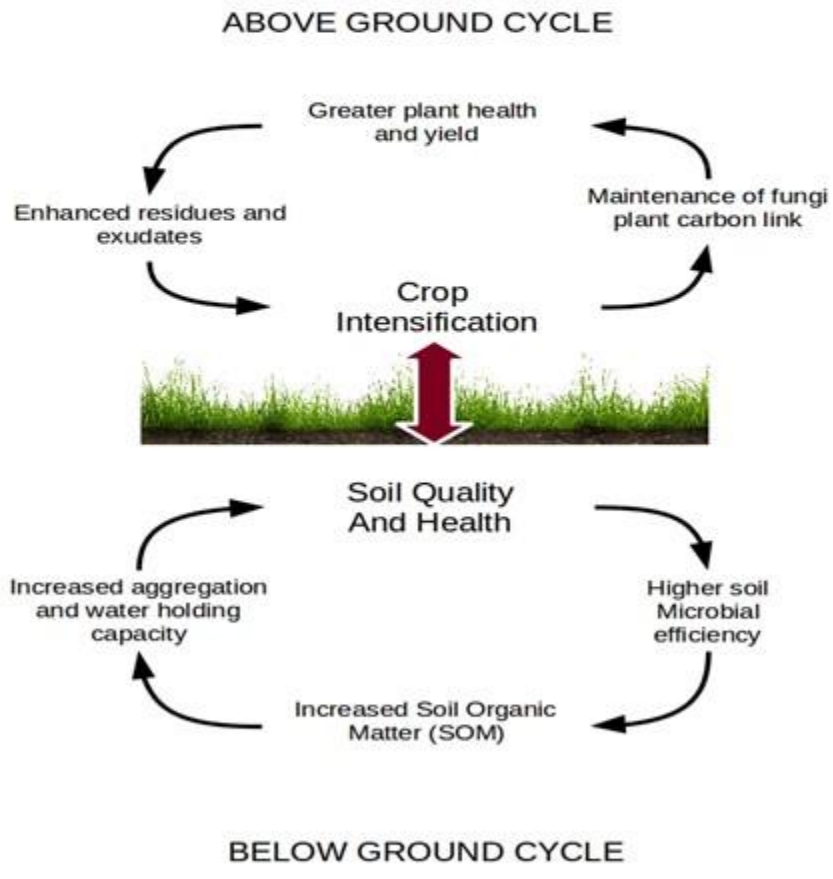




Smart Rotations

The Concept

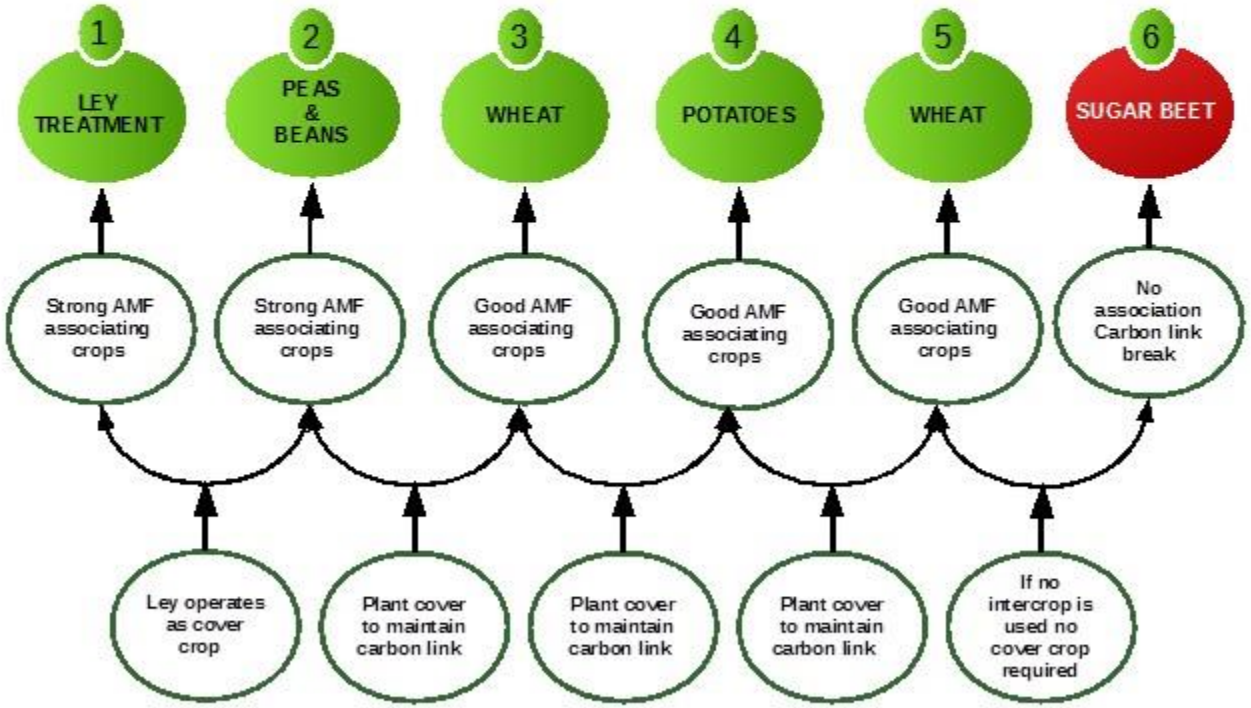
- Maintain a carbon link between microbial communities and host crops during commercial production of food and forage.



Smart Rotations

Mitigation by method

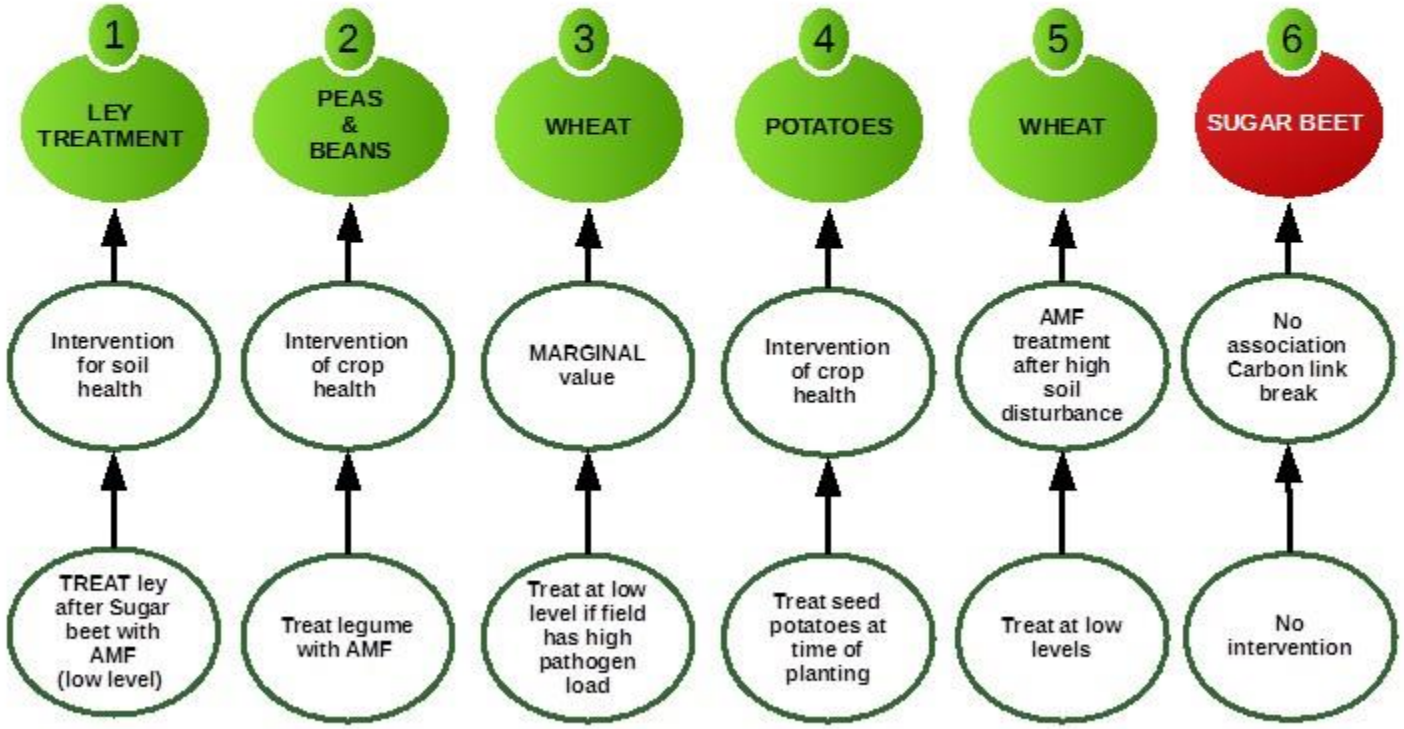
- Management of microbiology through farming method.



Smart Rotations

Mitigation by Intervention

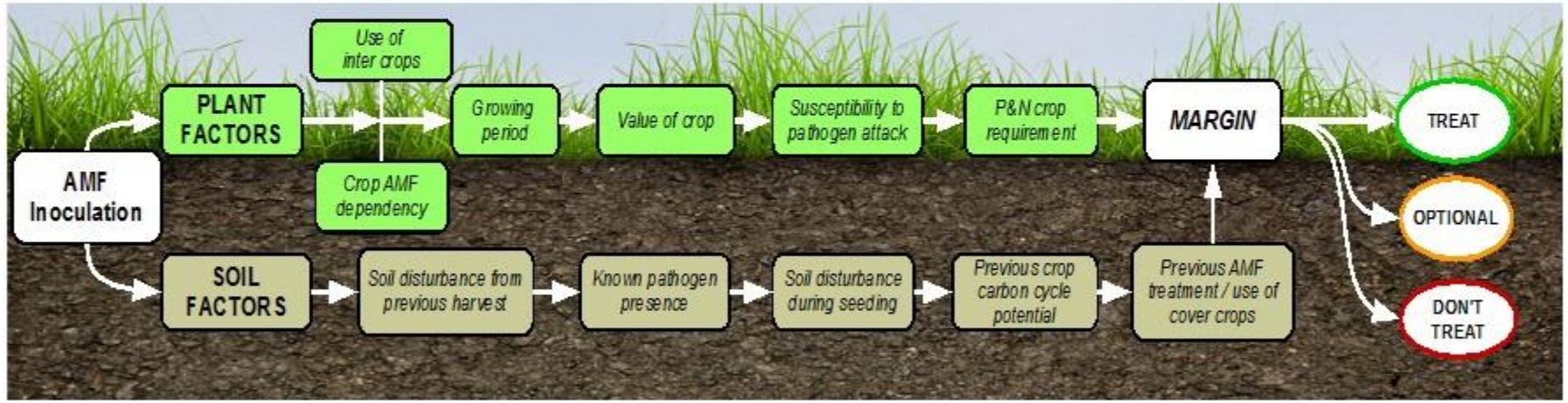
- Management of microbiology through use of inocula.



Smart Rotations

Plant and Soil Factors

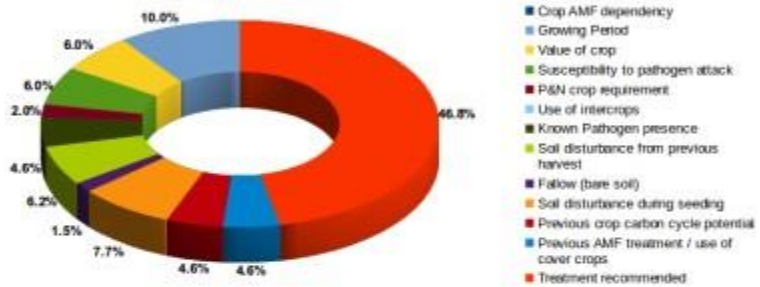
- Factors to be considered when inoculating.

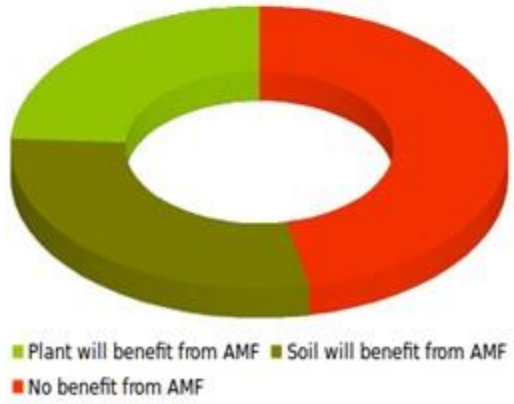


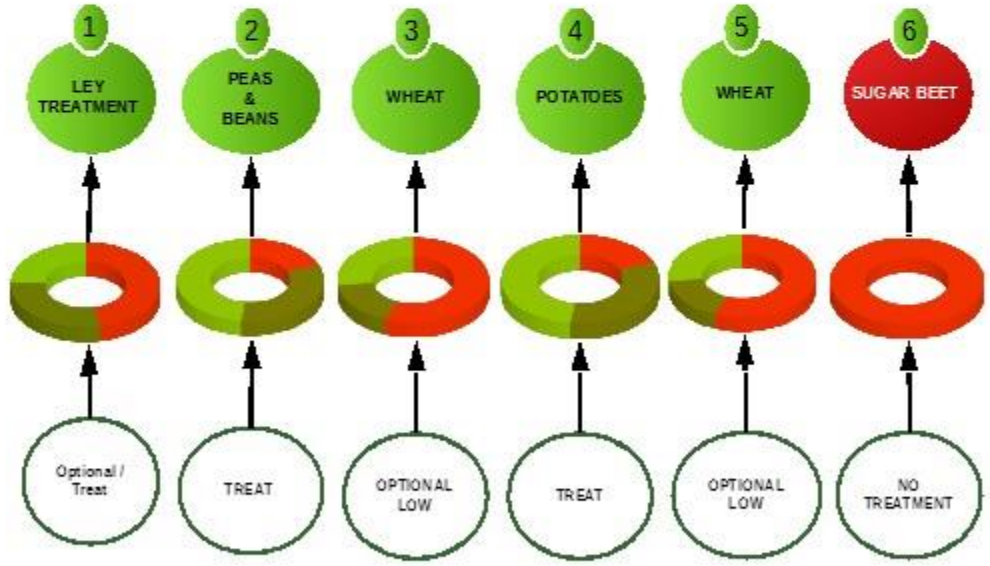
Smart Rotations

Score Card System

- Takes into account plant and soil factors to make treatment recommendation.







RGPro AG-Grow Products

Products designed for Agricultural Applications


RGPRO 1
AG • GROW

Many UK vegetables and pulses are highly dependent on soil micro-organisms for the delivery of essential nutrients, water and trace elements. RGPRO AG•GROW 1 contains a special blend of mycorrhizal fungi and plant growth promoting rhizobacteria to support enhanced soil microbial function when planting.

Benefits from treatment include:

- Increased N and P availability and uptake
- Improved crop quality
- Increased systemic plant resistance
- Increased water use efficiency

WHAT ARE MYCORRHIZAL FUNGI (AMF)?

WHAT ARE PLANT GROWTH PROMOTING RHIZOBACTERIA (PGPR)?

USES WITHIN ROTATION FARMING:

Seed Drilling:

APPLICATION:

RECOMMENDATION:

FORMULATION:

FARMERS NOTES:

RGPro AG-Grow Products

Products designed for Agricultural Applications

Product Name	Crop Types	Sowing Methods	AMF	PGPR
RGPRO AG•GROW 1	Vegetables and pulses	Seed drilling	Funneliformis mosseae, Funneliformis geosporus, Claroideoglomus claroideum, Rhizophagus irregularis, Rhizophagus microaggregatum	Gluconacetobacter diazotrophicus Agrobacterium spp Bacillus amyloliquifaciens Bacillus megaterium Rhizobium Species
RGPRO AG•GROW 2	For cover, leys and forage	Seed drilling & broadcasting	Funneliformis mosseae, Funneliformis geosporus, Claroideoglomus claroideum, Rhizophagus irregularis, Rhizophagus microaggregatum	Gluconacetobacter diazotrophicus Azosprilum brasilense Bacillus amyloliquifaciens Bacillus megaterium Rhizobium Species
RGPRO AG•GROW 3	Brassicaceae	Seed drilling	None	Gluconacetobacter diazotrophicus Agrobacterium spp Azosprilum brasilense Azotobacter chroococcum Bacillus amyloliquifaciens Bacillus megaterium Rhizobium Species

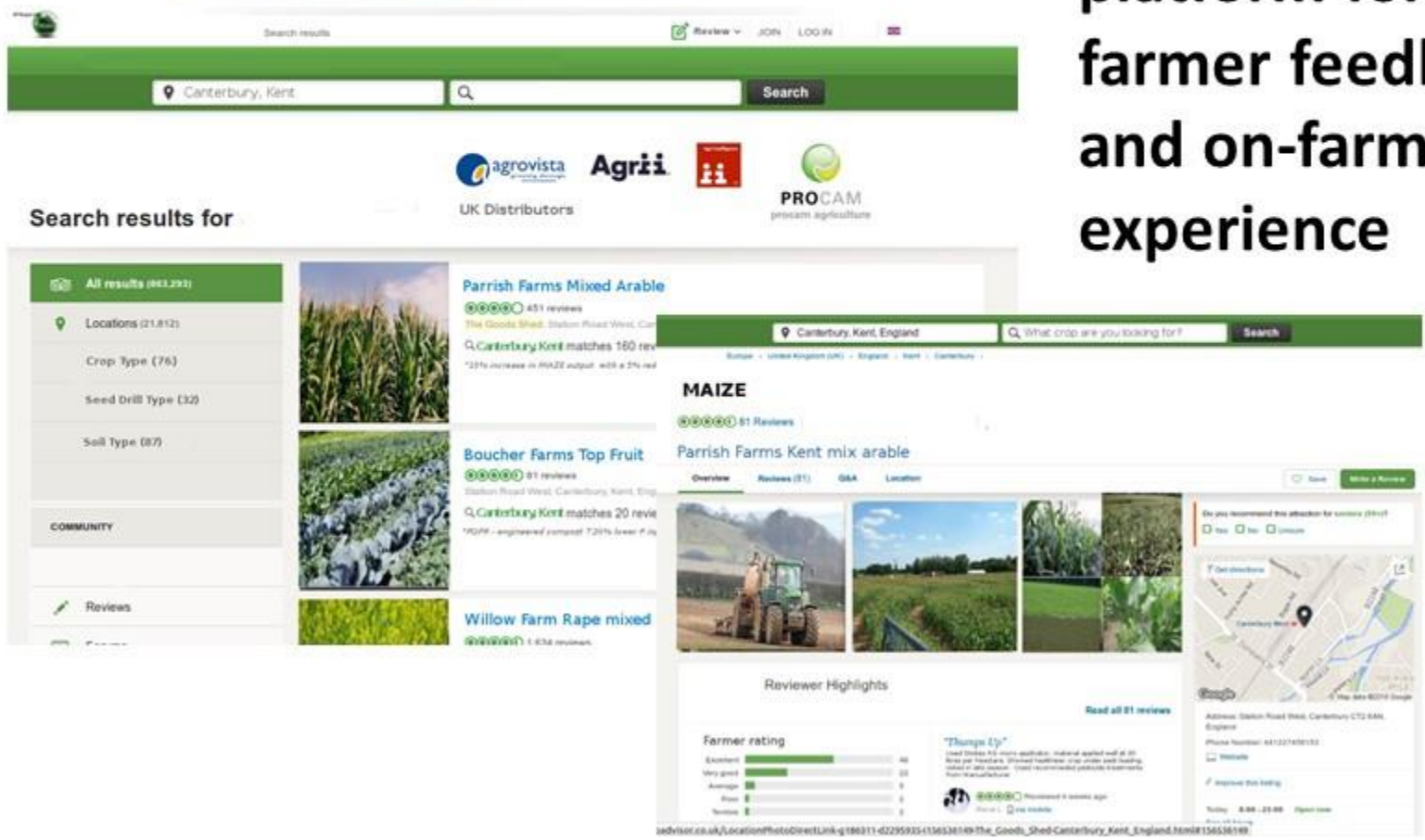
KEY

- Suitable for Seed Drilling
- Zero Harvest Interval
- Field Production
- Natural Bioadditives
- Zero Residue
- Suitable for Seed Broadcasting

Plant Works

PlantWorks Soil Hub

Web-based platform for farmer feedback and on-farm experience



Summary

- AMF: An ancient symbiont of 80% of vascular plant families
- Extensive scientific research shows wide range of benefits
- PlantWorks inoculum produced in UK and tested rigorously for efficacy
- Practices in Conservation Agriculture ideally support biological applications and maintenance
- Better understanding of application and management strategy for use of microbes in commercial farming needed

Microbes are a real possibility for aiding sustainable crop production

Contact

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