

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

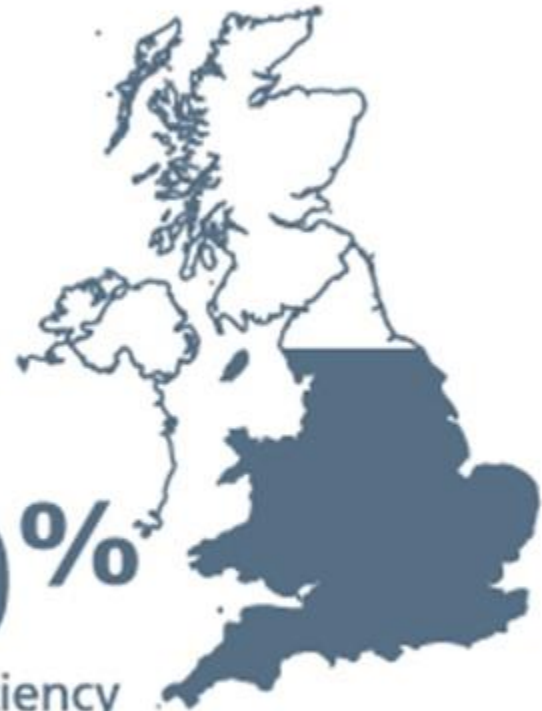
Food production in developing countries needs to almost double by 2050

The British Farming challenge

Produce more, sustainably, for the long term

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

60%
self-sufficiency



Mycology in the UK

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

Soil quality is a function of three factors:

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



The last domain of intervention

Mycology in the UK

Sheffield
University

JAMES HUTTON
INSTITUTE

YORK
University

CAMBRIDGE
University

BRISTOL
University

2016

ROYAL
HOLLOWAY
University

NIAB

EAST MALLING
RESEARCH

WARWICK
University

ABERDEEN
University

LEEDS
University

OXFORD
University

MANCHESTER
Met. University

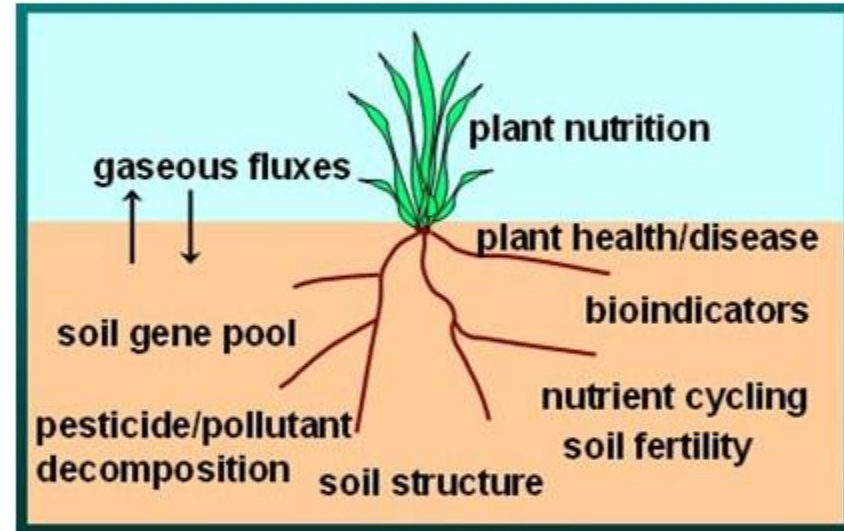


Soil Microorganisms

Essential for the maintenance of soil fertility

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

Fungi, Bacteria, Actinomycetes,
Algae and Protozoa



Rothamsted Research, 2016





*Arbuscular
Mycorrhizal Fungi*

What are Mycorrhizae

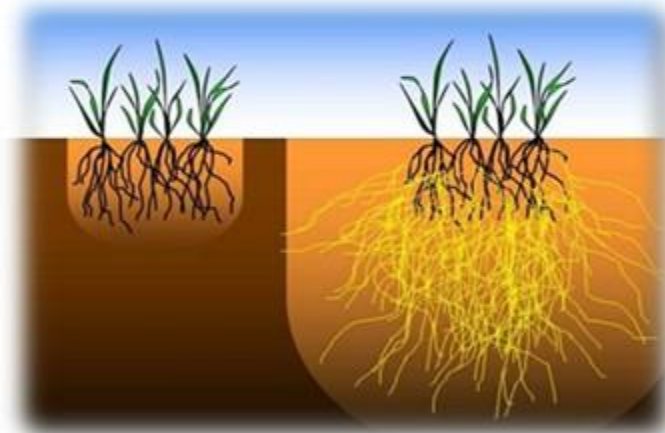
Symbiotic association
between a fungus and
the roots of a plant

Obligate mutualistic
symbiosis with >80%
vascular plant families



Mycorrhizal fungi

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



'Mycor' = Fungus

'Rhiza' = Root

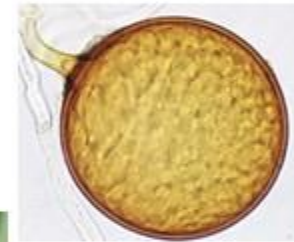
Root uptake surface increased up to 700 times

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

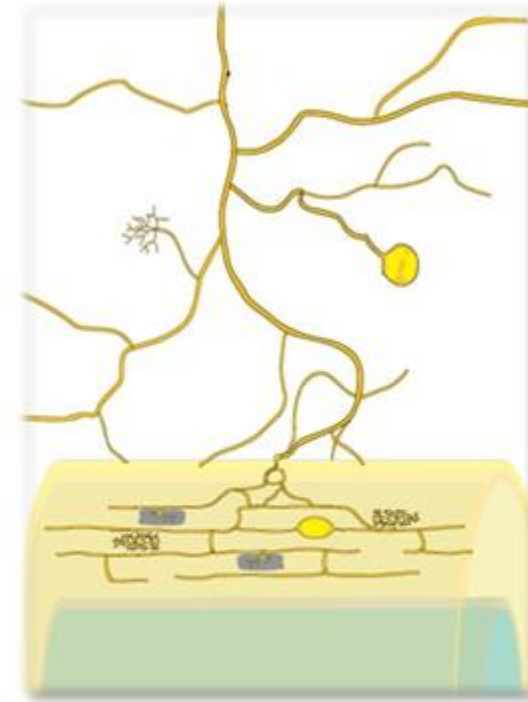


Non-mycorrhizal plants – Brassicaceae, Amaranthaceae

AMF

Arbuscular mycorrhizal fungi:

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

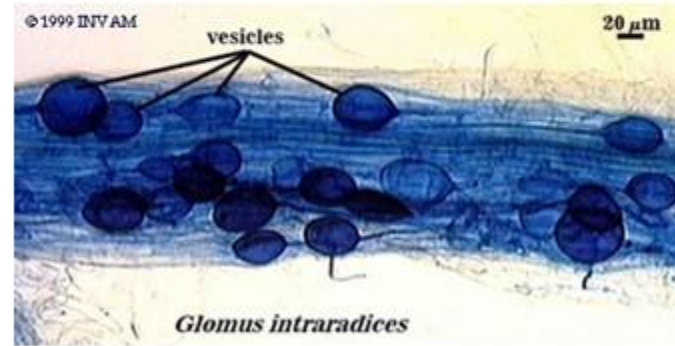
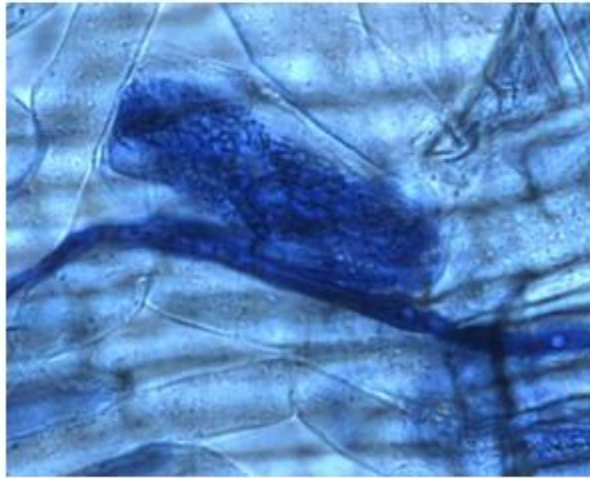
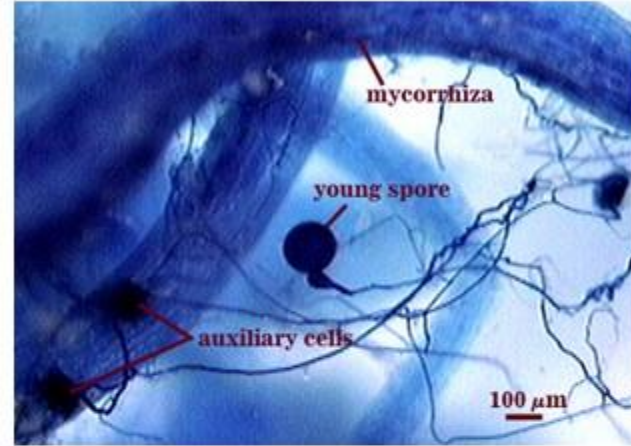
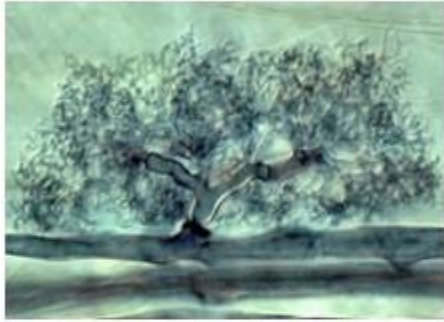


Mineral nutrients
and water extracted
from the soil

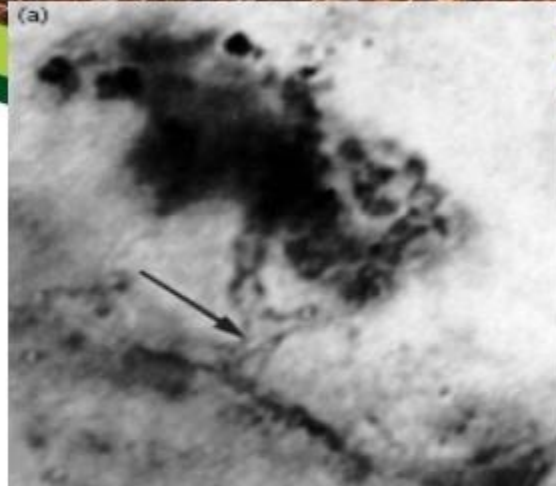


Organic carbon
compounds transferred
to fungus

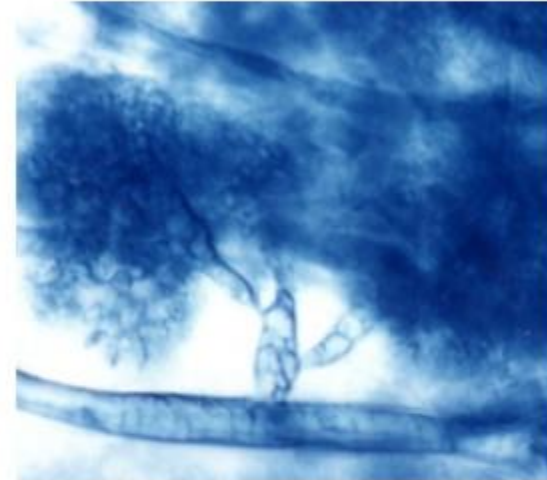
AMF



Fossil record



460 million year old fossil



Present Day stain

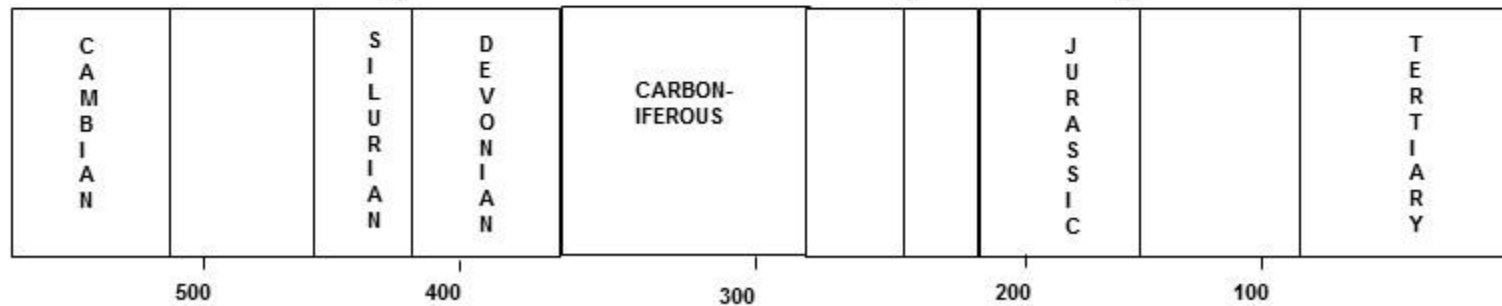
Origin of Arbuscular mycorrhizal fungi



Original land plants

ECMF evolve for trees

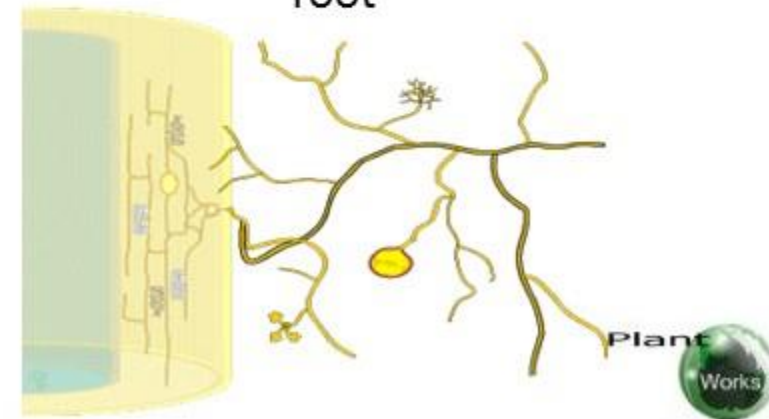
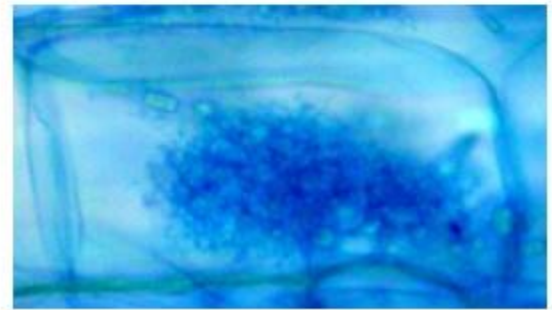
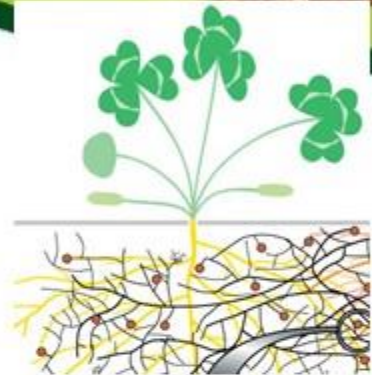
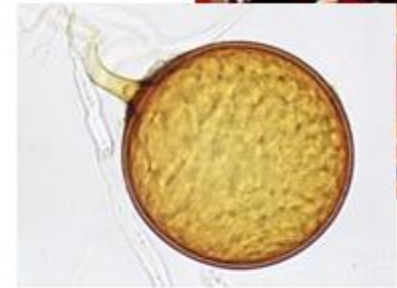
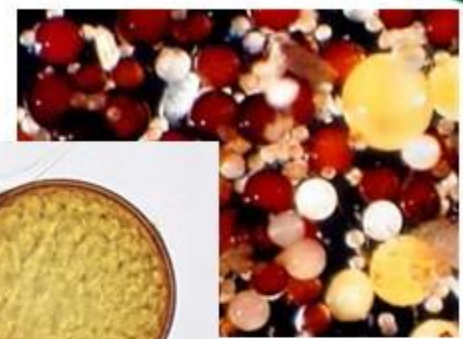
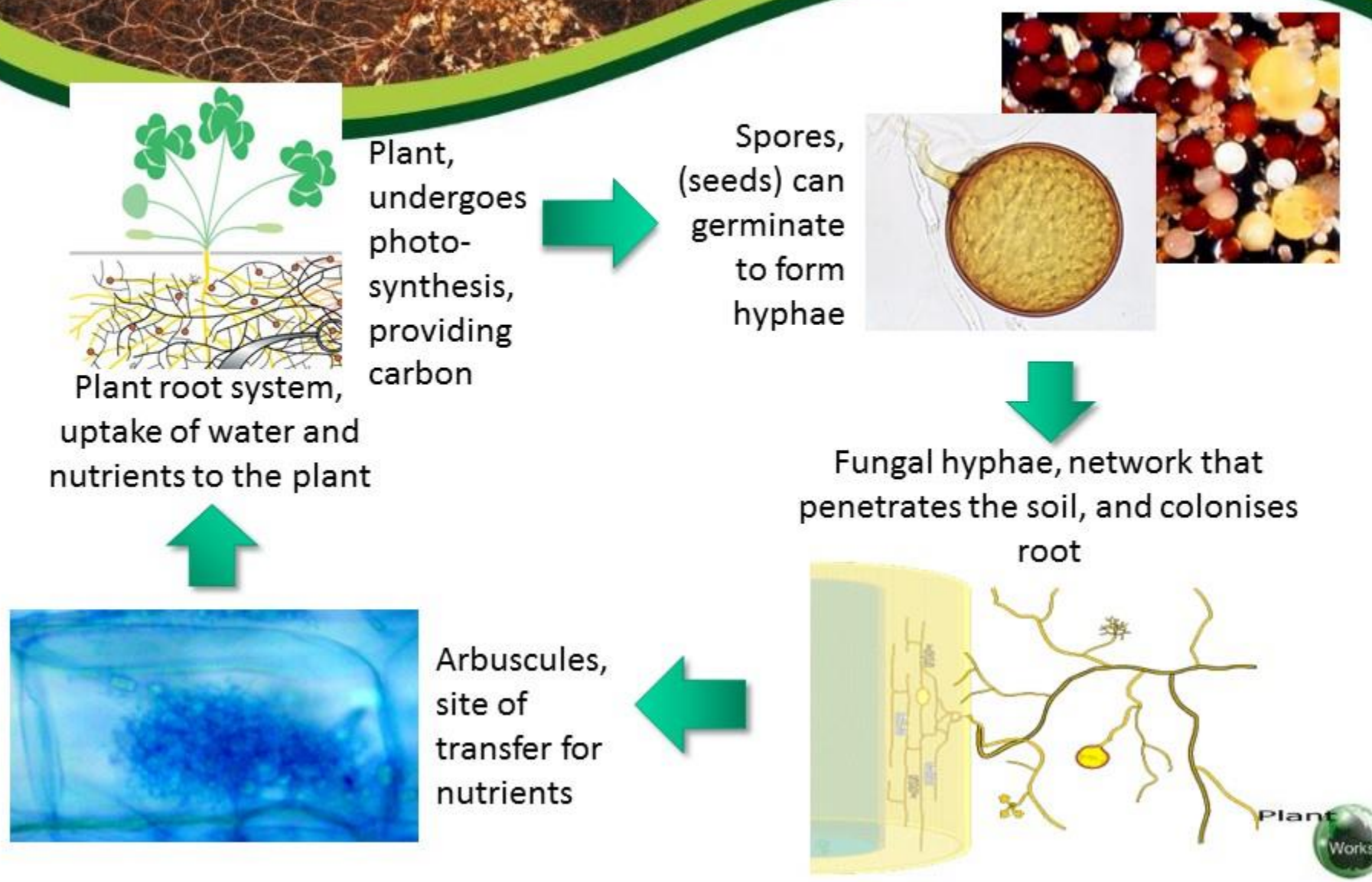
Flowering plants emerge



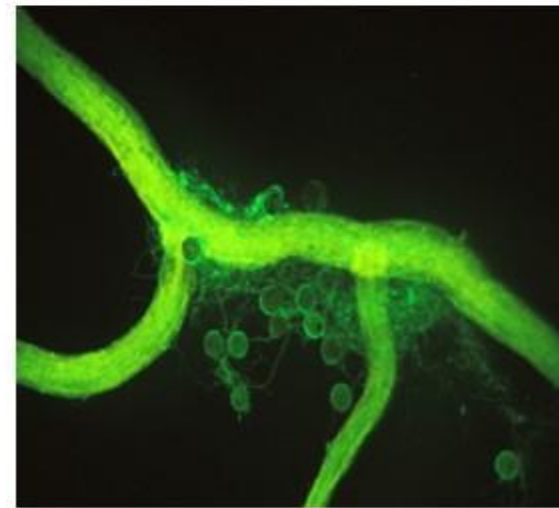
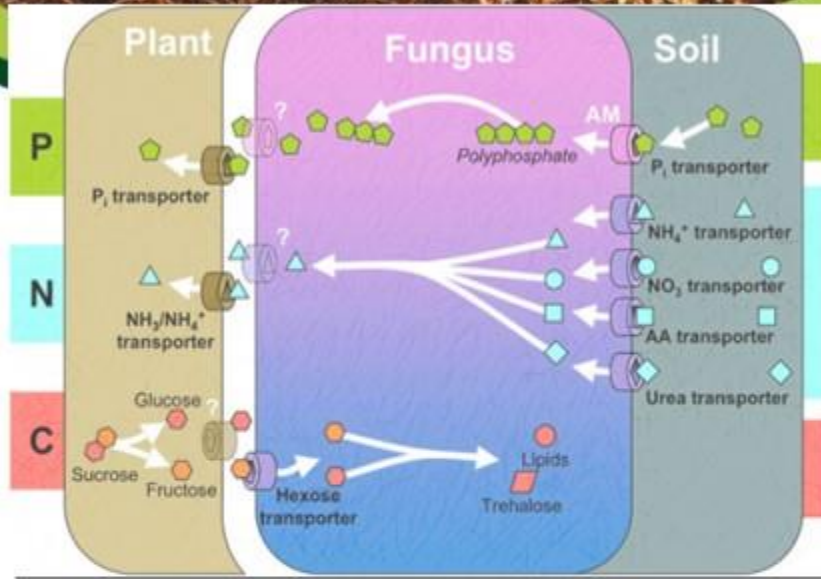
TIME (millions of years)



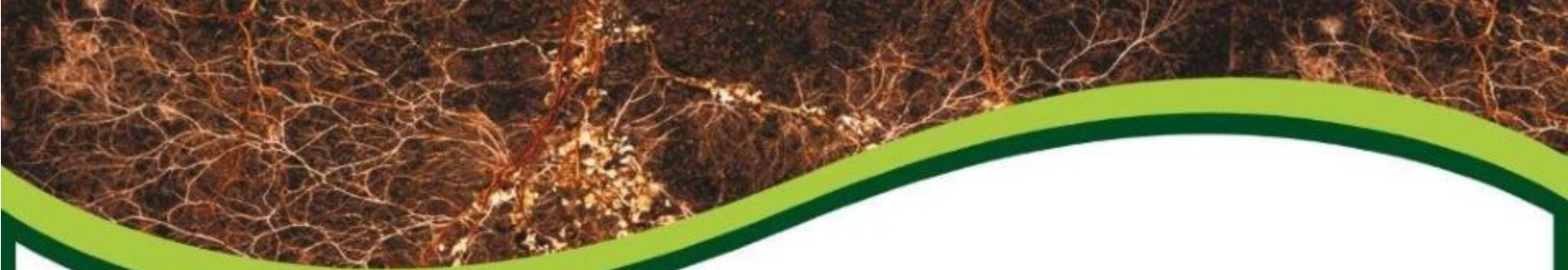
AMF



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)**.



- 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



Retail



Licensing



Production and QA

Current production:

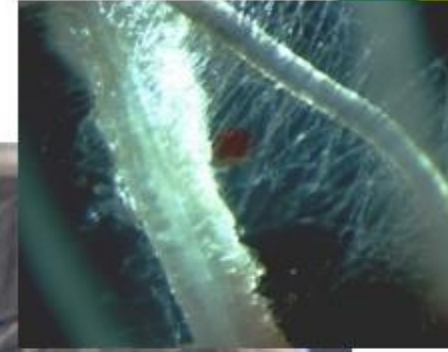
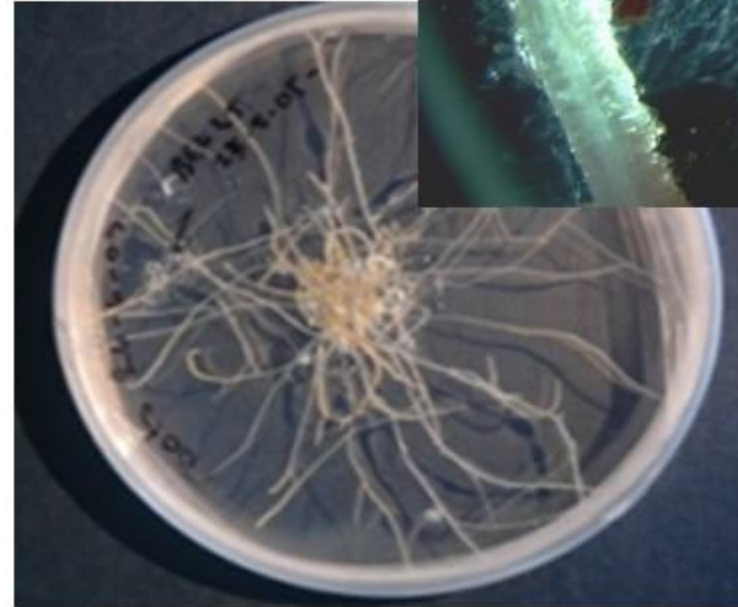
- **100 tonnes** per annum (*in vivo*)
- **5 species** in bulk pure culture
- Blended ex production to min **500,000 MPN**
- **Coarse and fine grade** substrates (1-3mm, 0.5-1mm)

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 Greenhouse 1 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 pratense*) and marigold mix (*Tagetes patula*).

QA manager	Signed	Date
Natalia Gubis		

- Protocol 4:** Clearly label bags with Batch No.
- Protocol 5:** Grow for 12 months in Greenhouse 1 and 2 or alternative grows environment, employing good greenhouse management.

QA manager	Signed	Date
Natalia Gubis		

- 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
Natalia Gubis		



PlantWorks Limited
Unit 8/9 Cornhill Drive
Kent Science Park
 Sittingbourne
Kent
ME9 8PX

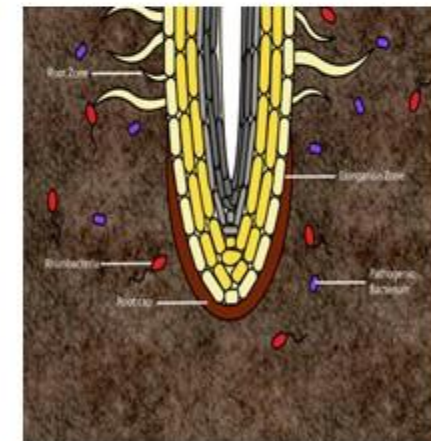
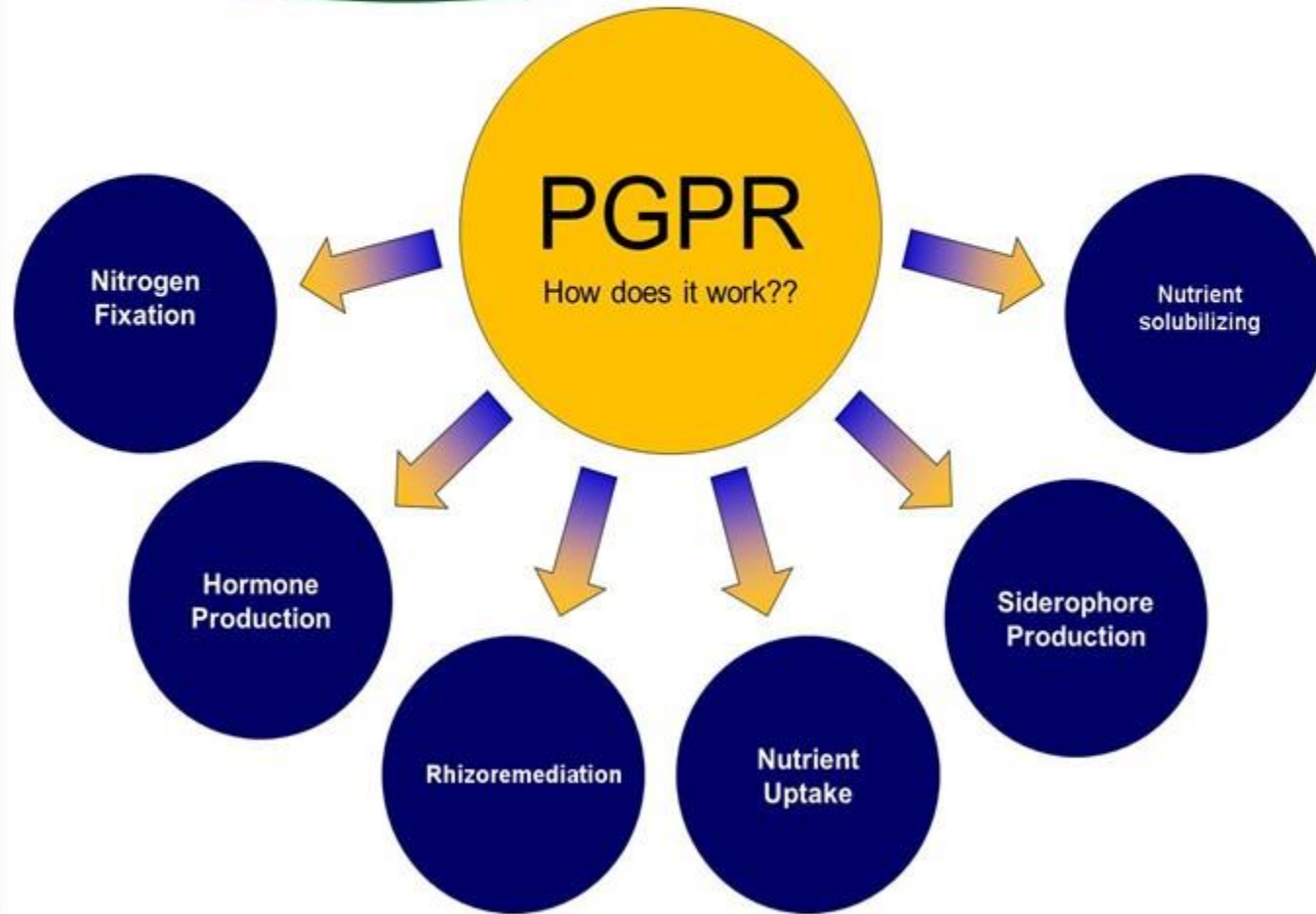
Tel: +44(0) 1875 411527
Fax: +44(0) 1875 411528

Email: info@plantworksuk.co.uk

Registered in England: 390685

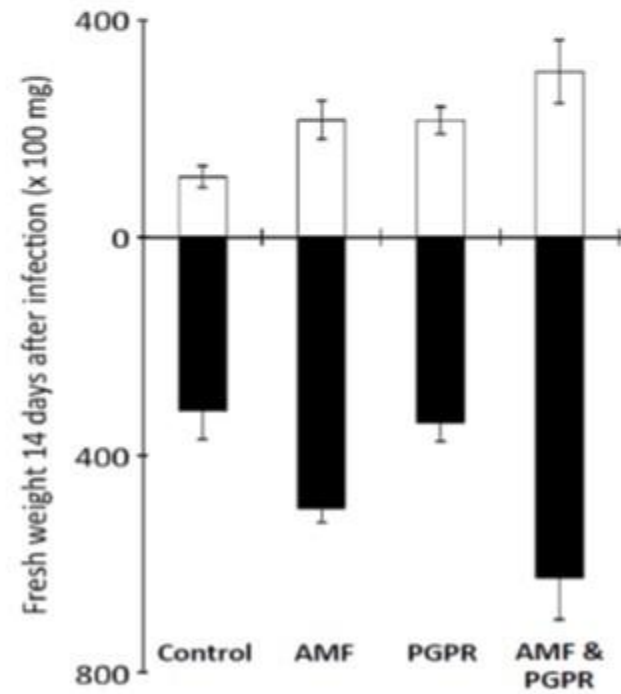
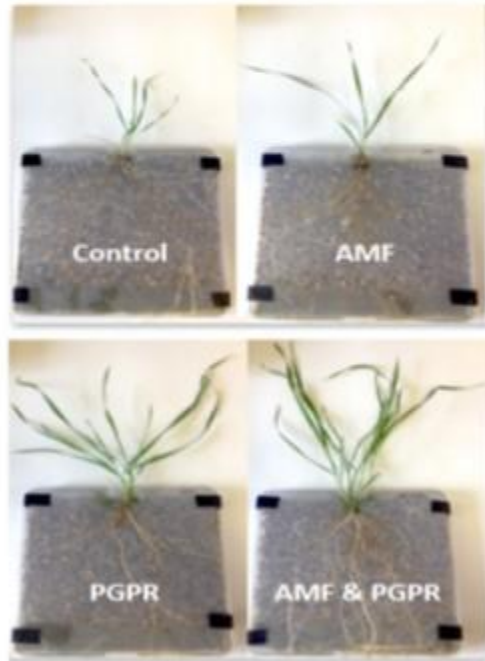


Plant Growth Promoting Rhizobacteria (PGPR):



AMF + PGPR - microorganisms in Synergy

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



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



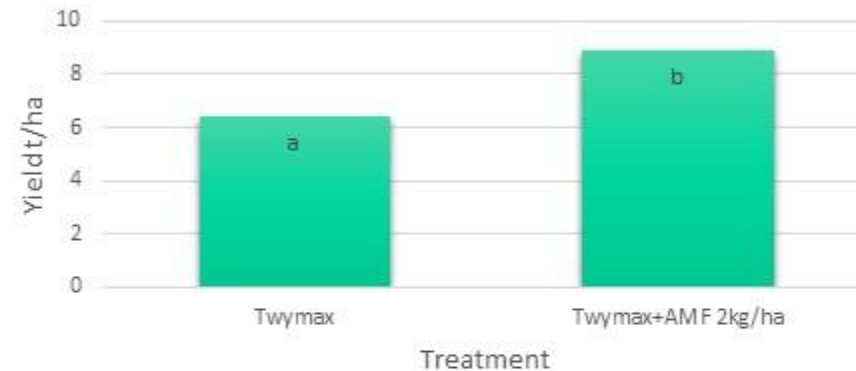
Trials 2015/16

Limagrain UK:

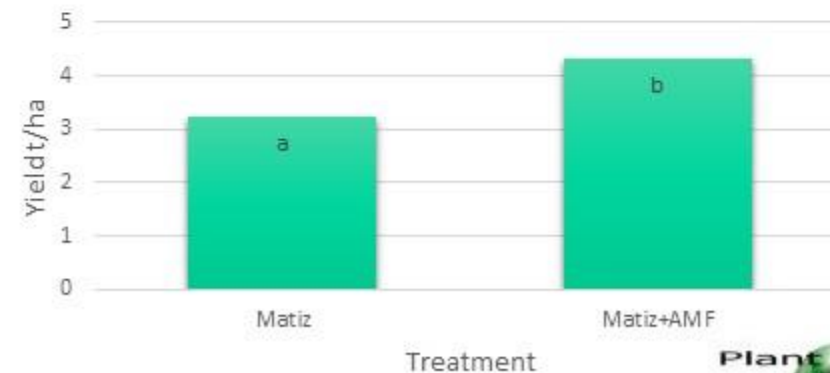
- Fodder grass and maize trials 2015
- Increased yields on grass
- Repeats on both crops in 2016
- Pea trials 2015: Increased yield



TWYMAX Perennial ryegrass Total Dry Matter Yield



Matiz Perennial Ryegrass Total Dry Matter Yield



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

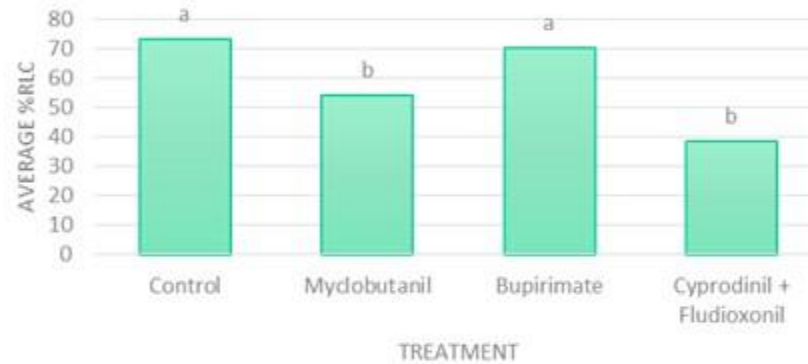


Challenges

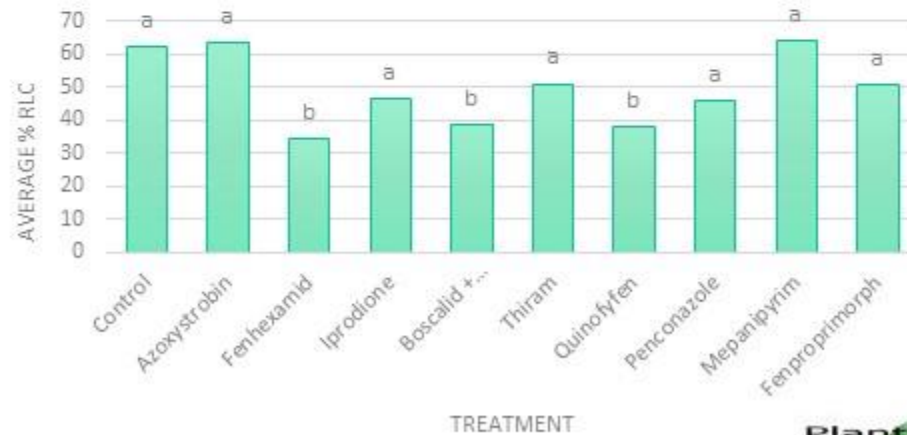
Pesticides

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

Fungicide AMF Interactions



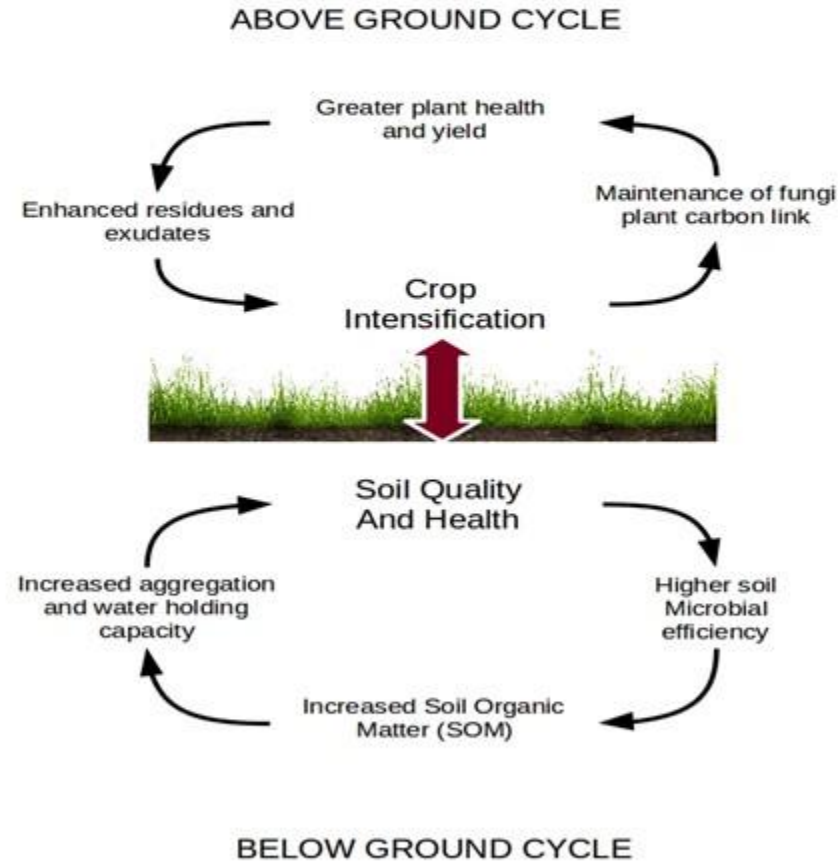
Fungicide AMF Interactions



Smart Rotations

The Concept

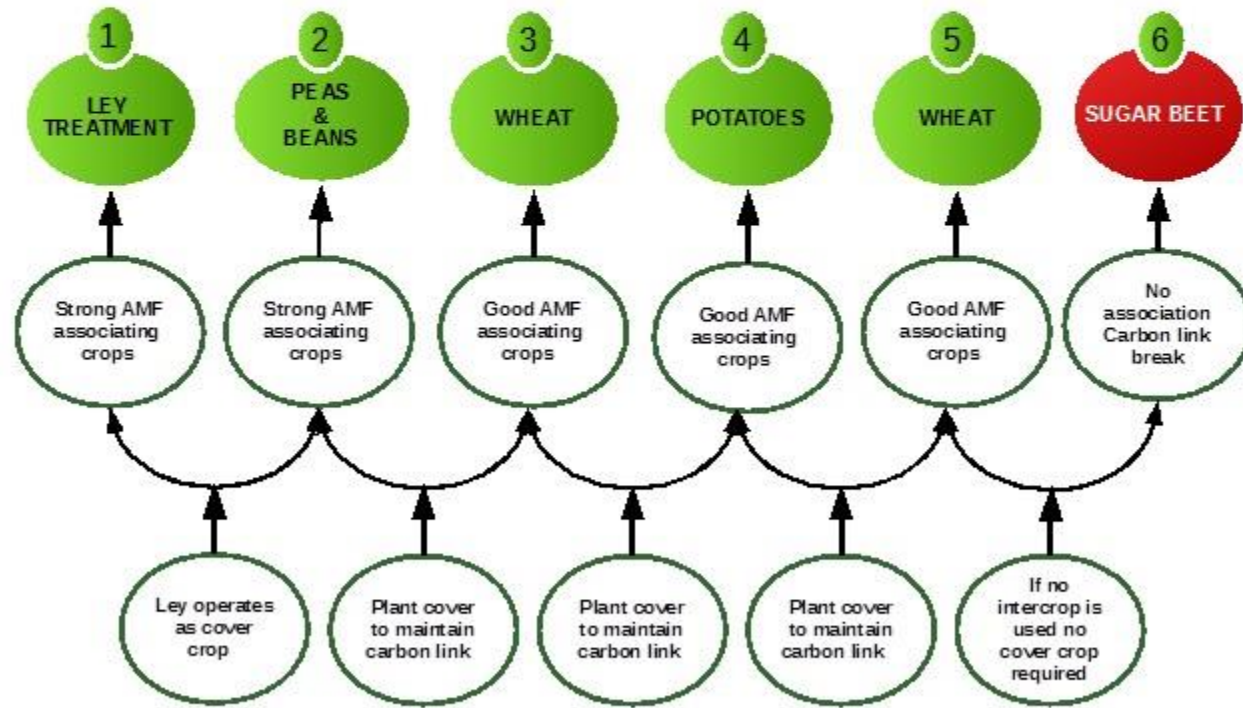
- Maintain a carbon link between microbial communities and host crops during commercial production of food and forage.



Smart Rotations

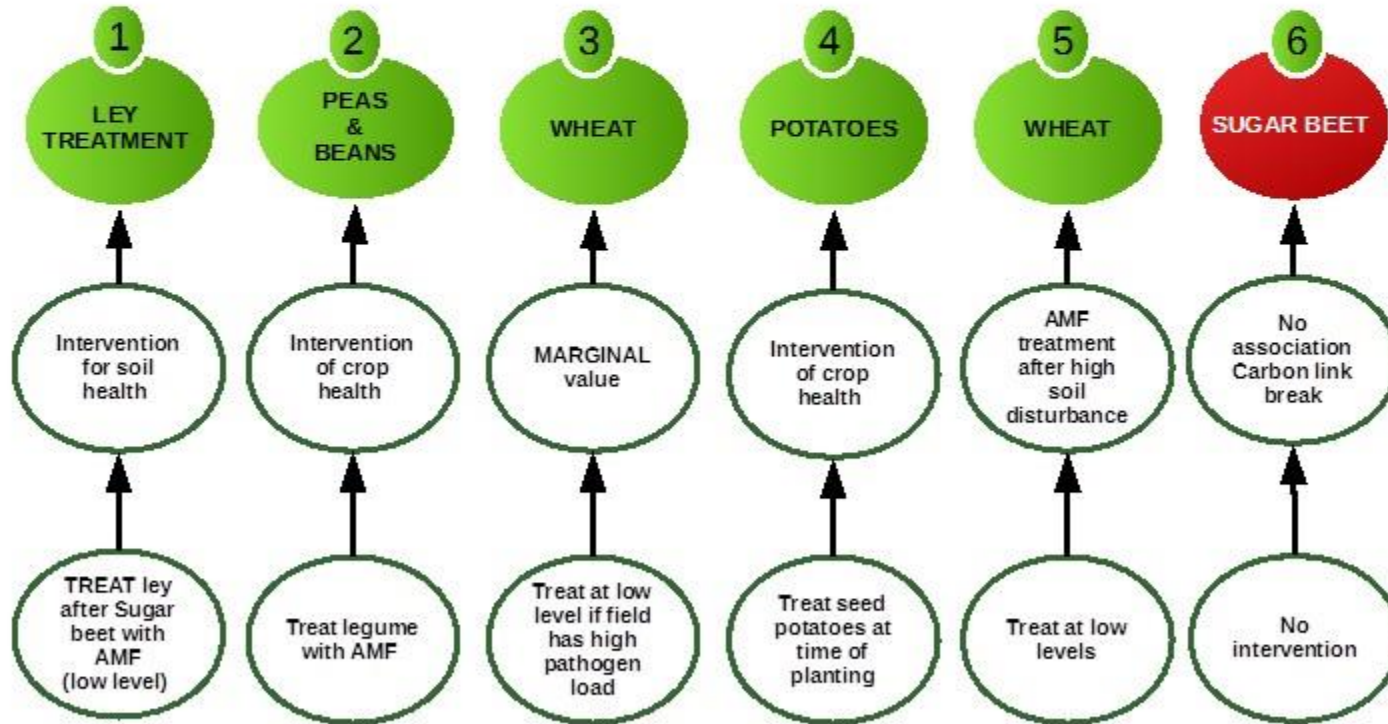
Mitigation by method

- Management of microbiology through farming method.



Mitigation by Intervention

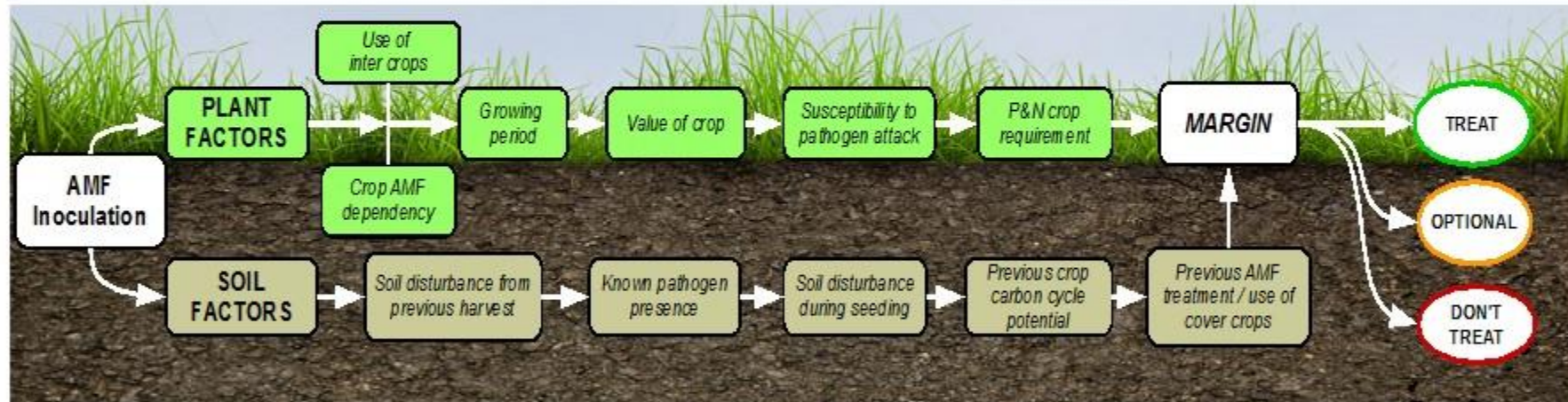
- Management of microbiology through use of inocula.



Smart Rotations

Plant and Soil Factors

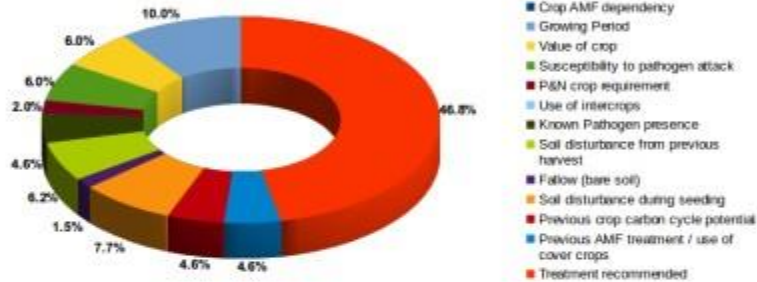
- Factors to be considered when inoculating.



Smart Rotations

Score Card System

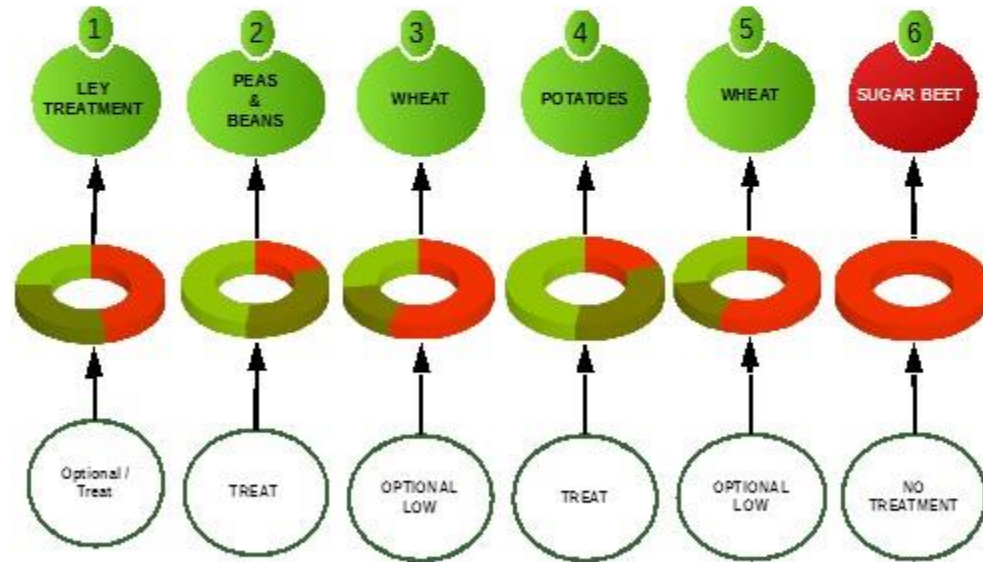
- Takes into account plant and soil factors to make treatment recommendation.



- Crop AMF dependency
- Growing Period
- Value of crop
- Susceptibility to pathogen attack
- P&N crop requirement
- Use of intercroops
- Known Pathogen presence
- Soil disturbance from previous harvest
- Fallow (bare soil)
- Soil disturbance during seeding
- Previous crop carbon cycle potential
- Previous AMF treatment / use of cover crops
- Treatment recommended



- Plant will benefit from AMF
- Soil will benefit from AMF
- No benefit from AMF



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)?

Mycorrhizal associations are symbiotic, enabling the plants to enhance acquisition and water uptake, reducing carbon transfer and protecting roots from pathogens. Mycorrhizal fungi associate with more than 80% of all land plants and as such most commercial crop plants can benefit from mycorrhizal colonisation.

WHAT ARE PLANT GROWTH PROMOTING RHIZOBACTERIA (PGPR)?

Plant growth promoting rhizobacteria (PGPR) form symbiotic associations with the mycorrhizal fungi in the soil, to increase nutrient availability for plants while stimulating plant growth by producing growth-promoting hormones and inducing systemic resistance against root and shoot diseases.

USES WITHIN NOTATION FARMING

Mycorrhizal fungi require a suitable host plant to support a mutual exchange of plant carbohydrates for nutrients and water. Although 80% of all food crops are compatible with mycorrhizal fungi non-associating plants include members of the Brassicaceae and Umbelliferae families.

Resowing the carbon cycle between plant and fungi within a rotation increases the soil microbial activity that can have a sedimentary effect on future on-crops.

Seed Drilling:

Normal rate: 10L ~ 10kg/ha
 Example: 24 coulters @ 400 over 5.0ha rate
 43776 linear meters per hectare (20kg)
 broadcast rate 5.2ha/ha

Optimal rate 20L ~ 20kg/ha
 24 coulters @ 400 over 5.0ha rate
 43776 linear meters per hectare (20kg)
 broadcast rate 5.2ha/ha



APPLICATION:
 Suitable for seed drilling and broadcasting, the recommended rate of application at time of planting.

RECOMMENDATIONS:
 It is RGPRO AG-GROW 1 for application on vegetables that follow on from crops that are non-mycorrhizal, such as brassicaceae and umbelliferae. Can also be used at any time when growing other crops.

FORMULATIONS:
 This product contains four arbuscular mycorrhizal fungi (AMF) and plant growth promoting rhizobacteria (PGPR) and is produced in the UK. The mycorrhizal fungi component contains spores, inoculum and dried commercial seed (Fragaria, L. SPIN - 5000). Bacteria are provided at 10¹⁰ CFU. This product does not contain herbicides.

FARMER'S NOTE:
 The carrier used in RGPRO AG-GROW 1 is a peat-based and may affect seed sowing if sowing holes are used in any broadcasting application. Please refer to your manufacturer's recommendations for suitability of your system when using this product.

PlantWorks Ltd Unit 8/9
 Cambridge Drive, Boreham Heath, West Sussex PO19 2AF
 Tel: 01795 411132
 Fax: 01795 411133
 Email: info@plantworksltd.co.uk
 www.rgpro1.co.uk




RGPRO 1 AG-GROW FOR SEED DRILLING

1

Mycorrhizal Fungi for AGRICULTURE

FIELD GROWN VEGETABLES



10L~10KG

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

For technical enquiries please contact your supplier or PlantWorks on 01795 411 327 or email info@plantworksltd.co.uk

Produced in the UK 



RGPro AG-Grow Products

Products designed for Agricultural Applications

RGPRO
AG-GROW
FOR SEED DRILLING

1

Mycorrhizal Fungi for
AGRICULTURE

FIELD GROWN VEGETABLES



RGPRO
AG-GROW
FOR COVER, LEYS, & FORAGE

2

Mycorrhizal Fungi for
AGRICULTURE

USE WITHIN ROTATION SYSTEM TO BUILD SOIL LIFE



RGPRO
AG-GROW
FOR BRASSICACEAE

3

Beneficial Bacteria for
AGRICULTURE

FOR FIELD GROWN CROPS



Product Name	Crop Types	Sowing Methods	AMF	POPR
RGPRO AG-GROW 1	Vegetables and pulses	Seed drilling	Funnelformis mosseae, Funnelformis geosporus, Claroideogiomus 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	Funnelformis mosseae, Funnelformis geosporus, Claroideogiomus claroideum, Rhizophagus irregularis, Rhizophagus microaggregatum	Gluconacetobacter diazotrophicus Azospirillum brasilense Bacillus amyloliquifaciens Bacillus megaterium Rhizobium Species
RGPRO AG-GROW 3	Brassicaceae	Seed drilling	None	Gluconacetobacter diazotrophicus Agrobacterium spp Azospirillum 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



PlantWorks Soil Hub

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

The screenshot displays the PlantWorks Soil Hub web application interface. At the top, there is a search bar with 'Canterbury, Kent' entered. Below the search bar, logos for 'agrovista', 'Agrii', and 'PROCAM' are visible. The main content area shows search results for 'Parrish Farms Mixed Arable' in Canterbury, Kent, England. The results include a list of items with their respective crop types and review counts. A detailed view of the 'Parrish Farms Kent mix arable' item is shown, featuring a 'Farmer rating' bar chart, a 'Thanks Ep!' section with a review snippet, and a map of the location. The interface is clean and professional, with a green and white color scheme.

Search results for

- All results (643,293)
- Locations (21,812)
- Crop Type (76)
- Seed Drill Type (32)
- Soil Type (87)

COMMUNITY

- Reviews

UK Distributors

agrovista Agrii PROCAM

Search results for: Canterbury, Kent

Search results for: Canterbury, Kent, England

What crop are you looking for?

MAIZE

Parrish Farms Mixed Arable

4.5/5 (451 reviews)

The Goods Shed, Station Road West, Canterbury, Kent, England

Canterbury, Kent matches 100 reviews

20% increase in MAIZE output with a 2% net

Boucher Farms Top Fruit

4.5/5 (81 reviews)

Station Road West, Canterbury, Kent, England

Canterbury, Kent matches 20 reviews

70% increase in arable output with a 2% net

Willow Farm Rape mixed

4.5/5 (1,434 reviews)

Parrish Farms Kent mix arable

4.5/5 (81 reviews)

Farmer rating

Excellent	40
Very good	20
Average	10
Poor	5
Terrible	5

"Thanks Ep!"

Used tractor for more application, material applied well at all. Worked well, showed excellent crop under good heading, which is also visible. Used recommended pesticide treatments from manufacturer.

Do you recommend this attraction for visitors (0/0)?

Yes No Unsure

Address: Station Road West, Canterbury CT2 6AN, England

Phone Number: 01227460033

Website

Approved this listing

Rating: 4.5/5 (81 reviews)

adviser.co.uk/LocationPhotoDetailLink?g186311-42295935-136536149-The_Goods_Shed-Canterbury_Kent_England.html#136536149



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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Mob: 07863 962 040

