Utilization and Management of Mycorrhiza to Support Land Productivity: The Philippines’ Experience

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Order of presentations

I. What is mycorrhiza?
II. Mycorrhizal technologies
III. Utilization for enhanced land productivity
MYCORRHIZA

“mykes” (fungus) “rhiza” (roots)

Highly interdependent mutualistic relationship

Benefits:

- Obtains photosynthetically derived carbon compounds = carbohydrates as food
- Host to complete life cycle - spore-hyphae-spore

- Receives more mineral nutrients and water
- Has root extenders, since fungal hyphae are thinner, spread wider and deeper into the soil
Facts about Mycorrhiza

- ubiquitous (found everywhere)
- normal plant status is mycorrhizal
- abnormal = non-mycorrhizal

Mycorrhizal effects are best observed if plants are grown under stressed conditions: infertile soil, low moisture, presence of heavy metals, too acidic or basic soil.
Why study mycorrhiza?

Benefits derived from mycorrhizal association:

- increased absorption of nutrients: P, Cu, Zn, N, K, Ca
  - hyphae are able to extend beyond reach of root hairs
    important for poorly mobile elements & those bound by soil particles
- increased drought resistance of plants
- serves as biological control of root pathogens
  - utilizes surplus CHO thus reducing attractiveness to root pathogens
  - provides physical barrier thus prevent direct contact of root tissues
- enhanced activity of other beneficial microorganisms
- production of growth promoting hormones
- improves soil structure by secreting mucilagenous substances
COMMON TYPES OF MYCORRHIZA

1. Vesicular-Arbuscular Mycorrhiza (VAM)

- Found in all vascular plants: grasses, agricultural crops, fruit & forest trees
- Belong to Zygomycetes (lower fungi)
- Produce special structures: vesicles (food storage) arbuscules (site of nutrient exchange)
- Cannot be cultured without the host
- Penetrate inside cortical cells hence also called endomycorrhizal (endo = inside)
Fig. 1 Spores of *Acacinospora scrobiculata* in water (Bar = 500 μm)

Fig. 2 Spores of *Glomus caledonium* in water (Bar = 500 μm)

Fig. 3 Spores of *Glomus constrictum* in water (Bar = 500 μm)

Fig. 4 Spores of *Scutellispora erythropa* in water (Bar = 500 μm)
Mycorrhizal spores

roots

Fungi going inside the roots and completing life cycle to make new spore

Each fungal hyphae serves as additional roots for greater nutrient & water absorption; also protects roots from pathogens

Mycorrhiza

Mycor= amag  rhiza= ugat
2. Ectomycorrhiza (ECM)

- found in tree species such as pines, Dipterocarps, Casuarinas & Eucalypts
- belong to Ascomycetes & Basidiomycetes (higher fungi)
- infected roots are enlarged and covered with fungal mantle (rhizomorphs) & hartig net = sheath
- can be cultured in agar media
- does not penetrate cortical cells but just between cell walls hence just outside “ecto”
Ectomycorrhizal roots

Brundrett et al. 1996

Sheath- cover
Summary of endo vs ecto mycorrhiza

Cross section of an ecto and endomycorrhiza.
Order of presentations

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Birth of BIOTECH-UPLB...

- The National Institute of Molecular Biology and Biotechnology (BIOTECH) was conceived during the energy crisis in 1970.
Birth of BIOTECH-UPLB...

- Key scientists of UPLB collaborated and fused the physical & biological sciences to capitalize on the country's resources for the development of alternative solutions to energy and food problems.
- Biotechnology as "a strategic tool for achieving sustained economic development" (DOST, 1986).
**BIOTECH microbial inoculants**

**Biofertilizers** – microbial inoculants with live or latent cells providing nutrients to crops *i.e.* N fixer, P&K solubilizers, cellulose degraders

**Biostimulants** – organic substances enhancing plant growth and development when applied in small quantities *i.e.* auxins, cytokinins, gibberellins

**Biopesticides** – naturally occurring substances and microbials that can reduce population of insect pests and pathogens *i.e.* antibiotics, microbes with antagonistic properties
Concerns on Low Productivity

- MORE FOOD
- SUBSTITUTE and/or SUPPLEMENT
- IMPROVE SUSTAINABLE AGRICULTURE

Bringback soil health and biodiversity
Plants need all 16 elements in order to grow and provide yield.
Inoculation with mycorrhiza can very well support the supply of the limiting nutrient.
Mycorrhiza research beginnings......

Dr. Reynaldo E. dela Cruz
Father of Mycorrhiza research

✔ isolation
✔ identification
✔ Mass production
✔ Inoculation trials
Mycorrhizal Technologies in the Philippines

ENDO
Mykovam
VAMRI

ECTO
Mycogroe

Brown magic
Hi Q VAM
MykoPlus
Vegetative mycelia
Order of presentations

I. What is mycorrhiza?
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Inoculation trials on Pinus caribea...
Dela Cruz, RE 1980s
Fertilizer and Mycogroe application trials on Eucalyptus deglupta Bislig, Surigao

Dela Cruz et al  1988
Phosphorus deficient soil

UNINOC  60-60-60  GL ETUNICATUM  60-60-60  GL MACROCARPUM  60-60-60  G MARGARITA  60-60-60
TWO MONTHS EGGPLANT

UNINOC  60-60-60  GL ETUNICATUM  60-60-60  GL MACROCARPUM  60-60-60  G MARGARITA  60-60-60
PEANUT TWO MONTHS

MYKOVAM
Zarate, JT. 1990
P deficient soil
How to use Mykovam?

- Banding (5 – 10 g/plant)
Uninoculated and MYKOVAM inoculated marang (A), langka (B) and honeydew (C)
Mykovam for growth promotion of banana

Source: NS Aggangan
Biological control of Mykovam in fusarium infested plant

Source: NS Aggangan
Biological control of Mykovam in tomato infested with nematodes

Source: NS Aggangan
Use in bioremediation (mine sites)

Biofertilizers’ use in Bioremediation

Establishment of Jatropha plantation for biofuel in a mine waste dump site (Mogpog, Marinduque)

Chemical fertilizer alone

Biofertilizers plus soil amendments
Crop growth promotion

Tissue-cultured orchids with Brown Magic

BROWN MAGIC

CONTROL

Source: MB Brown
Collaboration with Non-Government Organization for coconut establishment

13 Coconut cooperatives, with Federation of Free Farmers

Source: JT Zarate
Hi Q VAM developed by DENR for the National Greening Program (NGP)

The inauguration of the DENR-ERDB Mycorrhizal Mass Production Facility was participated by DENR top officials and regional and bureau directors, and representatives from other DENR agencies and UPLB Science Community.
2012 Onwards

Interaction studies
(Mycorrhiza and other microbes)
Paddy rice crop growth promotion with mycorrhiza in association with blue green algae

Control
Mycorrhiza + Nostoc

Pot trial on paddy rice

Source: JT Zarate with Nico Cedicol
BS Thesis, UPLB
Acacia crassicarpa on Louisiana soil series
Interaction studies, mycorrhiza and PGPR
Solution to problems on low yield and income

Mycorrhiza
“mykes” “rhizaa”
Fungus - Root association

Other Microbes
N fixers
P solubilizers
Growth hormone secretors

serves as root extenders, root protection, provide active microbial diversity for healthier soil and plant
Good seed germination
Increase uptake of water and nutrients
Better growth
Higher yield & income

MykoPlus application

- Coated on seeds
- Coated on planting materials (cane points, tubers)
- Soil treatment on germination medium

70% RR + MykoPlus
Recommended Rate (RR)

Higher yield & income
MykoPlus
(Mix Microbial Biofertilizers)

More complete approach to crop productivity problems

Eggplant and bell pepper

Site: Bay, Laguna
Variety: P30760
Planted: 1 September 2012
Harvested: 17 December 2012

Farmers practice
120-28-28

Farmers practice
128-28-280 + MykoPlus

Source: JT Zarate
Higher seed germination in Lettuce plants with MykoPlus

Source: JT Zarate
Cassava tuber production

Farmers practice (Foliar spray)

FP + MykoPlus

Cassava field trial in 2 sites with FP and FP+ MykoPlus treatment

3rd Field trials on cassava

<table>
<thead>
<tr>
<th></th>
<th>Farmers Practice</th>
<th>FP+ MykoPlus</th>
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<tbody>
<tr>
<td>Mamala</td>
<td>15.62</td>
<td>27.26</td>
</tr>
<tr>
<td>Lutucan</td>
<td>9.72</td>
<td>11.08</td>
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</table>
Leafy vegetable and fertilizer interaction studies

Lettuce cv Green span at harvest (8 plants per tray)
### Eggplant

<table>
<thead>
<tr>
<th></th>
<th>Farmer’s practice (Fertilizers)</th>
<th>Fertilizers + MykoPlus</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit Yield kg/ha)</td>
<td>2,675</td>
<td>3,407</td>
<td>27% inc</td>
</tr>
<tr>
<td>Total Production Cost (US $ /ha)</td>
<td>520.11</td>
<td>542.84</td>
<td></td>
</tr>
<tr>
<td>Gross Income (US $)</td>
<td>2,431</td>
<td>3,097</td>
<td></td>
</tr>
<tr>
<td>Net Income (US $)</td>
<td>1,911</td>
<td>2,554</td>
<td>34% inc</td>
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### Results in other crops
- Early flowering
- Enhanced fruiting
- Drought resistance
Soil properties are improved

- with MykoPlus soil acidity is lessened
- less acidic soil
Soil properties are enhanced:

- Soil N is higher in MykoPlus applied plots

### Soil N (%) content before and after cropping

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<tr>
<th></th>
<th>Before</th>
<th>FP</th>
<th>FP+MYK</th>
<th>RR</th>
<th>70%RR+MYK</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Nitrogen</td>
<td>0.97</td>
<td>1.07</td>
<td>1.20</td>
<td>1.25</td>
<td>1.33</td>
</tr>
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Other activities

IEC materials

Seminars/Symposium

RR

70% RR + MykoPlus

30% savings in chem fertilizers N P and K
Inoculation effects of Mycorrhizal Products

- Better seed germination
- Taller height
- More vigorous growth
- Higher yield
- Higher income for farmers
- Lesser fertilizer application
- Better survival in field sites
- Better resistance to pest, pathogens, heavy metals
- Preservation of the environment
Current Trends

- Continue trials and optimization of use of MykoPlus
- Participation of government and industry to support commercialization of mycorrhizal products for reforestation and agriculture
- Microbial community analysis
- Intellectual property protection (IP)
Recommendation

- Need for more collaborative research, to fully study and explore mycorrhizal technologies

- Need to disseminate technologies and educate farmers/users of the use of mycorrhizal technologies
Acknowledgement

SEAMEO BIOTROP
SEARCA Los Baños
UPLB BIOTECH
DOST PCAARRD
DOST PCIERRD
Students and staff

“Let us be like the tulips, always lifting up our petals in all praise to our Maker.”

Thank you very much for your attention!