Why is charcoal so effective for plant growth ？

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Symbiosis between plants and microorganisms

1. Bacteria (*Rhizobium*) + Leguminous plants……..Root nodules…….Nitrogen fixation

2. Actinomycetes (*Frankia)* + Non-leguminous plants……..Actinorhiza……..Nitrogen Fixation

3. A mycorrhizal fungi + Various plant species……A mycorrhiza……Water & mineral absorption

4. Mushrooms + Trees……Ectomycorrhiza……..Protection of root and water/mineral absorption

5. Mould (*Rhizoctonia)* and mushrooms + Orchids……Endomycorrhiza……Mutual Nutrients supply

6. Moulds + Ericaceae and Monotropaceae……Endomycorrhizas……..Nutrient and water absorption

7. Fungi (Ascomycetes,Basidiomycetes) + Cianobacter ……..Lichen…….Mutual nutrient supply

8. Double or triple symbiosis……..Leguminous plant + Root nodule bacteria + Amycorrhizal fungi, Pine tree + *Rhizopogon* + Nitrogen fixing bacteria etc.

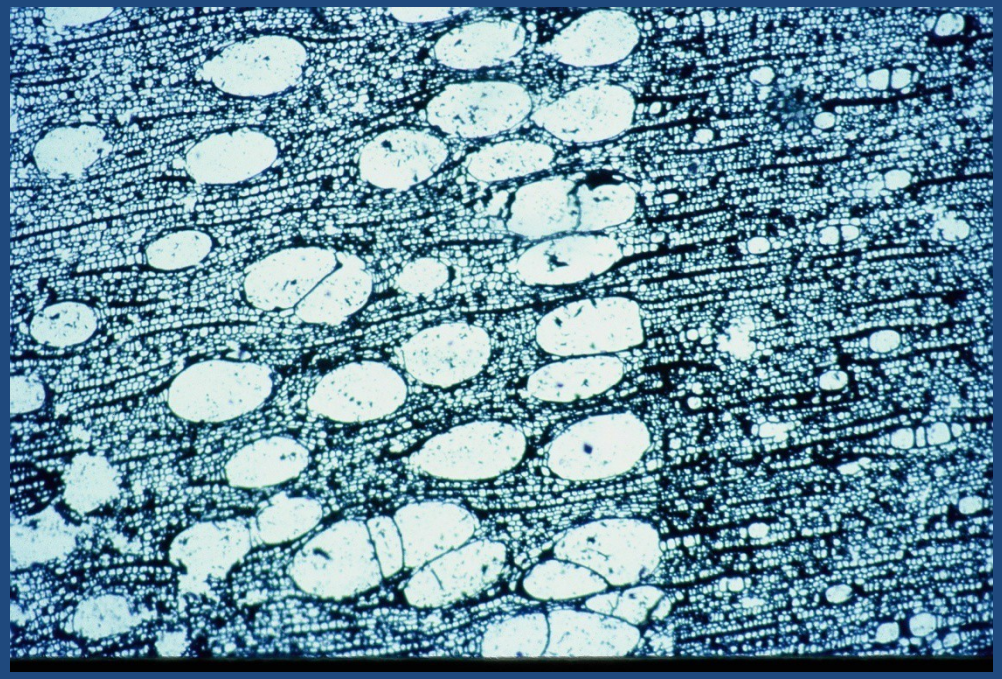
Technical Analysis of Bark Charcoal

Composition (%) ------Carbon, 77.58 : Volatile substances, 12.92 : Ash, 9.50

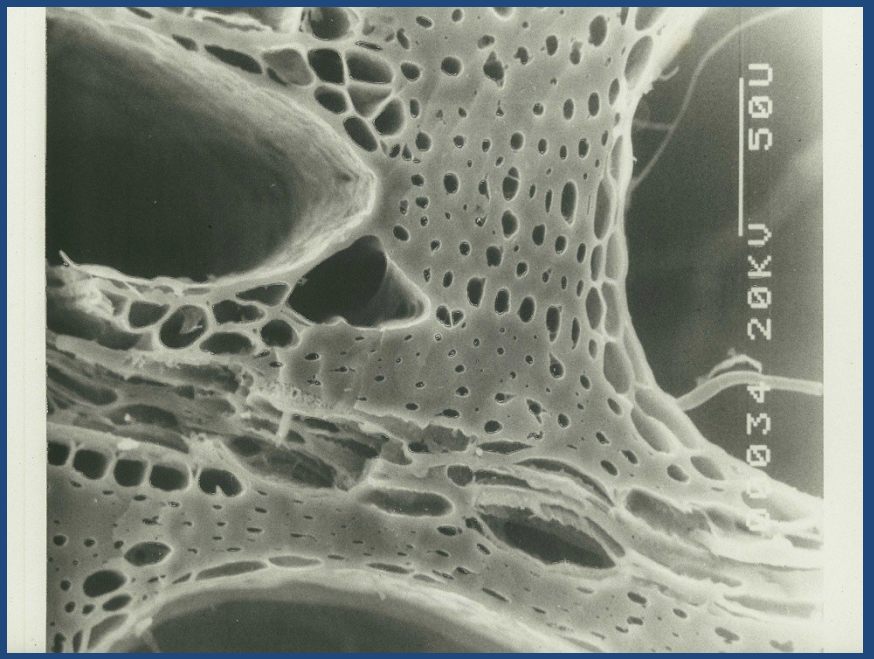
Mineral composition (%)--------SiO_2, 36.50 : Al_2O_3, 10.98 : CaO, 19.24 : K_2O, 1.17 : Na_2O, 5.35 : Fe_2O, 7.59 : MgO, 10.31 : MnO, 1.07 : P_2O_5, 1.77

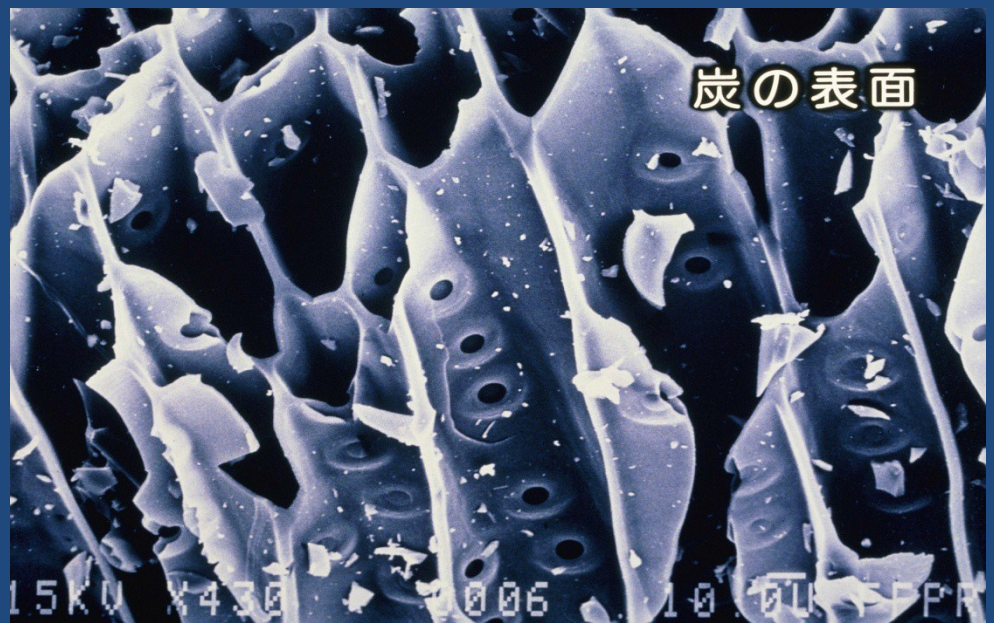
Structure of Charcoals

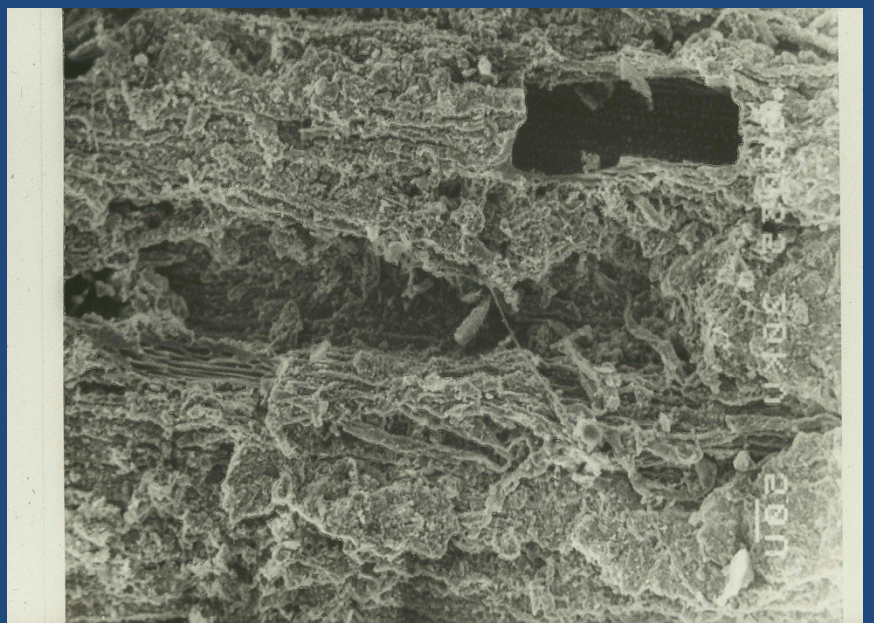
Hard wood , Conifer



Hard wood (SEM), White charcoal produced under high temperature.







Changes of Soil Microbial Flora in the sterilized and buried charcoal (2 months in field)
4. Soil Microorganisms.

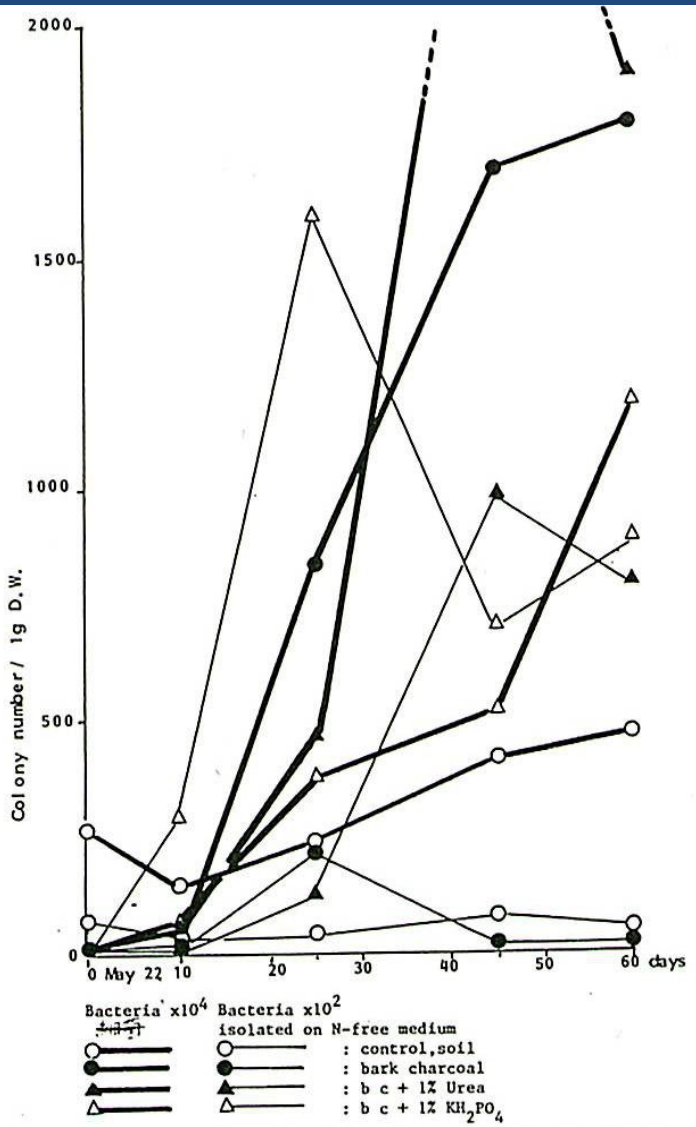
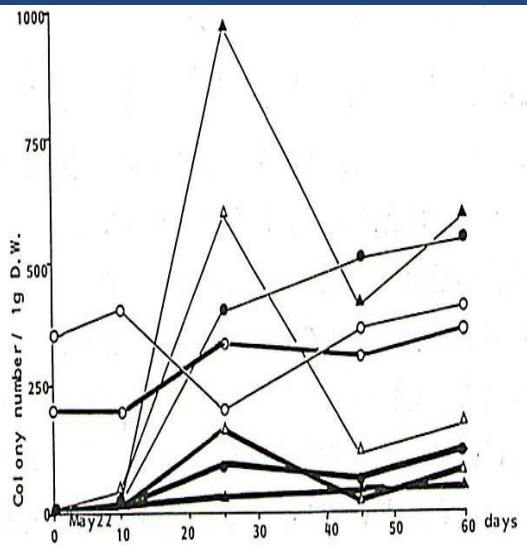
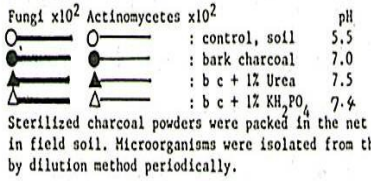


図８－８．　埋設した木炭中における微生物

Fig. 8－8.　Microorganisms in the buried charcoal (Bacteria)





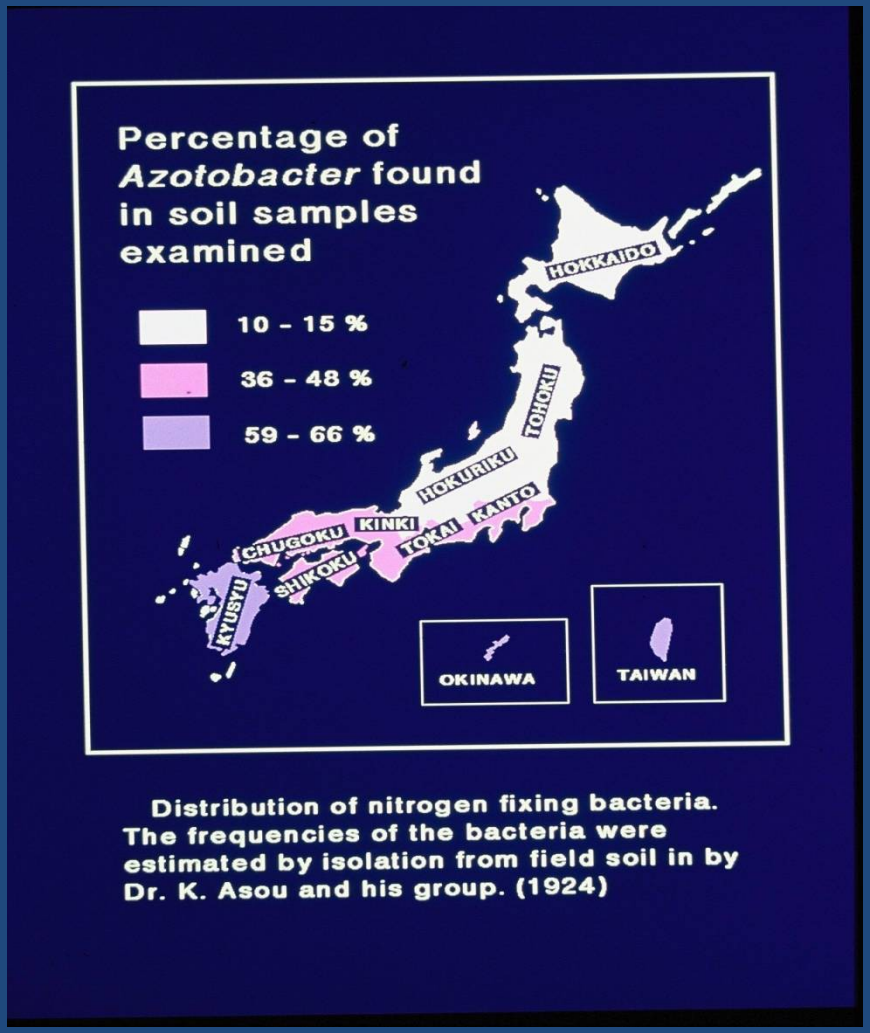
Sterilized charcoal powders were packed in the net and buried in field soil. Microorganisms were isolated from the charcoal by dilution method periodically.

図８－７．　埋設木炭の中の微生物

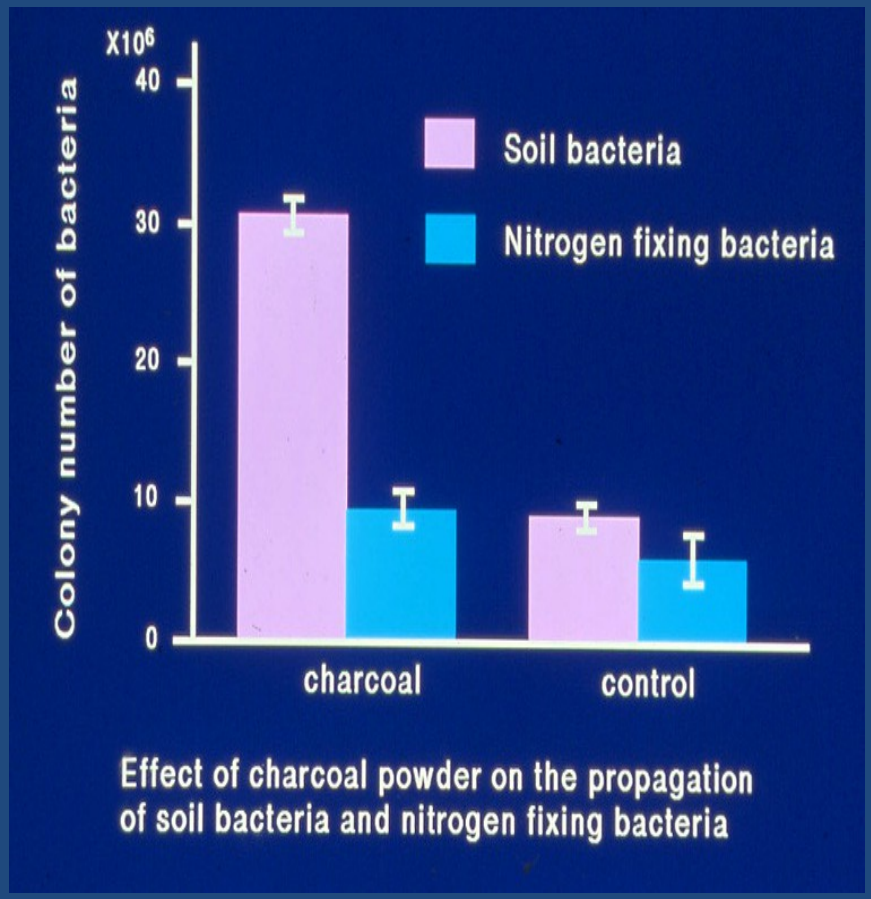
Fig. 8－7.　Microorganisms in the buried charcoal (Fungi and Actinomycetes)

1. Free -Living Nitrogen Fixing Bacteria

Charcoal, Nitrogen fixing bacteria and Shifting Cultivation in Tropical region.



Distribution of nitrogen fixing bacteria. The frequencies of the bacteria were estimated by isolation from field soil in by Dr. K. Asou and his group. (1924)

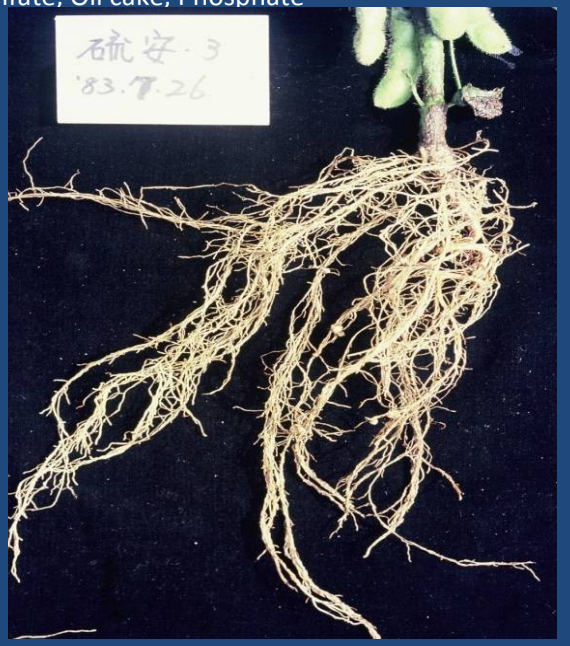


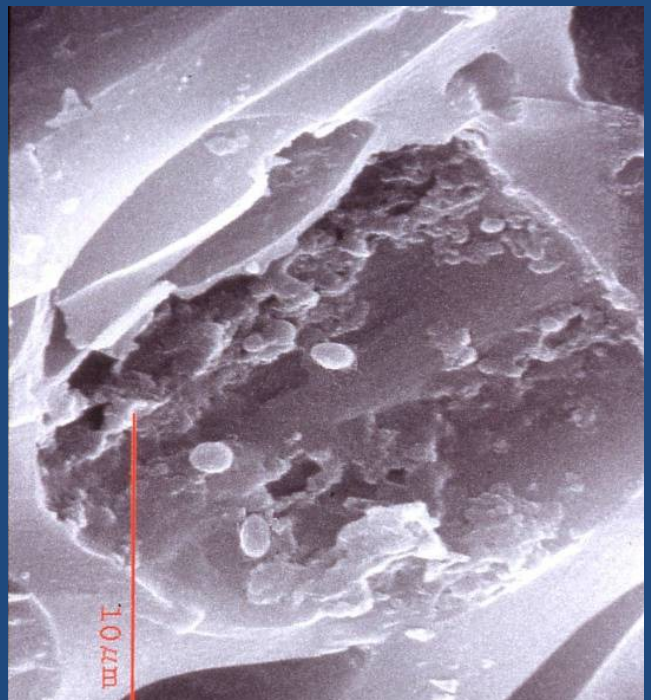
Effect of charcoal powder on the propagation of soil bacteria and nitrogen fixing bacteria

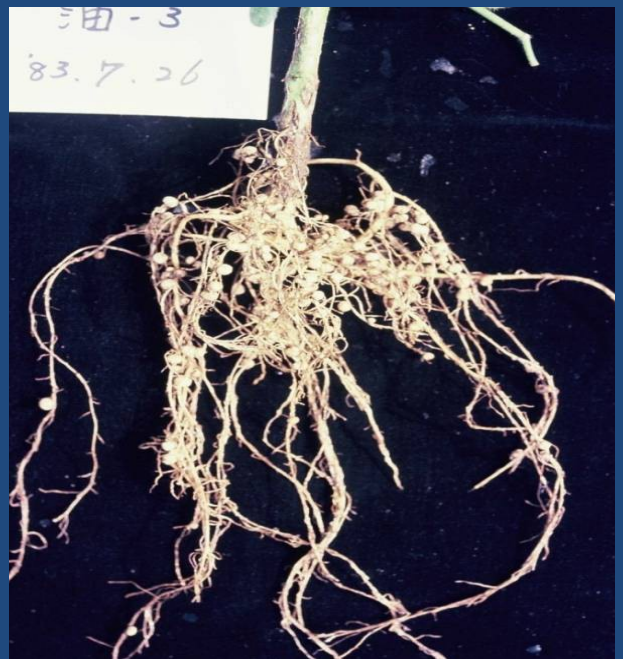
The frequency of free living nitrogen fixing bacteria in subtropical soil is generally higher than those in temperate zone (Asou et al. in 1924). Bacterial population including aerobic nitrogen fixing bacteria (Beijerinckia) increased when charcoal powder was mixed with top soil in Indonesia. Nitrogen fixation seems to be promoted by charcoal application or shifting cultivation in tropical region.

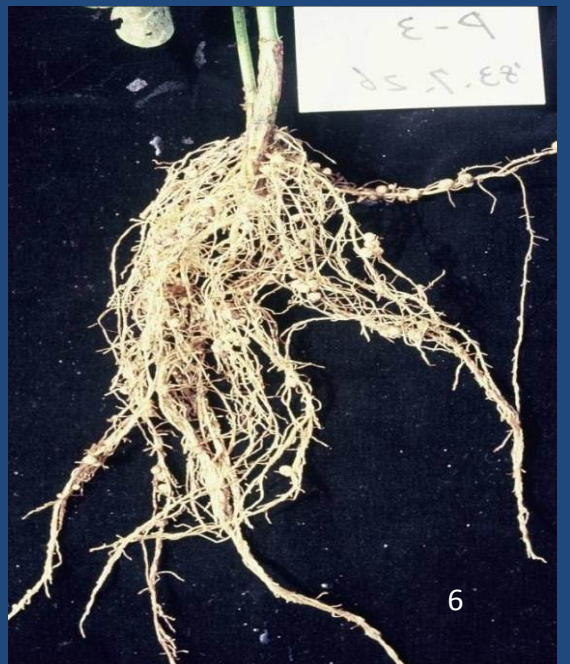
2. Root Nodule Bacteria, *Rhizobium* & *Bradyrhizobium* Soy Bean Cultivation by Charcoal

Control, Ammonium sulfate, Oil cake, Phosphate









Soy bean Cultivation and the Effects of Charcoal ----First Experiment of BIOCHAR, 1983
Relations between Root Nodule and A mycorrhiza

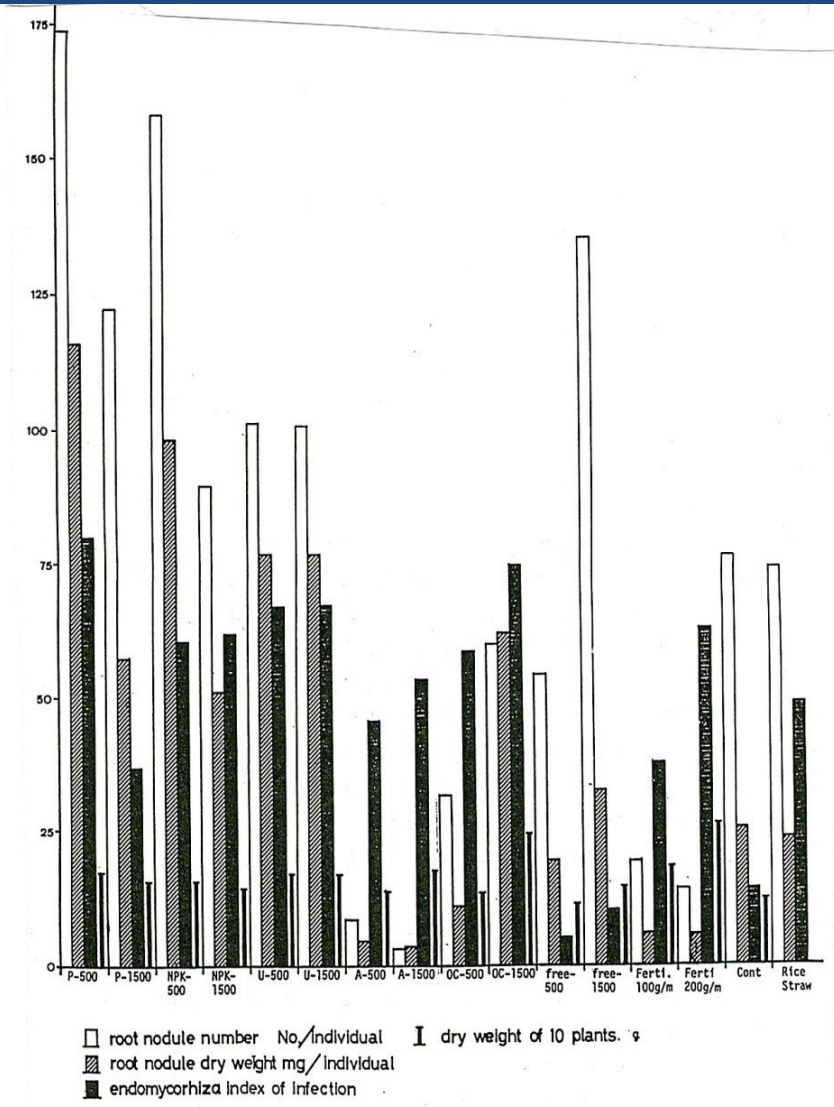


図８－２．１カ月後のダイズ生長量と根粒数，根粒重量およびVA菌根形成率

Fig. 8－2. Differences in the root nodule number, weight and the frequency of VA mycorrhiza a month after planting. The frequency of VA mycorrhiza was graded to 4 classes, 0, 1, 2 and 3。

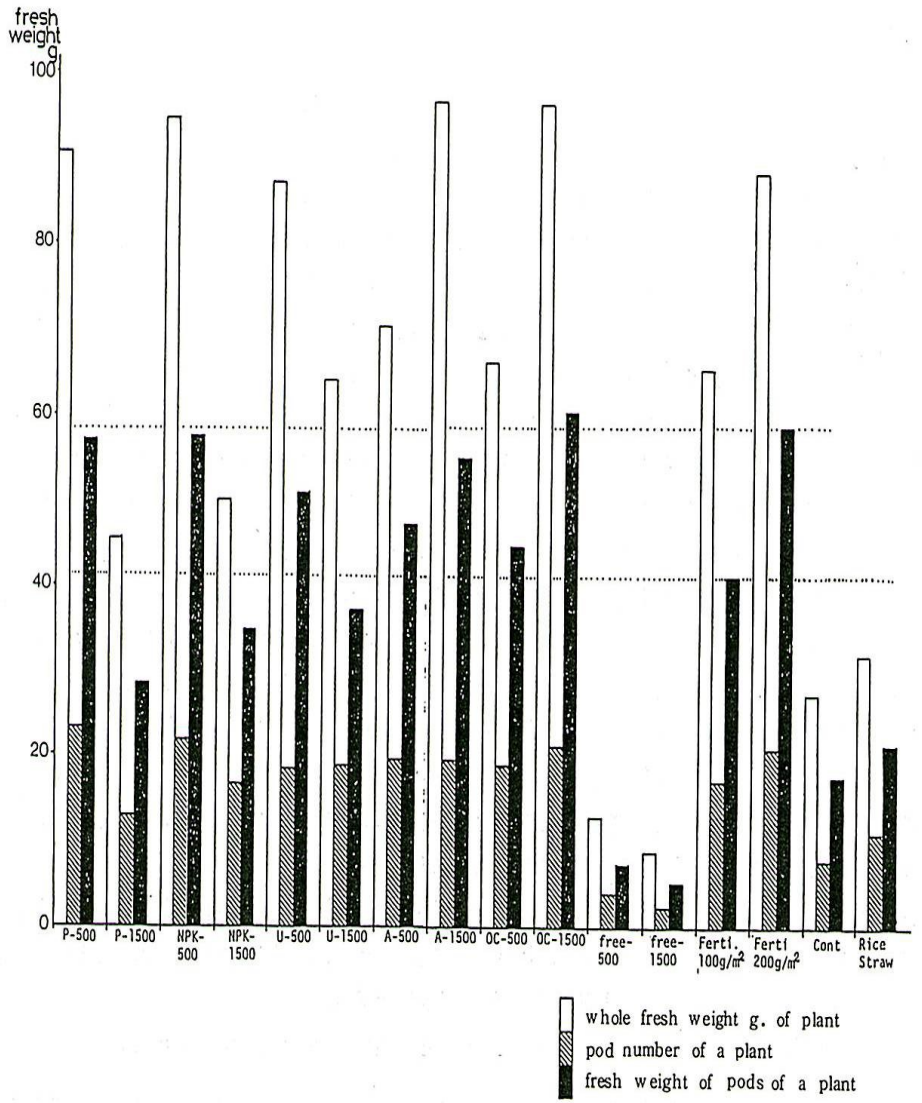


図８－１　ダイズの生育量と収量，栽培３カ月後

Fig. 8－1. Differences in the yields of soybean
Soybeans were harvested 3 months after planting


MOKI
対流空気
対流空気
炎
反射熱
伝導熱
伝導熱
反射熱
酸欠炭化
炭化器
無煙炭化器の燃焼イメージ

Maize

Millet

Soy bean

Left to rig

① Control

② Compost 0.5kg

③ Charcoal 1.0kg

④ Charcoal com post 1.5kg

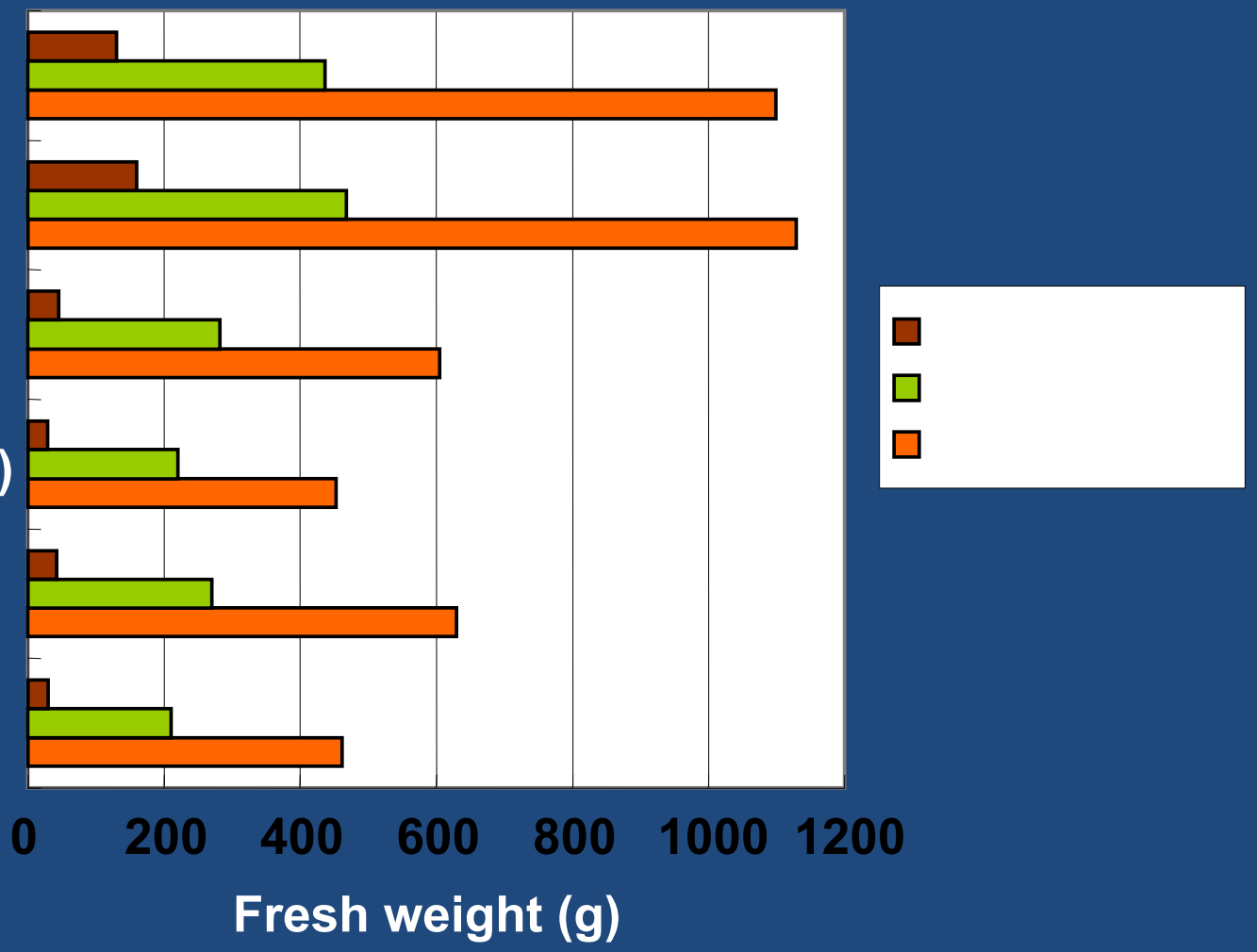
⑤ C. C 1.0kg

⑥ C. C 0.5kg

The effects of charcoal compost on the plant growth（China）

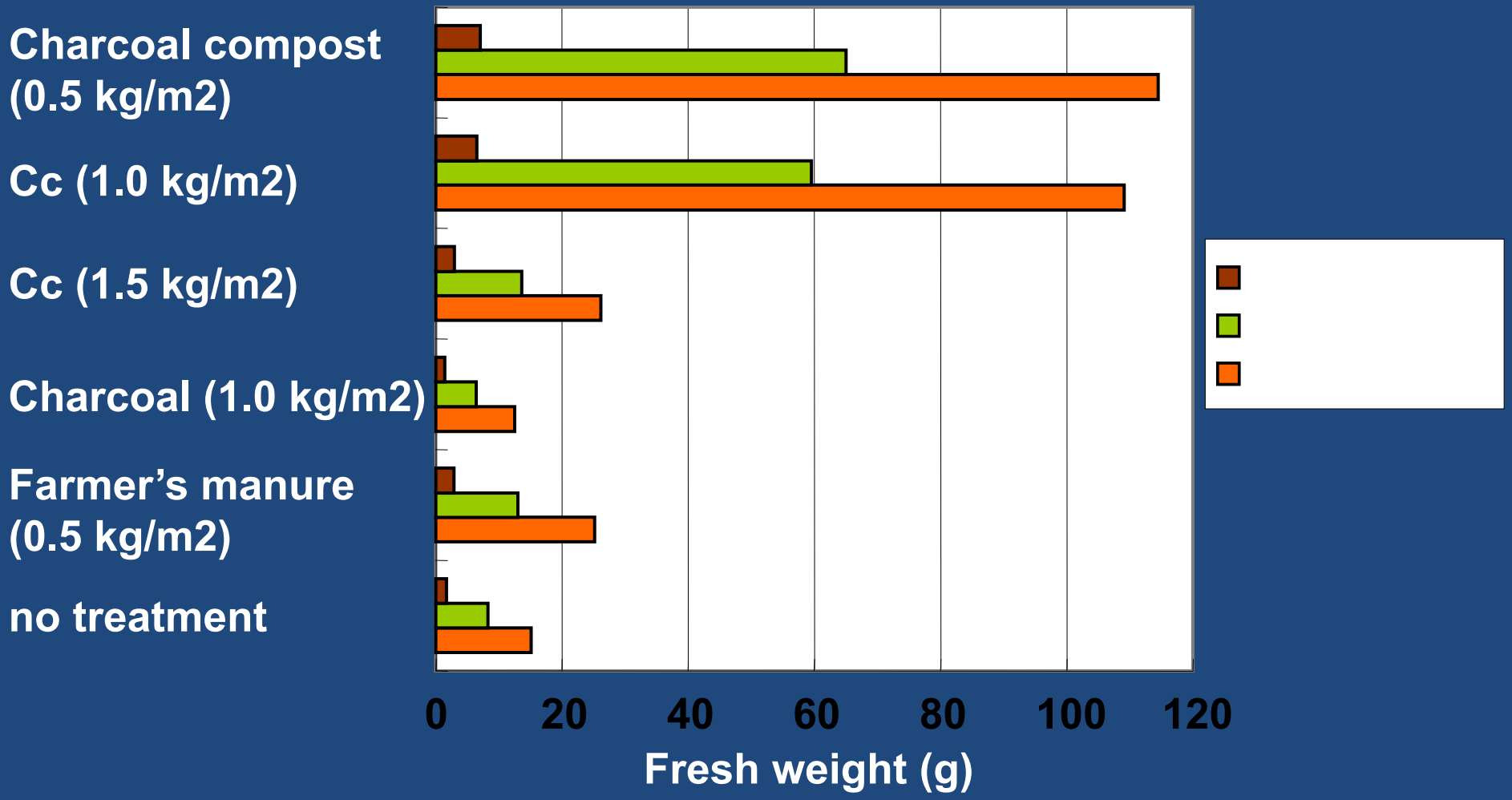
1 -

1）Maiz



The effects of charcoal compost on the growth of maize.

1 - 2) Soy bean

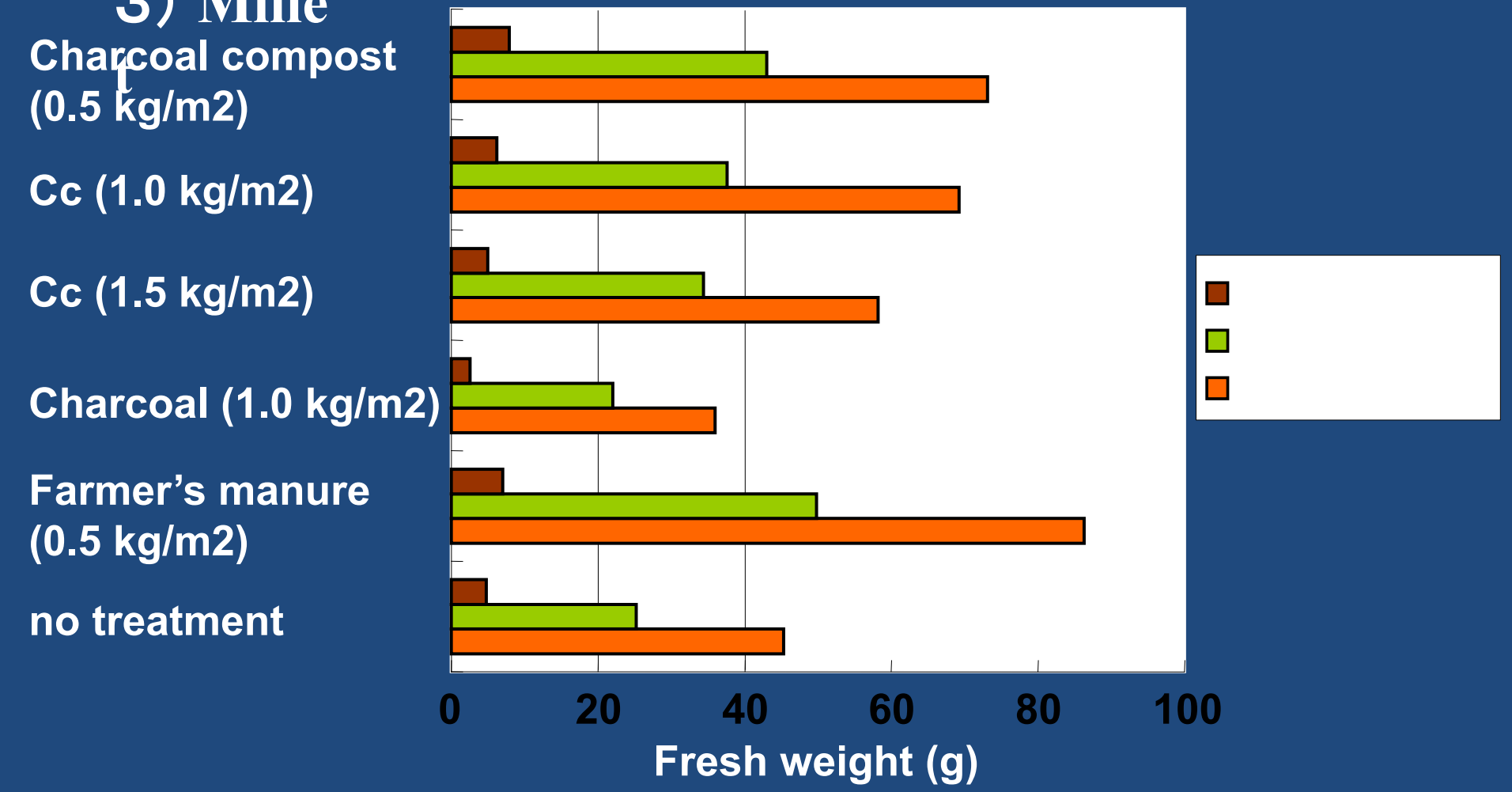


The effects of charcoal compost on the growth of soy bean.

1 -

3）Mille

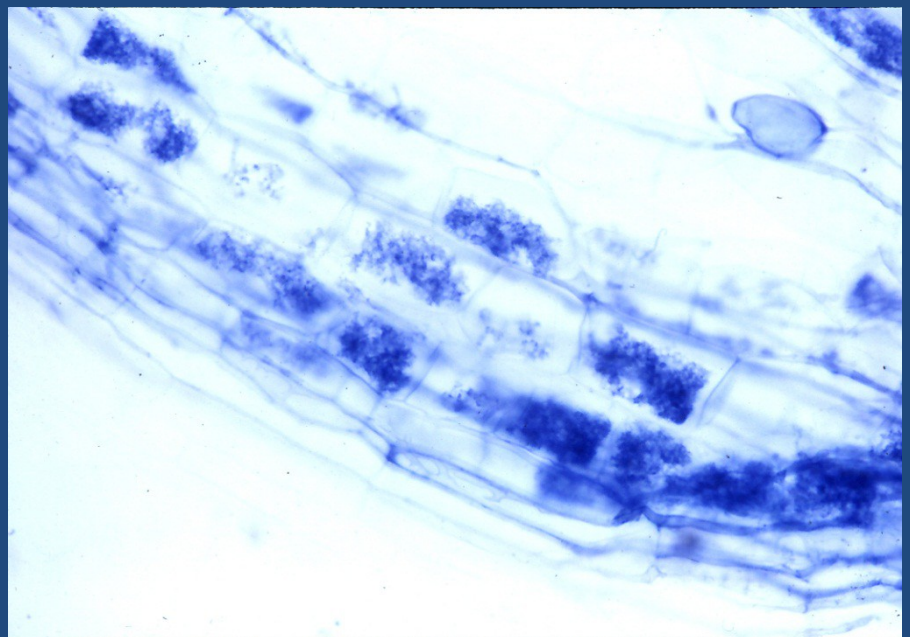
t

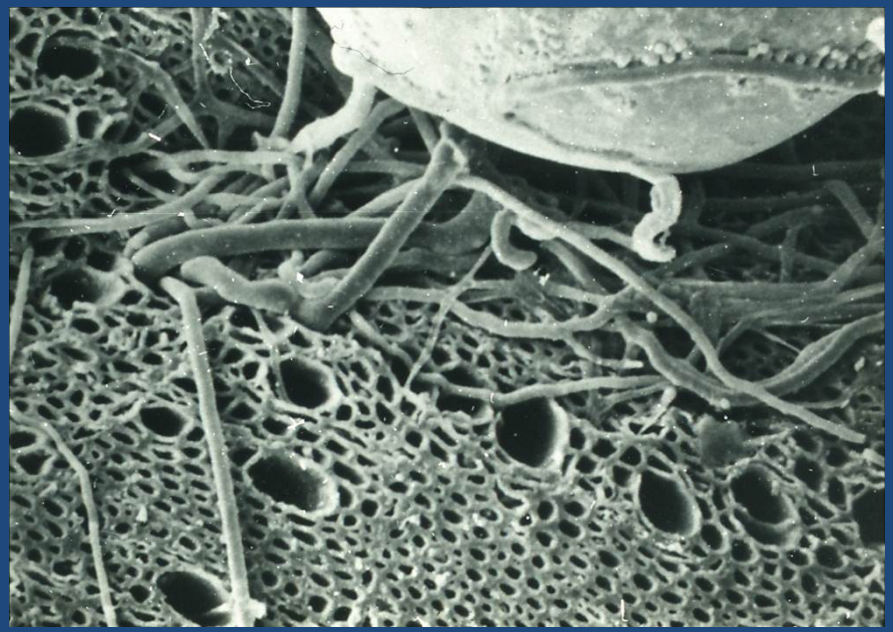


The effects of charcoal compost on the growth of millet.

3. Amycorrhizal Fungi. The Effects of Charcoal on the Spore Germination and Infection of *Gigaspora margarita* and *Glomus fasciculatum*

Root tip and the spores of *Glomus* sp.. The spores of *G. margarita* germinating on charcoal. A mycorrhiza was formed on soy bean root. The hyphae of *Gigaspora* enters into charcoal pores.





Inoculation Effects of A mycorrhizal Fungi on the Growth of Some Plants with Charcoal

Cucumber, Apple tree, and Japanese cedar (1200 years old)

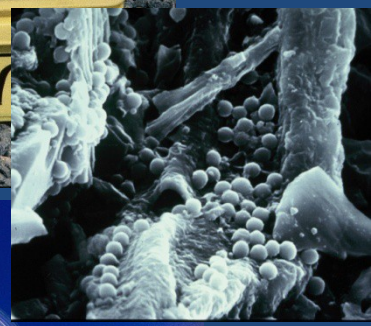
4. *Bacillus* and others

Miscellaneous Effects of Charcoal on some plant growths.

Recovery of Tomato Plant from the injury of Continuous Cropping, Herbicide

Non mycorrhizal plant, radish

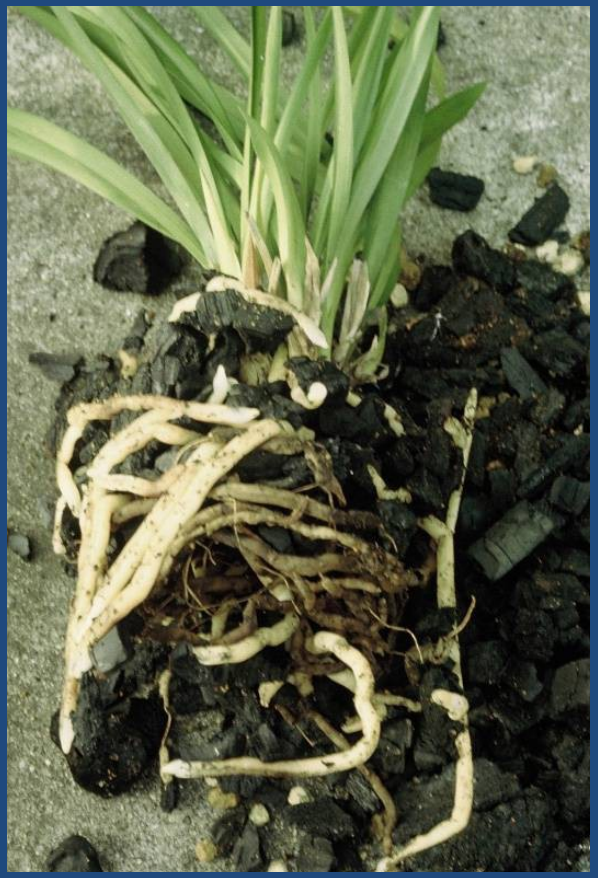
Effect of Charcoal Compost and the Production of Antifungal Substance by *Bacillus*

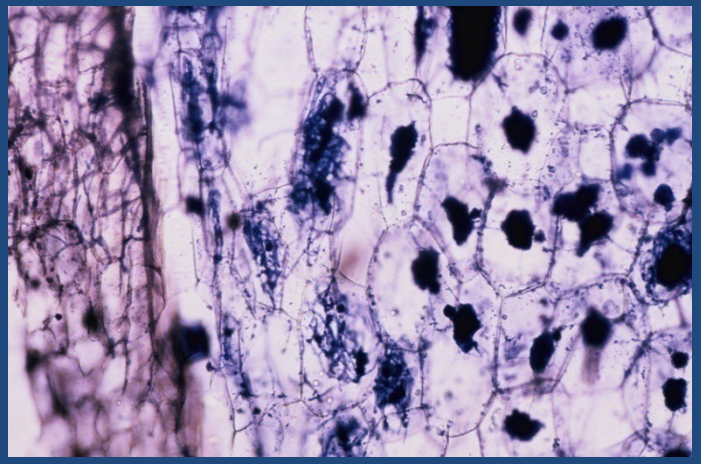


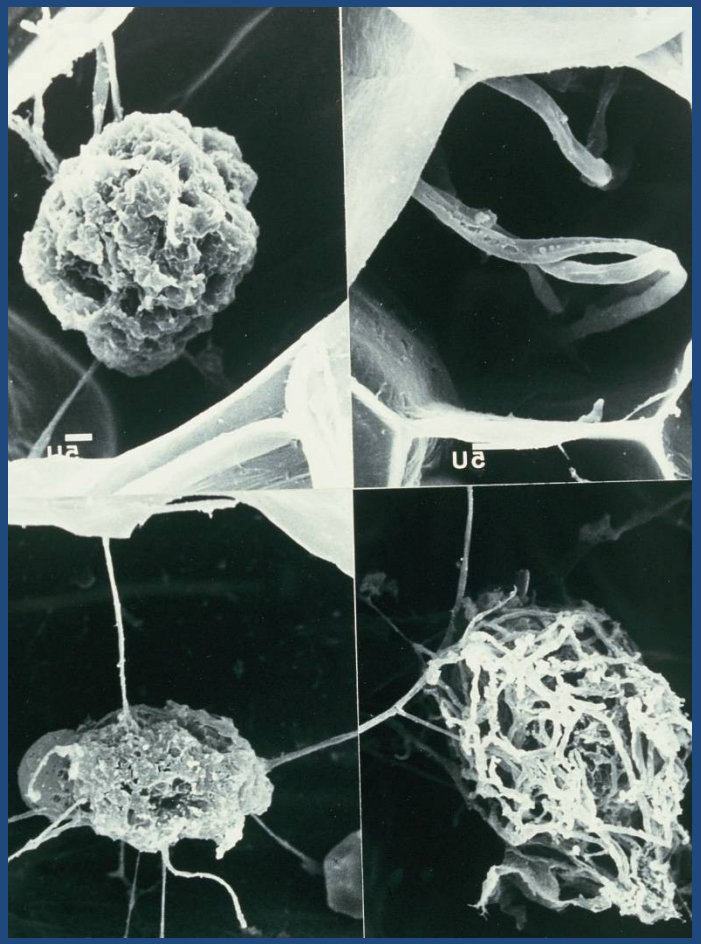
6. Orchid Fungi, *Rhizoctonia* sp.

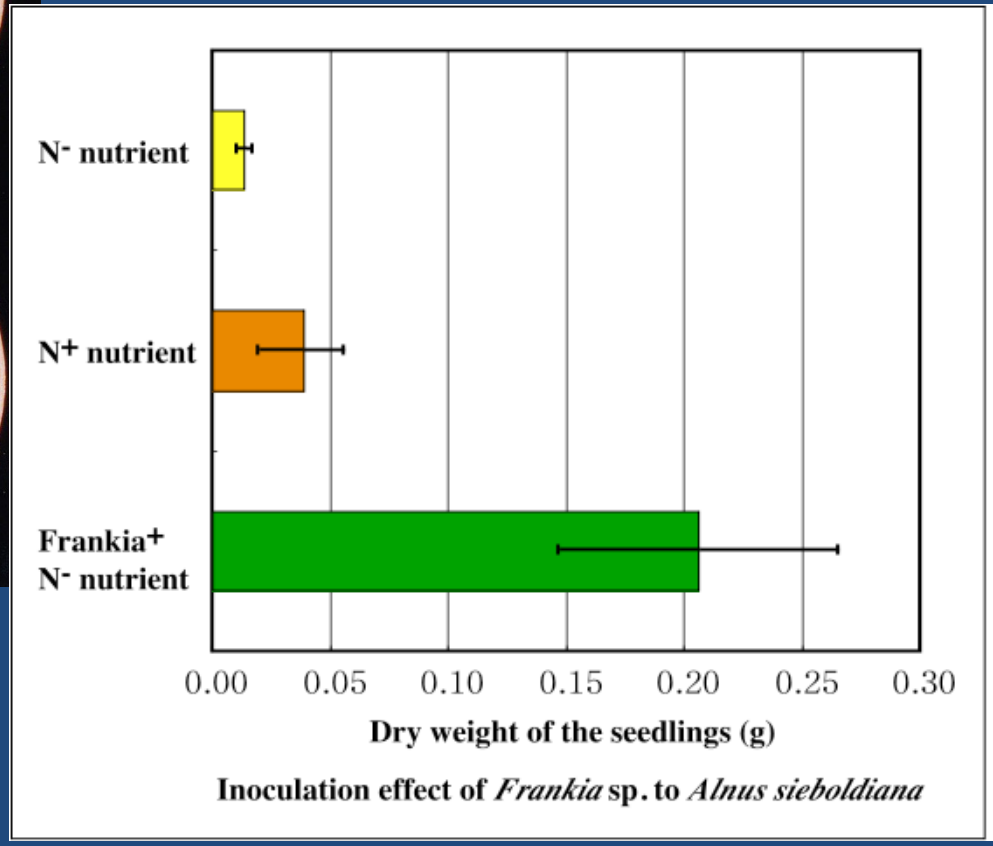
Cultivation of Orchid with charcoal

Mulberry and bamboo charcoals are best materials for orchid cultivation.







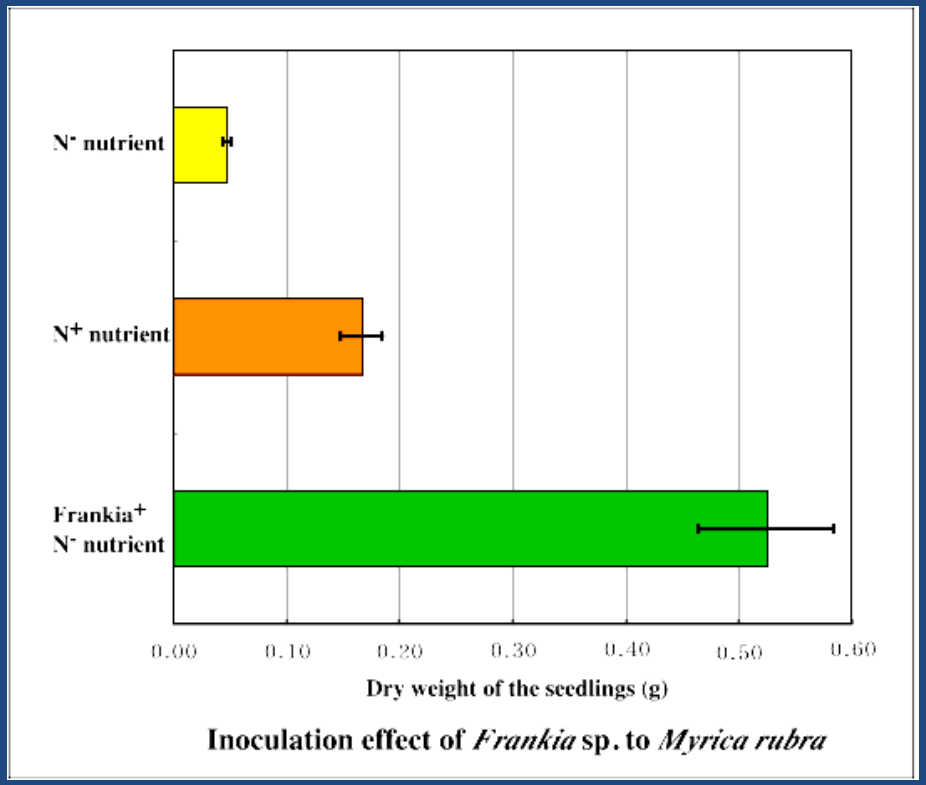


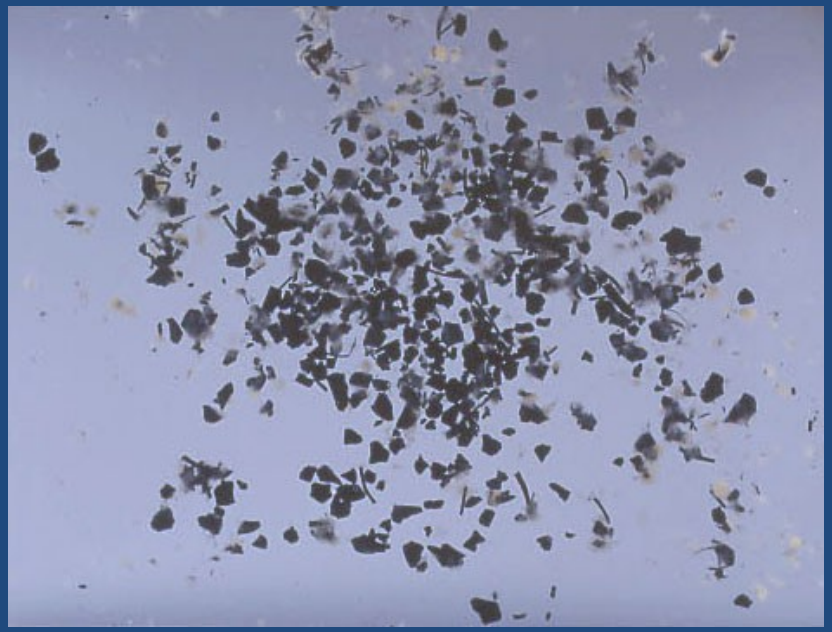
Inoculation effect of *Frankia* sp. on *Alnus sieboldiana*

A : Frankia + N^- nutrient
B : N^+ nutrient
C : N^- nutrient

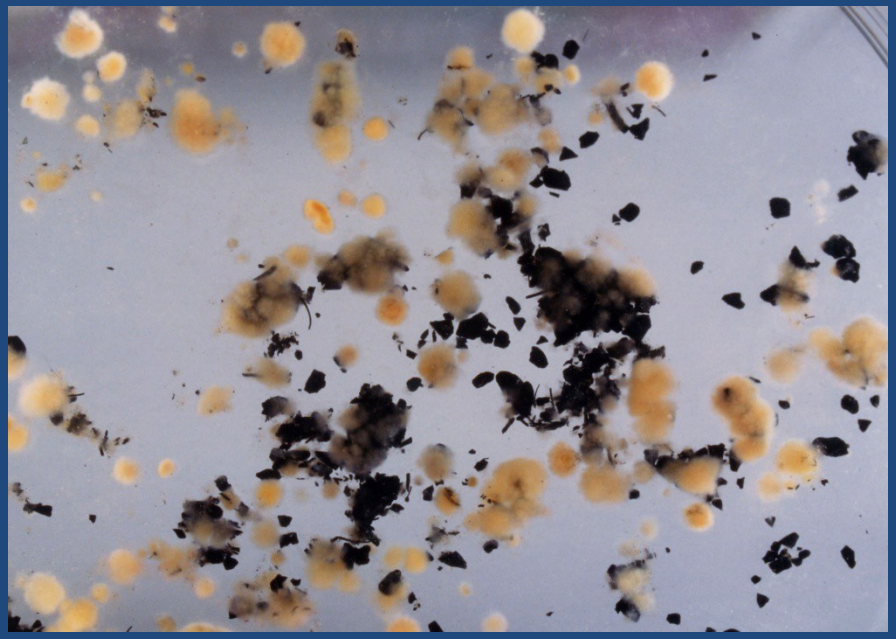
Inoculation effect of *Frankia* sp. on *Myrica rubra*

A : Frankia + N^- nutrient
B : N^+ nutrient
C : N^- nutrient





Inoculant of *Frankia* sp. made with charcoal



Propagation of *Frankia* sp. from the inoculant made with charcoal

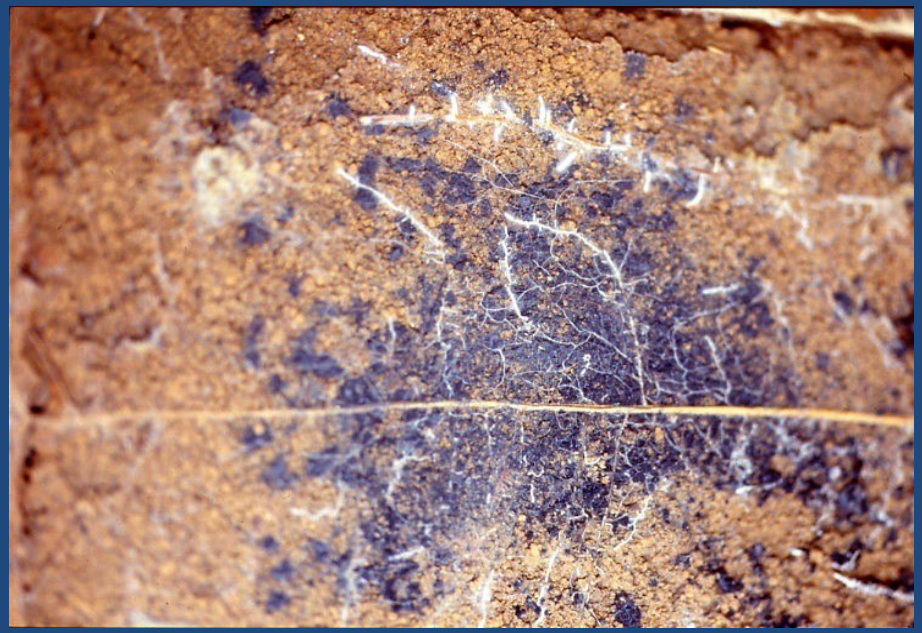
7. Ectomycorrhizal Fungi

Inoculation Effect of Ectomycorrhizal Fungi on the Growth of Dipterocarps and the Effect of Charcoal for mycorrhiza formation .

Fruit body of *Scleroderma columnare*

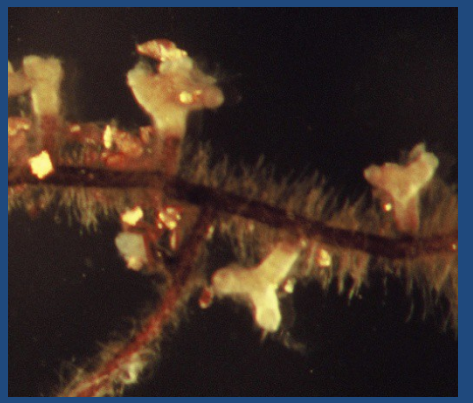
Parashorea lucida seedlings - mycorrhiza + mycorrhiza

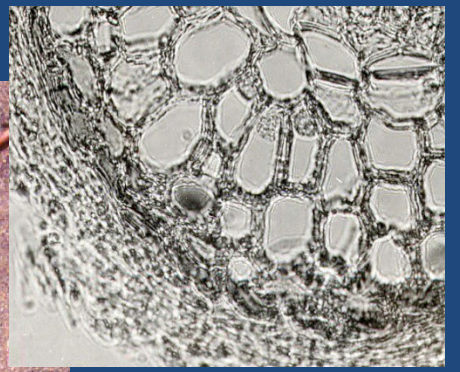
Parashorea lucida seedlings inoculated with *Scleroderma columnare*



Miraculous Recovery of Wilting Pine Trees by Charcoal.

Charcoal with fertilizer and spores is buried around pine roots. The ectomycorrhiza formed in the charcoal. Ectomycorrhiza of pine and the cross section.





Recovering Pine Trees from Disease and Wilting Shimane Pref. 2005-2008

Izumo shrine

Ornamental Pine Trees

Advancing Reforestation Project in Sea Coast Areas by Charcoal and Mycorrhiza

(Edible Mushroom, *Rhizopogon rubescens*)

The seedlings of *Pinus thunbergii ;* The growth was improved by inoculation of *R. rubescens* and charcoal. Pine seedlings are planted with charcoal and small amount of phosphate fertilizer. 7 years after planting. Fruit bodies occurring above the buried charcoal and the mycorrhiza.