Secretion of organic acids from root

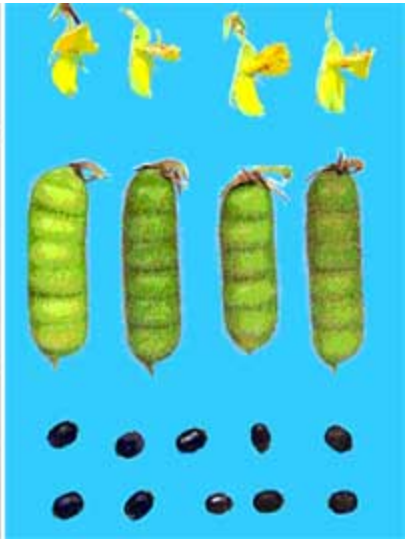
Lupin	Citric acid	Ca phosphate
Alfalfa	Citric acid	Ca phosphate
Rapeseed	Malic acid and citric acid	Ca phosphate
Pigeon pea	Piscidic, malonic, oxalic acids	Fe phosphate
Chick pea	Citric acid and succinic acid	Ca phosphate Fe phosphate
Buckwheat Brassica napus	Hydrogen ion	Ca phosphate

Chickpea

The bean adapted to Vertisol in India.

Grow well on high pH, high Ca, and dry soil. Secretes citric acid.

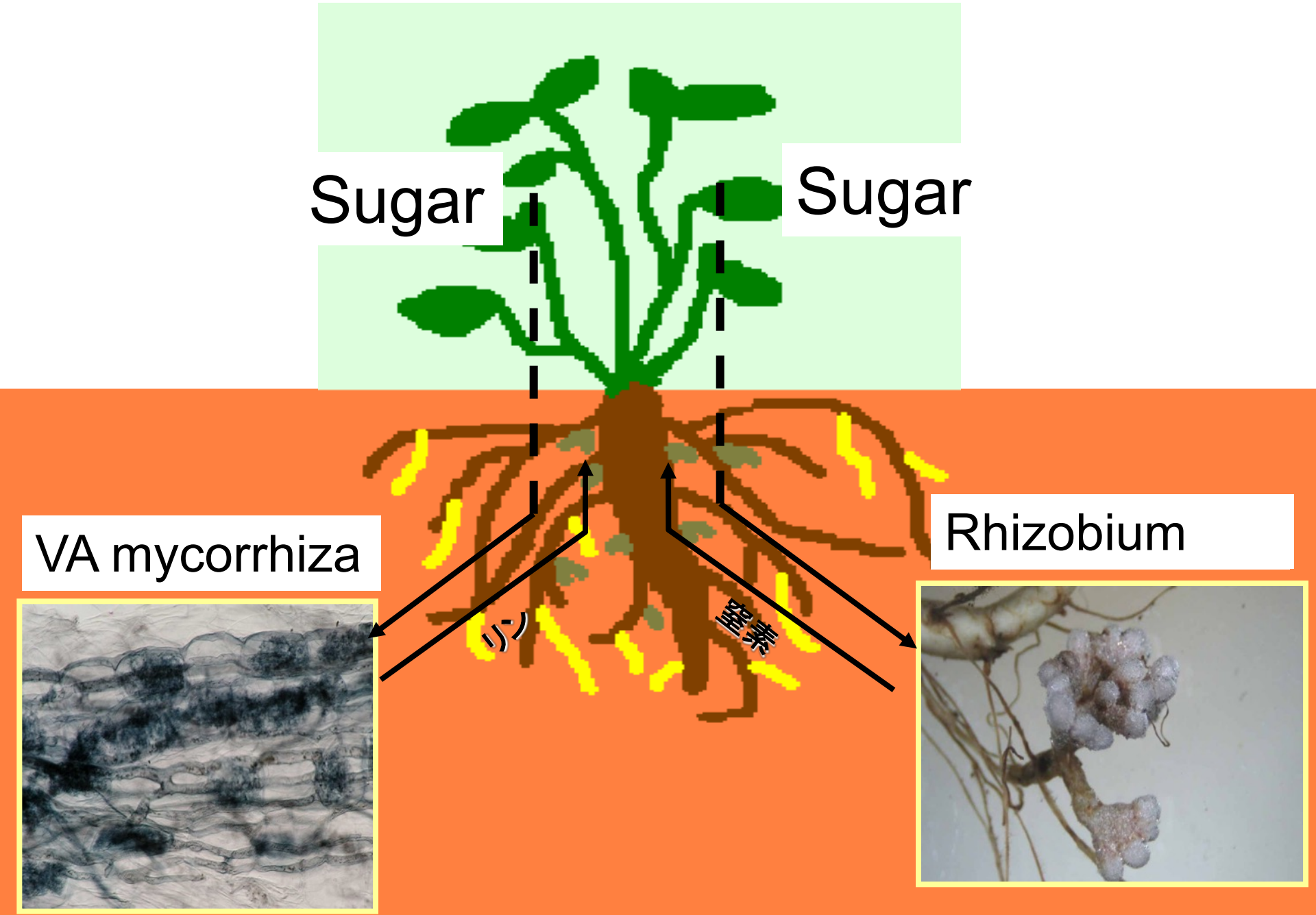
Pigeonpea



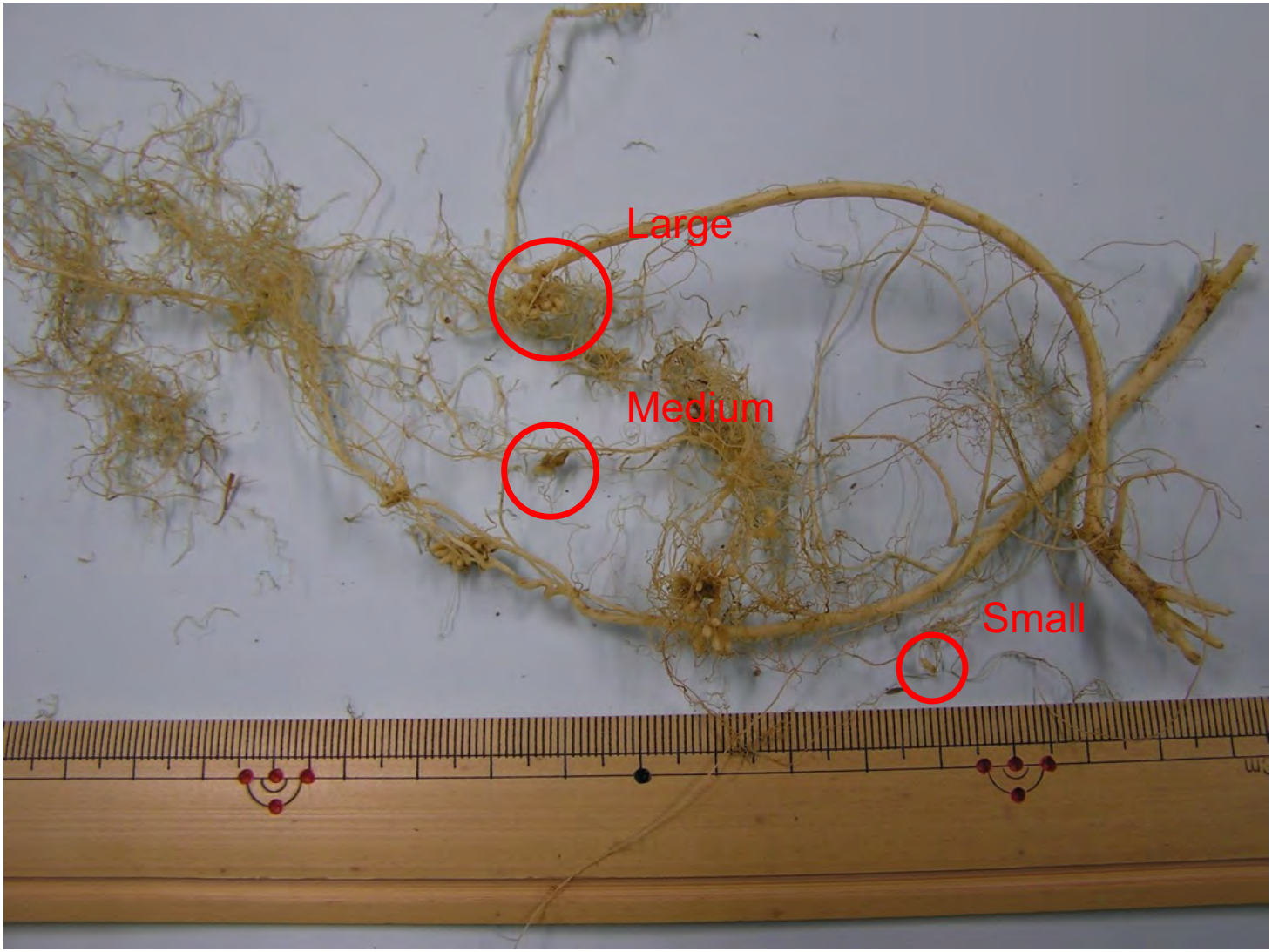
The bean adapted to red soil (Alfisol) in southern India.

Absorbs iron phosphate.

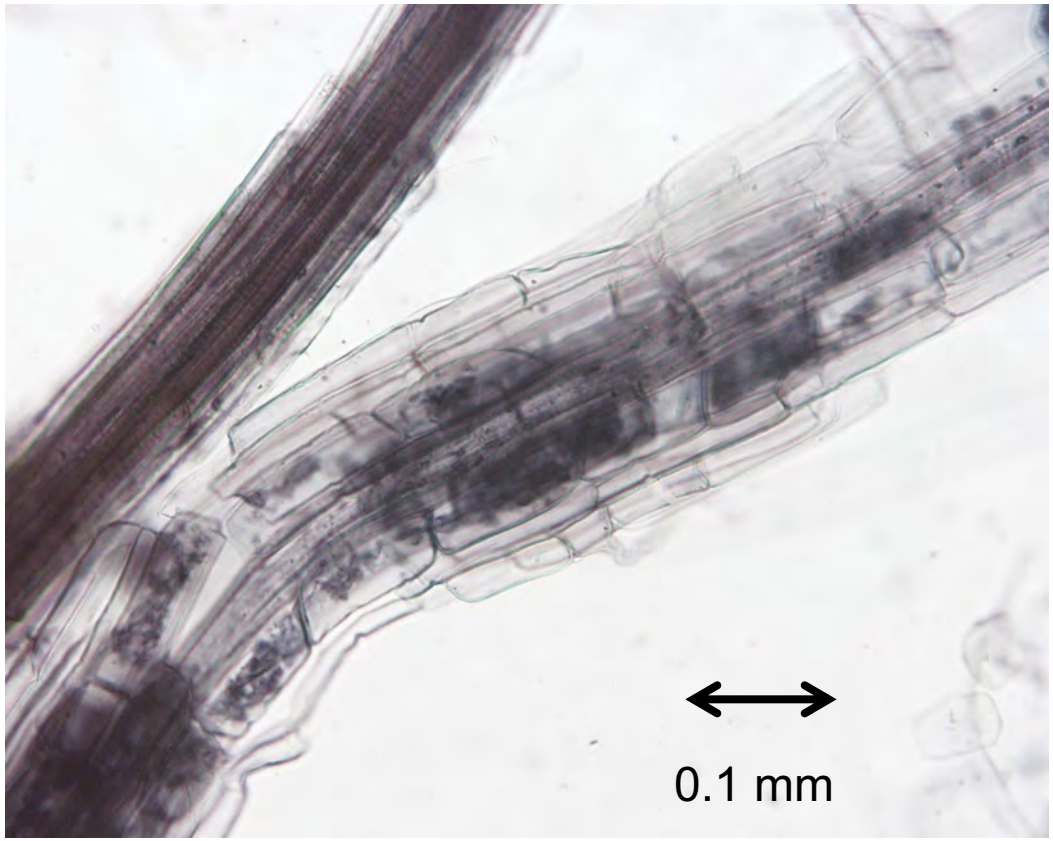
Secretes piscidic acid.


Sugar
Sugar
VA mycorrhiza
Rhizobium
リン
窒素

Root nodules of alfalfa



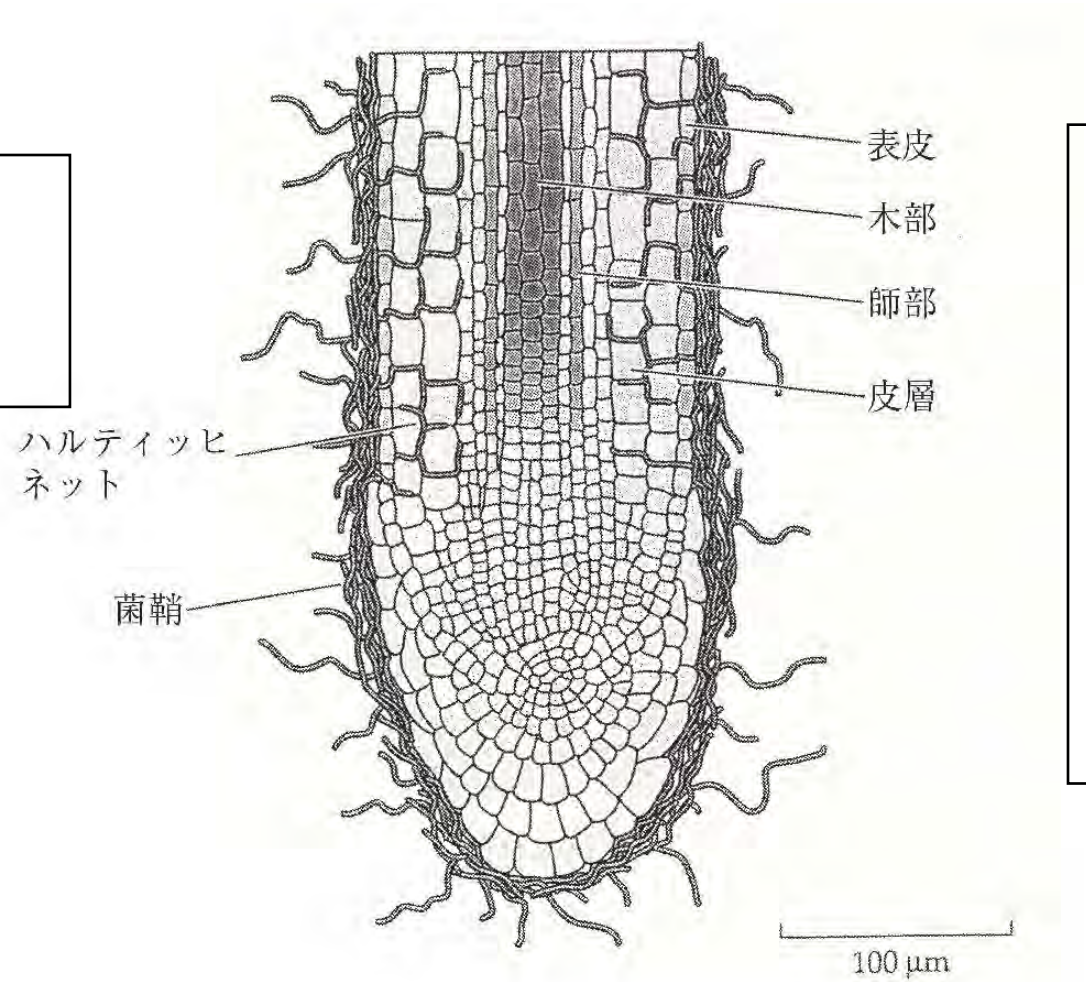
Mycorrhiza in the root of timothy



Ectomycorrhiza

Gymnosperm

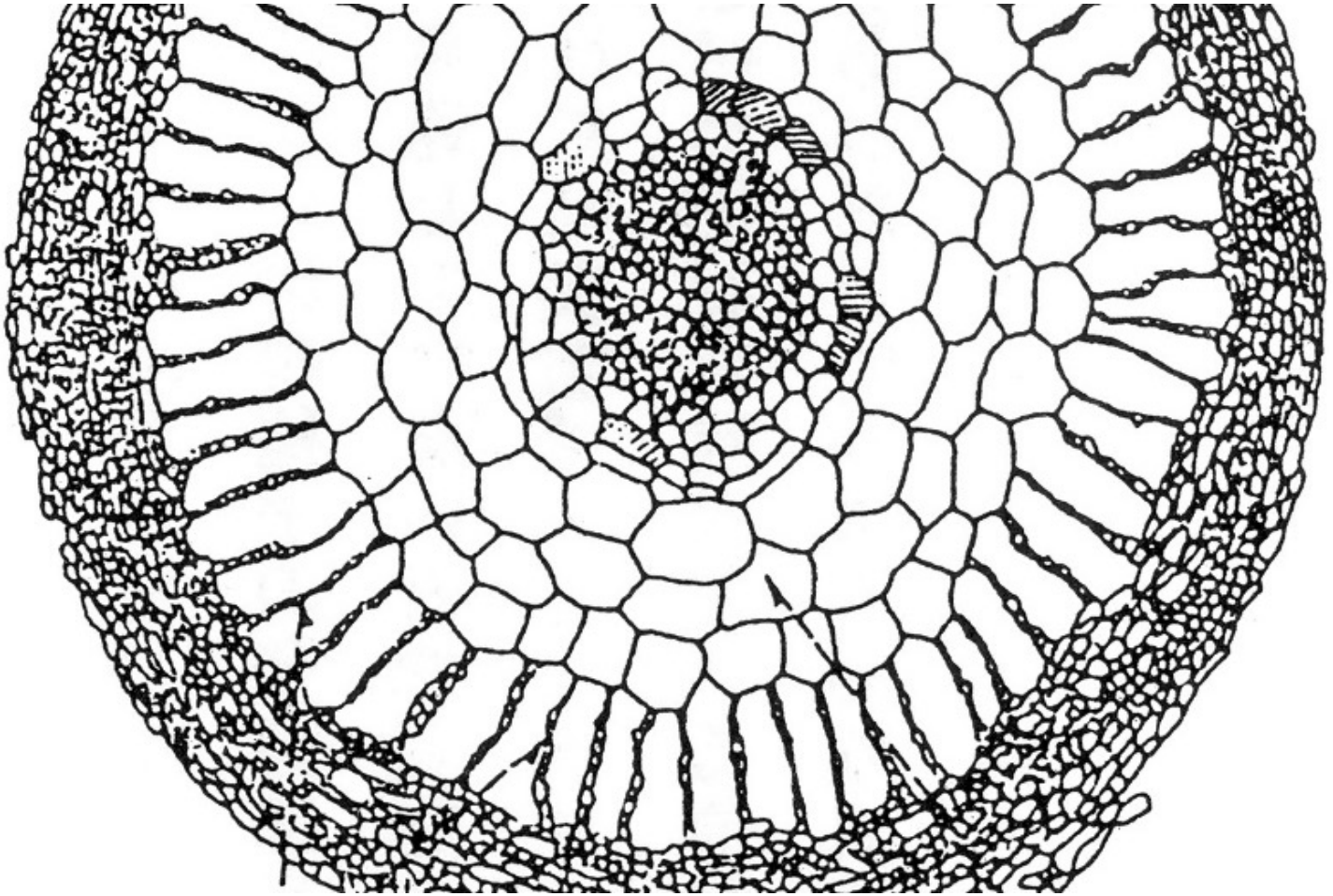
Pinaceae,
Cupressaceae



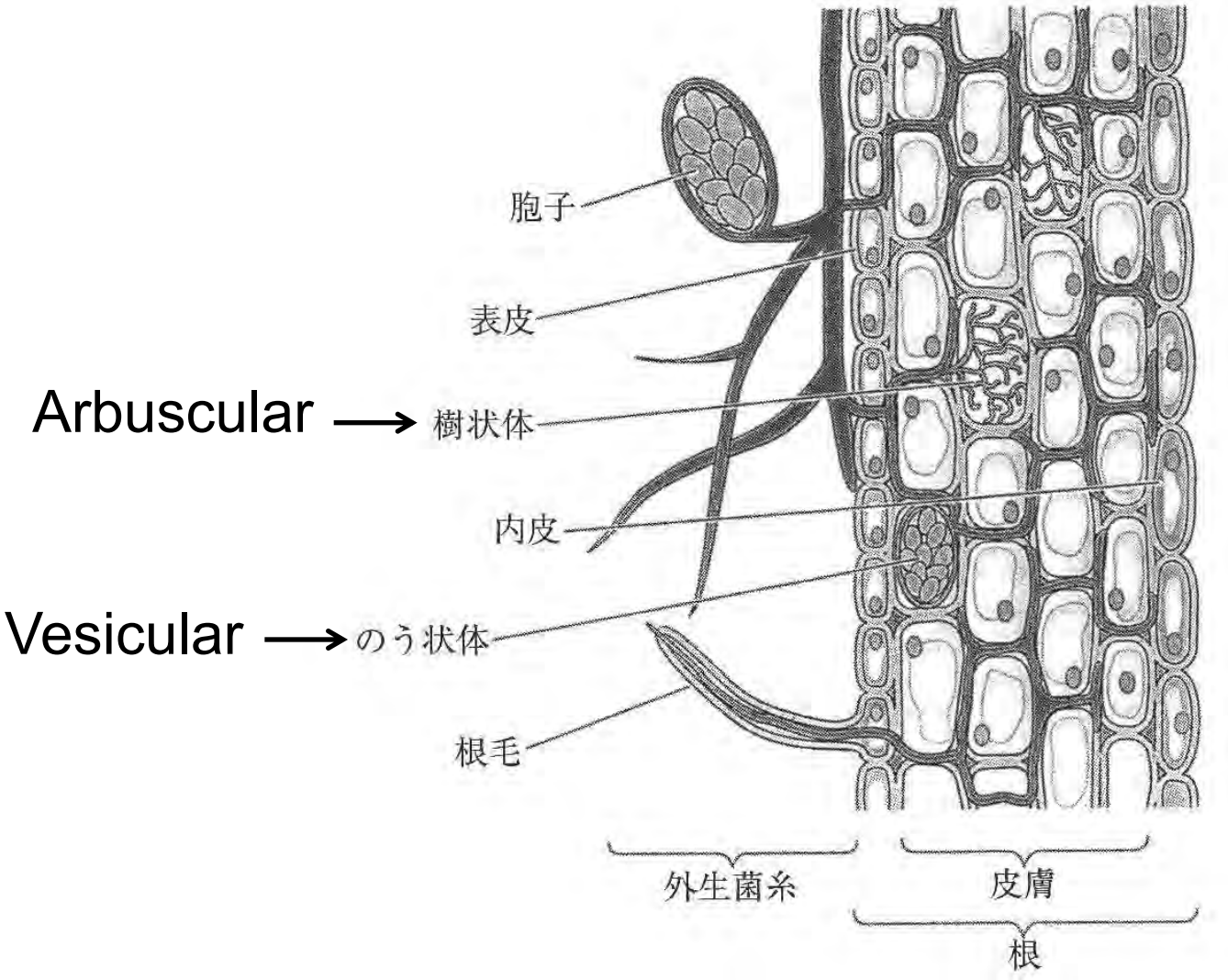
Angiosperm

Fagaceae,
Ulmaceae,
Dipterocarpaceae,
Betulaceae,
Aceraceae,
Salicaceae,
Rosaceae,
Tiliaceae, etc.

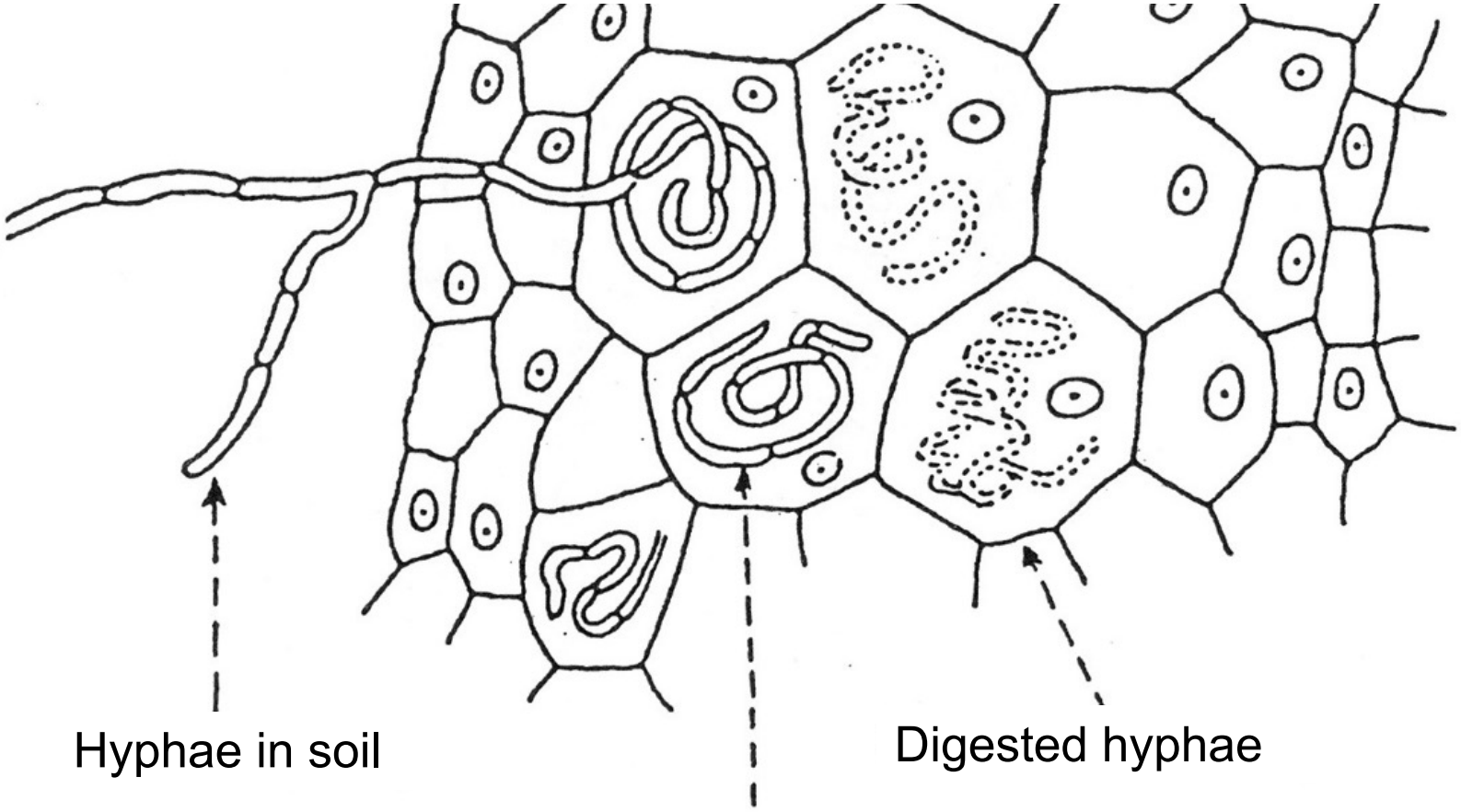
Beech root coated by exo-arbuscular fungi



VA mycorrhiza



endo-type arbuscular fungi in orchid

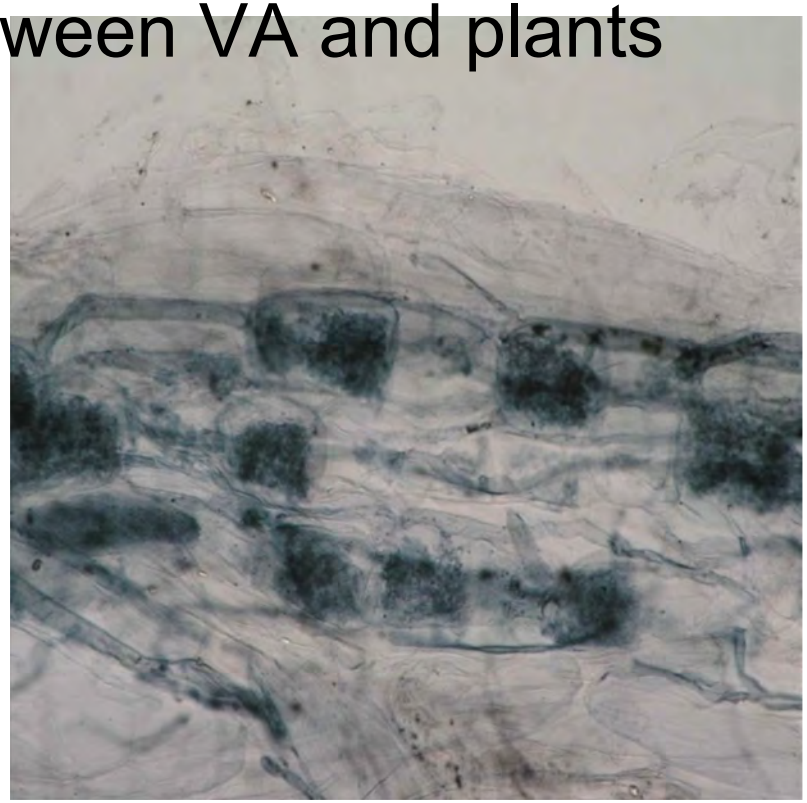


What is VA mycorrhiza?

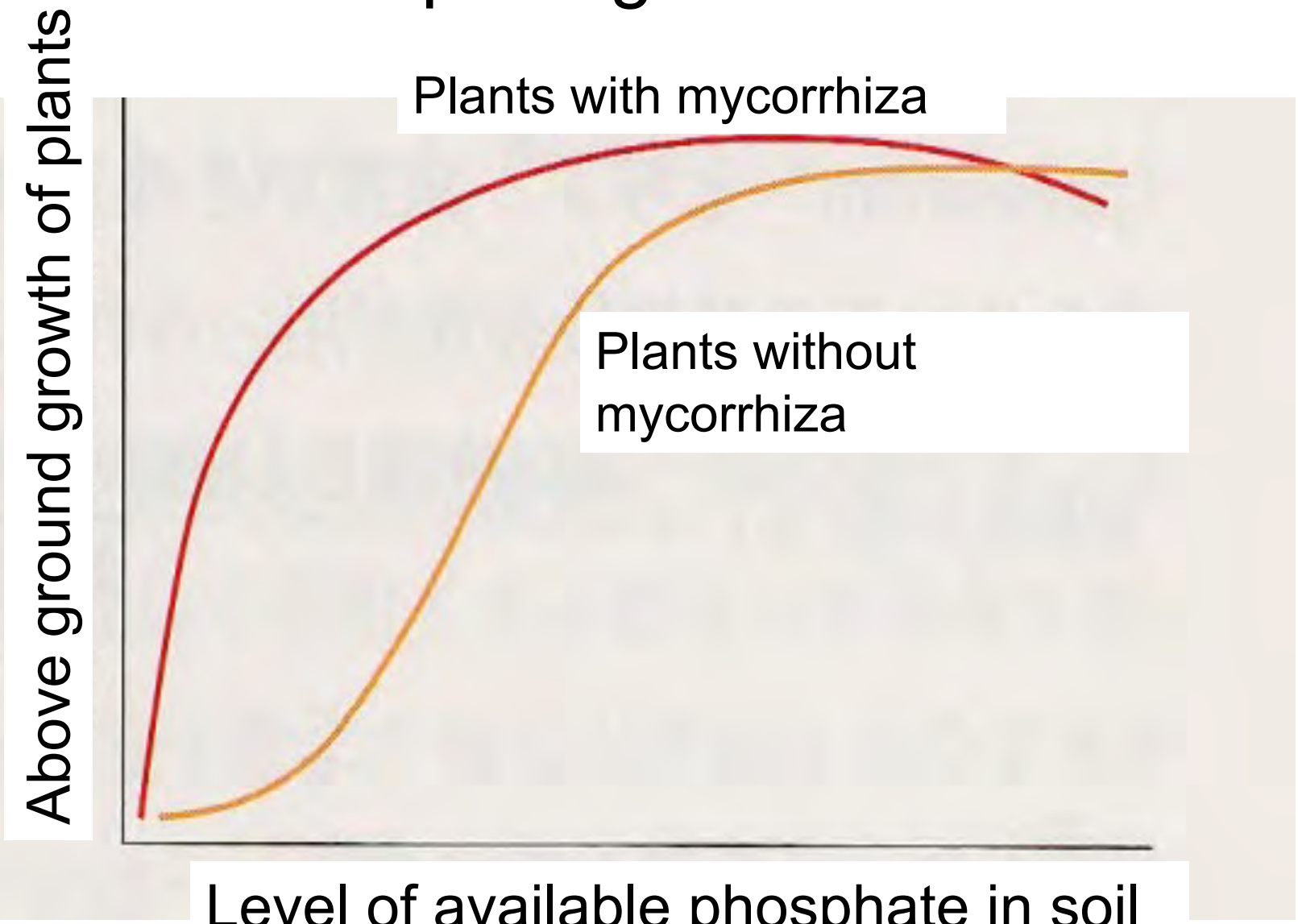
- Symbiotic microbes with plant root.
- Symbiotic relationships between VA and plants

Absorption of phosphate and water in plants is promoted by VA.

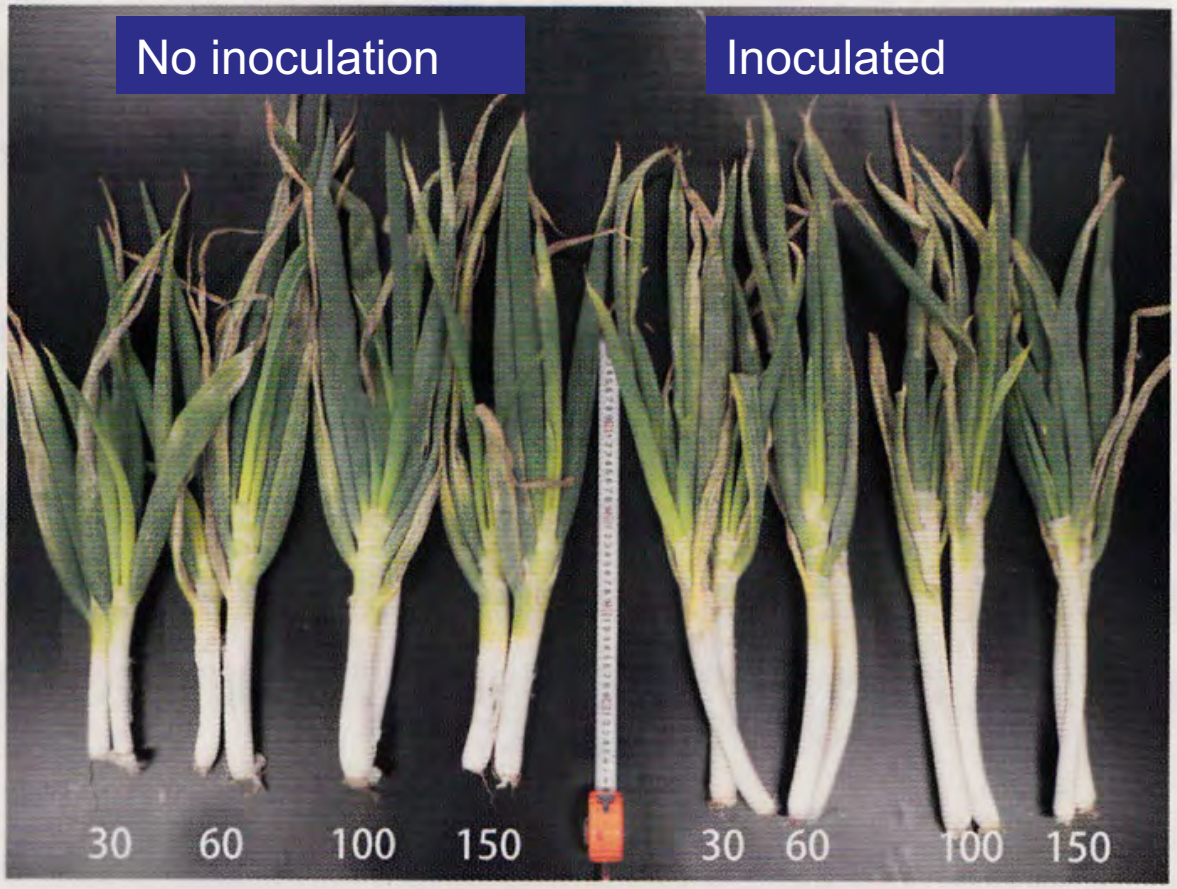
VA accepts photosynthetic products from plant.



Effect of mycorrhizal formation on the plant growth.



Effect of mycorrhizal inoculation on the growth of leek.

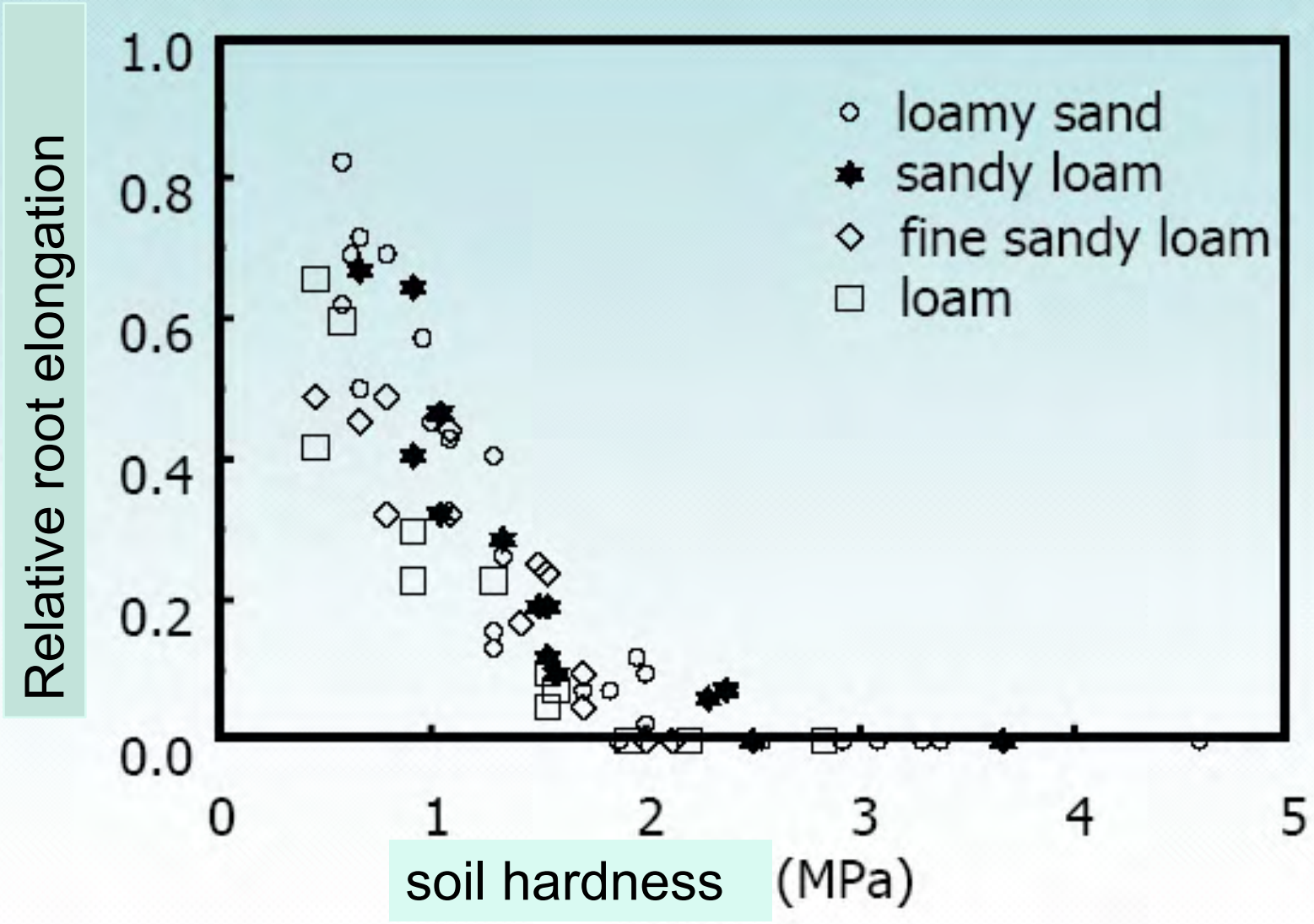


Effect of mycorrhizal inoculation on the growth of leek.

Available phosphate (mg/100g) in horizontal axis.

Relationship between soil hardness and root elongation

(Taylor, H. M. et al., 1966)



Cited from the homepage of Prof. Hatano, Hokkaido University

Physical properties of soil influencing the root growth

- Penetration resistance value

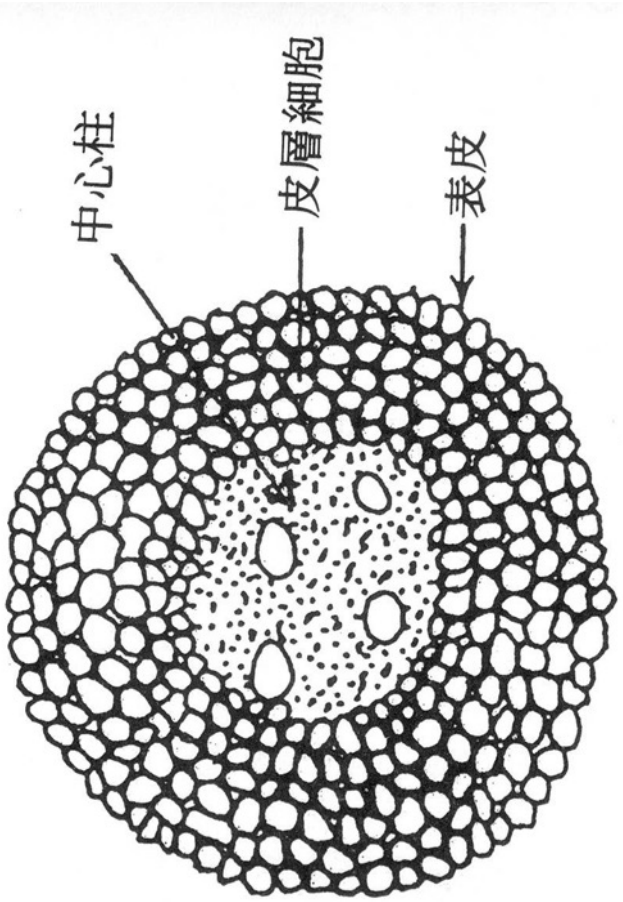
  Inverse proportion
- Moisture content

  Inverse proportion
- Air space volume

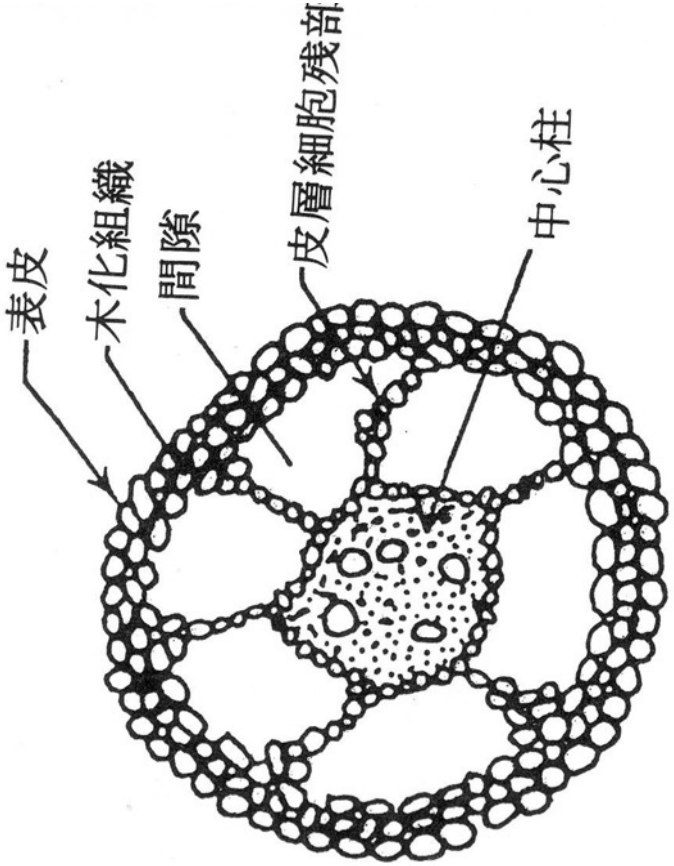
  Direct proportion
- Bulk density

  Optimum range around 1.0

Comparison of root sections between barley and rice



Barley



Rice

Non rhizosphere soils in upland and paddy fields

	Redox state	Major microbes	States of various substances
Upland	Oxidative	Aerobic microbes	NO_3^-, Fe^{3+}, MnO_2, SO_4^{2-}
Paddy	Reductive	Anaerobic microbes	NH_4^+, Fe^{2+}, Mn^{2+}, S^{2-}

Rhizosphere soils in upland and paddy fields

	Nitrogen absorption	pH	Redox state
Upland	Nitrate (absorbtion) CO_2 (secretion)	Increase compared with non rhizosphere	Decrease compared with non rhizosphere
Paddy	NH_4^+ (absorbtion) H^+ (secretion)	Decrease compared with non rhizosphere	Increase compared with non rhizosphere

What is good soil for the root growth?

- Root can develop deep, wide, and healthy, and can supply enough amounts of nutrient and water to above ground part.
- For this purpose ・・・・・・

What is good soil for the root growth?

① Good soil aeration, drainage, and water retention, and soft.

← Aggregate structure formation

← Application of organic matter

What is good soil for the root growth?

② Have a good balance in nutrients.

Have a proper pH value.

← Soil diagnosis is carried out.

← Improvement of soil acidity

（Application of lime）

What is good soil for the root growth?

③ Contains organic matter,
food for soil microbes and organisms.
Soil organisms are abundant.

← Application of compost
and green manure.