

# Plant Growth and Rhizosphere

Kiyoshi Tsutsuki

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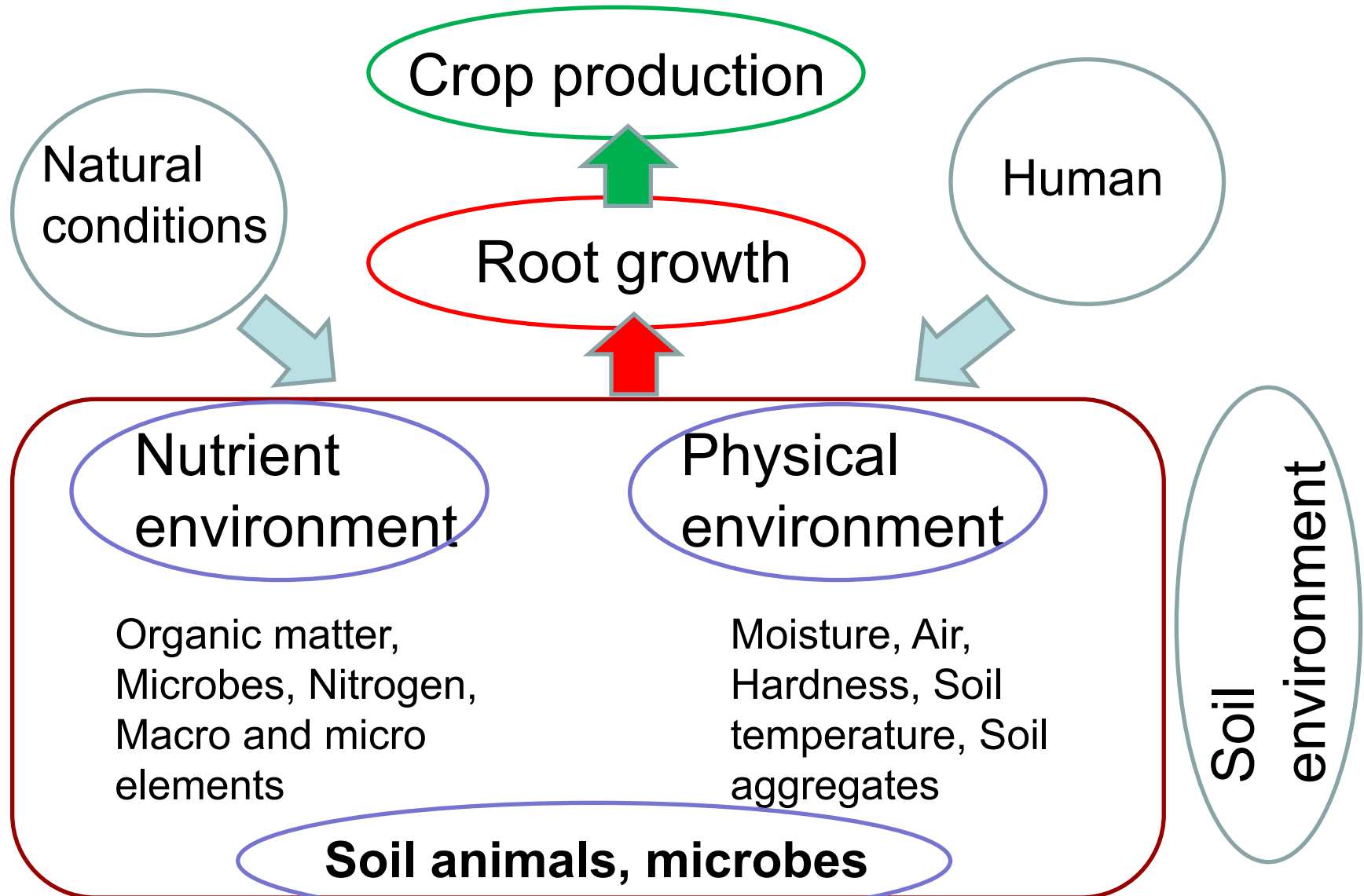
# “Root” is a contact point between plant and soil

- What gives root to soil?
- What gives soil to plant through root?
- Root improves soil.
- Soil supports the growth of plant through the root.

# “Ishiwari-zakura” in Morioka, Iwate. Cherry root breaking the big stone.



# Soil factors related to crop production



# History of earth and soil formation

Years b. present	Important Events	Atmosphere	Soil
$4.6 \times 10^9$	Birth of Earth		
$4.0 \times 10^9$	Ocean of HCl	CO <sub>2</sub> 97 %	
	Rock solubilization → Neutral Ocean		
	Precipitation of CaCO <sub>3</sub>		
$3.8 \times 10^9$	Evolution of aquatic anaerobic microbes.		
$3.5 - 2.7 \times 10^9$	Evolution of stromalite. Origin of photo-synthesis.		
$2.0 \times 10^9$	Evolution of sea algae.	O <sub>2</sub> 0.2 %	
$0.6 \times 10^9$	Evolution of lichen and terrestrial organisms.	O <sub>2</sub> 2 %	Start of root and
$0.4 \times 10^9$	Evolution of early terrestrial plants.	O <sub>2</sub> 21 %	Early soil formation
$0.3 \times 10^9$	Evolution of fern and cycad.		Soil formation
200,000	Evolution of humankind		
10,000	Homo sapiens sapiens		
6,000	Start of agriculture		

# Fossil of stromalite

First photosynthetic bacteria, producing oxygen.



Bridged the change from the worlds of anaerobic to aerobic organisms.

# Rhizoid and True root

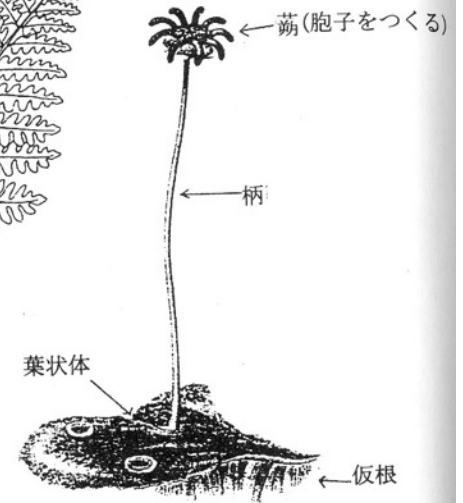
Seed plant



Fern



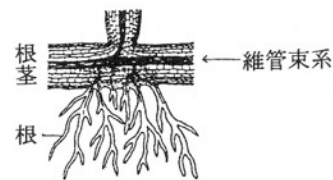
Moss plant



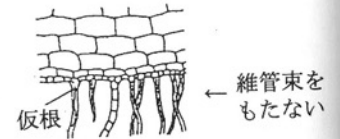
Vascular bundle



種子植物  
(アサガオ)



シダ植物  
(ワラビ)



Moss plant

Vascular plant

図 2・6 仮根と真の根

(伊沢正名「コケの世界」より)

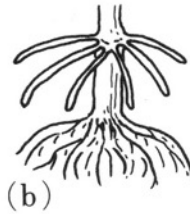
# Adventitious root

## Various roots

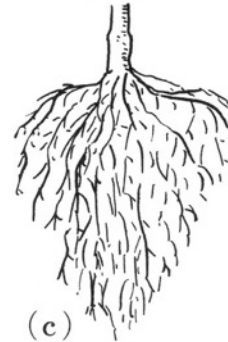
Dandelion



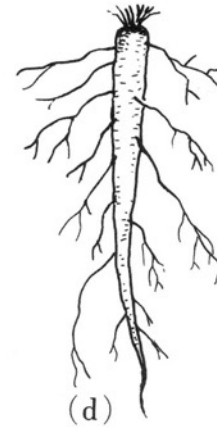
Geranium



Corn



Grasses

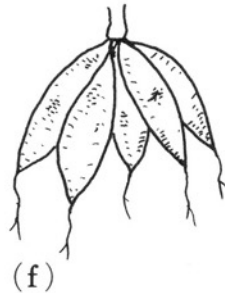


(d)



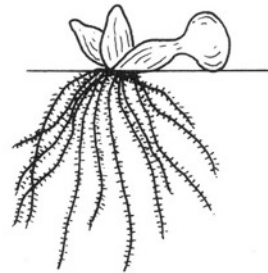
Carrot

(e)



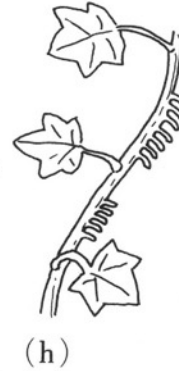
Dahlia

(f)



Water hyacinth

(g)



Ivy

(h)



Orchid

(i)



Cuscuta australis

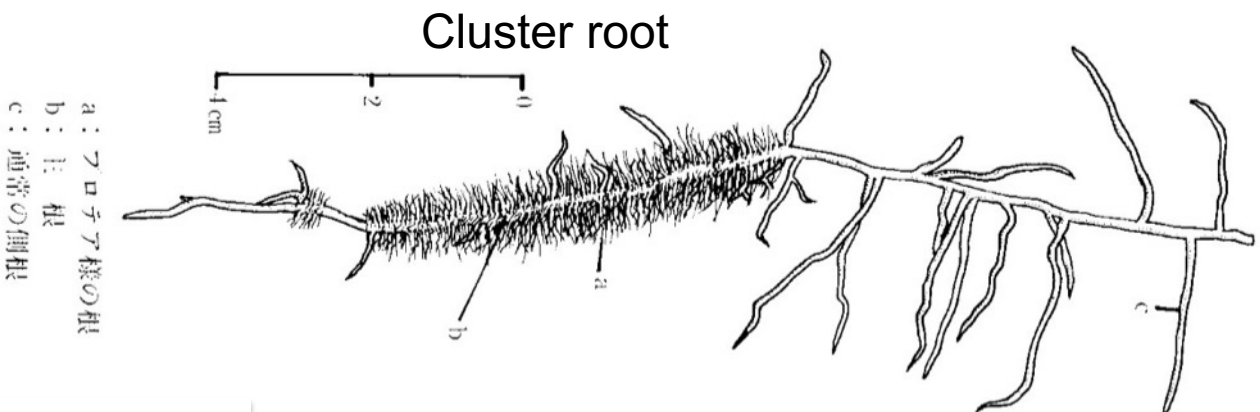
(j)

(a) さし木から生じた不定根(ゼラニウム). (b) 支持根とそれ以外の不定根(トウモロコシ). (c) ひげ根(草本). (d) 主根(タンポポ). (e) 多肉質の主根(ニンジン). (f) 多肉質で、群生している不定根(ダリア). (g) 水生の不定根(ヒヤシンス). (h) 気根(キヅタ). (i) 気根(ラン). (j) 寄生根(マメダオシ).



# Root of protea and lupin

図3-7 プロテア様の根の形態  
(Ramont.R., 1972を図化)



# Rows of *Taxodium distichum* (swamp cedar) in Saga University



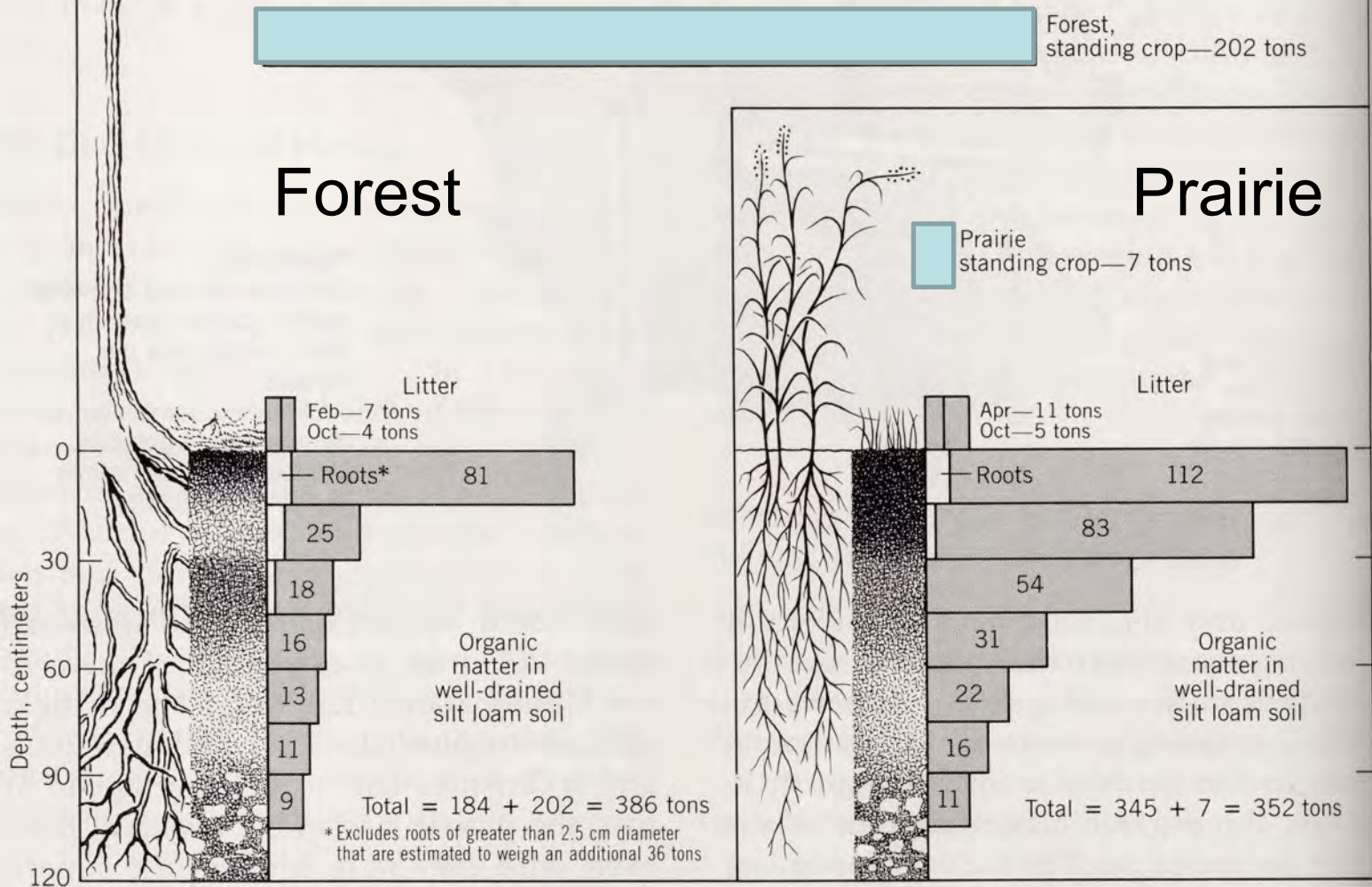
# Aerobic roots of swamp cedar



# Aerobic roots of aquatic trees Sarawak river, Malaysia



# Organic matter distribution



**Figure 6-3**

Metric tons per hectare distribution of organic matter in forest (white oak, black oak) and prairie (big bluestem, Indian grass) ecosystems in south central Wisconsin. (Adapted from Nielsen and Hole, 1963. Courtesy of F. D. Hole, Soil Survey Division, Wisconsin Geological and Natural History Survey, University Extension, University of Wisconsin.)

# Annual dry matter production in root and above ground parts

	Plants	Root (t/ha)	Above (t/ha)	Total (t/ha)	Root/Above
Grasses	barley	1.3-3.0	7.2-12	8.5-15	0.18-0.26
	wheat	1.4-2.5	4.5-9.2	6.5-11.7	0.21-0.44
	clover	1.8-4.5	5.0-6.7	7.5-11.2	0.28-0.67
	corn	4.4-4.5	8.3-9.0	12.8-13.5	0.50-0.54
	potato	3.9-4.0	2.4-2.8	6.4-6.7	1.39-1.67
	Sugar beet	6.6-13	1.2-5.0	7.8-18.0	2.6-5.5
Woods	pine	1.8-1.9	7.4-10.5	8.6-12.4	0.16-0.18
	oak	1.3-1.8	6.5-10.0	7.8-11.8	0.18-0.20
	Tropical f.	2.6-2.8	21.7-28.7	24.3-31.6	0.10-0.12
	German f.				0.15-0.33

# Proportion of root to whole plant :

**Grasses**                      **13-84%**

**Woods**                         **9-24%**

## Root residue remained in soil after harvest :

**Some hundreds kg/10a,**

**Some t / ha**

# Root length

- **Total root length / unit area**

Grasses            50-90 km/m<sup>2</sup>

Soy bean            25-40 km/m<sup>2</sup>

Potato                20 km/m<sup>2</sup>

- **Total root length / unit mass**

Grasses            300-400 km/m<sup>3</sup>

Potato              100 km/m<sup>3</sup>

Generally large in surface layer and decrease with depth. Large at 10 – 20 cm depth for corns and soy bean.



# Factors influencing root development

- Crops with long growth period have longer roots.
  - winter wheat
- No difference between C3 and C4 plants.
- Water shortage, high or low temperature, nutrients deficiency enhance the root growth. Shortage of sunshine retards the root growth.

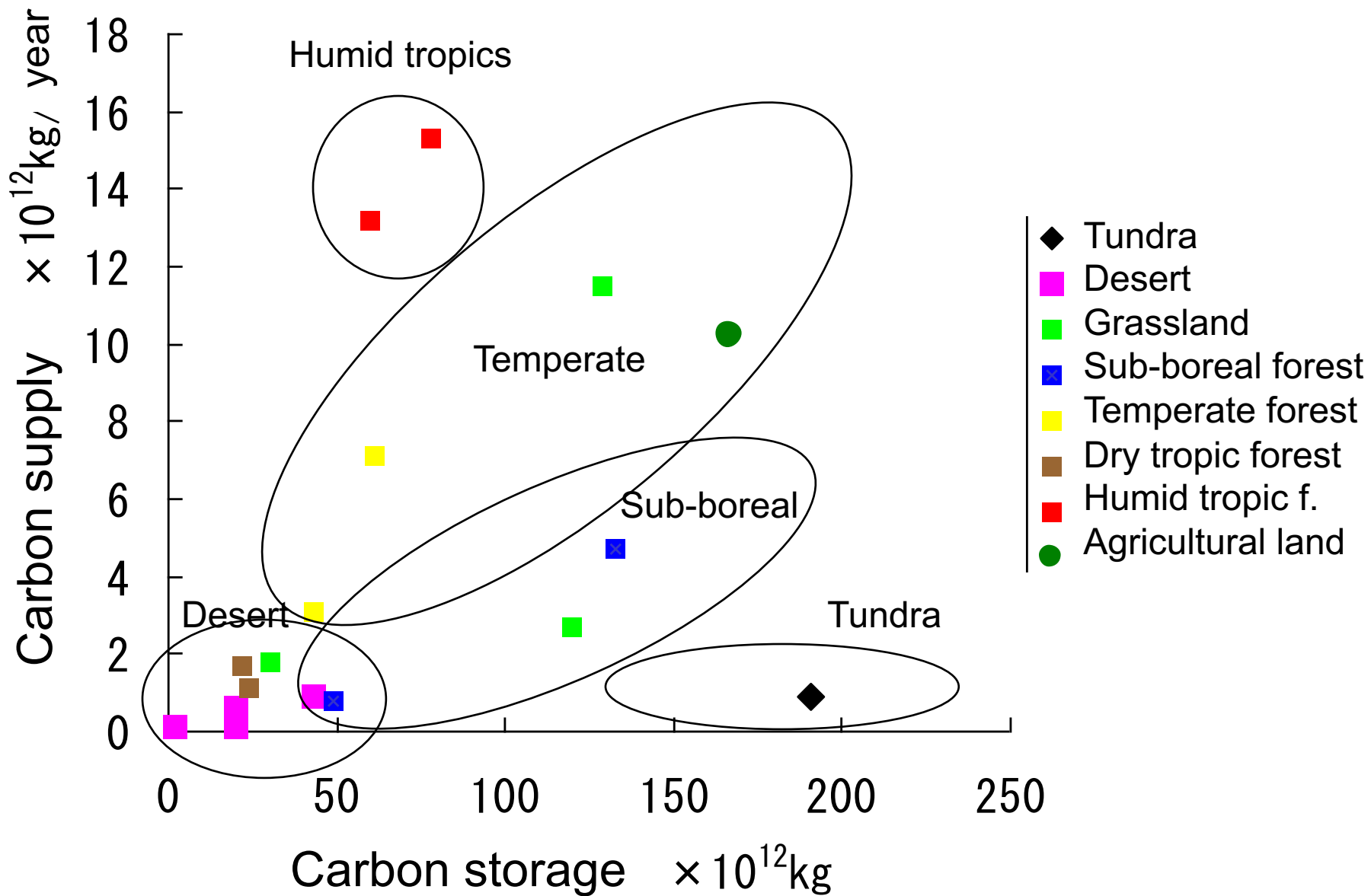
# Maximum and frequent root depth of various crops.

Plants	Maximum (cm)	Frequent (cm)
Rice	60	55
Winter wheat	190	130
Spring wheat	145	90
Barley	135	80
Corn	240	180
Soy bean	60	40
Sugar beet	170	160
Sweet potato	100	80

# Maximum and frequent root depth of various crops.

Plants	Maximum (cm)	Frequent (cm)
Tomato	150	90
Cabbage	145	80
Cucumber	110	30
Onion	100	80
Asparagus (6 <sup>th</sup> year)	310	180
Sunflower	200	70
Alfalfa (2 <sup>nd</sup> year)	300	160
Red clover	280	100

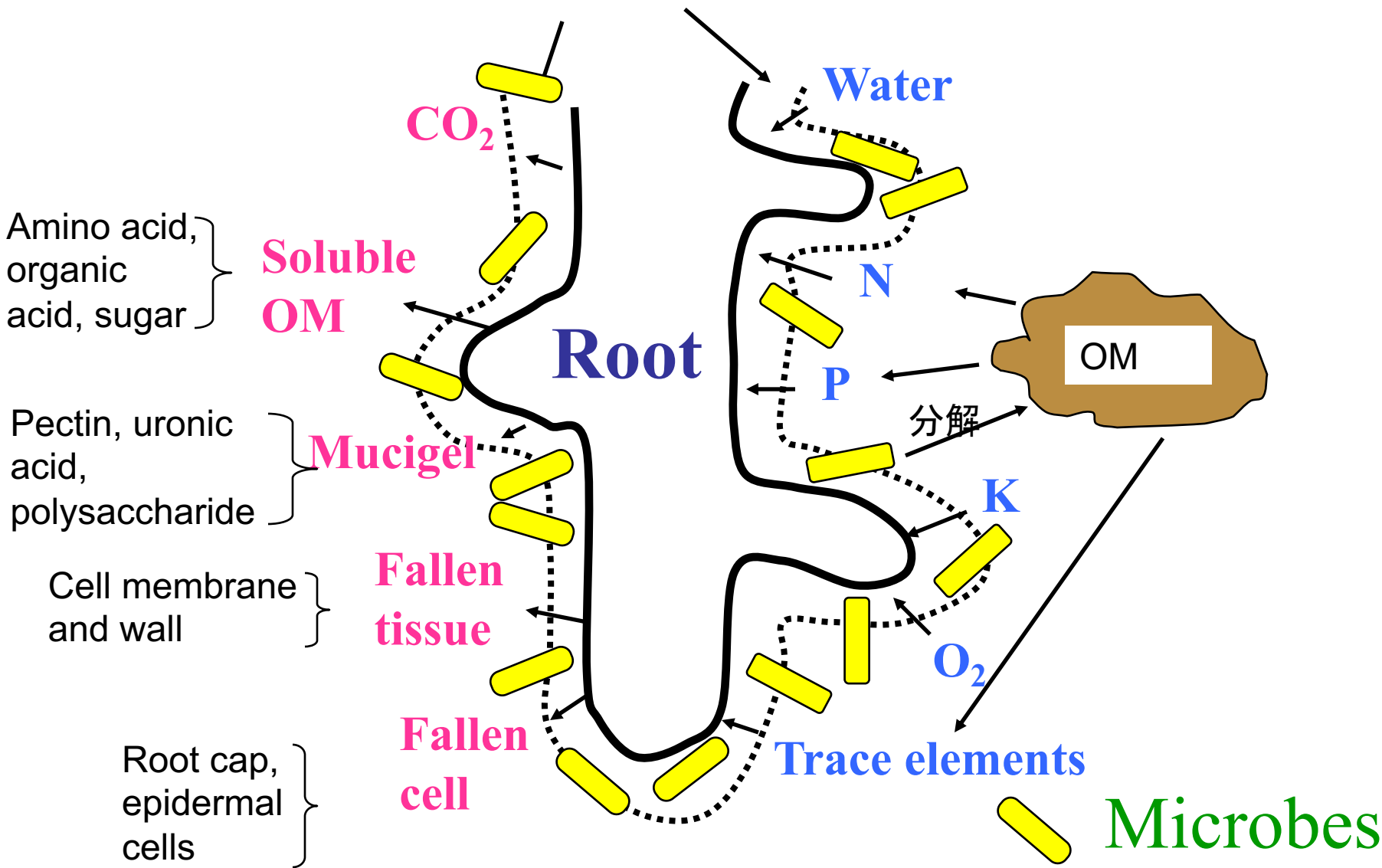
# Supply and storage of carbon to soil



## Turn over rate of soil carbon in 3 climate zones.

	<b>England</b>	<b>West Canada</b>	<b>Brasil</b>
Climate zone	Temperate	Cool temperate	Tropics
Soil types	Luvisol	Mollisol	Spodosol
Crop	Wheat	Wheat - fallow	Sugar cane
Soil weight (Mg/ha)	2200	2700	2400
Organic carbon (Mg/ha)	26	65	26
Annual carbon input (Mg/ha)	1.2	1.6	13
Turn over rate of C (years)	22	40	2

# Root zone



# Rhizosphere environment

# Microbial numbers ratio between rhizosphere and non rhisosphere

<b>Plants</b>	<b>Rhizo / Non-rhizo</b>
<b>Wheat</b>	<b>7. 6</b>
<b>Oat</b>	<b>5. 2</b>
<b>Flax</b>	<b>6. 5</b>
<b>Timothy</b>	<b>10. 8</b>
<b>Alfalfa</b>	<b>10. 8</b>
<b>Red clover</b>	<b>10. 1</b>

# Change in the root system of corn after the infection by microbes



Infected root

(a)



Aseptic root

(b)



# Functions of rhizosphere microbes

**Decompose organic matter and hand nutrients to root.**

**Protect root from disease germs.**

**Symbiosis with mycorrhizal fungi enhance the absorption of hardly soluble phosphate and water far from root.**

**Symbiosis with rhizobium bacteria enables nitrogen fixation.**

# What root system does to soil : 1

**Formation of soil aggregate.**

**Secretion of amino acid and sugar.**

**Old root hair and root cap cell are fell.**

→ **Stimulation of rhizosphere microbes**

**Increase soil organic matter.**

# What root system does to soil : 2

**Solubilize hardly soluble nutrients such as phosphates in Ca, Fe and Al salt form.**

**Mugineic acid for wheat.**

**Piscidic acid for pignon pea.**

**Oxalic acid, citric acid, malic acid are very common in various plants.**