Integrated Soil, Water, and Plant Nutrient Management For Sustainable Vegetable Production

WVC 36th International Training Course

Kumut Sangkhasila

Soil Conservation and Management Laboratory

Kasetsart University, KPS Campus

Basic Soil Knowledge

Mineral
Bacteria
Protozoa
Fungi
Non-Living stuff

solid

Living stuff

pores

Soil properties

- physical ----- touchable, visible, measurable

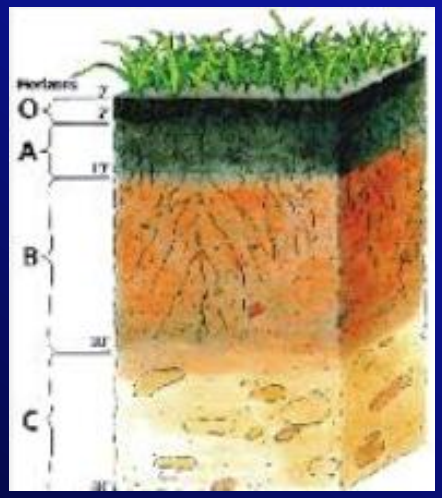
- chemical -- non-touch, imagine, invisible, measurable

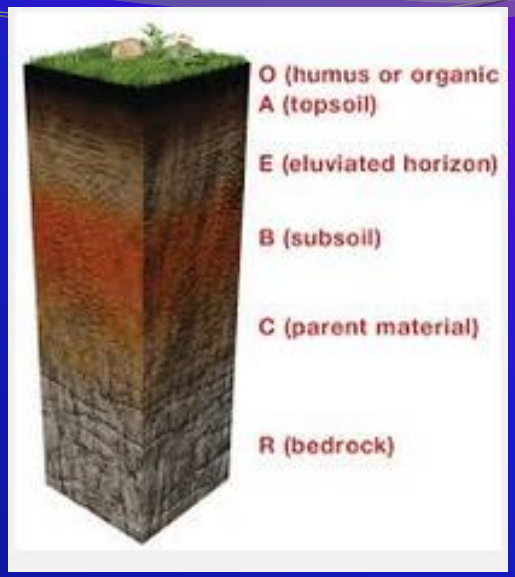
- biological ---- visible-invisible, imagine, measurable

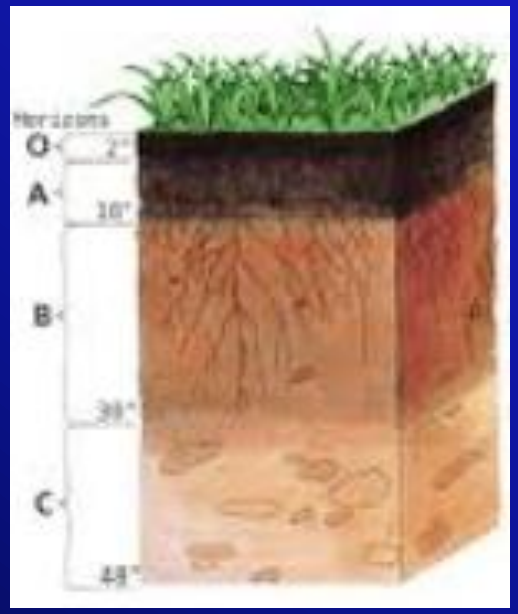
- nutrient ---- non-touchable, invisible, measurable

Physical soil properties

- Soil color and depth



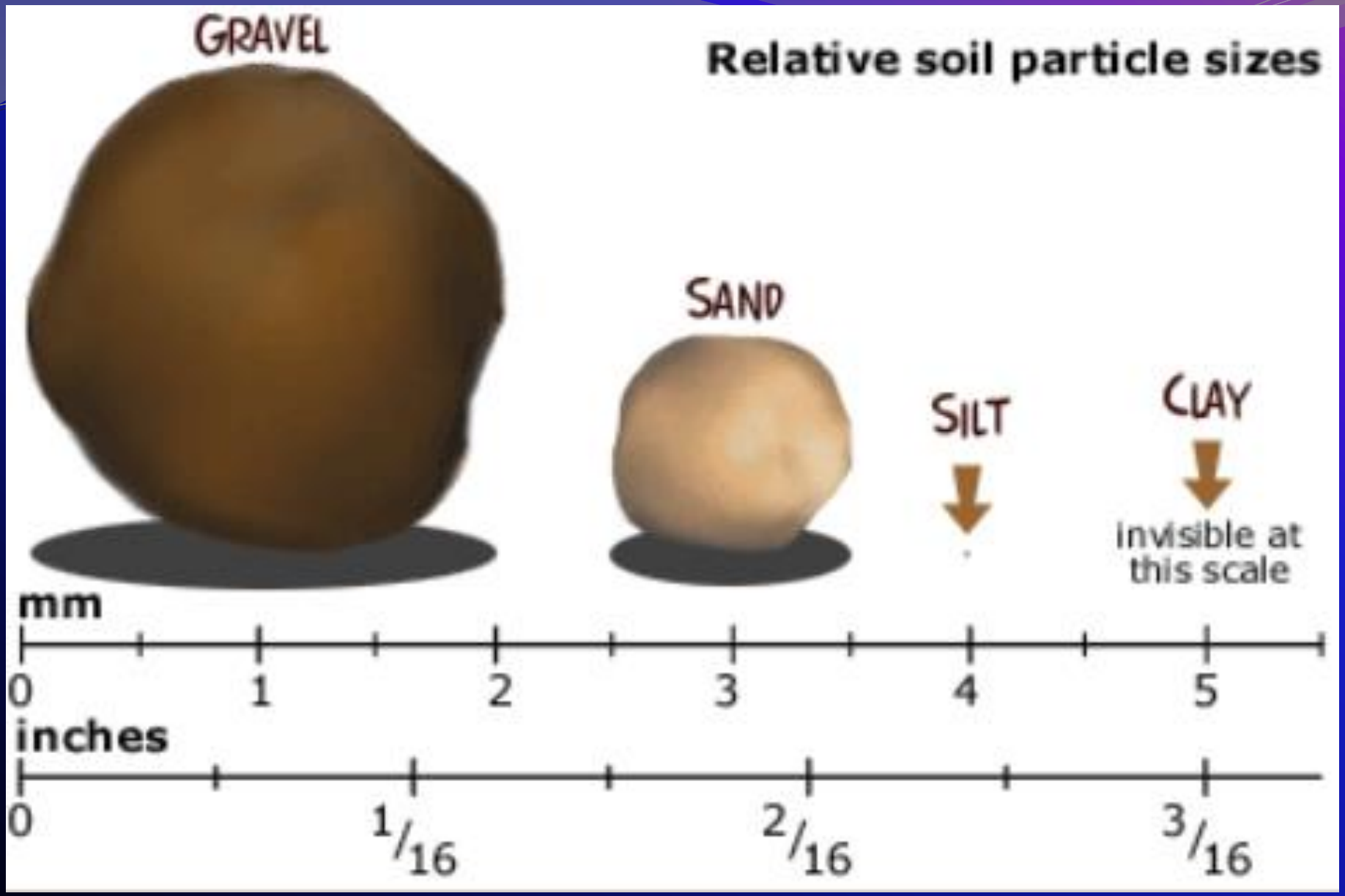




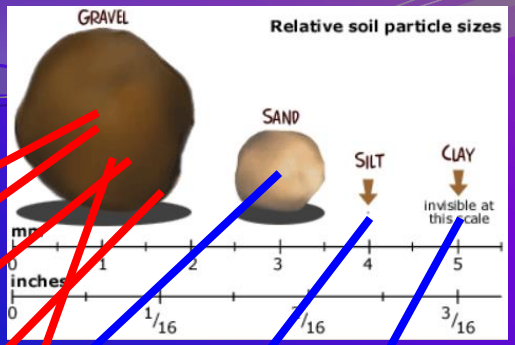
What does soil color roughly tell?

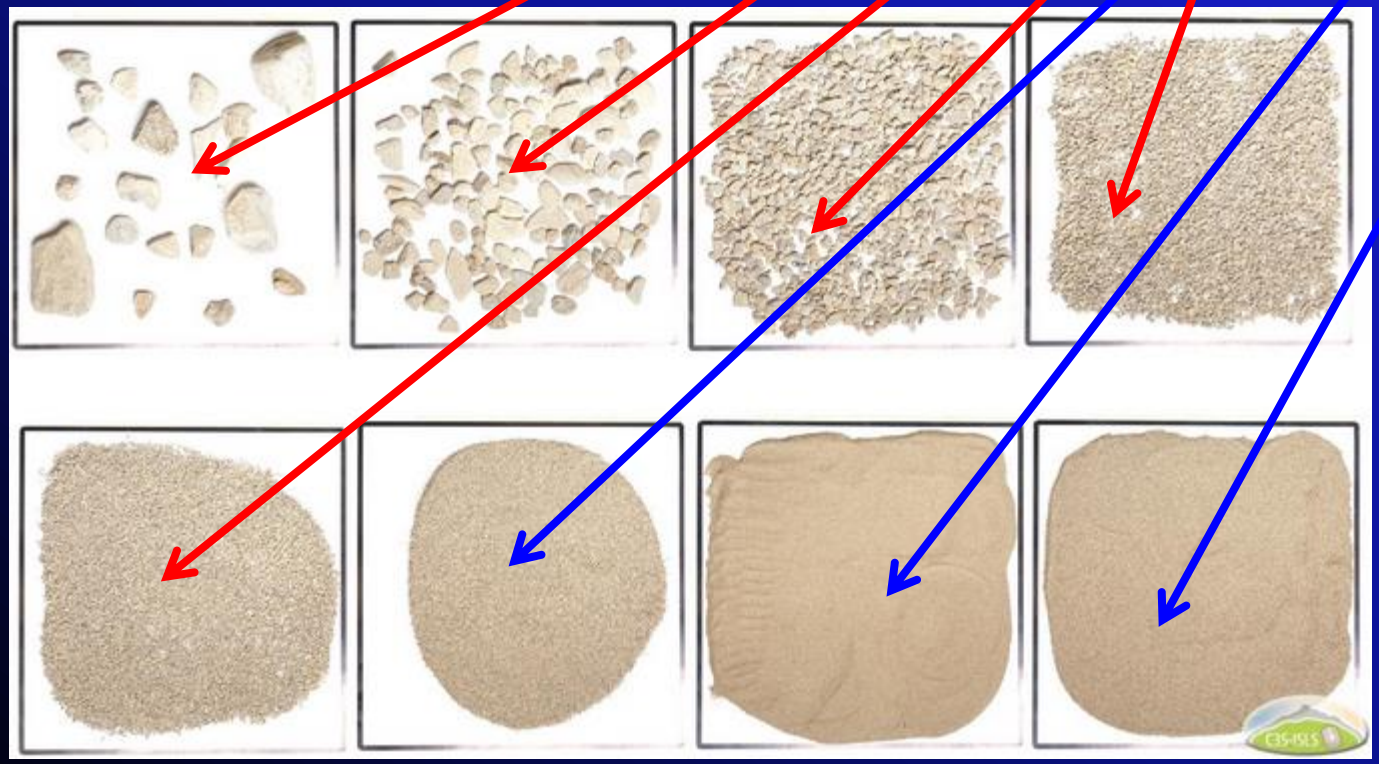
Physical soil properties

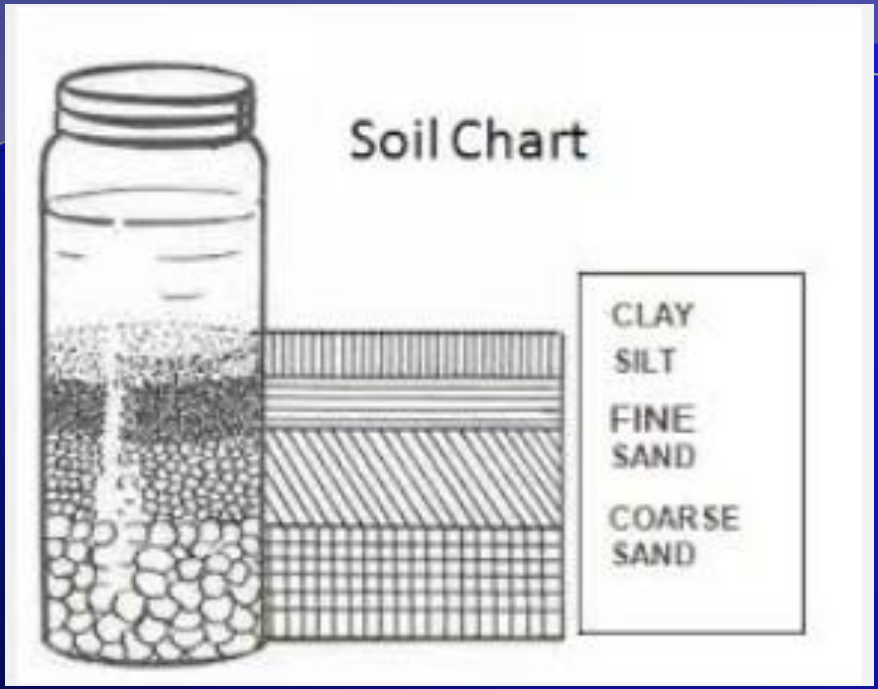
- Texture indicate roughness and fineness of soils

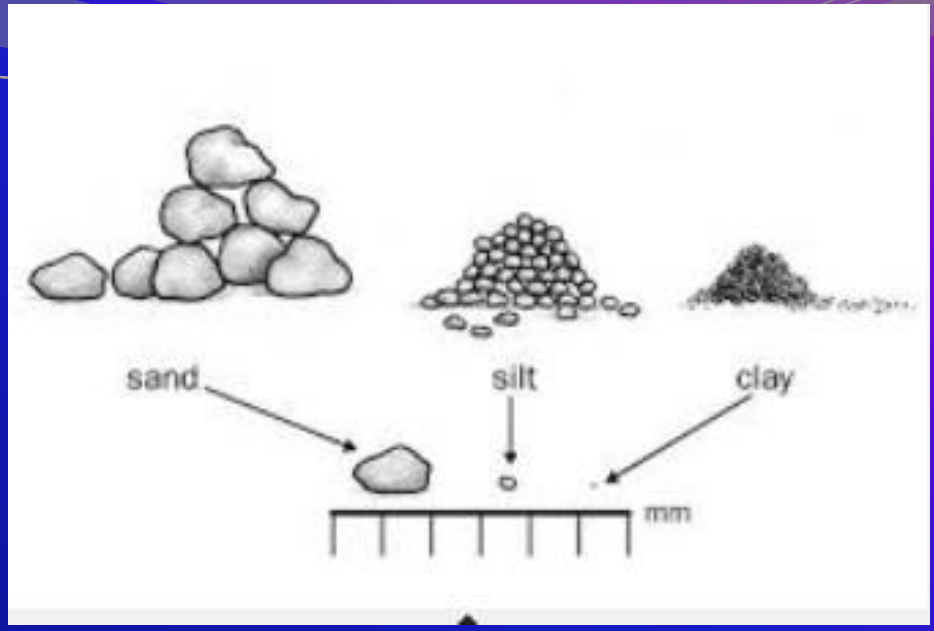


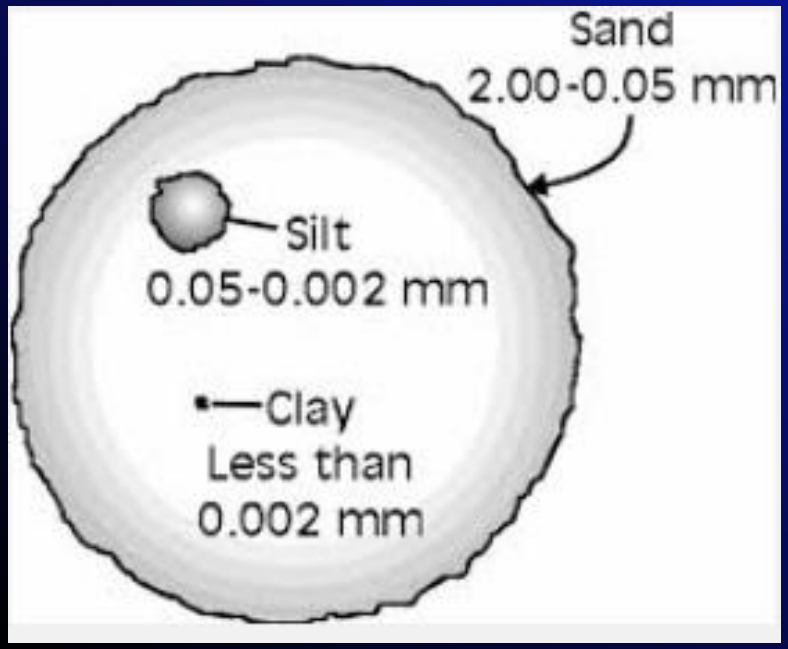
Primary particle of soils

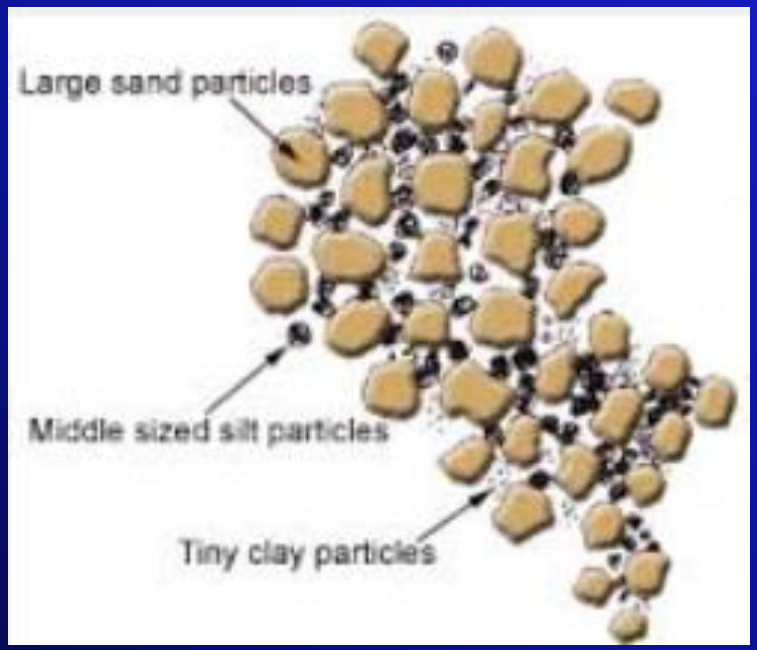

GRAVEL
Relative soil particle sizes
SAND
SILT
CLAY
invisible at this scale
mm
0
1
2
3
4
5
inches
0
1/16
2/16
3/16




Soil Chart
CLAY
SILT
FINE SAND
COARSE SAND


sand
silt
clay
mm


Sand
2.00-0.05 mm
Silt
0.05-0.002 mm
Clay
Less than
0.002 mm


Large sand particles
Middle sized silt particles
Tiny clay particles

Fine texture

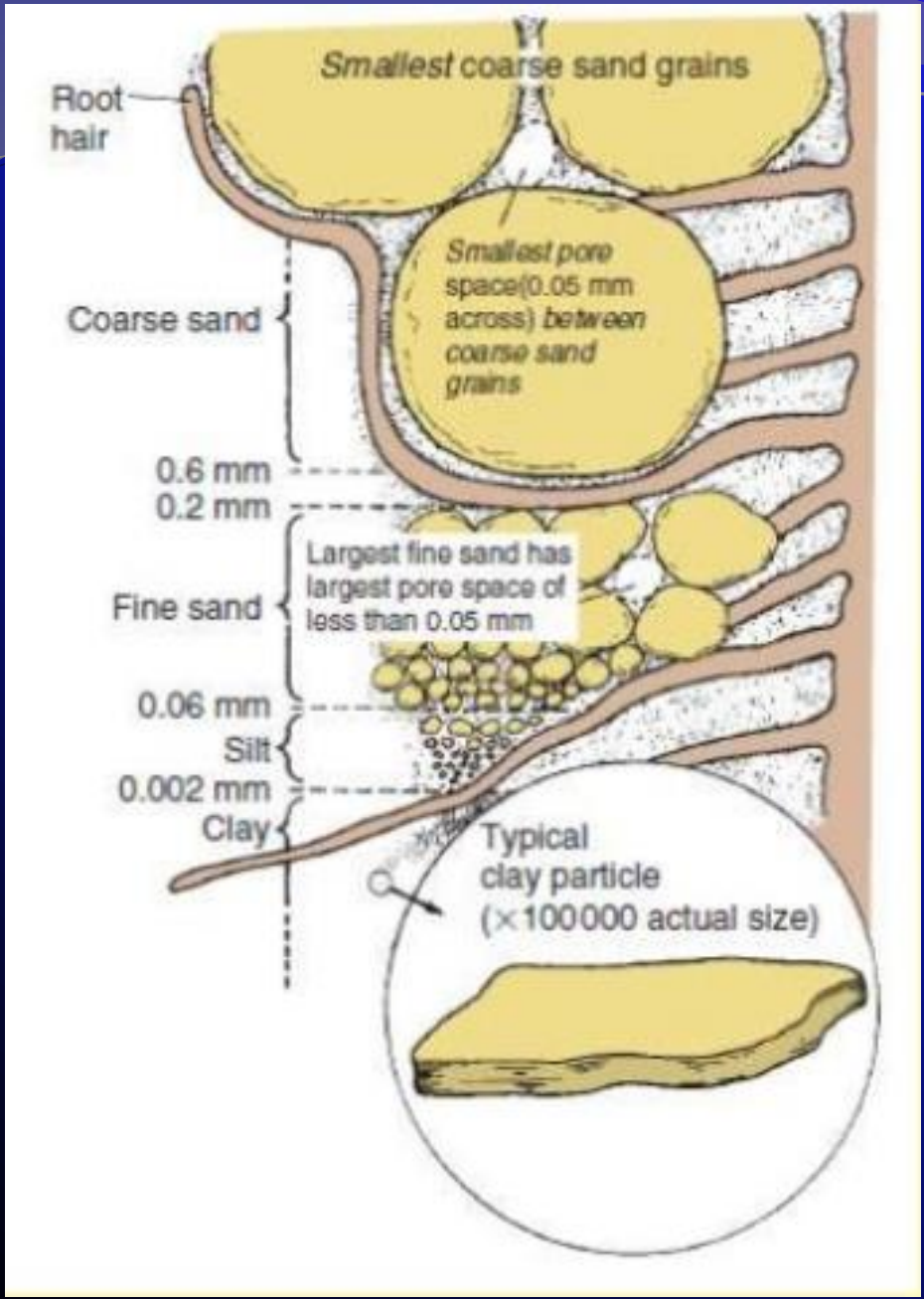
- เหนียว (Clay)
- เหนียวปนทรายแป้ง (Silty clay)
- เหนียวปนทราย (Sandy clay)
- ร่วนเหนียว (Clay loam)
- ร่วนเหนียวปนทรายแป้ง (Silty clay loam)

Course texture

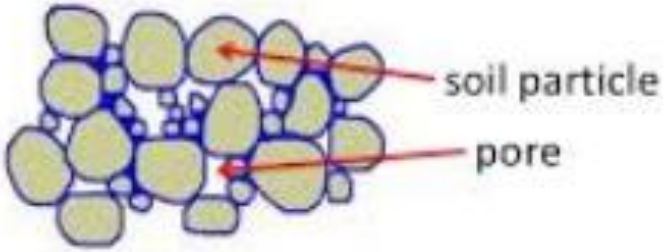
- ทราย (sand)
- ทรายร่วน (Loamy sand)
- ร่วนทราย (Sandy loam)

Moderate texture

- ร่วนเหนียวปนทราย (Sandy clay loam)
- ร่วน (Loam)
- ร่วนปนทรายแป้ง (Silt loam)
- ทรายแป้ง (Silt)



The size particles that make up each type of soil determines the size of the pores between the particles.

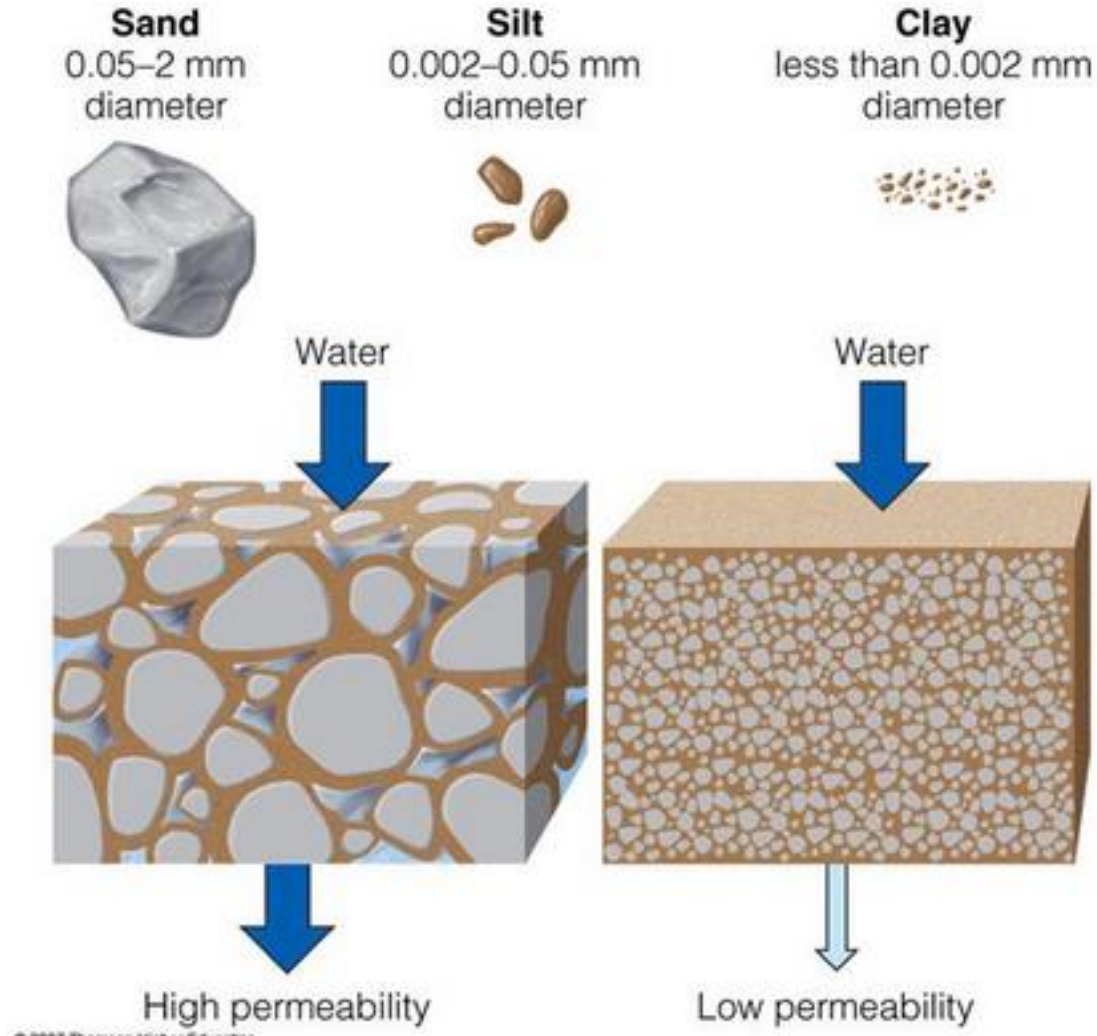


The pores in the soil hold air and water.

The larger the particles making up the

Soil Particle Size

- **Sand**
  - Largest
- **Silt**
  - Medium
- **Clay**
  - Smallest



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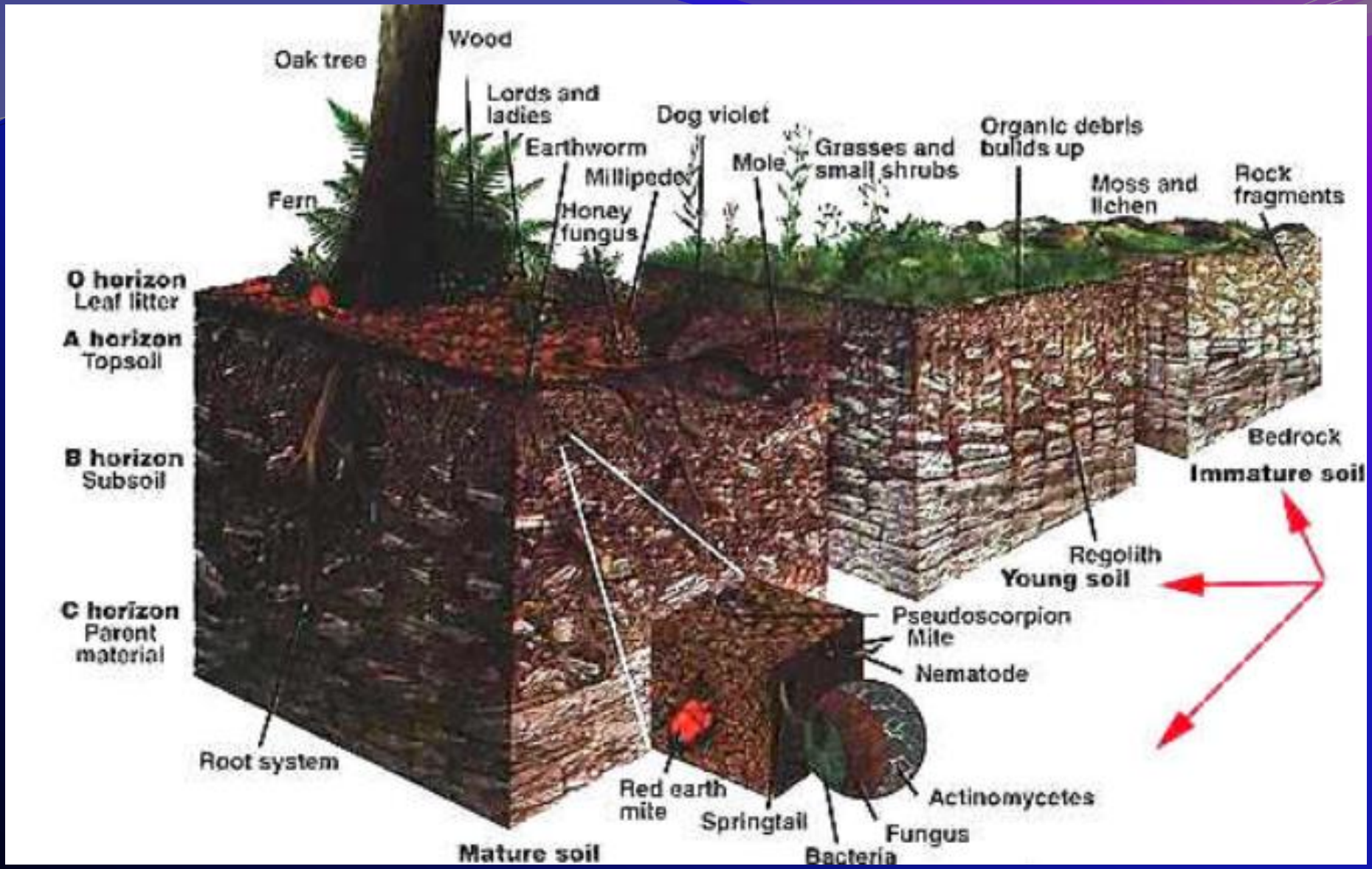
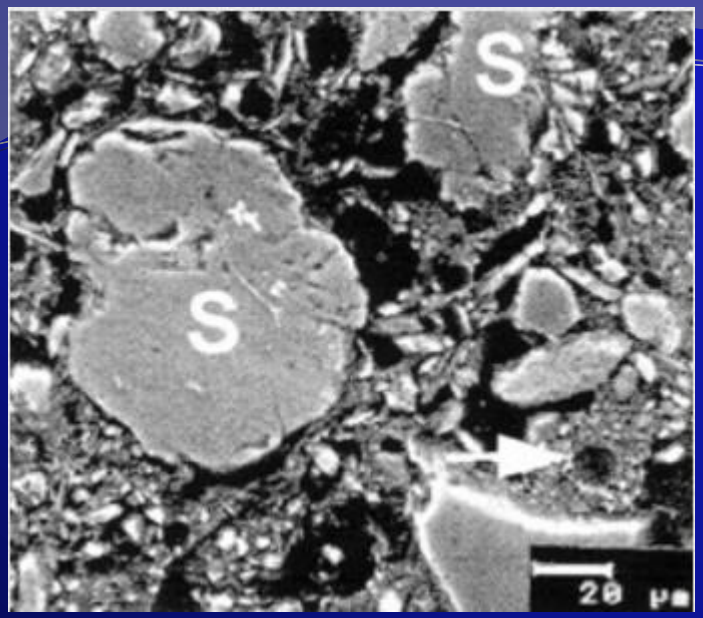
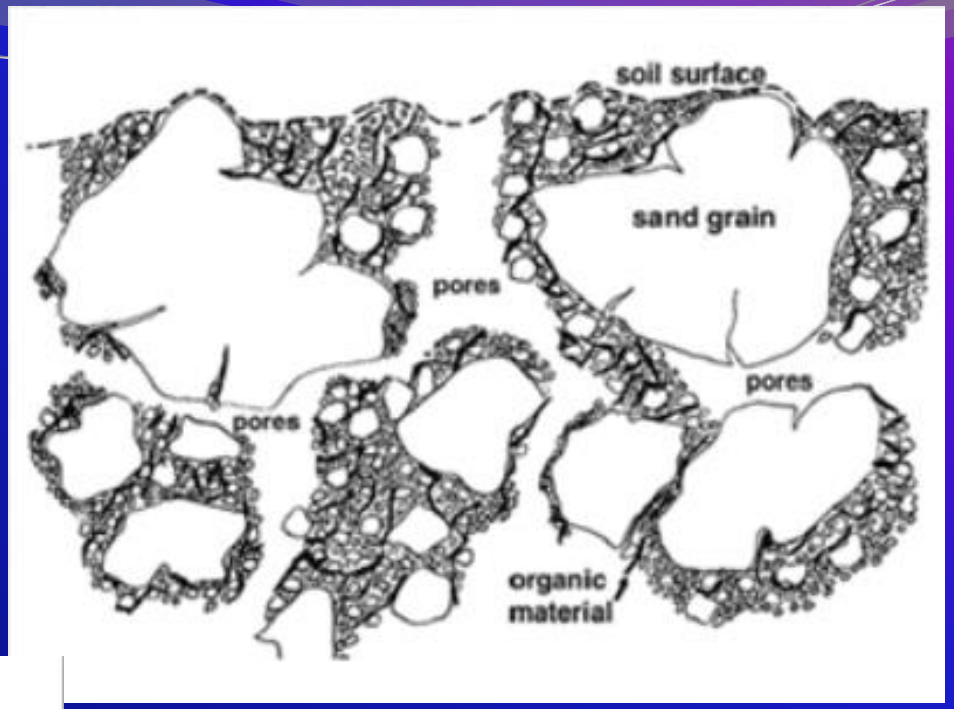
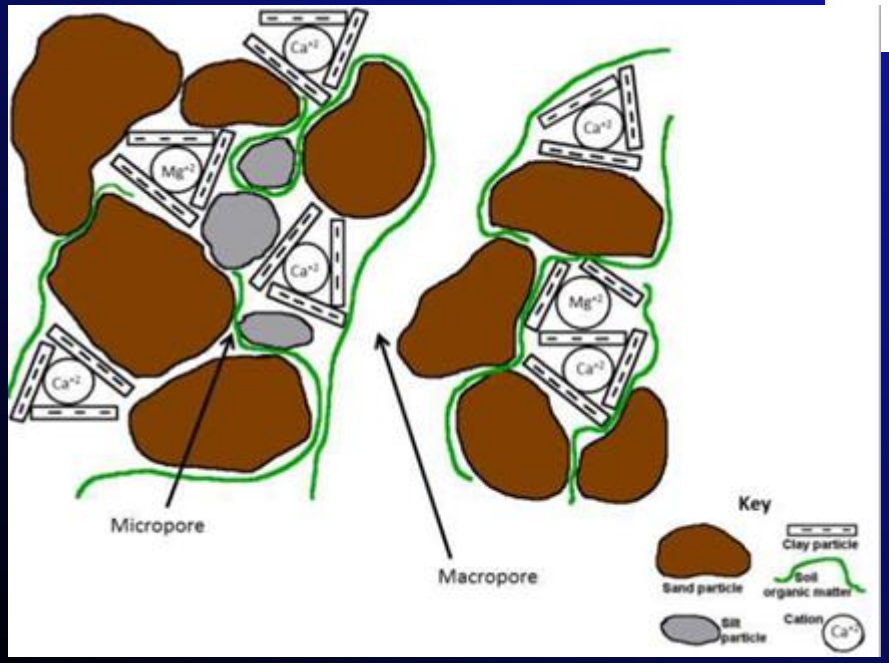
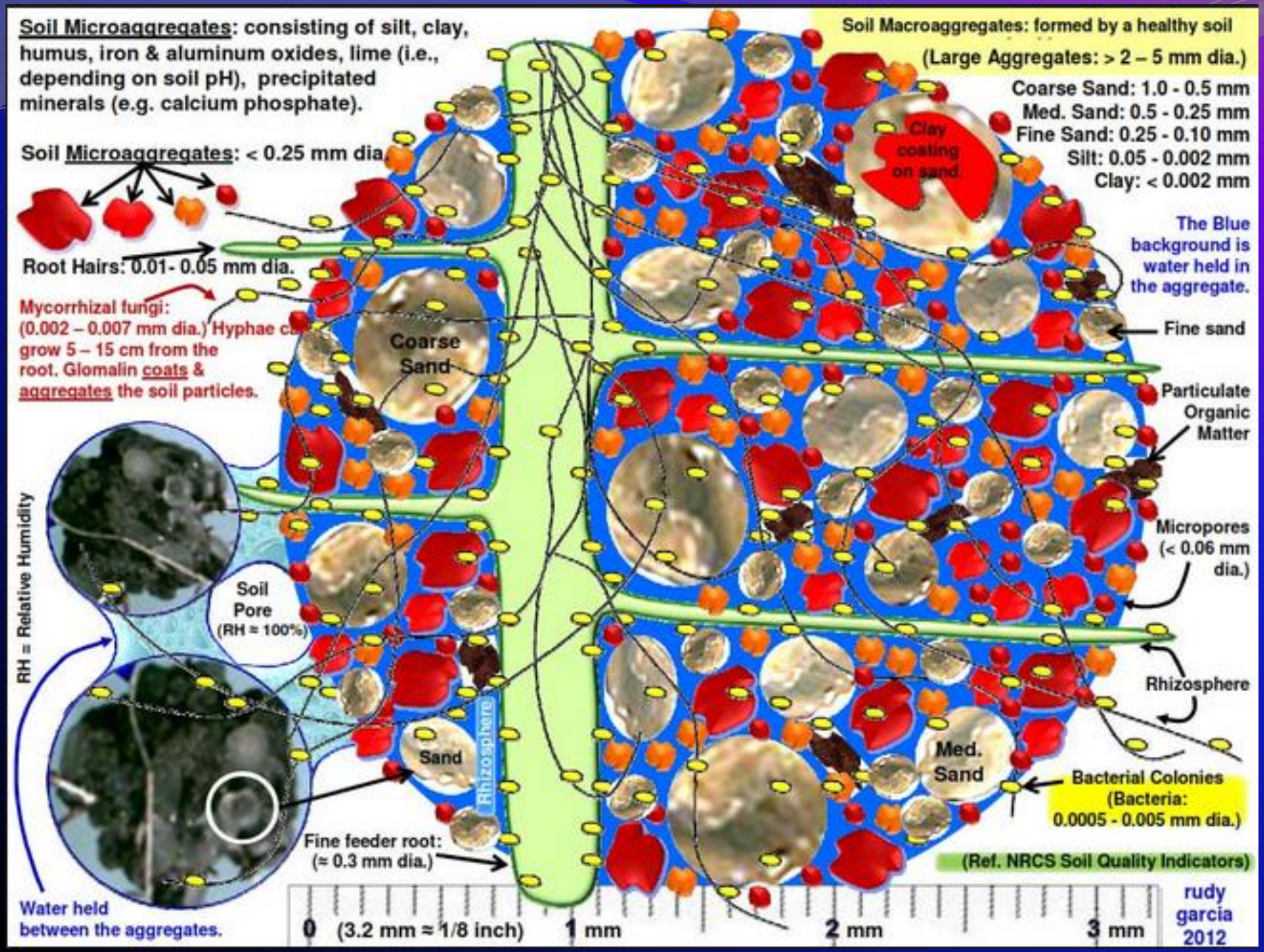

Oak tree
Wood
Lords and ladies
Dog violet
Earthworm
Millipede
Mole
Grasses and small shrubs
Organic debris builds up
Moss and lichen
Rock fragments
Fern
Honey fungus
O horizon
Leaf litter
A horizon
Topsoil
B horizon
Subsoil
C horizon
Parent material
Bedrock
Immature soil
Regolith
Young soil
Pseudoscorpion
Mite
Nematode
Root system
Red earth mite
Springtail
Actinomycetes
Fungus
Bacteria
Mature soil


S
S
20 µm

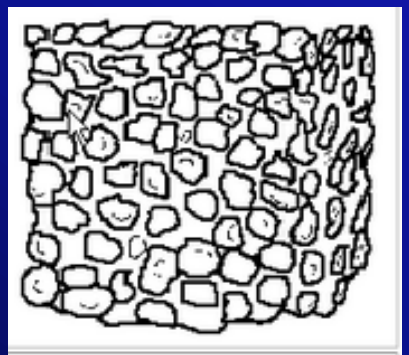

soil surface
sand grain
pores
pores
pores
organic material


Ca+2
Mg+2
Ca+2
Ca+2
Ca+2
Mg+2
Ca+2
Micropore
Macropore
Key
Clay particle
Sand particle
Soil organic matter
Silt particle
Cation
Ca+2


Soil Microaggregates: consisting of silt, clay, humus, iron & aluminum oxides, lime (i.e., depending on soil pH), precipitated minerals (e.g. calcium phosphate).
Soil Microaggregates: < 0.25 mm dia.
Root Hairs: 0.01- 0.05 mm dia.
Mycorrhizal fungi: (0.002 – 0.007 mm dia.) Hyphae can grow 5 – 15 cm from the root. Glomalin coats & aggregates the soil particles.
Soil Macroaggregates: formed by a healthy soil
(Large Aggregates: > 2 – 5 mm dia.)
Coarse Sand: 1.0 - 0.5 mm
Med. Sand: 0.5 - 0.25 mm
Fine Sand: 0.25 - 0.10 mm
Silt: 0.05 - 0.002 mm
Clay: < 0.002 mm
Clay coating on sand
The Blue background is water held in the aggregate.
Fine sand
Particulate Organic Matter
Micropores (< 0.06 mm dia.)
Rhizosphere
Bacterial Colonies (Bacteria: 0.0005 - 0.005 mm dia.)
(Ref. NRCS Soil Quality Indicators)
Coarse Sand
Soil Pore (RH = 100%)
RH = Relative Humidity
Sand
Rhizosphere
Med. Sand
Fine feeder root: (≈ 0.3 mm dia.)
Water held between the aggregates.
0 (3.2 mm ≈ 1/8 inch) 1 mm 2 mm 3 mm
rudy garcia 2012

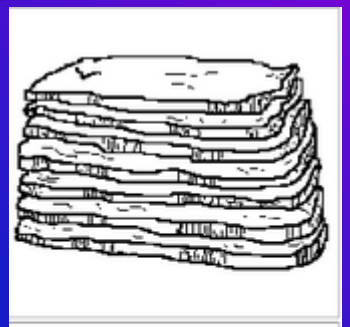
Physical soil properties

- Soil structure



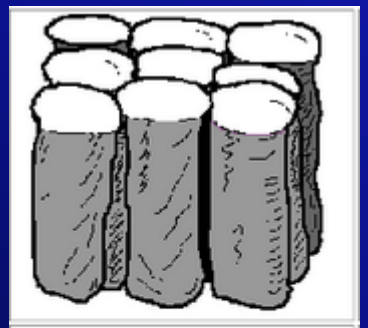
Granular: Resembles cookie crumbs and is usually less than 0.5 cm in diameter. Commonly found in surface horizons where roots have been growing.

Blocky: Irregular blocks that are usually 1.5 - 5.0 cm in diameter.



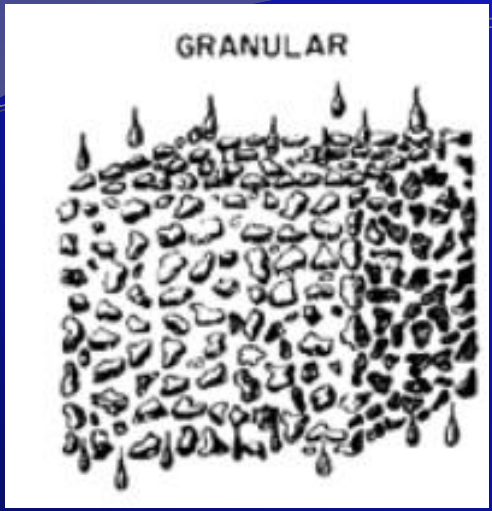
Platy: Thin, flat plates of soil that lie horizontally. Usually found in compacted soil.

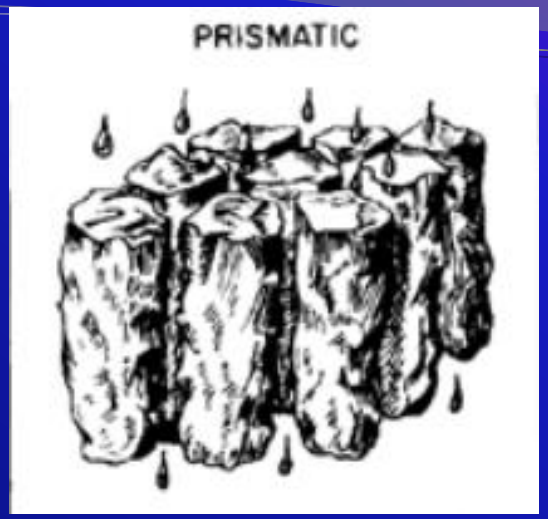
Prismatic: Vertical columns of soil that might be a number of cm long. Usually found in lower horizons.

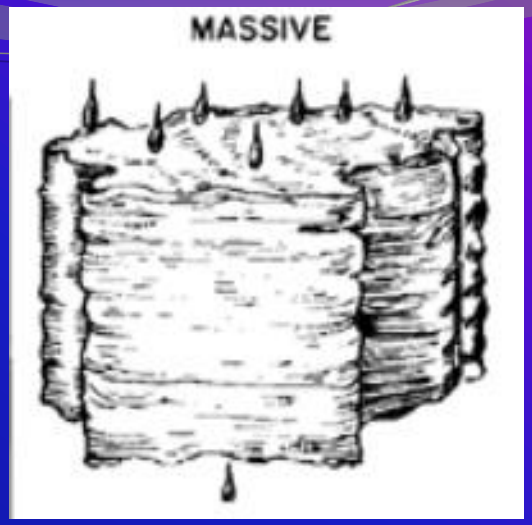


Columnar: Vertical columns of soil that have a salt "cap" at the top. Found in soils of arid climates.

Single Grained: Soil is broken into individual particles that do not stick together. Always accompanies a loose consistence. Commonly found in sandy soils.





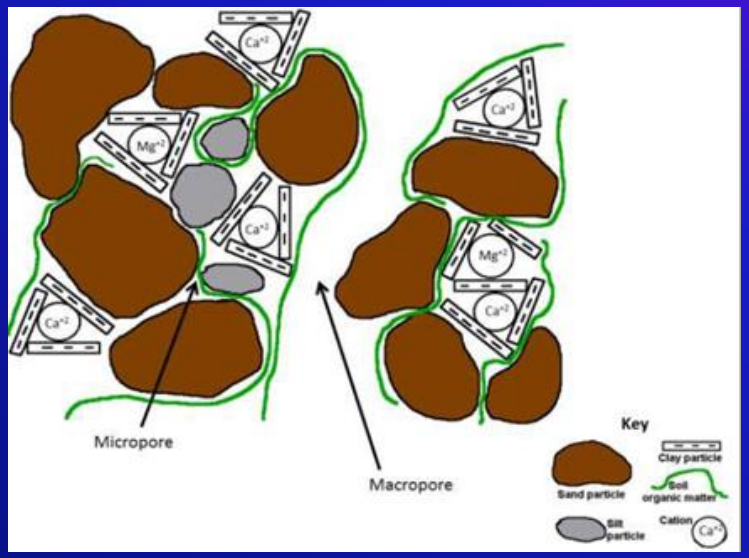


Soil structure vs water permeability --- water transfer

From single particle to aggregation

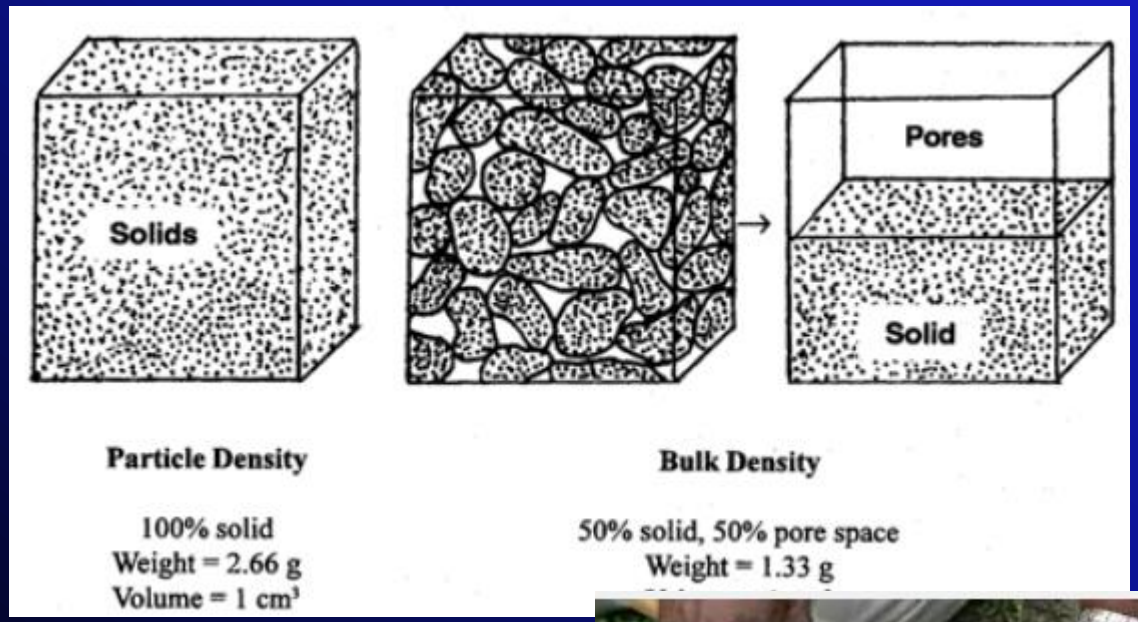
(primary particle ----> aggregates)

- Initial primary particle
- Organic matter
- Plant roots
- Fungi hyphe
- Clay size particle
- Colloid charges in soil solution

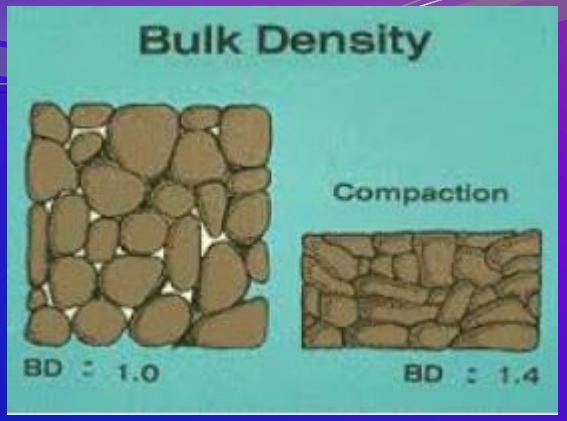


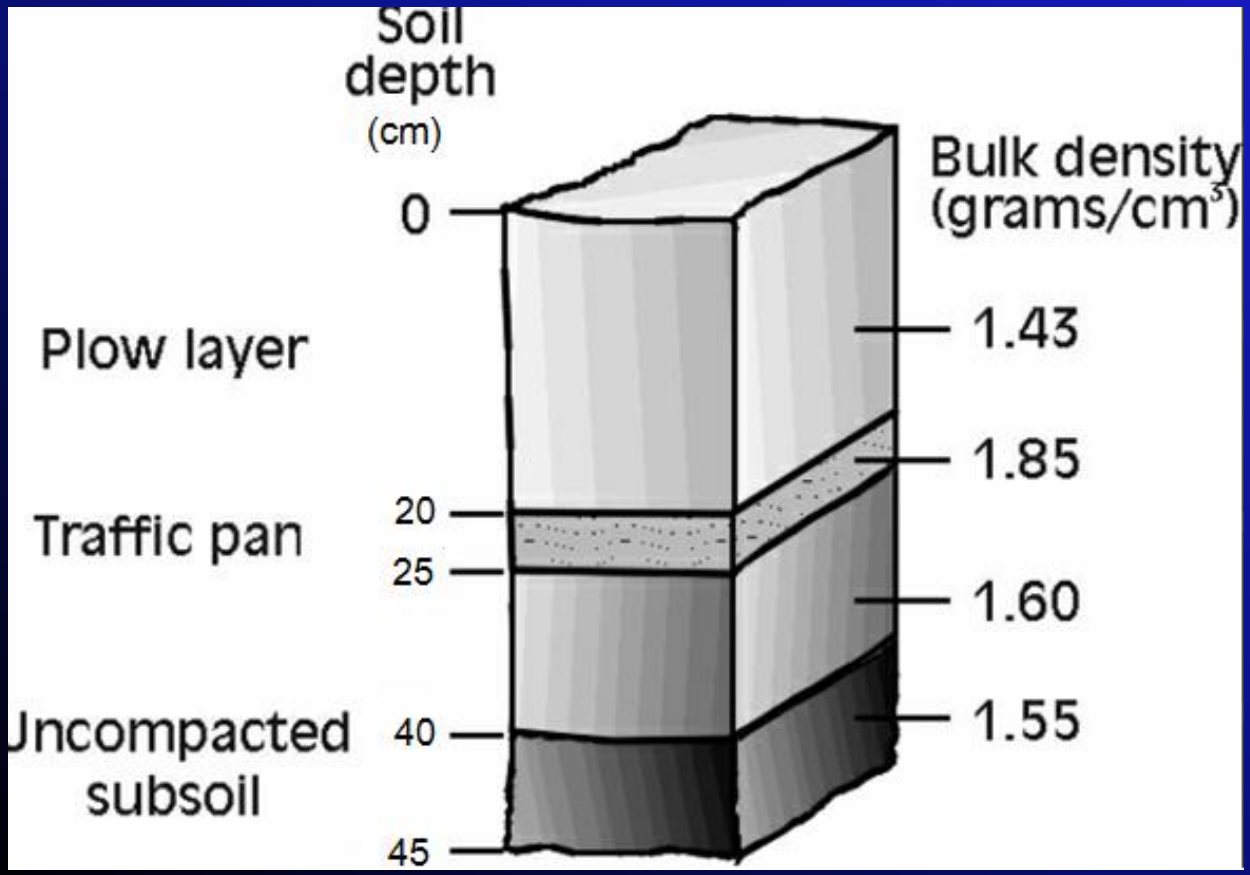
Physical soil properties

-Soil density --- indicates packing degree

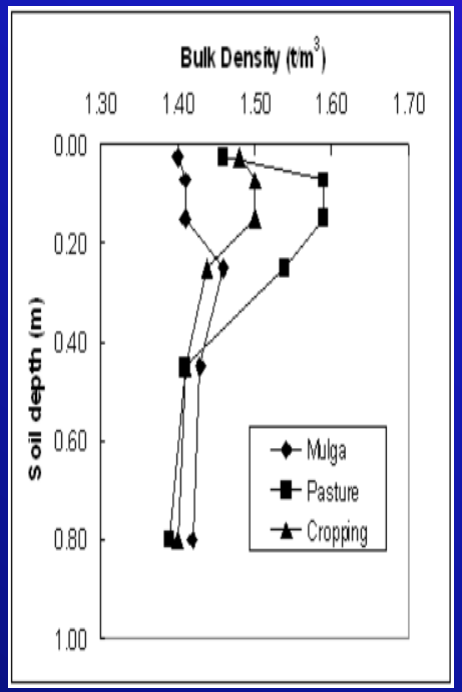


Normally, suitable soil bulk density for growing plant is lower than 1.3 g/cm3





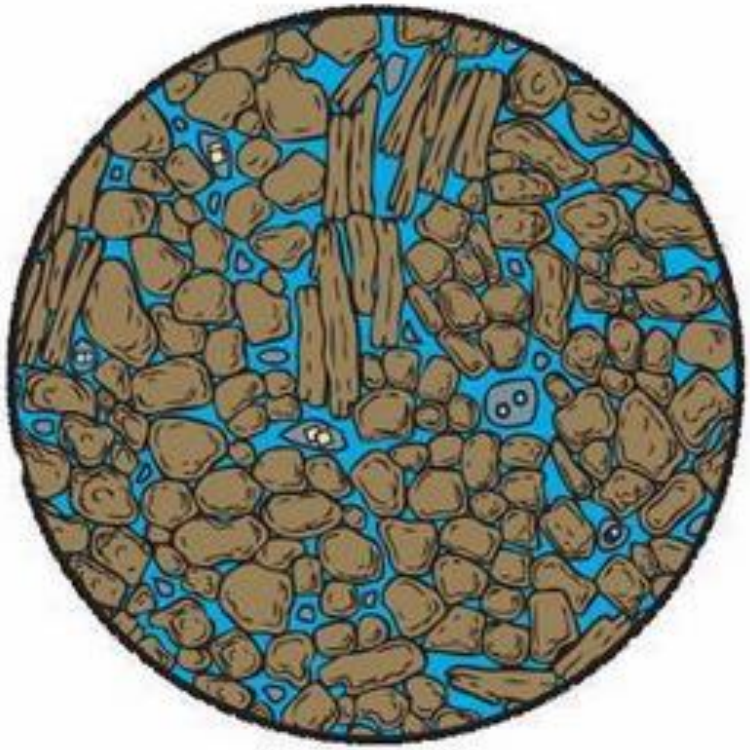
Interpret ?



How to lower soil bulk density

Table 1: Reported Activities That Restore or Decrease Soil Bulk Density		
Land Use or Activity	Decrease in Bulk Density (gms/cc)	Source:
Tilling of Soil	0.00 to 0.02	Randrup, 1998, Patterson and Bates, 1994
Specialized Soil Loosening	0.05 to 0.15	Rolf, 1998
Selective Grading	0.00	Randrup, 1998 and Lichter and Lindsey, 1994
Soil Amendments	0.17	Patterson and Bates, 1994
Compost Amendment	0.25 to 0.35	Kolsti *et al.*, 1995
Time	0.20	Legg *et al.*, 1996
Reforestation	0.25 to 0.35	Article 36

Most favorite for Thai farmers is the use of sub-soiler

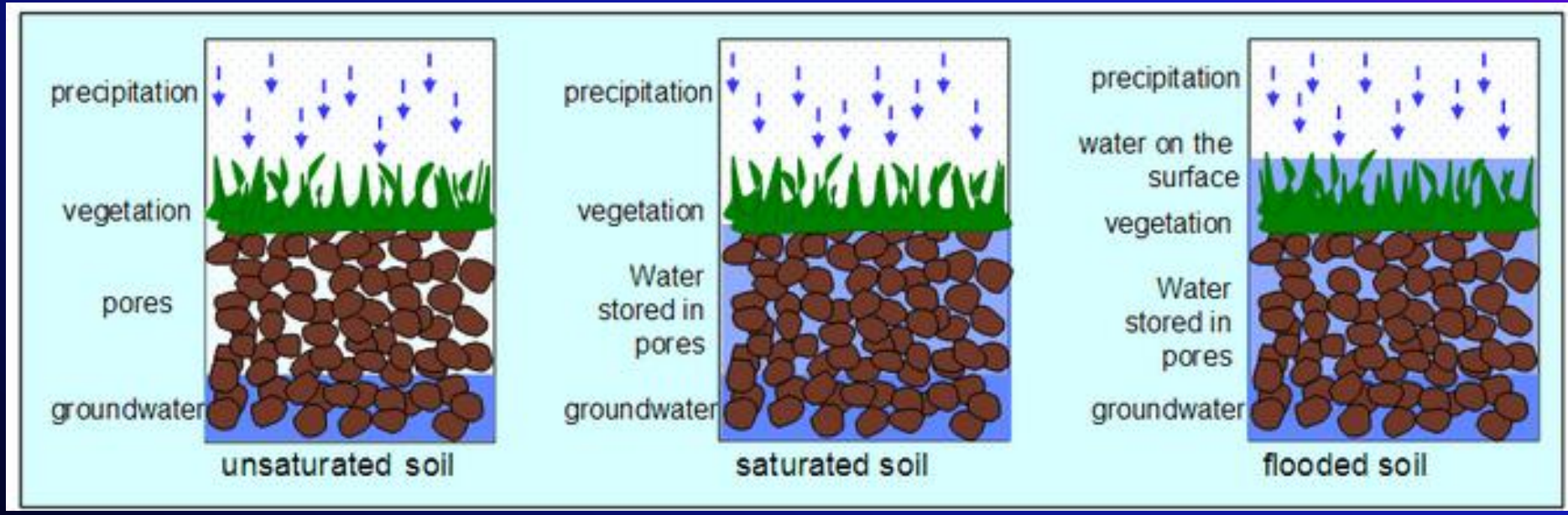


Lower bulk density
Lower weight
More pore space

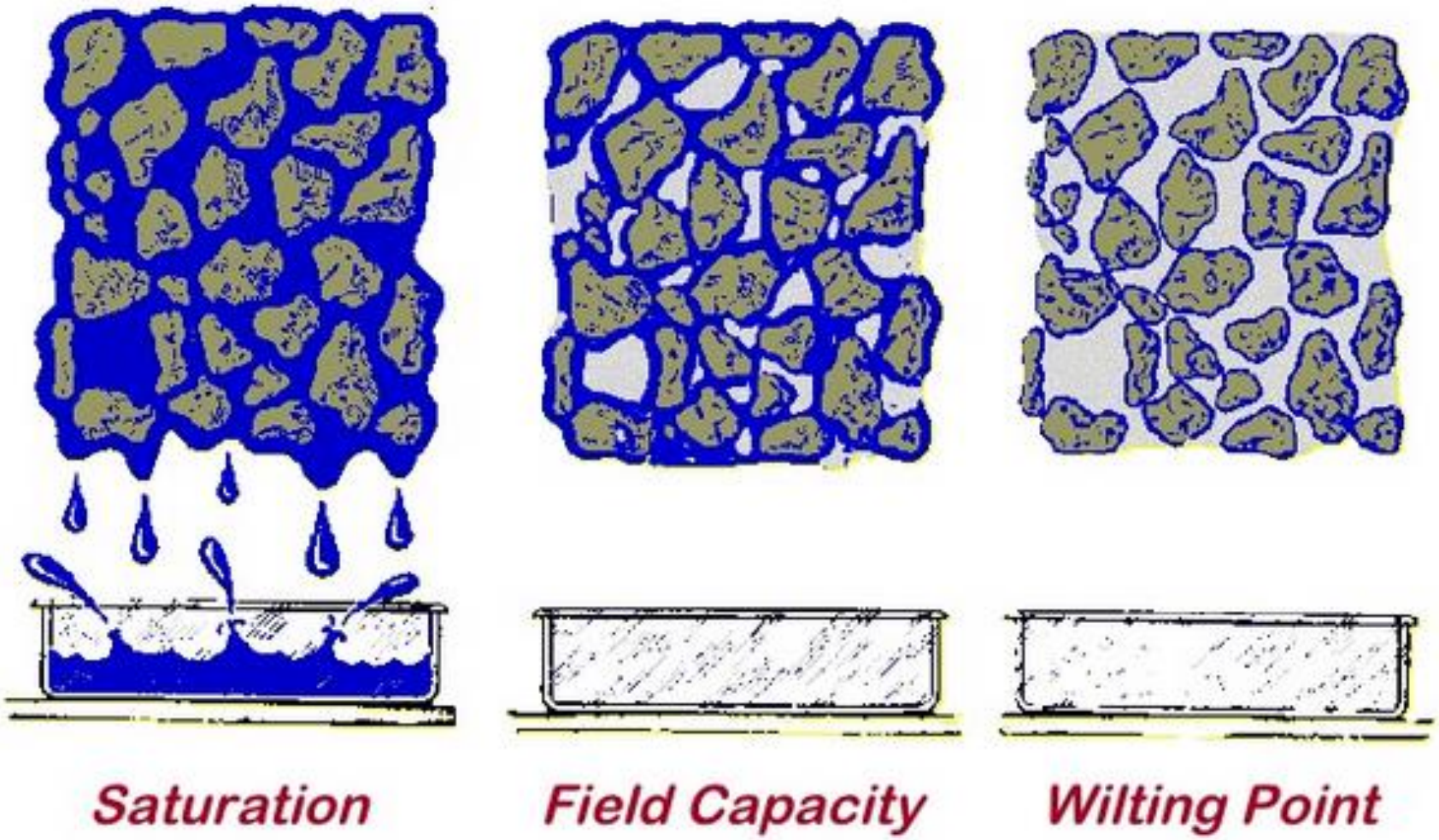
Higher bulk density
Higher weight
Less pore space

Physical soil properties

- Soil water storage capacity
- Soil water release capacity



Water holding capacity

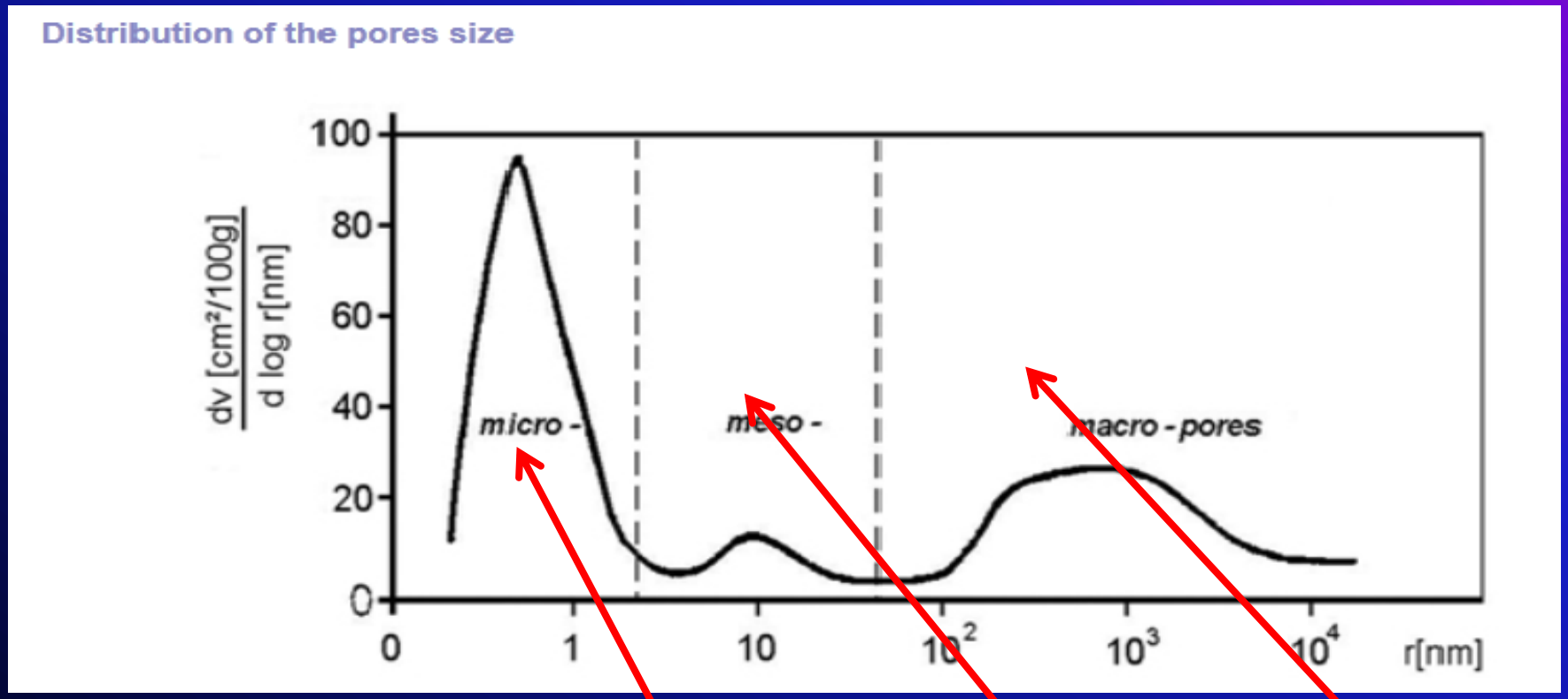


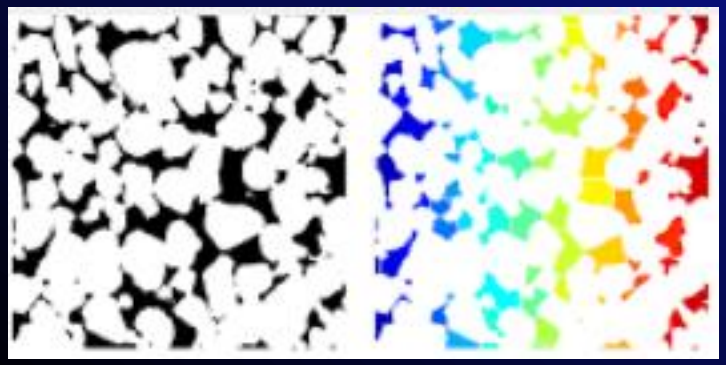
Questions

- Either difference in soil texture or structure all soil pores is filled w/ water, is total amount of water storage equally with the same soil depth of 45 cm?

- Either difference in soil texture or structure all soil pores is filled w/ water, is total water available pore equally with the same soil depth of 45 cm?

Which sizes of pores do u want?

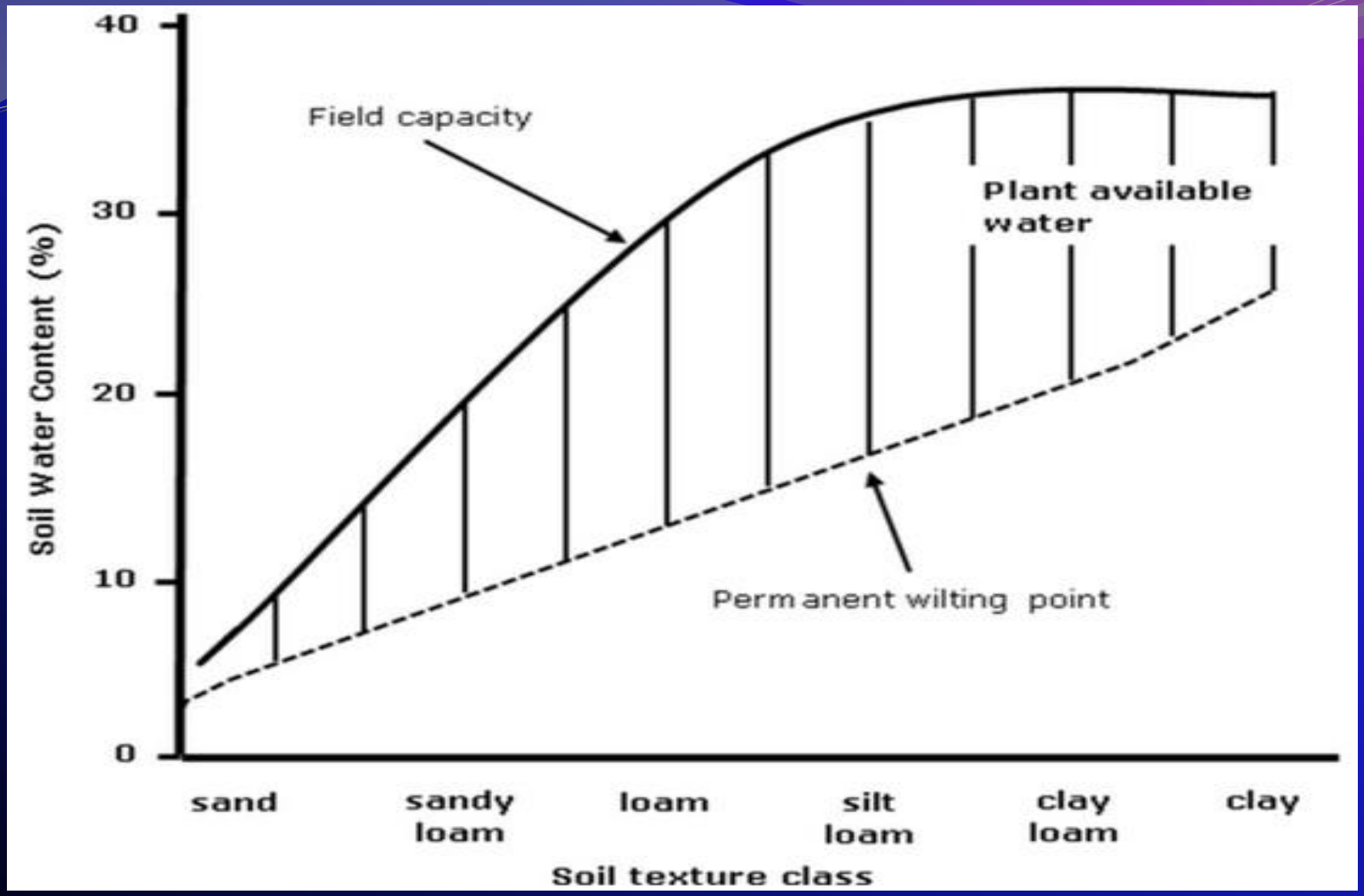




Large pores, rapidly drain

Water available pores, plant uptake easily

Small pores, water strickly absorbed by particles



Comparison of water available pores of various soil textures

How to calculate the water availability of each soil type for vegetable production

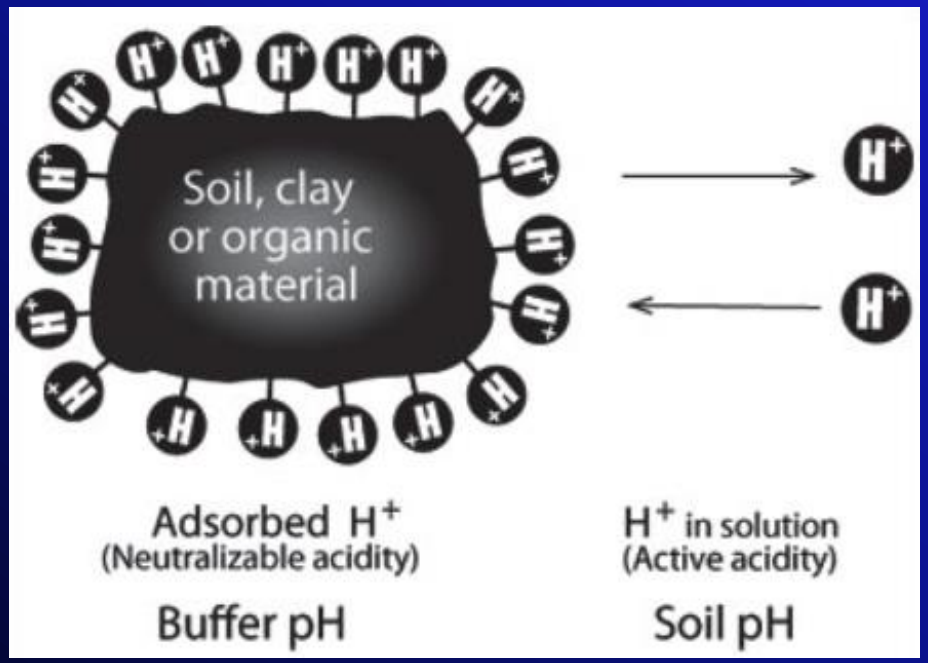
- determine soil depth for vegetable, ex. 45 cm.
- determine type of soil, ex. loamy sand
- determine AWC for that soil, ex. (35-14)%=21%
- calculate

450 mm x 21/100 = 94.5 mm

That is amount of water available to plant is 95 mm.

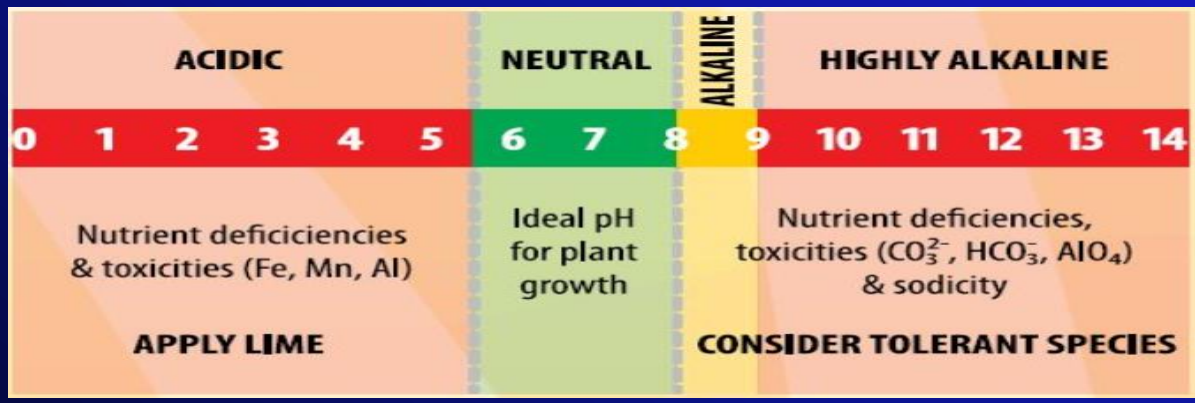
Chemical properties

-Soil reaction (soil pH)



Measure of

$[H^+]$ in soil solution



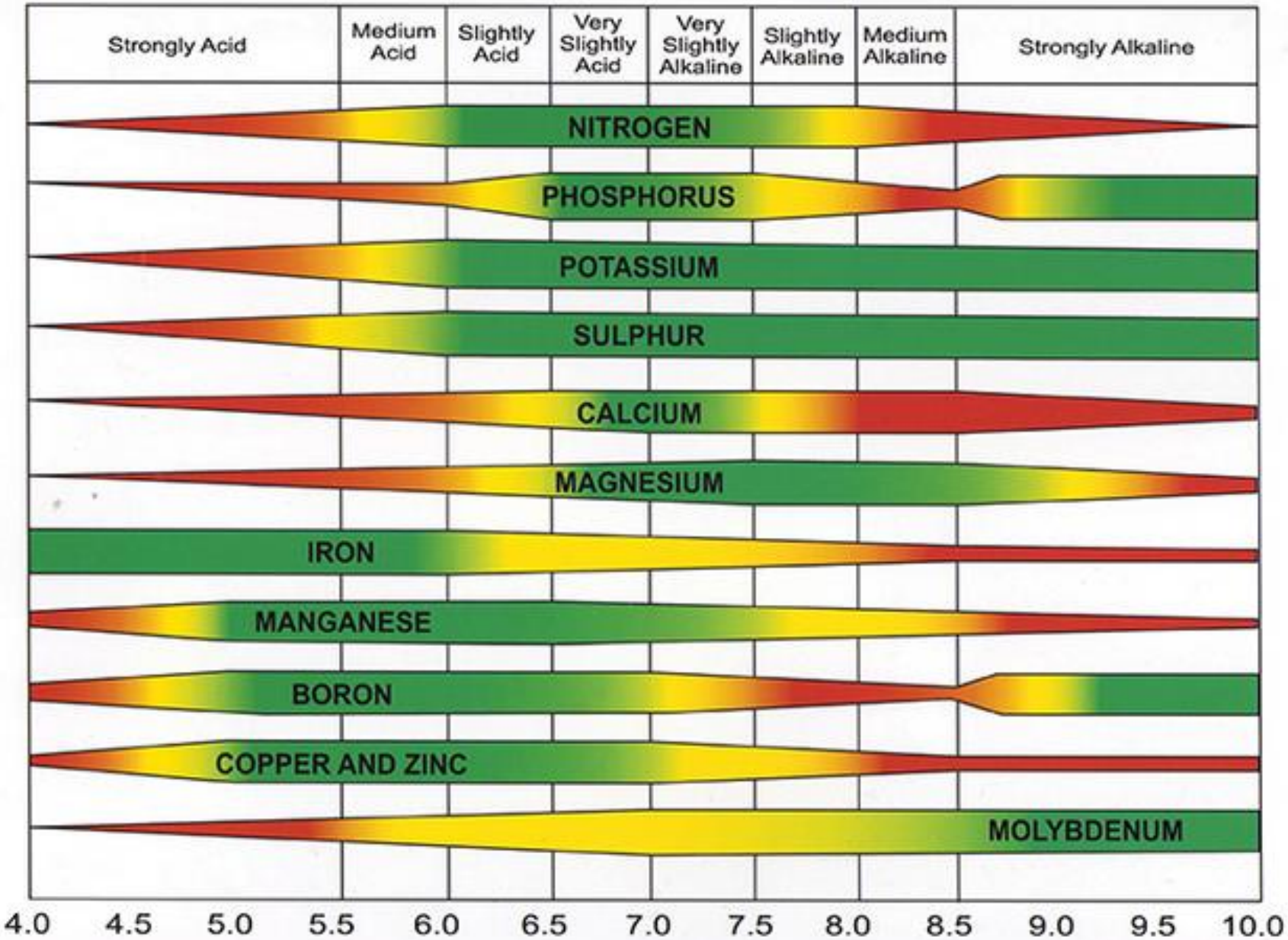
source: acid rain, Al3+

uptake cations, NH4-fertilizer

Soil pH

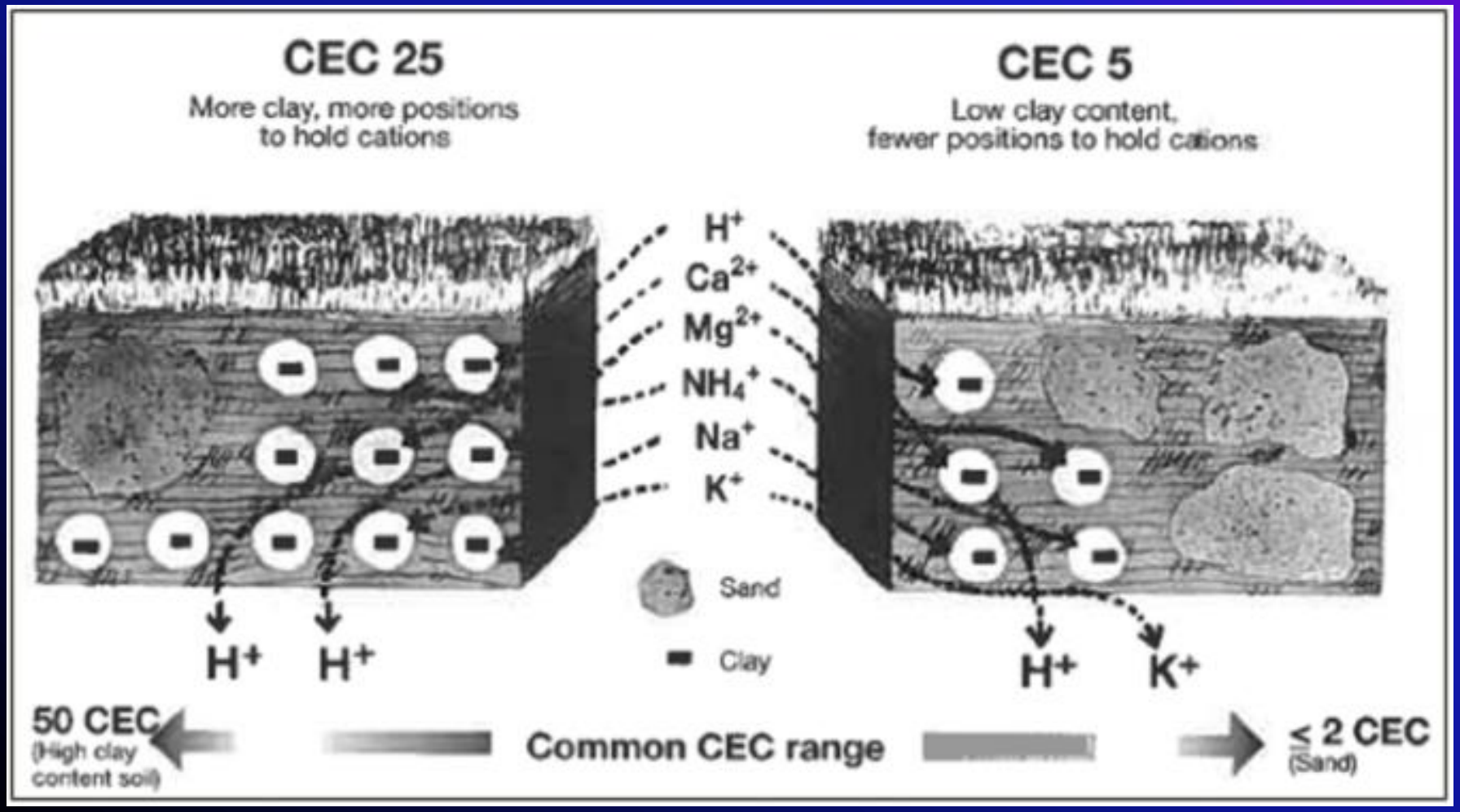
- A measure of the acidity or alkalinity of a soil.
- Neutral = 7.0
- Acidic < 7.0
- Alkaline > 7.0
- Logarithmic scale which means that a 1-unit drop in pH is a 10-fold increase in acidity.

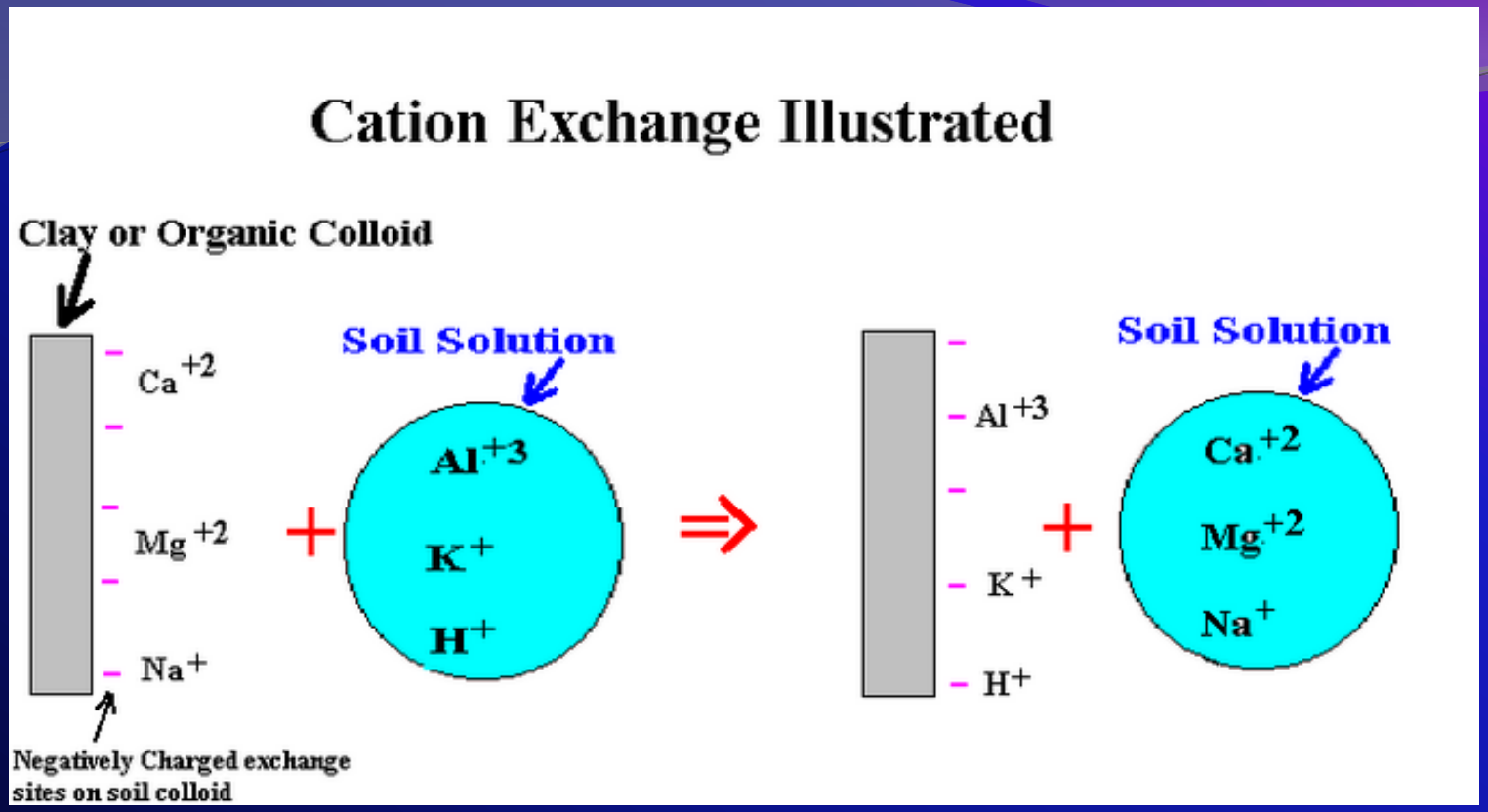
How soil pH affects availability of plant nutrients.



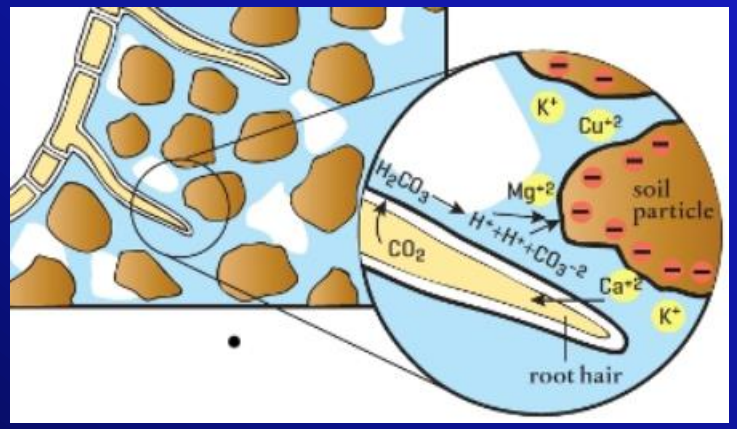
Chemical properties

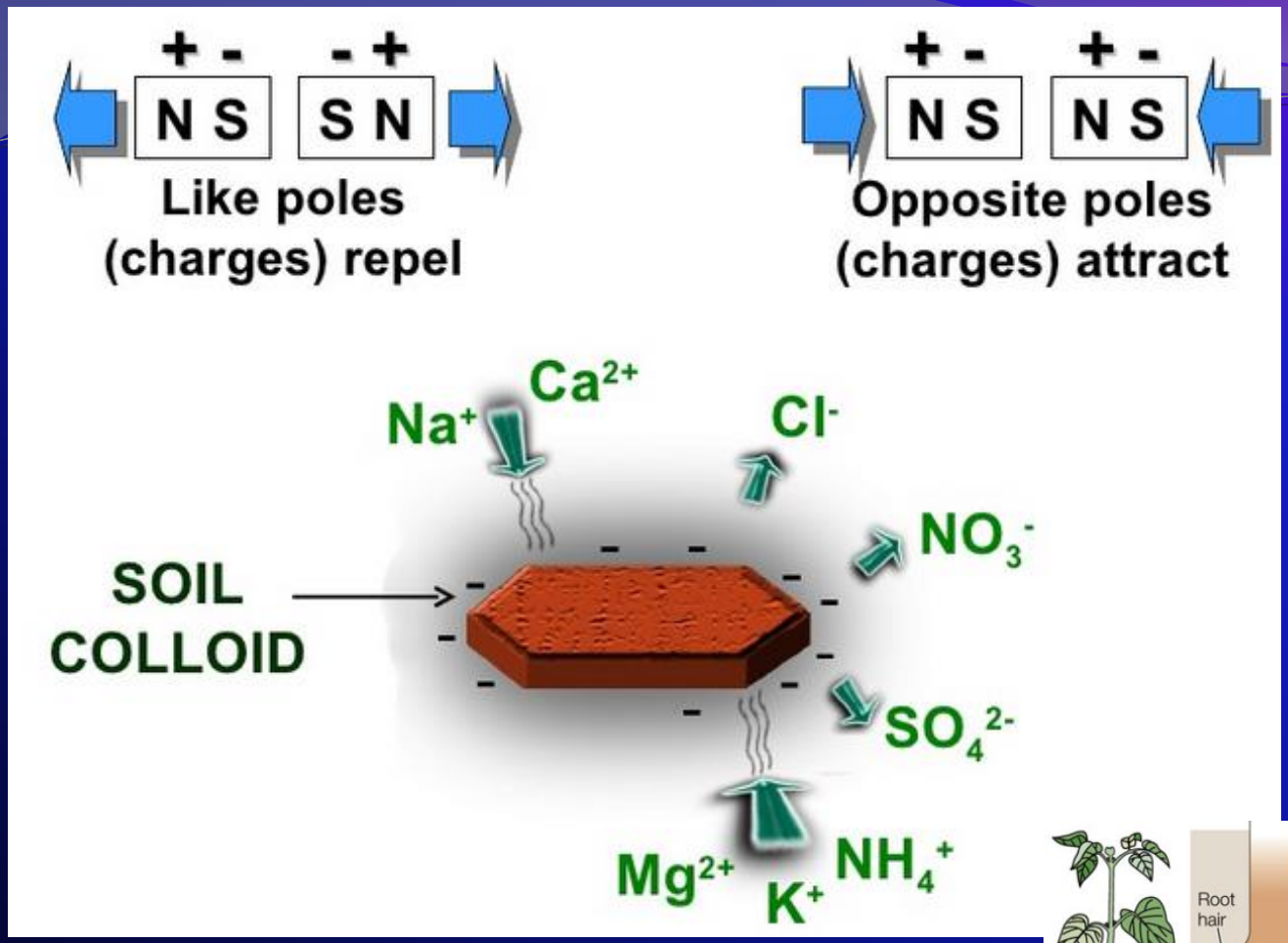
- Cation excahnge capacity (CEC)





Cation exchange process



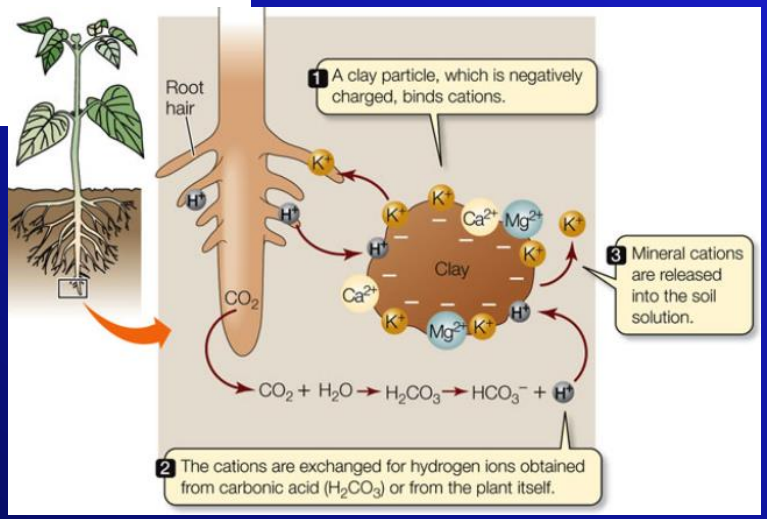


cmol kg^{-1}

วัดได้ ถ้ามีค่ามากบอกว่า

มีความสามารถแลกเปลี่ยนได้มาก

ไม่ได้บอกว่ามีไอออนมาก



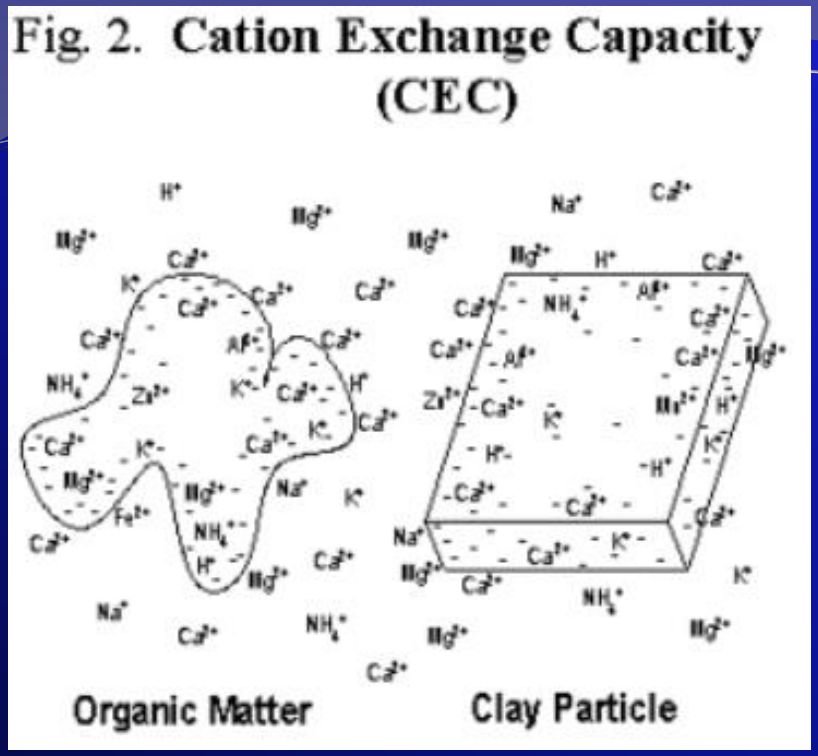
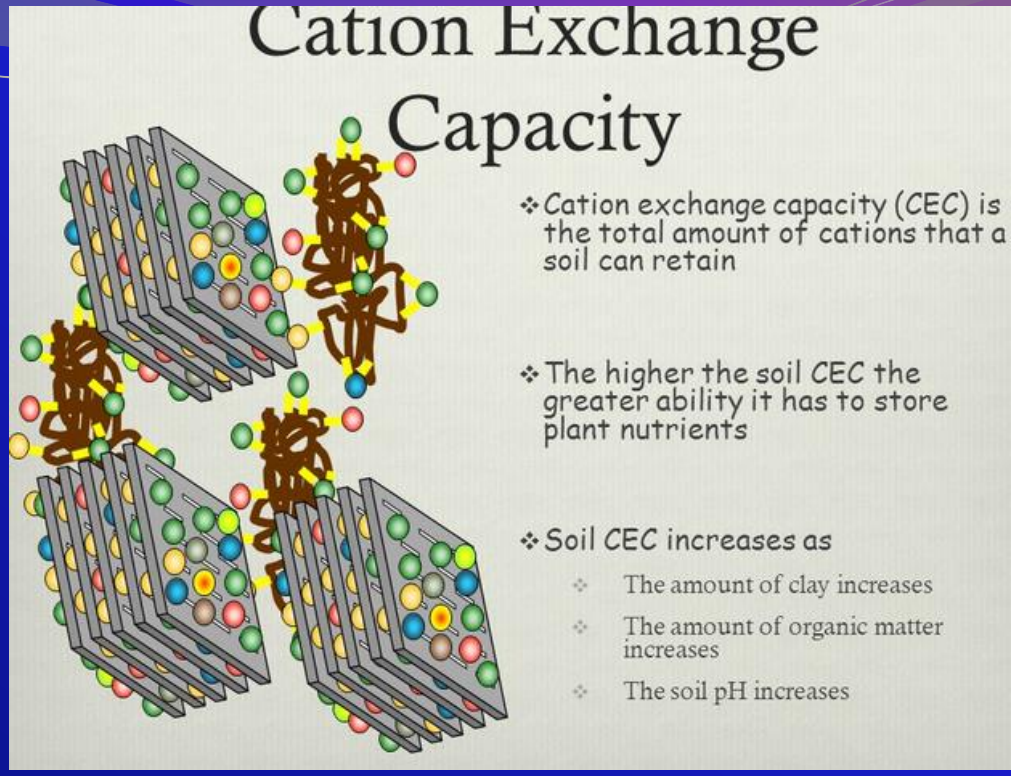
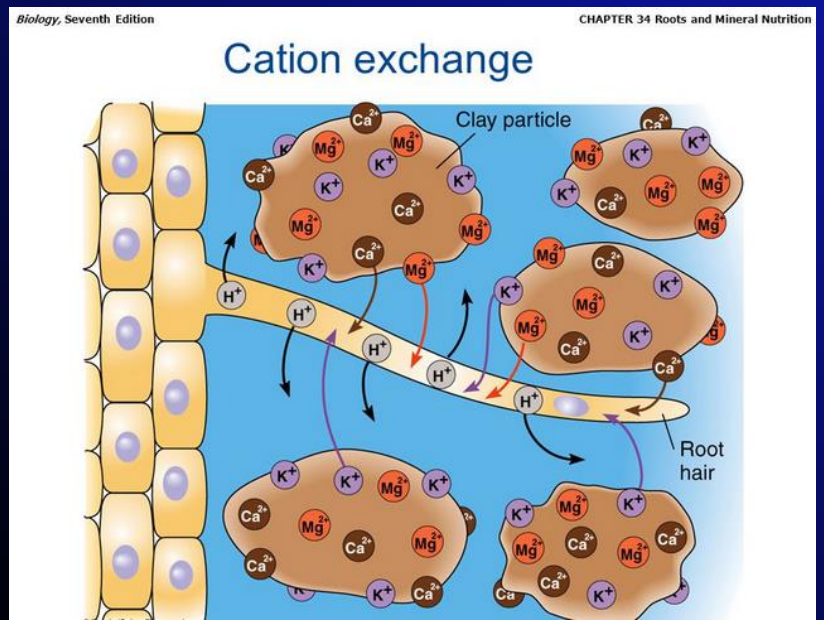
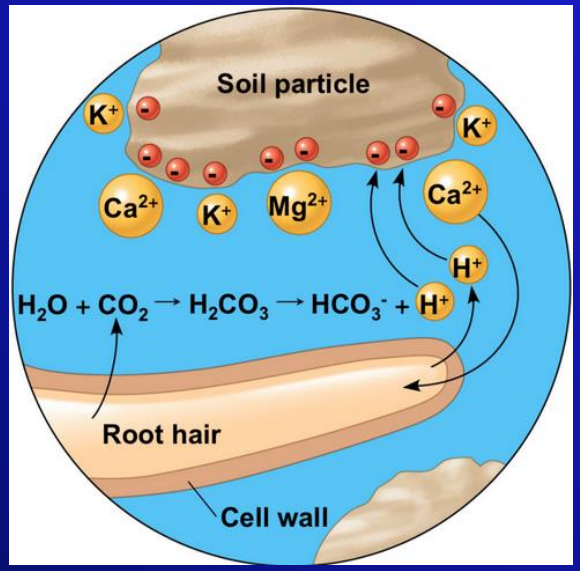


Fig. 2. Cation Exchange Capacity (CEC)
Organic Matter
Clay Particle


Cation Exchange Capacity
Cation exchange capacity (CEC) is the total amount of cations that a soil can retain
The higher the soil CEC the greater ability it has to store plant nutrients
Soil CEC increases as
The amount of clay increases
The amount of organic matter increases
The soil pH increases


Biology, Seventh Edition
CHAPTER 34 Roots and Mineral Nutrition
Cation exchange
Clay particle
Root hair


Soil particle
K^+
Ca^{2+}
Mg^{2+}
H^+
$H_2O + CO_2 \rightarrow H_2CO_3 \rightarrow HCO_3^- + H^+$
Root hair
Cell wall

Chemical Properties of Soil

1. pH
2. Salinity (EC)
3. Cation exchange capacity (CEC)
4. Organic matter
5. C:N ratio (Carbon to Nitrogen)

กันลืม

Chemical properties

- Salt affected soils --- measure by EC

Analog Soil Salinity Meter

" Under low price, this analog soil salinity meter provides accurate measurements and offers durability to use in tough conditions "

Soil Salinity

Scale of Conductivity*		Grass Response
mmhos/cm	*ppm soluble salts*	
0	0	Salinity negligible
2	1300	Sensitive plants may be affected
4	2600	Sensitive grasses affected (cool season grasses)
8	5200	Only salt tolerant grasses thrive (bermudagrass, meyer zoysia)
16	10,400	Only very salt tolerant grasses thrive (seashore paspalum, alkali sacaton)

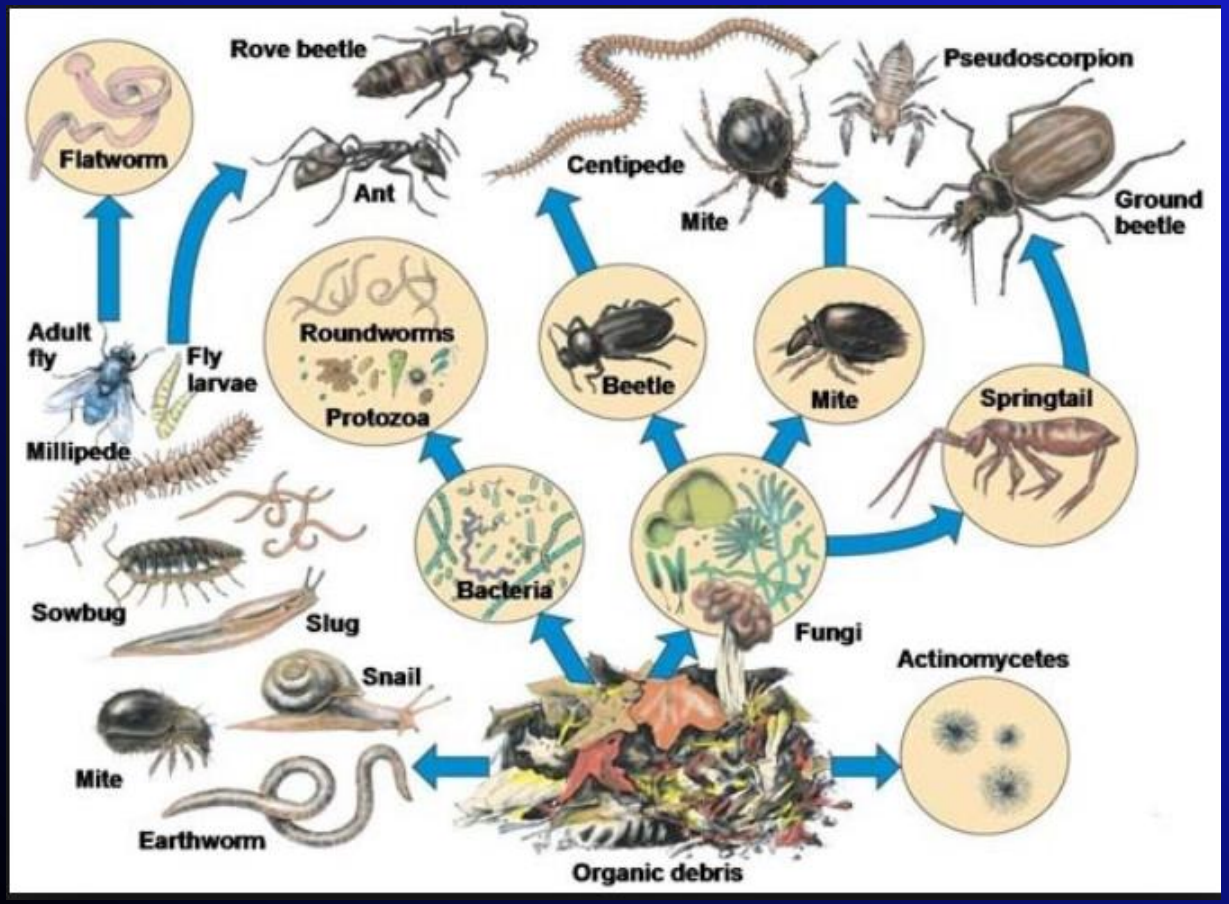
**Electrical conductivity of saturated soil paste expressed as mmhos/cm.*

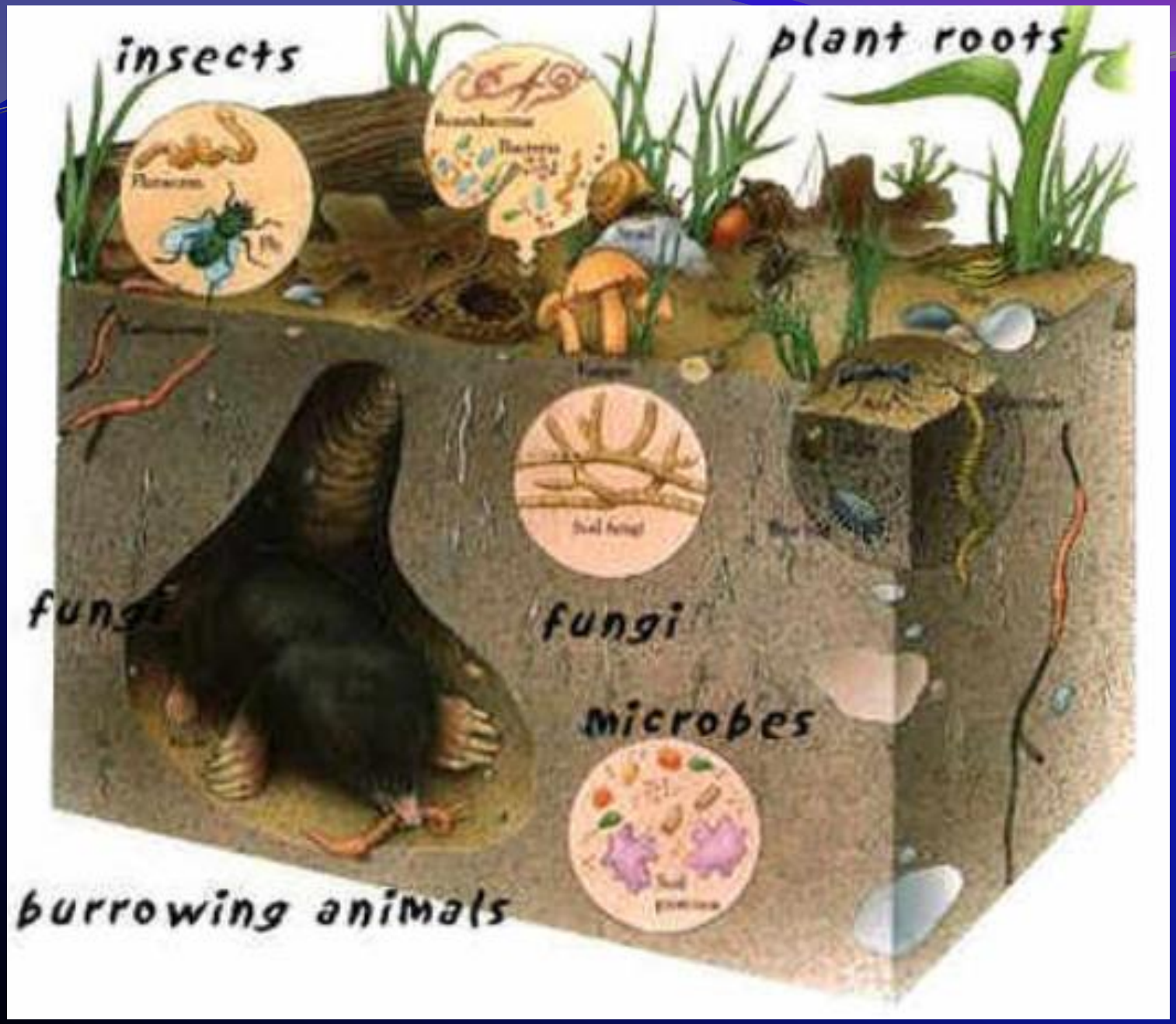
Soil organic matter

Unit: mass basis of soil

Biological properties

- Indicating amount of living stuff in soils
- Number and what species




insects
plant roots
fungi
fungi
microbes
burrowing animals

Higher Number and higher species

More suitable to grow plant

Type of organic materials

- Leaf debris
- bargase
- Filter cake, etc

N content, lignin,

Poly-phenol

Burnt bargase

filter cake

Fresh bargase

Fly ash

ปล่องระบาย
หม้อไอน้ำ
เครื่องกังหันไอน้ำ
เครื่องกำเนิดไฟฟ้า
หม้อแปลง
สายส่งไฟฟ้า
เครื่องอุ่นน้ำ
เครื่องดักฝุ่น
เครื่องอุ่นอากาศ
พัดลม
เครื่องควบแน่น
หอหล่อเย็น
แหล่งน้ำ
ลานไกไฟฟ้า
รูปภาพแสดงกระบวนการผลิตไฟฟ้าจากชีวมวล

Other organic materials

- Left over materials
- Chicken, duck, castle, swine dunks
- Rice bran
- Fermented sludge
- manure,
- bio-fermented sludge
- DLD fermentating
- regulator

Organic materials

Visible morpho. (litter)

Improve soil physical properties
Decrease bulk density
Improve water holding capacity

simple aliphatic acid to complex aromatics
- formic acid
- acetic acid
- heterocyclic acids
- humic and fluvic acids
- vanillic acid
- pyruvic acid
- lactic acid

Well degradation (humus)

humified fractions
most active substances in soils
increases CEC

non humified fractions
lignin, protein, nucleic acids, amino acids
hemicellulose
cellulose
waxes

Sources of Soil Organic Matter

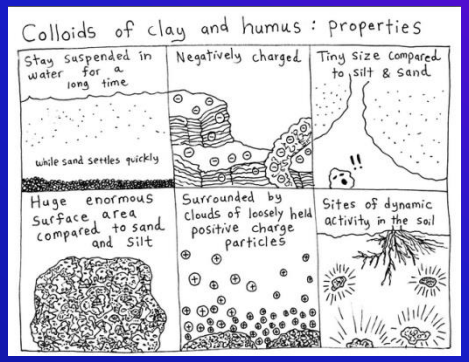
- Living Plant debris (almost living roots)
- Dead plant organ (litter, dead roots)
- Other living stuff
- Organic materials for amendment

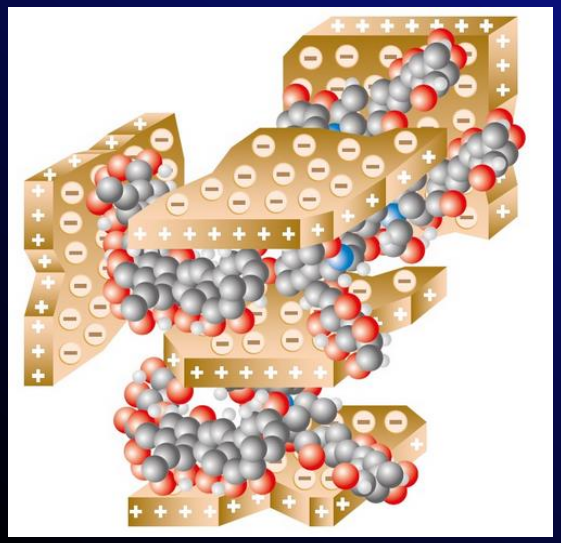
These will help improve physical chemical and biological properties of soils

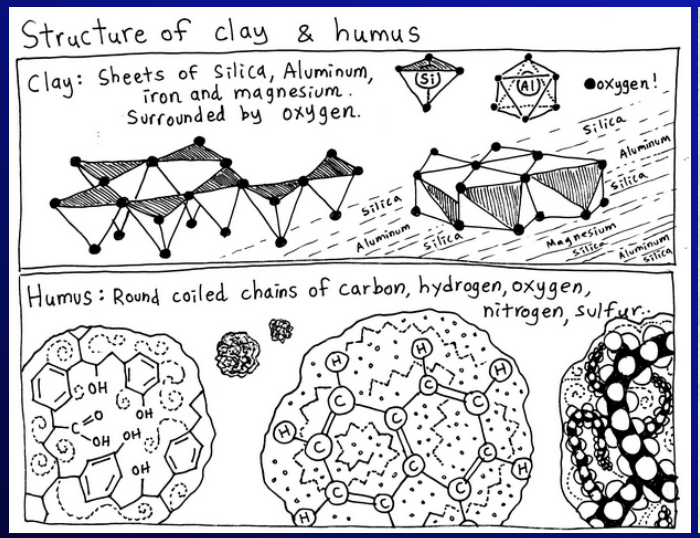
- improve N availability to plant
- improve other nutrients
- improve soil aggregation
- alter number and species of living stuff in soils

Benefits of organic materials to soils

- Improve soil structure
- Improve water holding capacity
- Increase bio-diversity
- Increase nutrient availability
- Increase CEC







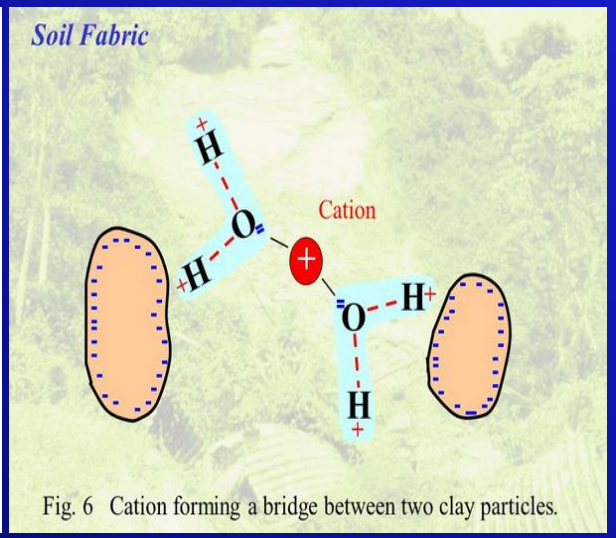


Fig. 6 Cation forming a bridge between two clay particles.

Organic materials management

- Synchrony concept
- Soil Organic Matter Concept

Synchrony concept

The release of N and P from the degradation of organic materials at the rate synchronization to plant demand

Soil Organic Matter Concept:

Organic matter in soils acts as sources of nutrient and simultaneously adsorbing of nutrient – thus act as if it were a machine to manage the availability of plant nutrient temporally and spatially. Content and quality of Soil organic matter depend largely on its type of organic materials.

Degradation rate of organic materials depends on

- Physico-chemical environment
- Chemical compositions of materials
- Decomposers

To manage organic materials in soils required to make optimal conditions for quality, quantity, time, and locations of these 3 factors

Release of plant nutrient depend on quality of organic materials which determined by

- Content of plant nutrients in organic materials
- C to other nutrients ratios in organic materials

Depend on N content, lignin, poly-phenol

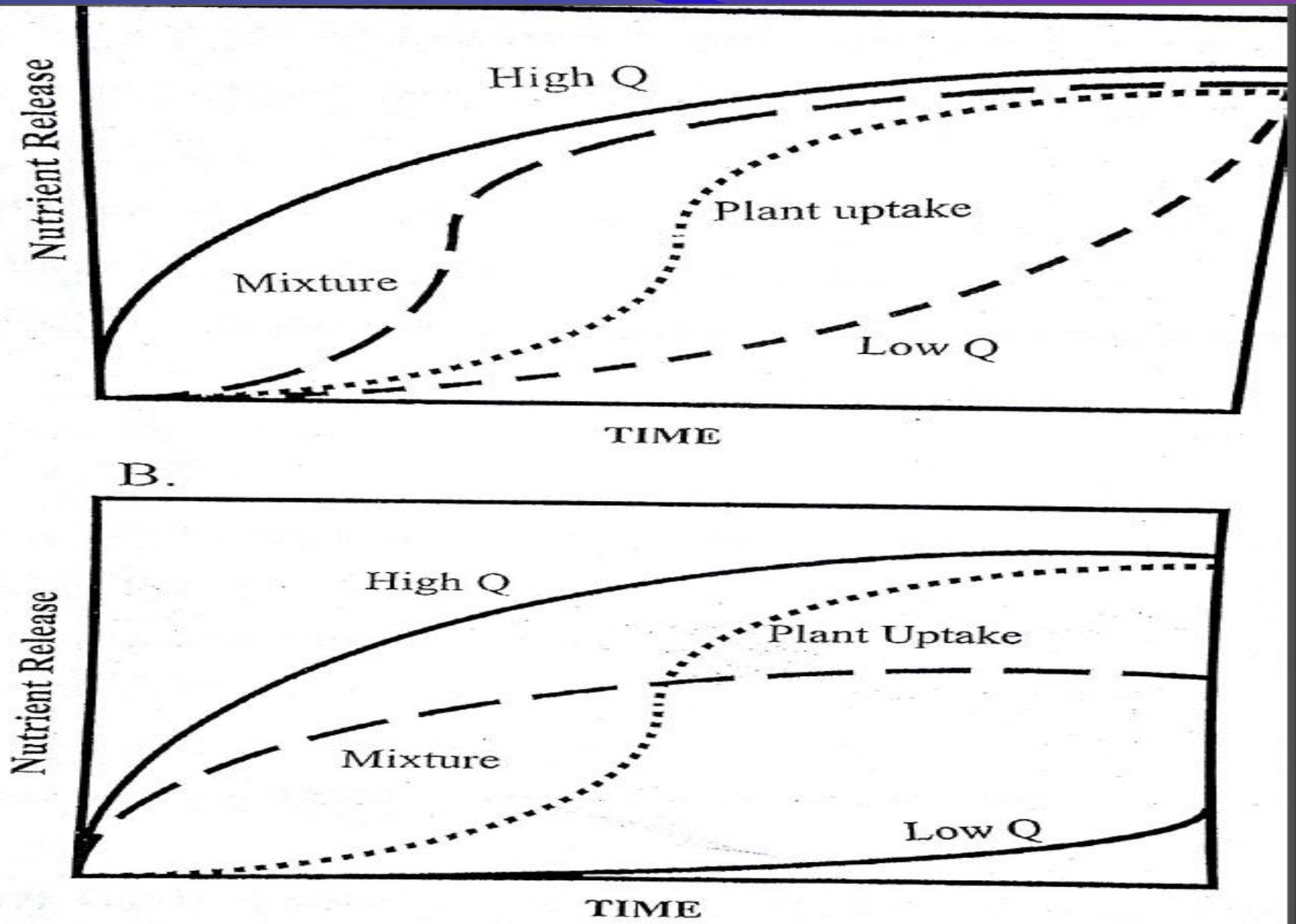


Figure 1. Schematics of original concept of the Synchrony principle (A) and current understanding (B). (Q = resource quality of the organic material).

Soil Organic Matter: SOM hypothesis

SOM: short-term nutrient release organic materials will never be SOM

Continually applies organic materials to soil will help raise SOM content --- thus leading to condition to accelerate the high rate of mineralization

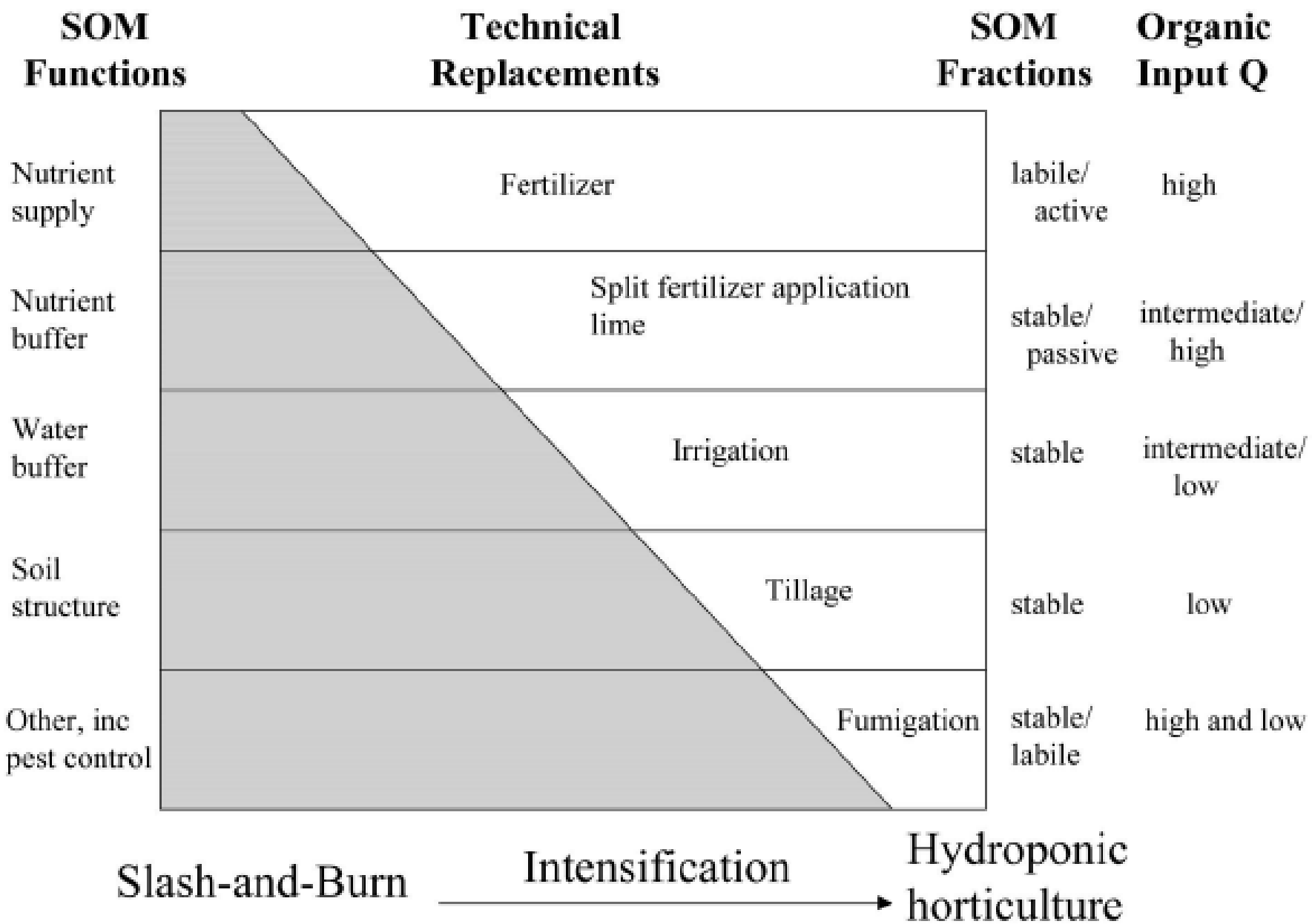


Figure 3. Proposed relationships among SOM fractions, functions, and organic input quality (adapted from van Noordwijk et al. (1997)).

SOM content in soil also dependent on

- silt + clay content – affecting soil texture
- soil structure
- Tropical conditions
- Tillage frequency
- Adding organic materials
- N > 30-40 g/kg; lignin < 100 g/kg (good quality organic materials)

Regulation

Continually apply OM to raise the OM upto 3-5%

Control its content not exceed 6%

Have to know the initial OM content

Research results, not yet published

Table 2 Percent by volume of various pore size distribution in different of continuous situation of organic material application in top and subsoil.

Diameter (μm)	Very Large >28.8	8.7-28.8	Large 5.7-8.7	2.8-5.7	Total Large	Medium 1.0-2.8	0.6-1.0	0.3-0.6	0.2-0.3	Total Medium	Small <0.2
Topsoil											
1. Texture											
CT	42.77	29.69	4.27	5.31	79.47	2.76	3.69	1.09	1.07	7.34	10.03
MT	24.22	22.16	4.43	10.52	59.13	6.50	5.72	1.11	2.33	15.66	20.73
P-value	<0.01	0.02	0.11	<0.01	0.97	<0.01	0.17	0.67	0.17	<0.01	<0.01
2. OM											
OM_0	51.08	30.00	6.50	7.43	94.66	2.85c	1.96	1.26	2.84	10.94	13.73
OM_1	30.37	29.09	5.01	7.70	81.80	4.29ab	4.30	0.86	1.32	10.84	17.39
OM_2	37.03	21.67	6.14	8.26	96.07	5.79a	2.30	0.99	1.38	9.85	17.05
OM_3	39.36	22.43	3.79	8.45	94.04	5.65a	2.79	1.24	2.35	12.02	14.53
P-value	0.42	0.13	0.54	0.95	0.14	0.04	0.19	0.68	0.70	0.71	0.42
Texture*OM	0.65	0.57	0.84	0.24	0.22	0.71	0.13	0.26	0.28	0.33	0.16
Subsoil											
1. Texture											
CT	36.23	29.77	3.20	8.12	40.89	3.50	3.34	0.95	1.32	8.92	33.97
MT	23.20	19.59	5.52	10.41	36.52	7.44	1.84	1.21	1.67	12.16	28.13
P-value	<0.01	<0.01	<0.01	0.09	0.10	<0.01	<0.01	0.48	0.54	<0.01	<0.01
2. OM											
OM_0	25.08b	25.08	7.14a	9.39	41.61	4.52	6.85a	1.46	1.84	12.07	25.08
OM_1	26.03b	28.67	5.00ab	9.46	43.13	5.11	2.74b	0.48	1.03	9.36	21.48
OM_2	33.82a	20.23	3.96b	9.56	33.76	6.53	1.59b	1.15	1.21	10.42	22.00
OM_3	33.77a	34.76	2.92b	8.65	36.31	5.54	1.62b	1.73	1.91	10.30	19.62
P-value	0.02	0.11	0.02	0.95	0.05	0.27	<0.01	0.28	0.21	0.22	0.74
Texture*OM	<0.01	<0.01	0.52	0.16	<0.01	0.27	<0.01	0.50	0.44	0.56	0.44

Vegetable water requirement

General equation for irrigation water

Supply = Demand + loss + Exist

All term is function of time (dynamic condition)

Demand of water comes from

- surface evaporation
- leaf transpiration

Evaporation --- movement of water in gas phase

amount leaving soil surface depend on

gradient of water potential between soil and atmosphere

Temperature and relative humidity

$$\frac{\partial T}{\partial t} = K_x \frac{\partial^2 T}{\partial x^2} + H_x \frac{\partial^2 T}{\partial x^2}$$

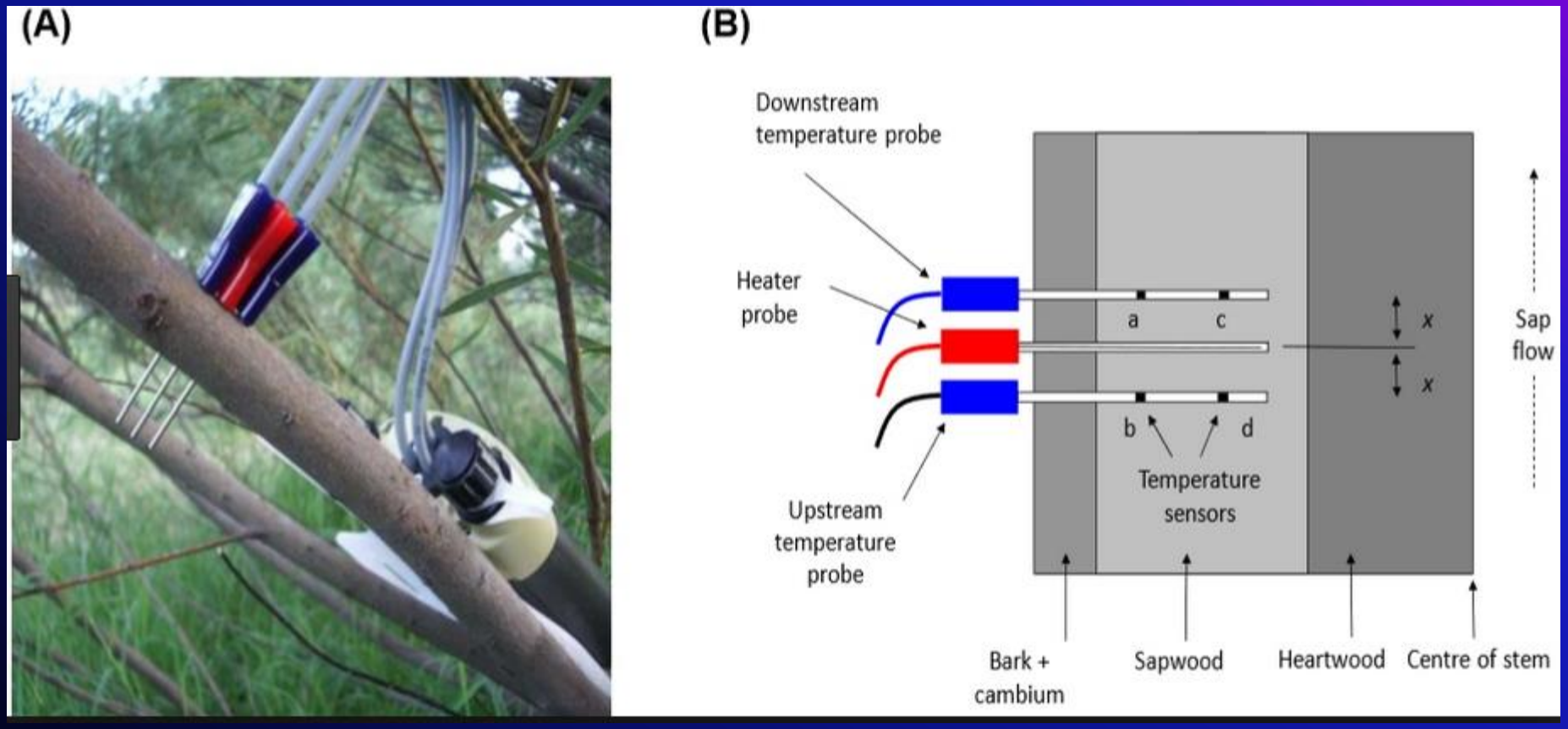
$$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial x}\left(D(\theta) \frac{\partial \theta}{\partial x} \right)$$

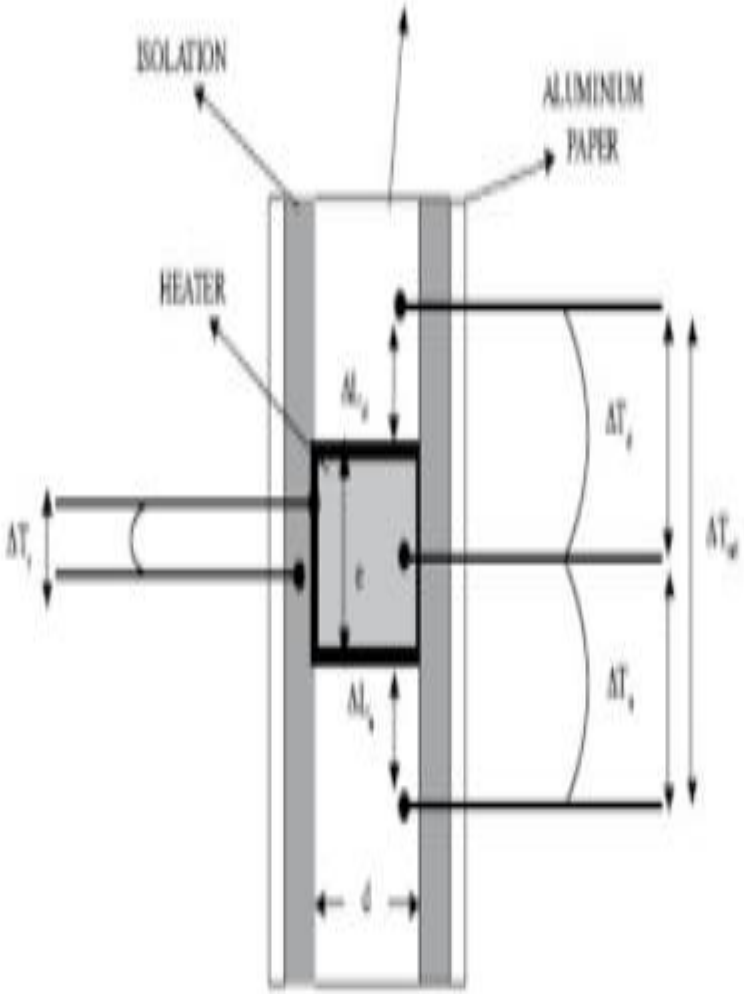
Transpiration can be measured by

- sap flow measurement

  (heat balance; heat pulse method)

- Weighting method


(A)
(B)
Downstream temperature probe
Heater probe
Upstream temperature probe
a
c
b
d
x
x
Temperature sensors
Sap flow
Bark + cambium
Sapwood
Heartwood
Centre of stem



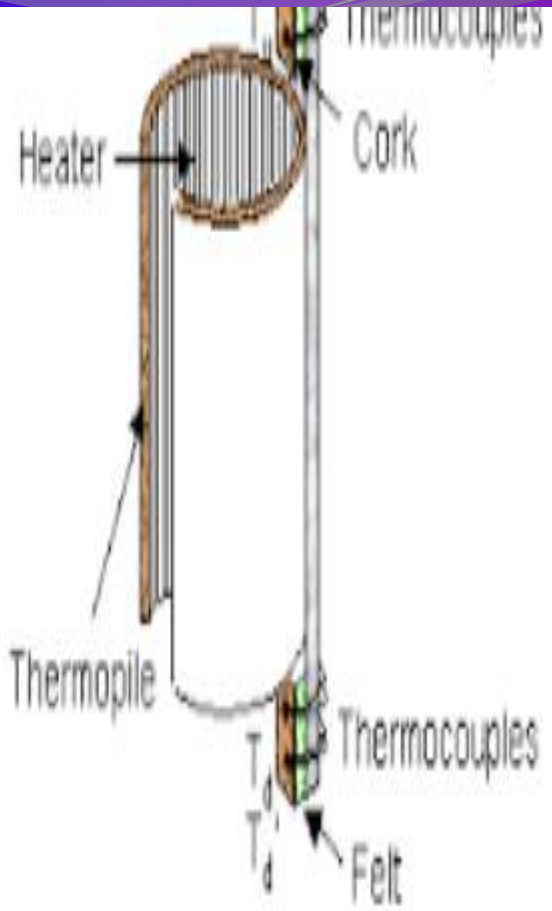
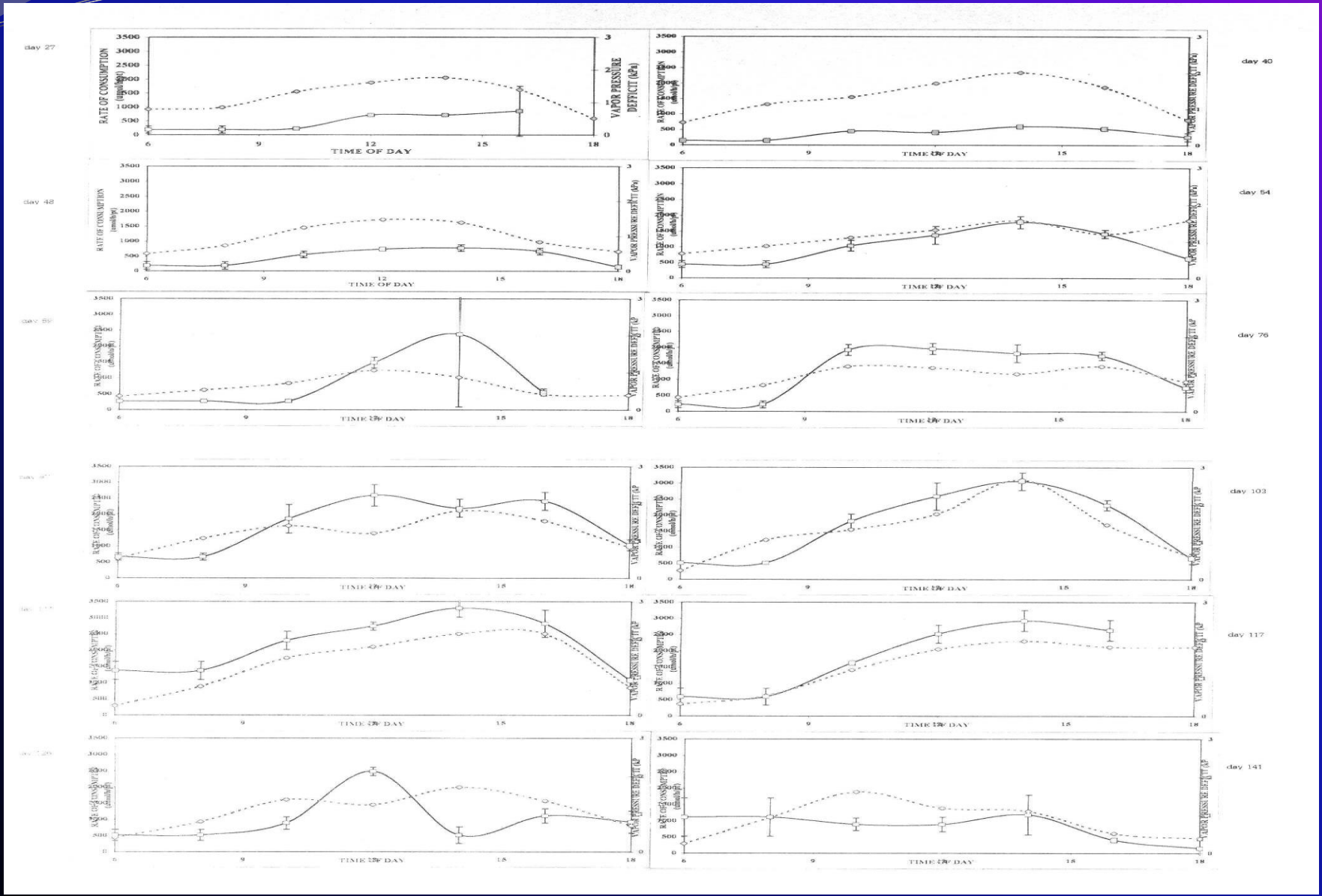


Fig.2. Diagram of the heat balance sap flow sensor (Sakuratani, 1984).

ตัวอย่างวิธีนี้


day 27
day 40
day 48
day 54
day 76
day 103
day 117
day 141
RATE OF CONSUMPTION
VAPOR PRESSURE DEFICIT (kPa)
TIME OF DAY

Demand = Evaporation + Transpiration

Engineers had combined these two processes and

Called it – as Evapotranspiration, ET_a

ET_a can be obtained through

- lysimeter
- Bowen ratio
- Eddy covariance
- Climatic calculation

Lysimeter method

- weight the whole vegetable including its container

For example

m_{t+1} = 20.0520 kg

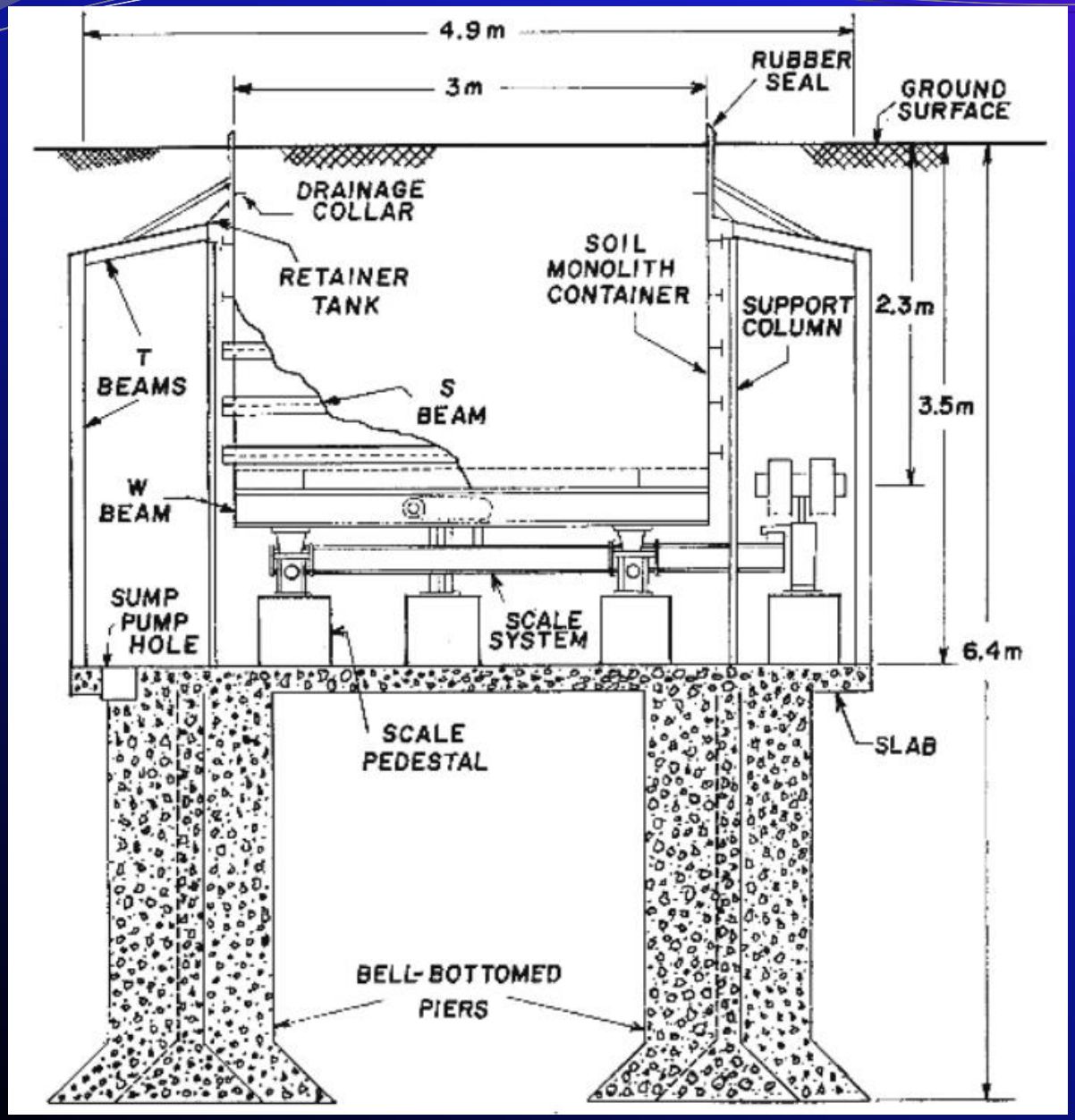
m_t = 20.1222 kg

ET_a is 20.1222-20.0520 = 0.07 kg

= 70 g

During the period of time m_t **to** m_{t+1}

Weighting method or lysimeter

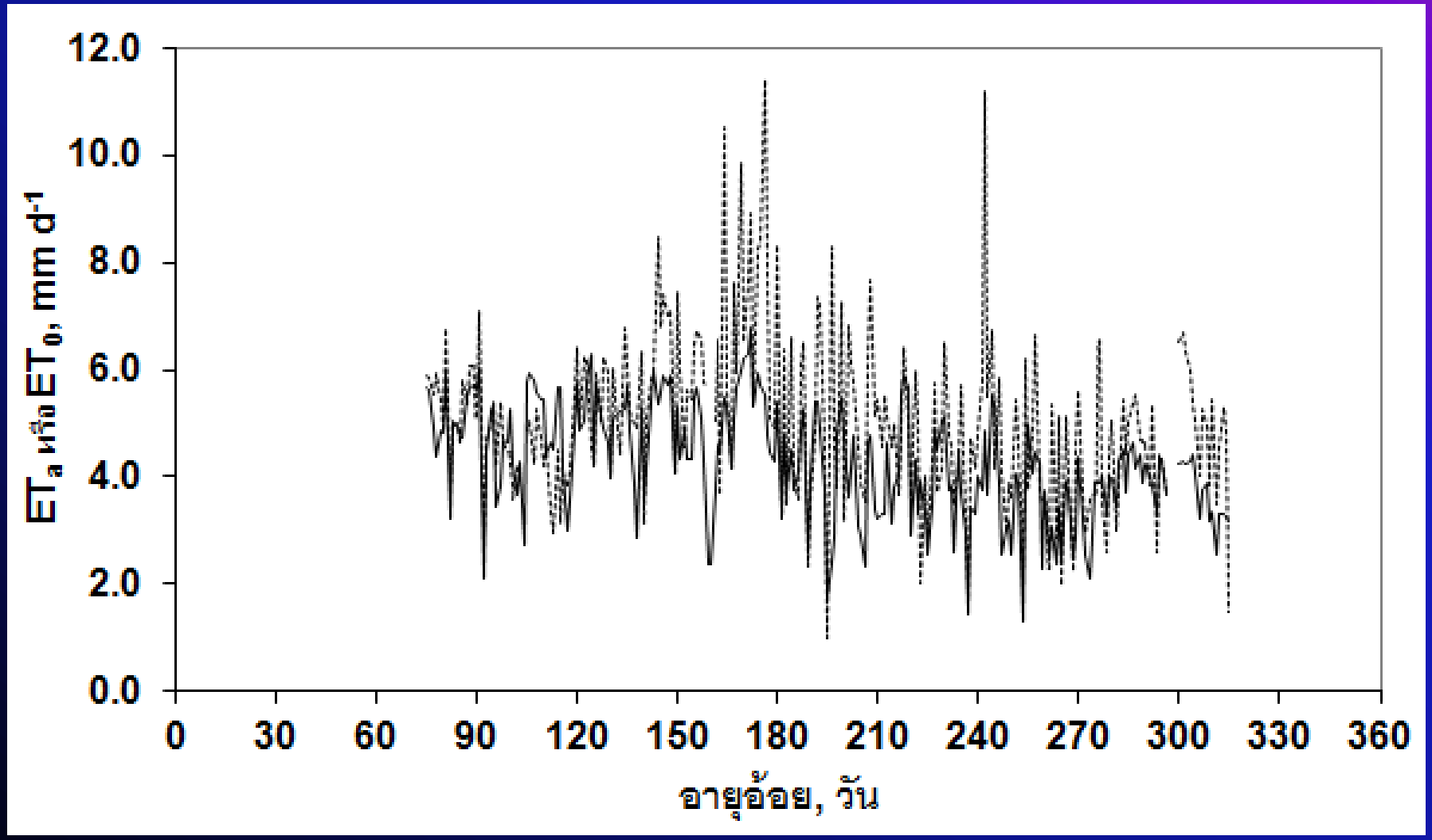


Bowen Ratio Method

$$ET_t = \frac{R_n + G}{1 + \beta}$$

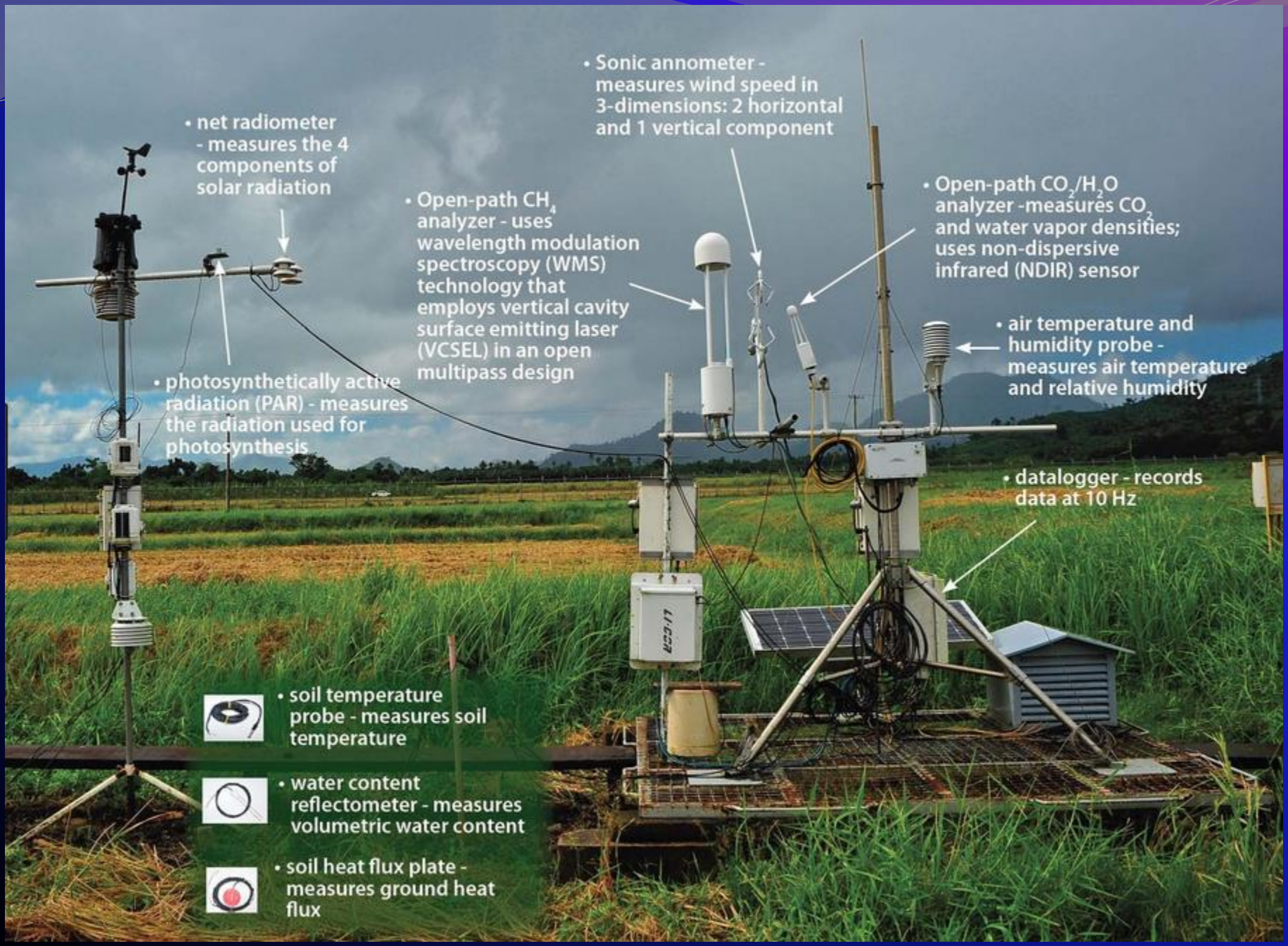
$$\beta = \frac{C_p P_a (T_2 - T_1)}{L\varepsilon(e_2 - e_1)}$$

ตัวอย่างวิธีนี้

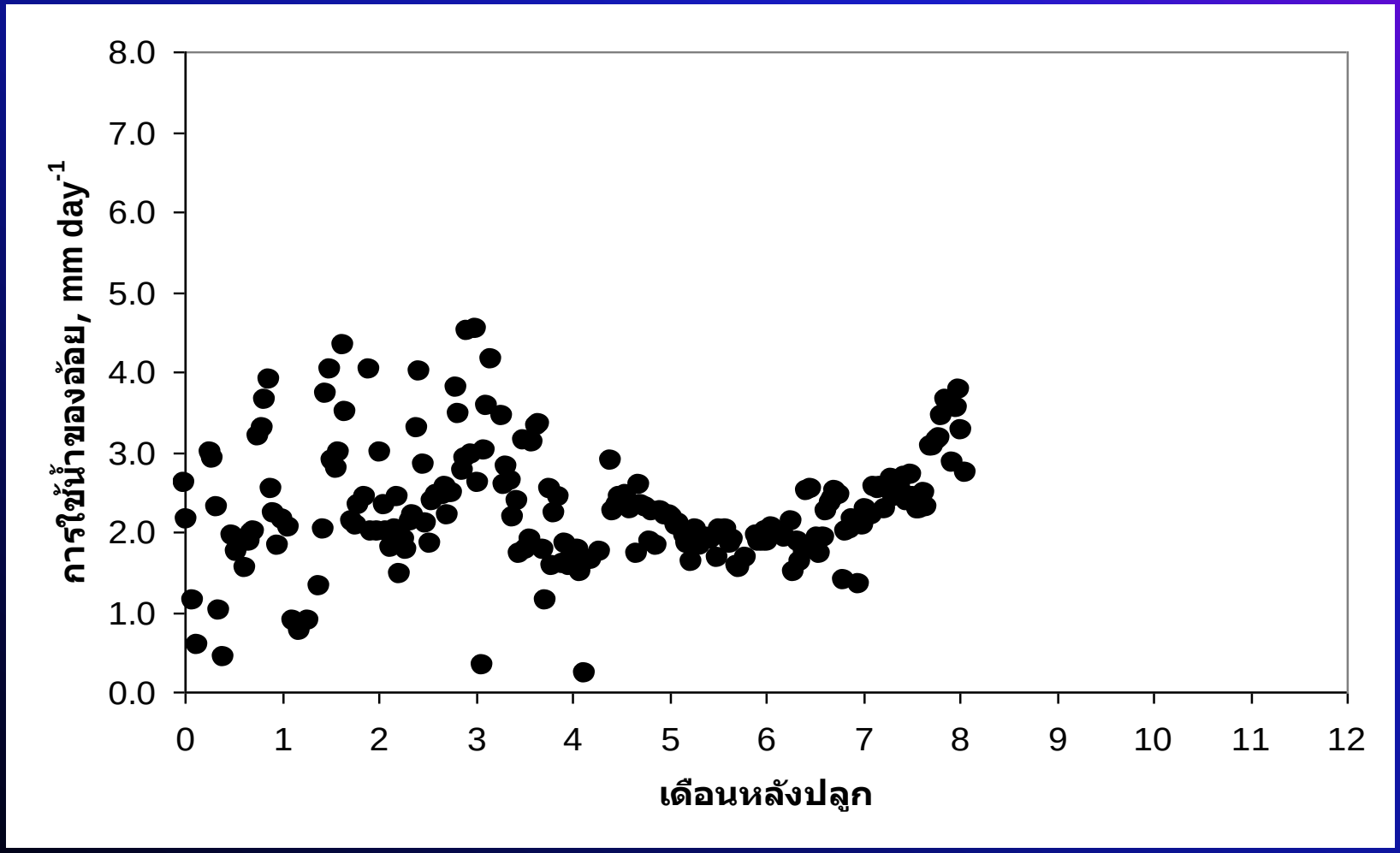

12.0
10.0
8.0
6.0
4.0
2.0
0.0
ET_a หรือ ET_0, mm d^{-1}
0
30
60
90
120
150
180
210
240
270
300
330
360
อายุอ้อย, วัน

Eddy Correlation Method

Analysis of deviation term of vapor from mean in the vertical direction above vegetable canopy


• Sonic annometer - measures wind speed in 3-dimensions: 2 horizontal and 1 vertical component
• net radiometer - measures the 4 components of solar radiation
• Open-path CH_4 analyzer - uses wavelength modulation spectroscopy (WMS) technology that employs vertical cavity surface emitting laser (VCSEL) in an open multipass design
• Open-path CO_2/H_2O analyzer -measures CO_2 and water vapor densities; uses non-dispersive infrared (NDIR) sensor
• air temperature and humidity probe - measures air temperature and relative humidity
• photosynthetically active radiation (PAR) - measures the radiation used for photosynthesis
• datalogger - records data at 10 Hz
• soil temperature probe - measures soil temperature
• water content reflectometer - measures volumetric water content
• soil heat flux plate - measures ground heat flux

ตัวอย่างวิธีนี้


8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
การใช้น้ำของอ้อย, mm day-1
0
1
2
3
4
5
6
7
8
9
10
11
12
เดือนหลังปลูก

Climatic Calculation

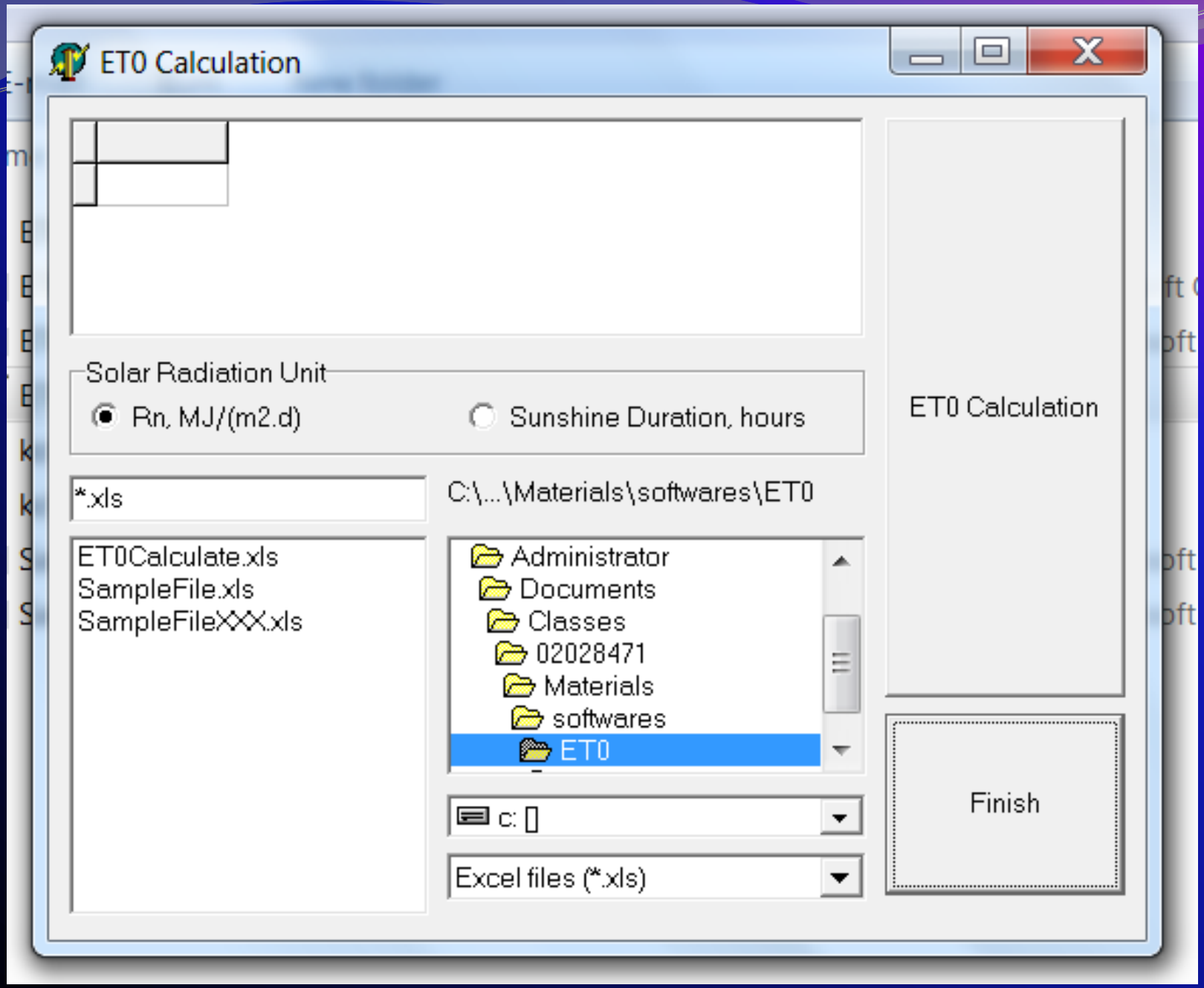
$$ET_a(t) = k_c(t) \cdot ET_a(t)$$

k_c = crop coefficient dependent on age and species

$$\mathrm{ETp} = \frac{0.408 * \Delta * (R_n - G) + \gamma * \frac{900}{T + 273} u_2 * (e_s - e_a)}{\Delta + \gamma * (1 + 0.34 * u_2)}$$

A1 fx Julian

	A	B	C	D	E	F	G	H	I	J	K	L
1	Julian	Rainfall	Tmax	Tmin	Tmean	RH	Wind2m	Sunshine	ET0	Altitude	Longitude	Latitude
2	1	0	33.04	20.17	26.19	65.7	4.32	8.49	4.9203	0	101.94300	14.8289003
3	2	0	33.62	15.05	23.06	70.12	5.11	9.55	4.9166			
4	3	0.04	34.61	18.53	25.43	70.21	4.46	6.61	4.2762			
5	4	0	30.48	19.85	24.45	70.86	3.9	8.77	4.2016			
6	5	0	33.5	19.92	24.35	66.76	4.63	7.48	4.8682			
7	6	0	34.48	18.71	24.9	65.96	4.77	10.18	5.5927			
8	7	0	32.6	20.4	24.94	66.29	6.85	6.78	5.4256			
9	8	1.33	30.06	22.71	25.08	74.58	4.95	9.93	4.4970			
10	9	0	32.22	19	25.29	65.95	4.96	9.34	5.1868			
11	10	0	32.51	21.44	28.29	66.1	6.47	10.02	5.8219			
12	11	0.14	34.49	18.16	25.21	69.05	5.88	9.31	5.3974			
13	12	0	34.97	19.83	26.4	69.15	4.72	10.29	5.3372			
14	13	0	33.42	19.85	26.51	63.87	3.45	9.76	5.0042			
15	14	0	35.68	16.55	26.05	75.64	5.26	9.68	4.6210			
16	15	0	32.93	16.92	25.35	78.96	6.87	8.2	3.9841			
17	16	0	31.84	21.27	23.56	66.07	3.53	9.93	4.9334			
18	17	0.01	30.56	18.26	28.3	75.16	5.03	10.36	4.3303			
19	18	0	32.49	20.96	24.14	75.73	4.39	9.31	4.2646			
20	19	0	32.66	21.4	23.45	72.27	5.07	10.19	5.0302			
21	20	0	33.92	16.93	25.12	73.94	2.83	10.11	4.1125			


ET0 Calculation
Solar Radiation Unit
Rn, MJ/(m2.d)
Sunshine Duration, hours
*.xls
C:\...\Materials\softwares\ET0
ET0Calculate.xls
SampleFile.xls
SampleFileXXX.xls
Administrator
Documents
Classes
02028471
Materials
softwares
ET0
c: []
Excel files (*.xls)
ET0 Calculation
Finish

$$k_c = C_0 + C_1\left(1 - \exp\left(\frac{-\tau^2}{A^2}\right)\right)$$

เมื่อ k_c กำหนดให้เป็นของฟังก์ชันของเวลา τ ซึ่งสามารถเขียนได้ในรูป

$$\tau = \begin{cases} \dfrac{t}{t_{\max}}, when \dfrac{t}{t_{\max}} < 0.5 \\ \dfrac{t}{t_{\max}} - \left(0.5 - \dfrac{t}{t_{\max}}\right), when \dfrac{t}{t_{\max}} \geq 0.5 \end{cases}$$

เมื่อ exp เป็นสัญลักษณ์แทนเลขยกกำลังฐาน e และ t คืออายุอ้อยมีหน่วยเป็นเดือนหลังปลูก และ $t_{\max}$ คืออายุอ้อยเมื่อเก็บเกี่ยวมีหน่วยเป็นเดือนเช่นเดียวกัน C_0 และ C_1 เป็นค่าคงที่กำหนดค่าสูงสุดและต่ำสุดของค่าสัมประสิทธิการใช้น้ำ และค่า A คือค่าปรับรูปร่างของเส้นสมการ ซึ่งขึ้นกับค่าคงที่การปรับเส้นสมการ θ และ φ ซึ่งสามารถเขียนสมการค่าปรับแก้ได้เป็น

$$A = \sqrt{a^2\cos^2(\theta - \varphi) + b^2\sin^2(\theta - \varphi)}$$

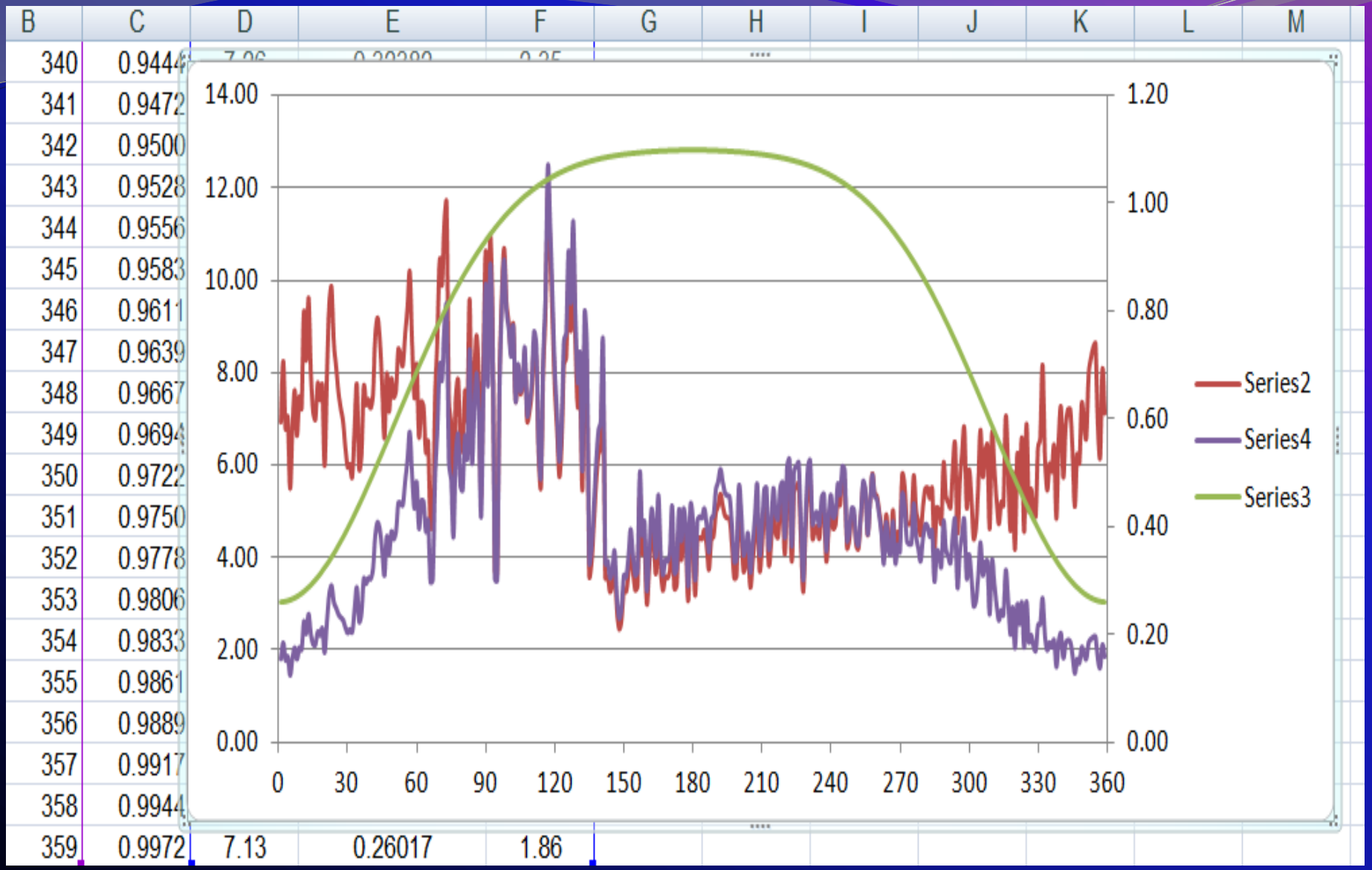
$$a = \varphi \text{ radian}$$

$$b = (\varphi + \frac{\pi}{2}) \text{ radian}$$

kcCaneUsed.bas - Notepad

File Edit Format View Help

```
Attribute VB_Name = "Module1"
Function KcCane(x)
a = 0.039059
If x <= 0.5 Then
tao = -x * x
Else
tao = 0.5 - (x - 0.5)
tao = -tao * tao
End If
tao = Exp(tao / a)
tao = 1 - tao
tao = 0.26 + 0.84 * tao
KcCane = tao
End Function
```

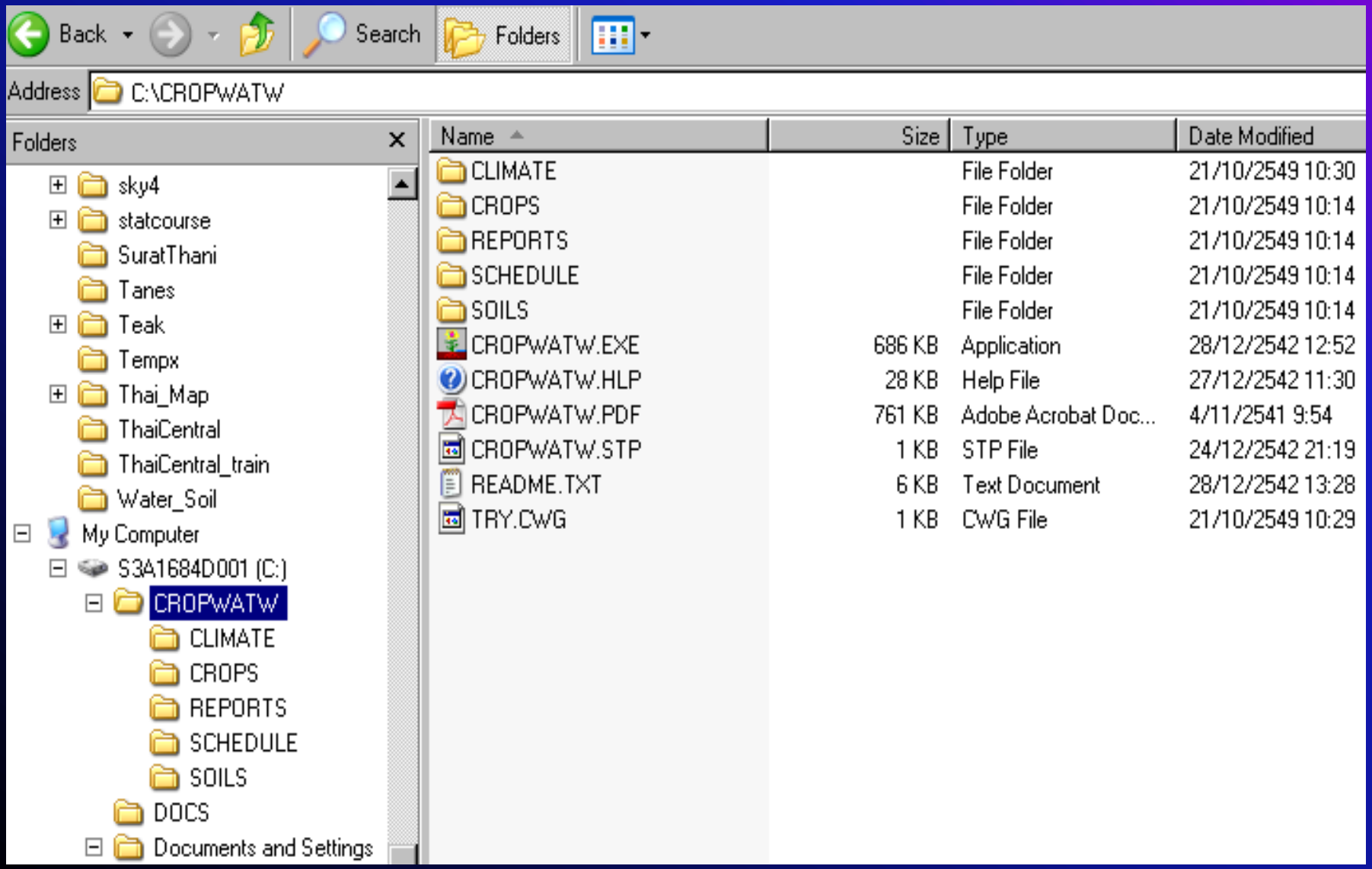


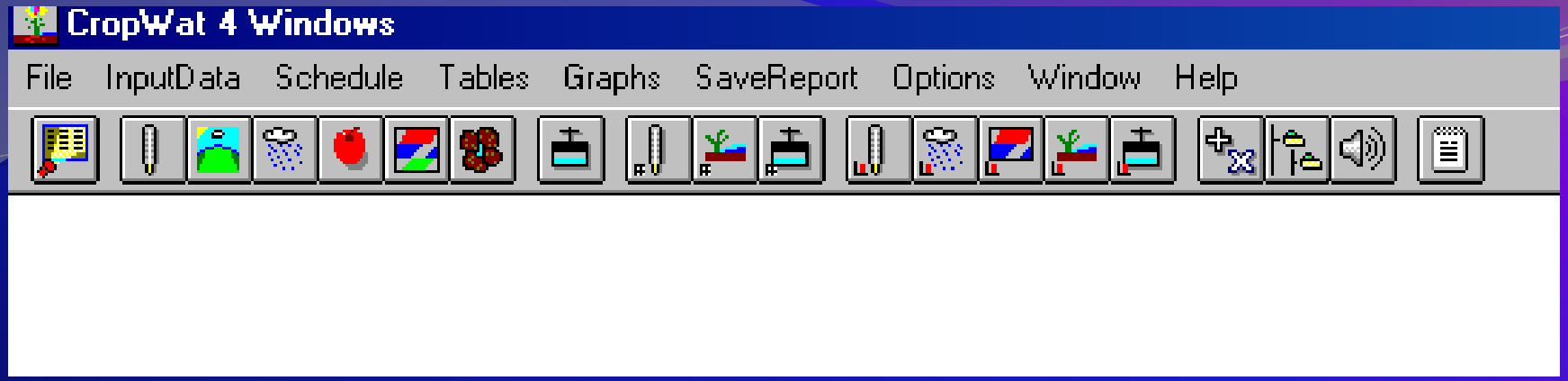
samplefileXXX.xls

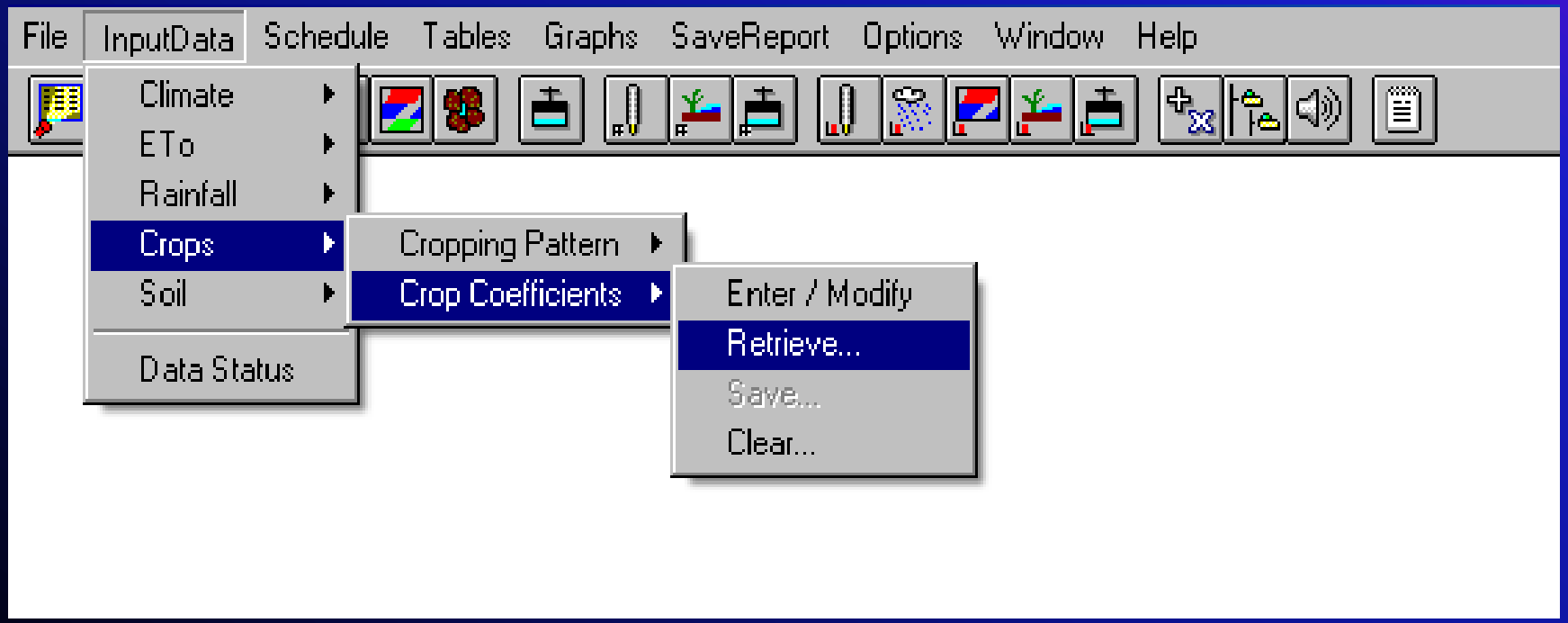
Kc can be found with CROPWATW program

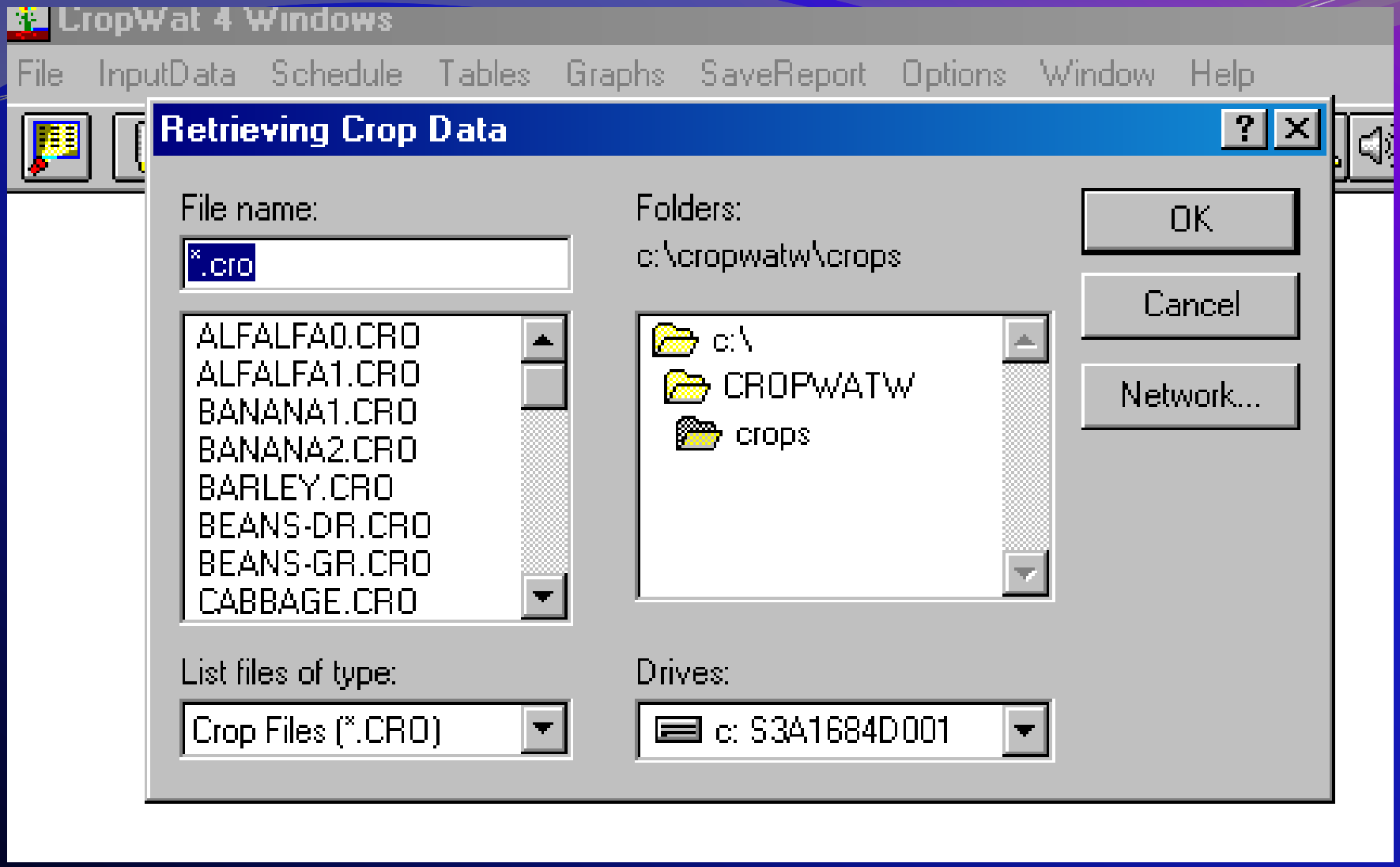
- FAO freeware

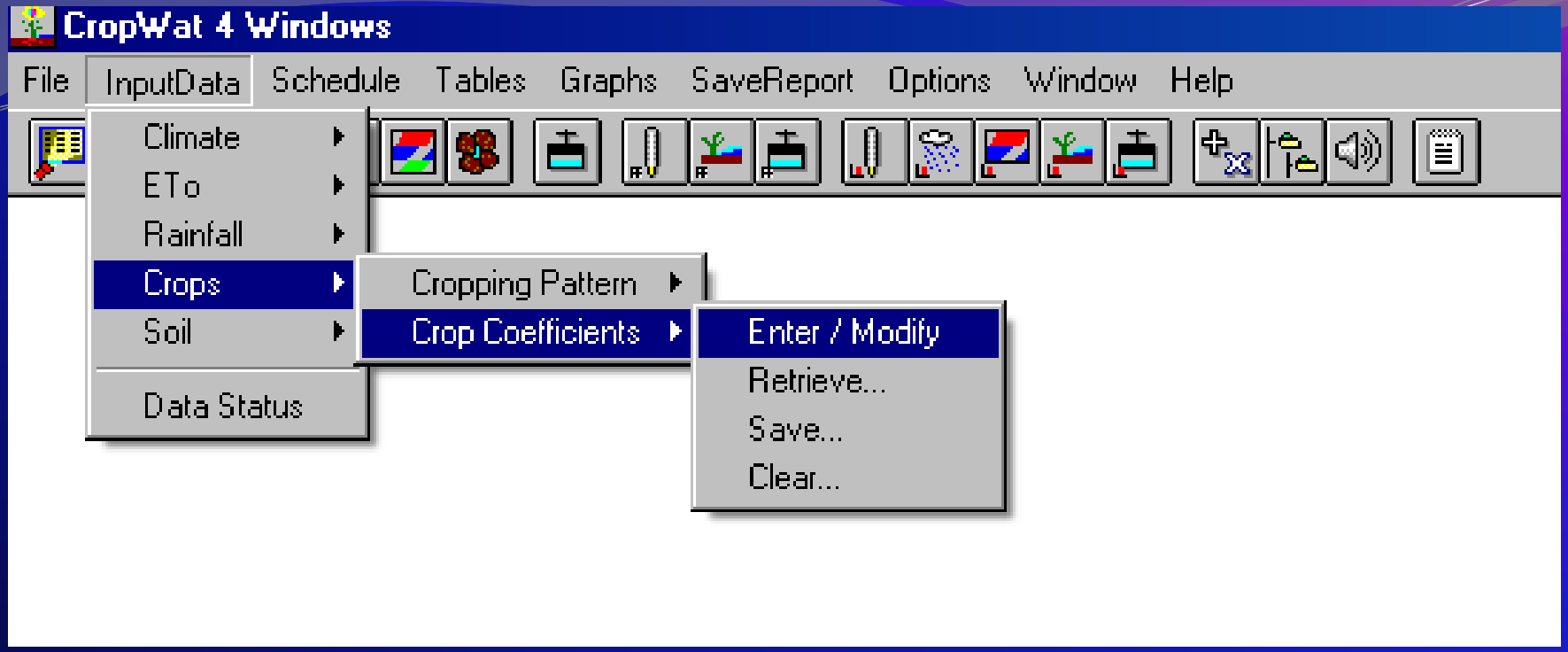
CROPWATW system

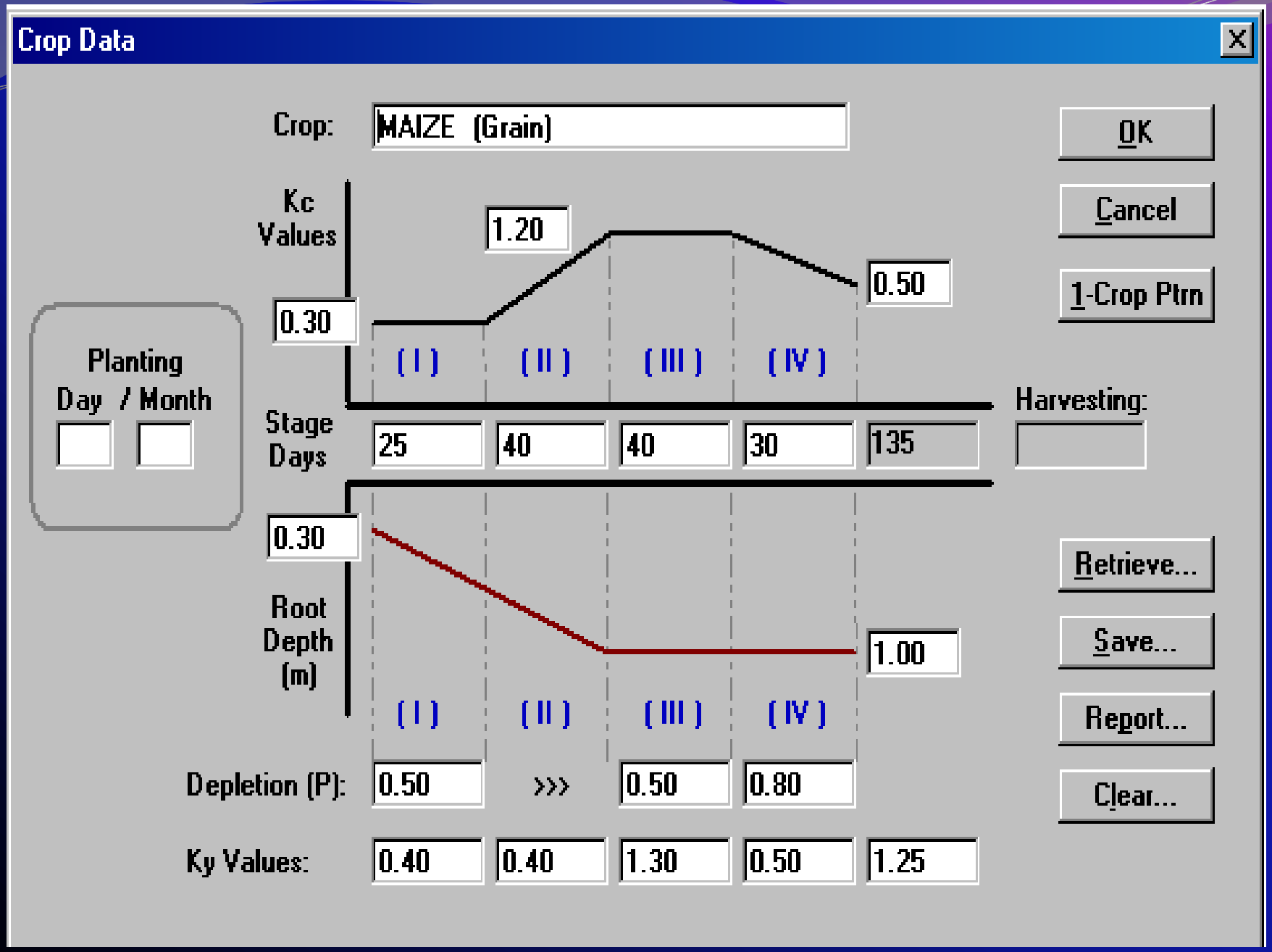



CropWat 4 Windows
File
InputData
Schedule
Tables
Graphs
SaveReport
Options
Window
Help


File
InputData
Schedule
Tables
Graphs
SaveReport
Options
Window
Help
Climate
ETo
Rainfall
Crops
Soil
Data Status
Cropping Pattern
Crop Coefficients
Enter / Modify
Retrieve...
Save...
Clear...


CropWat 4 Windows
File InputData Schedule Tables Graphs SaveReport Options Window Help
Retrieving Crop Data
File name:
*.cro
ALFALFA0.CRO
ALFALFA1.CRO
BANANA1.CRO
BANANA2.CRO
BARLEY.CRO
BEANS-DR.CRO
BEANS-GR.CRO
CABBAGE.CRO
Folders:
c:\cropwatw\crops
c:\
CROPWATW
crops
OK
Cancel
Network...
List files of type:
Crop Files (*.CRO)
Drives:
c: S3A1684D001


CropWat 4 Windows
File
InputData
Schedule
Tables
Graphs
SaveReport
Options
Window
Help
Climate
ETo
Rainfall
Crops
Soil
Data Status
Cropping Pattern
Crop Coefficients
Enter / Modify
Retrieve...
Save...
Clear...

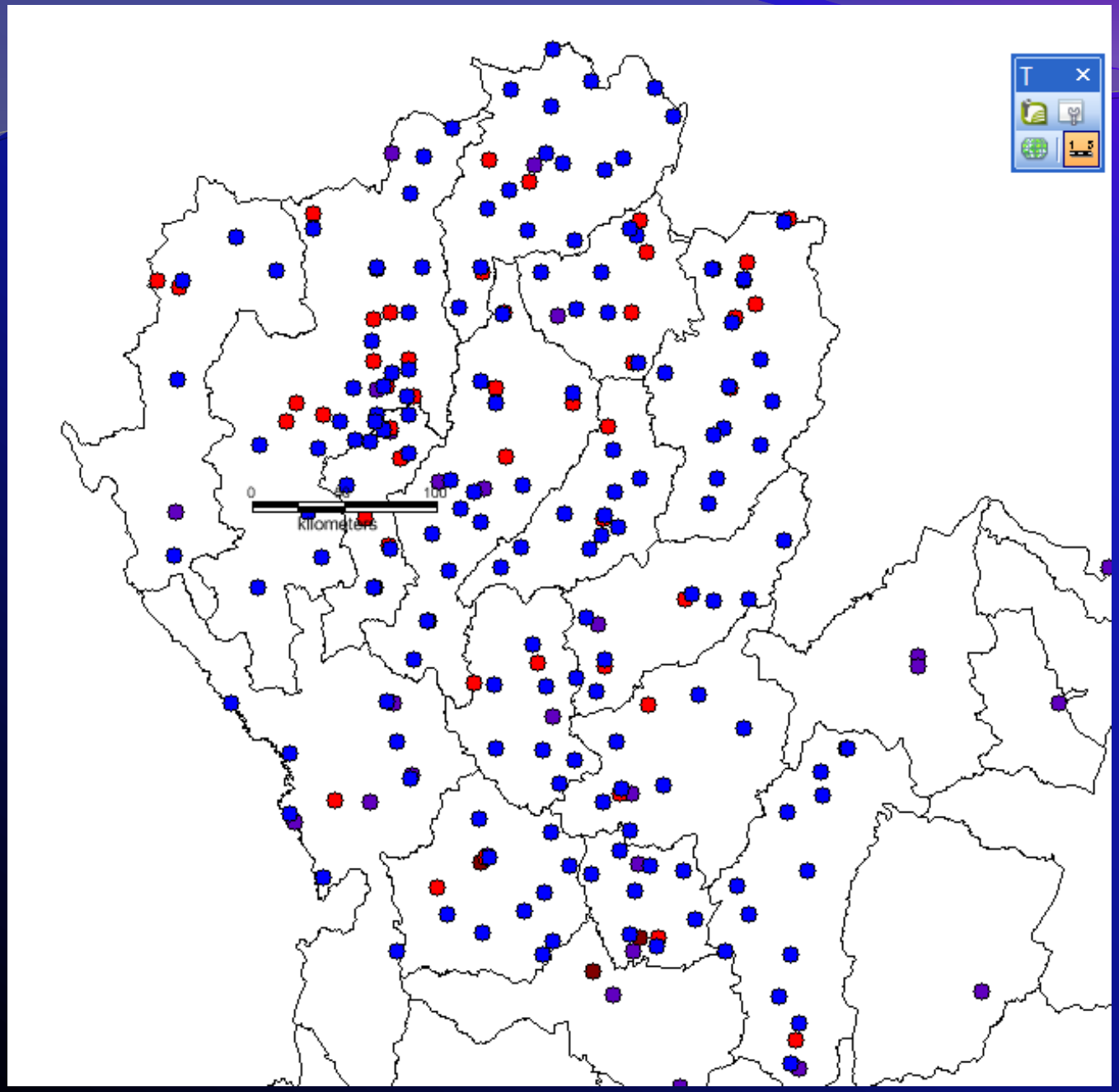

Crop Data
Crop:
MAIZE (Grain)
OK
Cancel
1-Crop Ptrn
Kc Values
1.20
0.50
0.30
Planting Day / Month
(I)
(II)
(III)
(IV)
Harvesting:
Stage Days
25
40
40
30
135
0.30
Retrieve...
Root Depth (m)
1.00
Save...
Report...
Clear...
Depletion (P):
0.50
>>>
0.50
0.80
Ky Values:
0.40
0.40
1.30
0.50
1.25

Loss

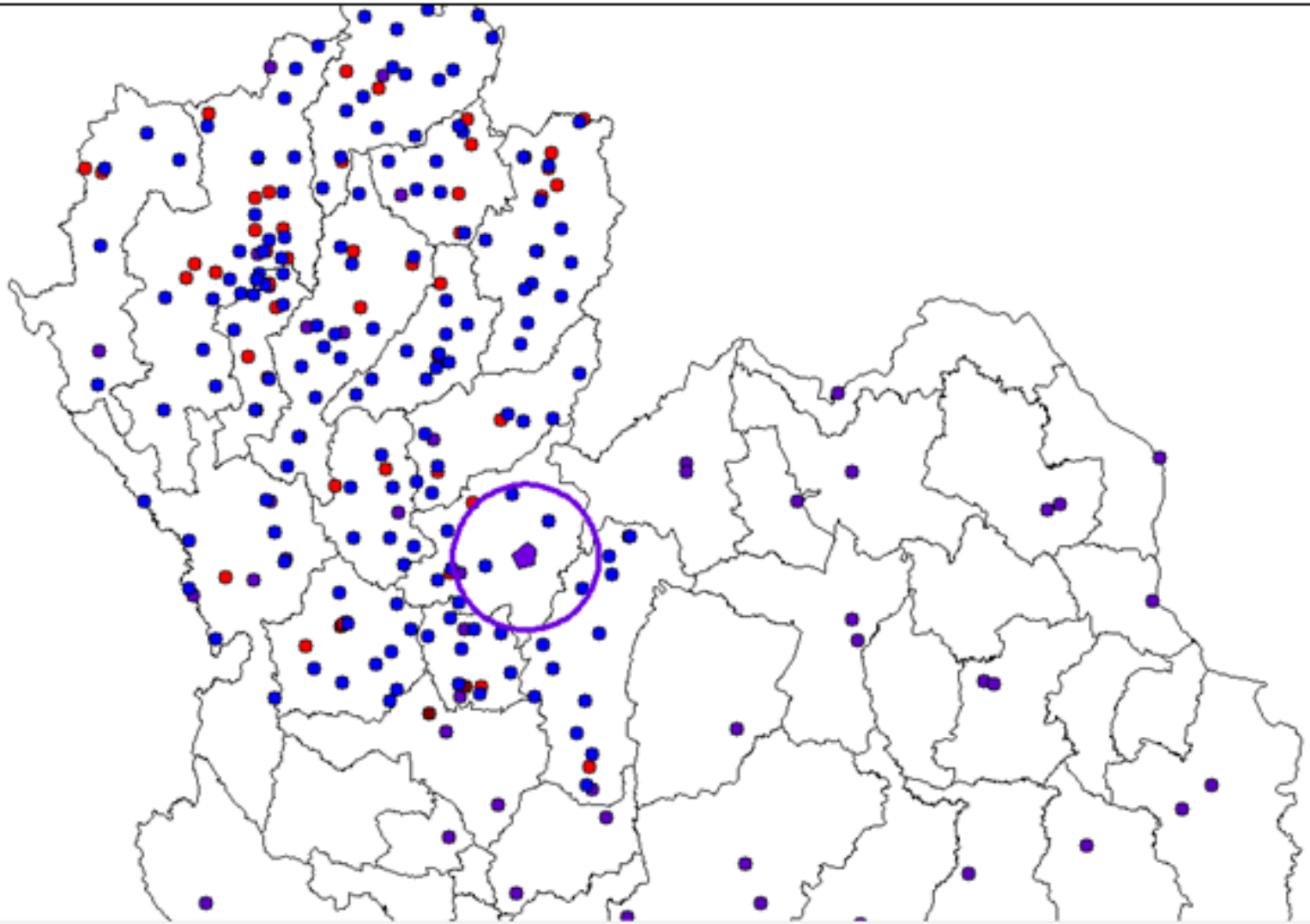
- deep percolation
- runoff

Exist

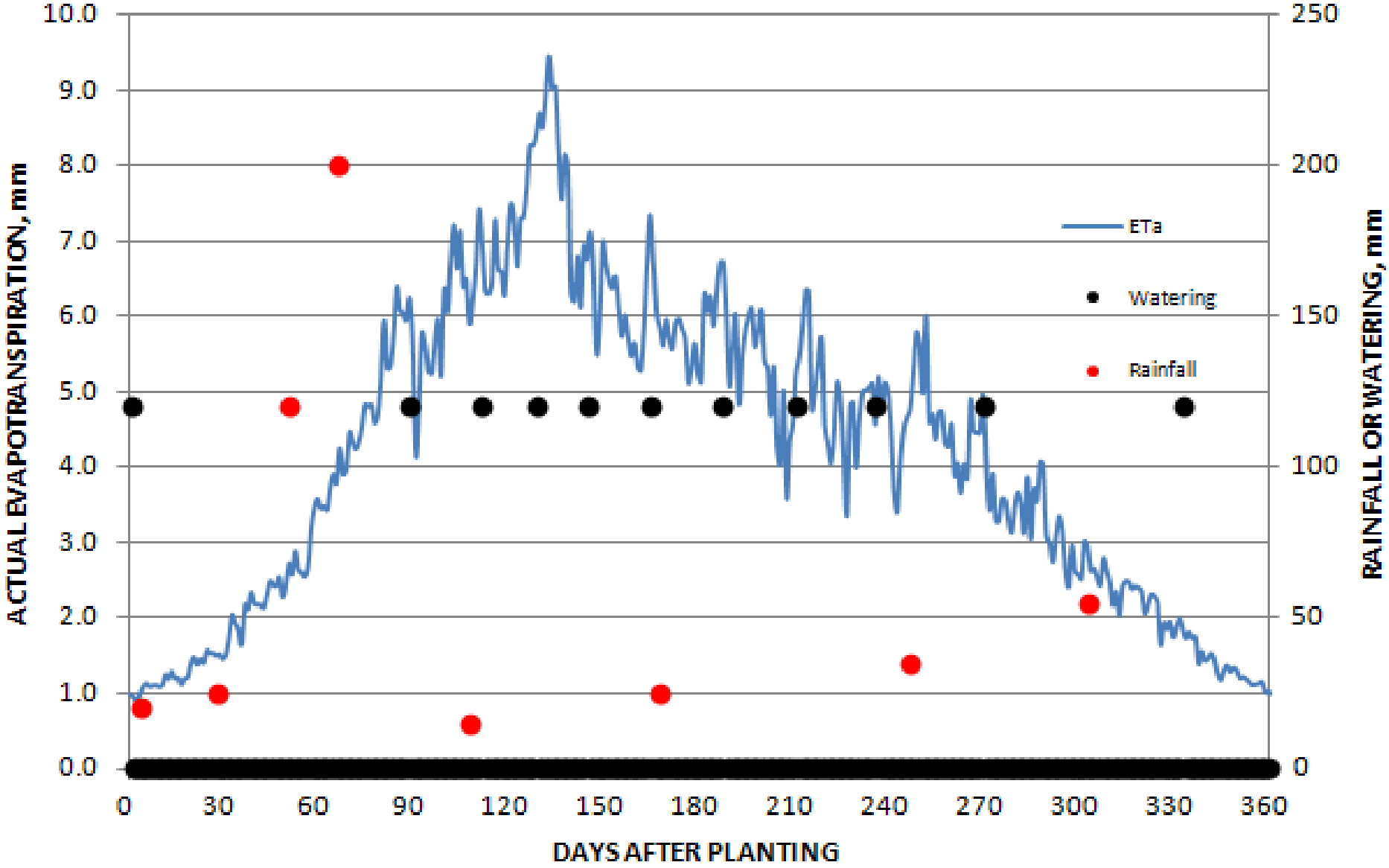
- soil water content


0
50
100
Kilometers

IoT CLIMATIC-DB



ภาพที่ 2 การเลือกใช้ข้อมูลจากสถานีที่อยู่ภายใต้อิทธิพลของความสัมพันธ์เชิงพื้นที่แบบเดียวกัน แปลงปลูกอ้อยสีม่วง ไม่มีข้อมูลภูมิอากาศและน้ำฝน แต่สามารถนำข้อมูลจากสถานีที่มีความสัมพันธ์เชิงพื้นที่แบบเดียวกัน (สถานีภายในวงกลมสีม่วง) มาประมวลเพื่อใช้งานได้ ซึ่งผลที่ได้มีความน่าเชื่อถือสูง



Ex. Sandy loam AWC 120 mm

Nutrient Management

Supply = Demand + Loss + Exist

Sustainable --- do not use existing nutrient in soil but borrow is OK, have to return back to soil

Evaluation on nutrient demand requires

- Vegetable growth rate
- Biomass calculation & composition
- fresh and dry biomass
- nutrients necessary for vegetable growth
- moisture content in veg biomass

Necessary Nutrients

- C, H, O

  N, P, K, Ca, Mg, S

  B, Zn, Mo, Cl, Fe, Cu, Mn

- Available forms

  C --> CO_2

  H --> H_2, H_2O

  O --> O_2

$N \rightarrow NH_4^+, NO_3^-, NO_2^-$

$P \rightarrow H_2PO_4^-, HPO_4^=$

$K \rightarrow K^+$

$Ca \rightarrow Ca^{++}$

$Mg \rightarrow Mg^{++}$

$S \rightarrow SO_3^=, SO_4^=$

$B \dashrightarrow B_4O_7^{=}, H_3BO_3$

$Zn \dashrightarrow Zn^{++}$

$Mo \dashrightarrow MoO_4^{=}$

$Cl \dashrightarrow Cl^{-}$

$Fe \dashrightarrow Fe^{++}, Fe^{+++}$

$Cu \dashrightarrow Cu^{+}, Cu^{++}$

$Mn \dashrightarrow Mn^{++}, Mn^{++++}$

Biomass

components of vegetables such as roots, trunk, branch, petiole, leaves, flowers, fruits , and others.

Fresh and Dry Biomass

fresh = weight of any organs including water (fresh mass, W_f)

dry = over dry fresh biomass at 65C for 3 days or more (dry mass, W_d)

$$W_f = W_d + W_w$$

W_w = water mass

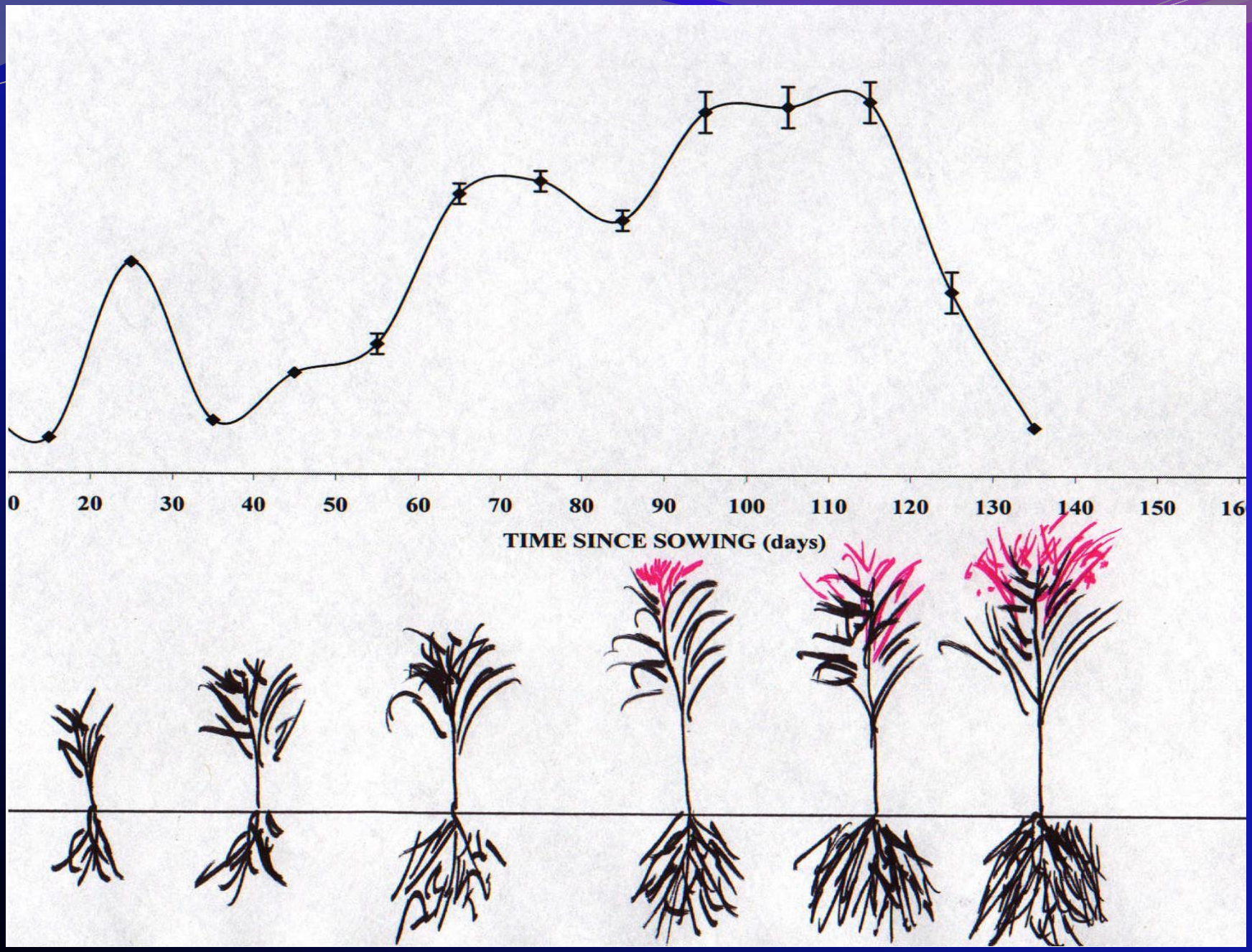
Moisture content

water mass over dry mass ratio

$$\%moisture = W_w/W_f \times 100$$

$$\%moisture = W_w/(W_d + W_w) \times 100$$

$$= (1+(W_w/W_d)) \times 100$$


0
20
30
40
50
60
70
80
90
100
110
120
130
140
150
16
TIME SINCE SOWING (days)

Example of root biomass of Chinese cabbage

	root	
DAP	fresh biomass	dry biomass
6	172	45
15	170	44
21	173	43
31	30	8
40	20	5

	stem	
DAP	fresh	dry
6	760	190
15	780	192
21	760	195
31	1890	480
40	1880	460

leaf

DAP	fresh	dry
6	393	100
15	395	101
21	398	98
31	639	160
40	473	120

	root+stem+leaves	
DAP	fresh	dry
6	1325	335
15	1345	337
21	1331	336
31	2559	648
40	2373	585

จากตัวเลขที่จัดเก็บข้อมูลได้ อาจกล่าวได้ว่า

- อัตราการเจริญเติบโตของอ้อยจะเติบโตอย่างช้าๆ ในช่วง 2 เดือน
- จากนั้นอัตราการเจริญจะชะงักในช่วงต่อมาอีก 5 เดือน
- และมีอัตราการเจริญอย่างรวดเร็วในเวลาต่อมาอีก 3 เดือน
- และอัตราการเจริญจะลดลงเล็กน้อยหลังจากนั้น เช่น

Rate of growth g/pt/day

3 organs

DAP	Fresh	Dry
6	19.7	5
15	0.4	0.05
21	-0.1	-0.01
31	12.0	3.1
40	-2.2	0.75

Calculation of nutrient requirement requires nutrient constiuent in any organs

organ	%N-by dry wt.
root	0.55
stem	0.35
leave	1.15

g-N/pt

DAP	ราก	ลำต้น	ใบ+กาบ	รวม
67	0.25	0.67	1.15	2.07
115	0.24	0.67	1.16	2.07
217	0.24	0.68	1.13	2.05
318	0.04	1.68	1.84	3.56
402	0.03	1.61	1.38	3.02

คิดเป็น g-N/pt

วันหลังปลูก	ราก	ลำต้น	ใบ+กาบ	รวม
67	0.25	0.67	1.15	2.07
115	0.24	0.67	1.16	2.07
217	0.24	0.68	1.13	2.05
318	0.04	1.68	1.84	3.56
402	0.03	1.61	1.38	3.02

จากตารางด้านหน้าอาจกล่าวได้ว่า

ความต้องการไนโตรเจนสำหรับการปลูกอ้อยให้ได้น้ำหนัก 2559 g/pt มีค่าเป็น 3 g ถ้าปลูกอ้อย 1 ไร่มีจำนวนลำทั้งสิ้น 10000 ลำ จะได้ผลผลิตเป็น 25.59 ตัน/ไร่ ต้องใช้ปุ๋ยไนโตรเจนในอัตรา 30 kg/rai

จากตารางอาจกล่าวได้อีกว่า อ้อยมีความต้องการใช้ N อย่างมากอยู่ 2 ช่วง คือช่วงเริ่มปลูกจนถึง 2 เดือน และในช่วง 5-8 เดือน โดยที่ช่วงแรกมีอัตราความต้องการใช้ที่สูงกว่า (ลองยกตัวเลขแสดงบนกระดานขาว)

ข้อควรคำนึงเกี่ยวกับการจัดการเรื่องธาตุอาหาร น่าจะเกี่ยวข้องกับสมบัติการแลกเปลี่ยนประจุบวกของดิน (CEC) ถ้าในดินมีค่า CEC มาก การใส่ปุ๋ยอาจใส่เพียงครั้งเดียวก็ได้ แต่ไม่แนะนำ เพราะ N เปลี่ยนรูปได้ง่ายมาก โดยเฉพาะอย่างยิ่ง ถ้าขณะเกิดฝนตกมากๆ ดินจะเปลี่ยนสภาพจาก aerobic --> anaerobic ซึ่ง NH4+ -------> N2 ซึ่งจะ loss ไปบางส่วน