Method of Soil Diagnosis

The year 2015 was International Year of Soils

2015

International Year of Soils

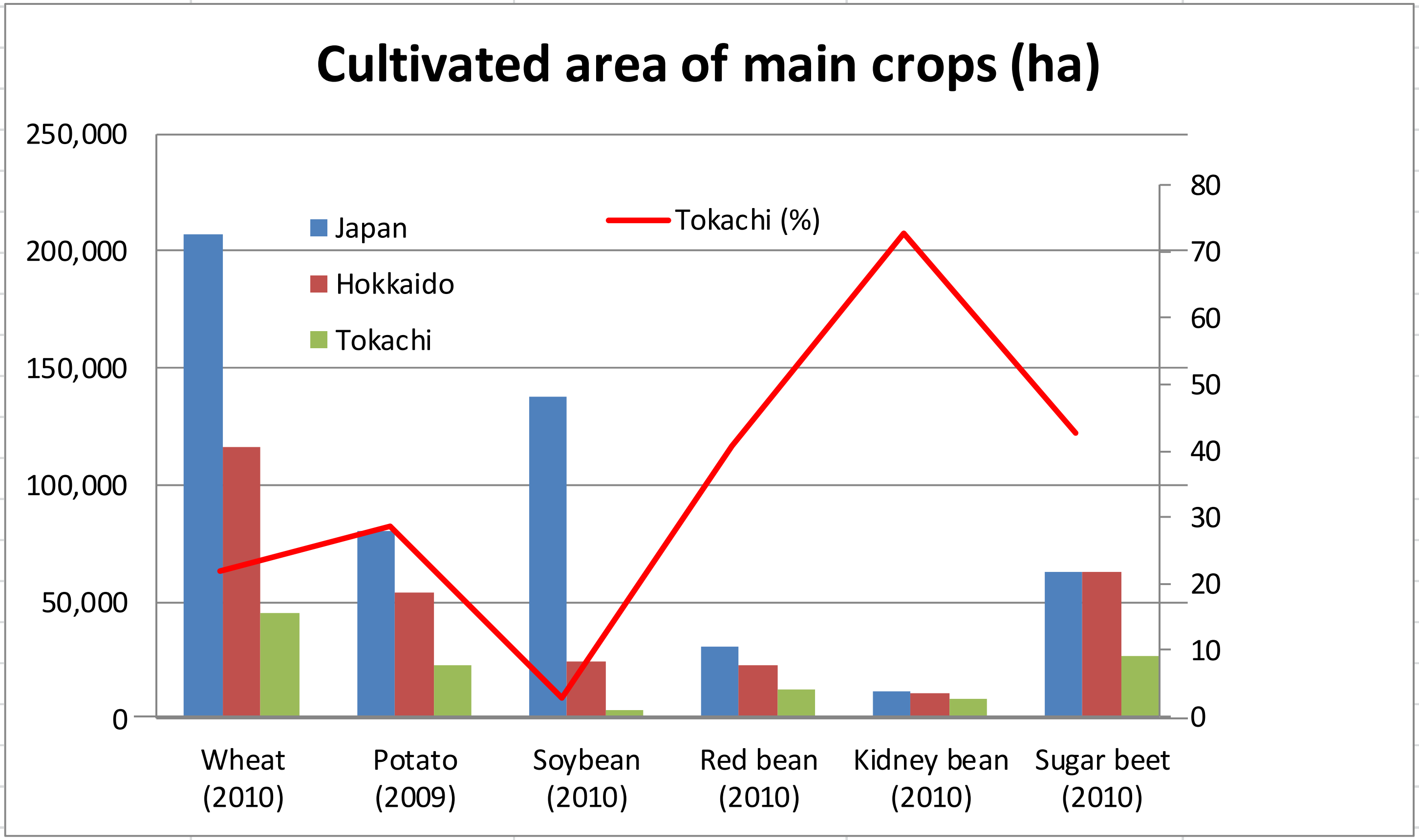
Why Soil Year 2015?

- Healthy soil is a basis for healthy food production.
- Soils support our plant's biodiversity and they host a quarter of the total.
- Soil is a non-renewable resource, its preservation is essential for food security and our sustainable future.

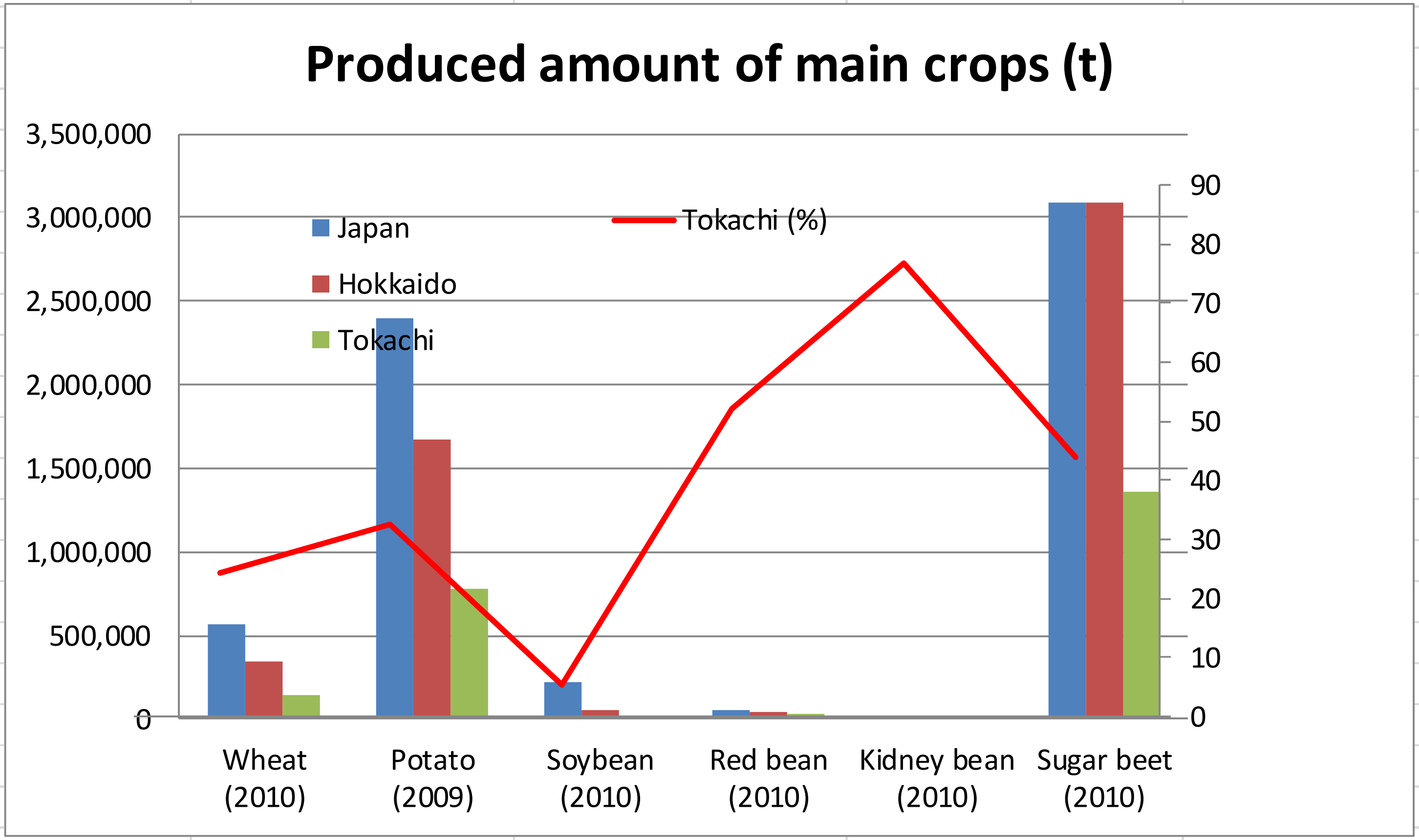
Why Soil Year 2015?

- Soil stores and filter water improving our resilience to flood and drought.
- Soils are foundation of vegetation which is cultivated or managed for feed, fibre, fuel, and medicinal plants.
- Soils help to combat and adapt to climate change by playing a key role in the carbon cycle.

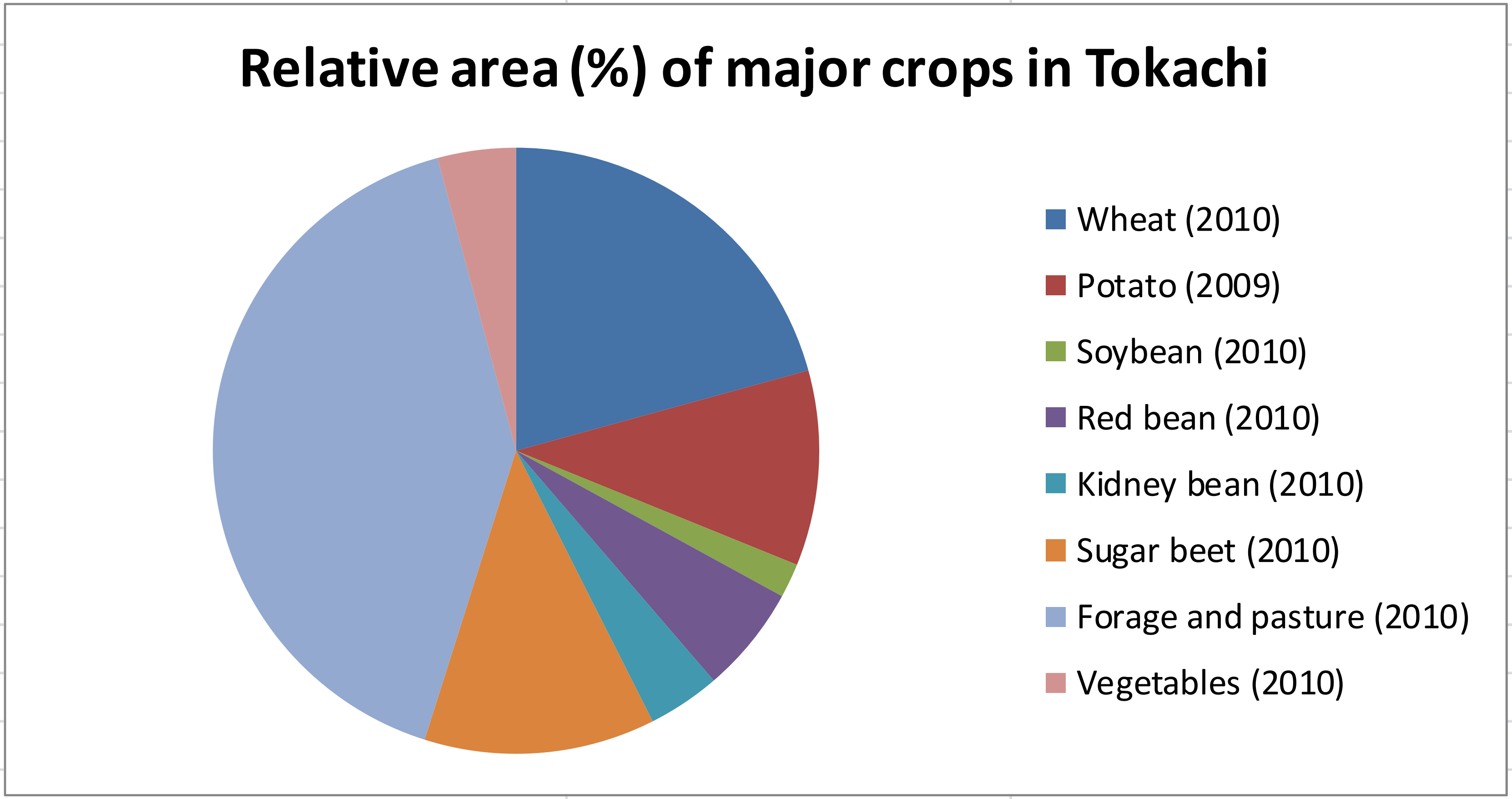
Cultivated area of major upland crops in Japan



Produced amount of major upland crops in Japan (t)



Proportions of cultivated area of major upland crops in Tokachi (%)



Purpose 1

- Find out the soil-related factor inhibiting the growth of crops, and improve it.

Example →

Correct soil acidity

Correct phosphate deficiency

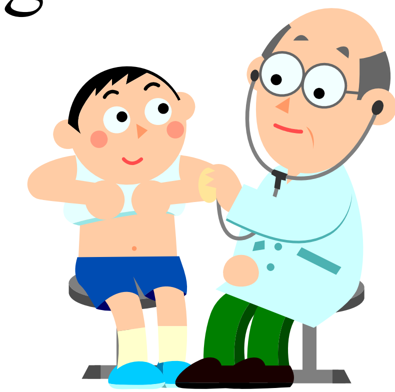
Improve drainage

Purpose 2

- Supply proper amount of nutrients necessary for the growth of crops, matching the nutrition status in soil.

Example →

Fertilizer application diagnosis



Purpose 3

Contribution to clean agriculture

← Excess fertilization pollute the environment

Nutrient absorption by plants

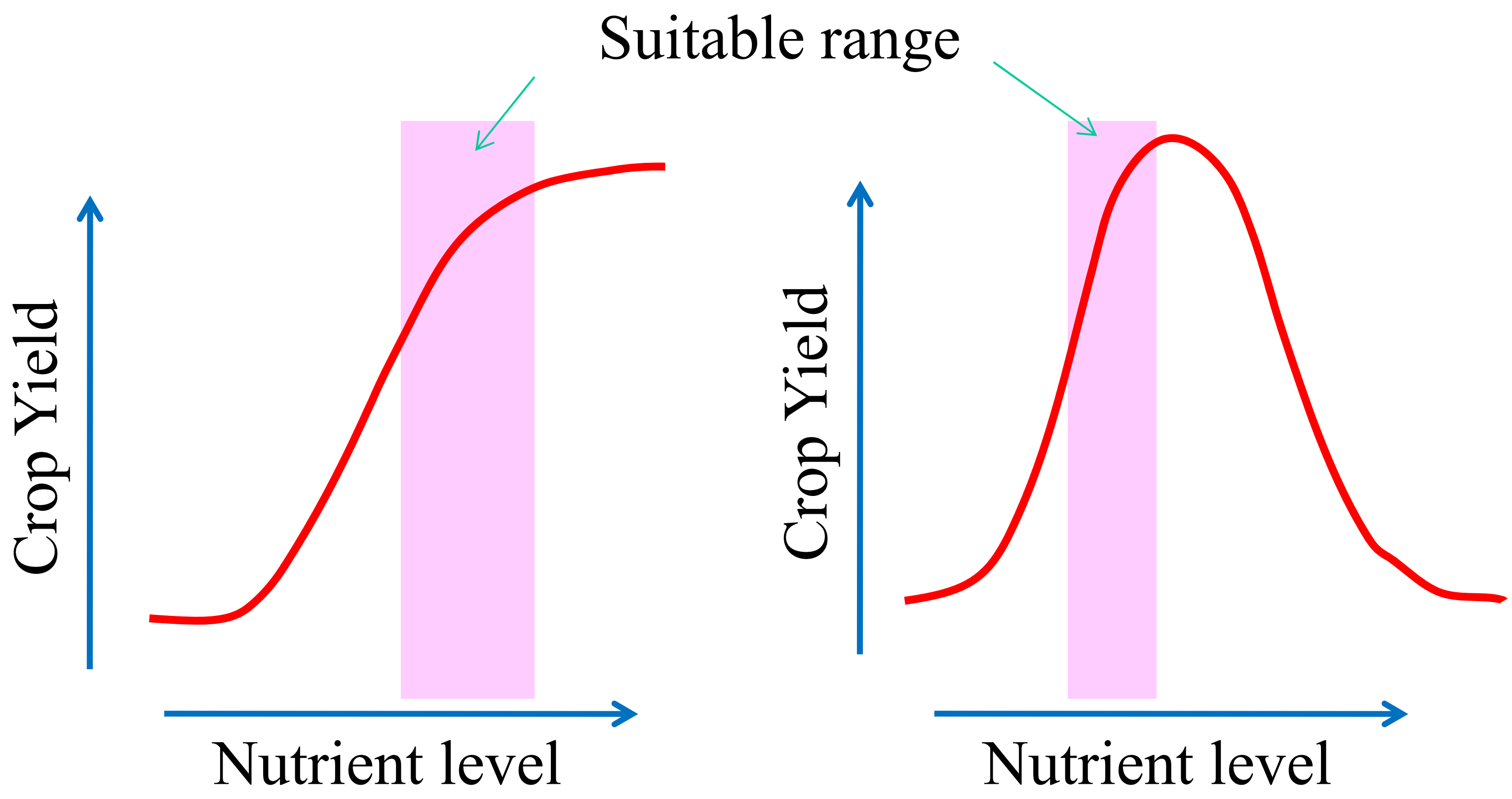
Nutrient holding capacity of soil

Present nutrient content in soil should be known.

Disorder in crop growth caused by nutrition status of soil

- Scab disease of potato
  （too high soil pH）
- Infertility of rice・Softning
  （excess nitrogen, silicate deficiency）
- Bolting phenomena of vegetables
  （excess phosphate）

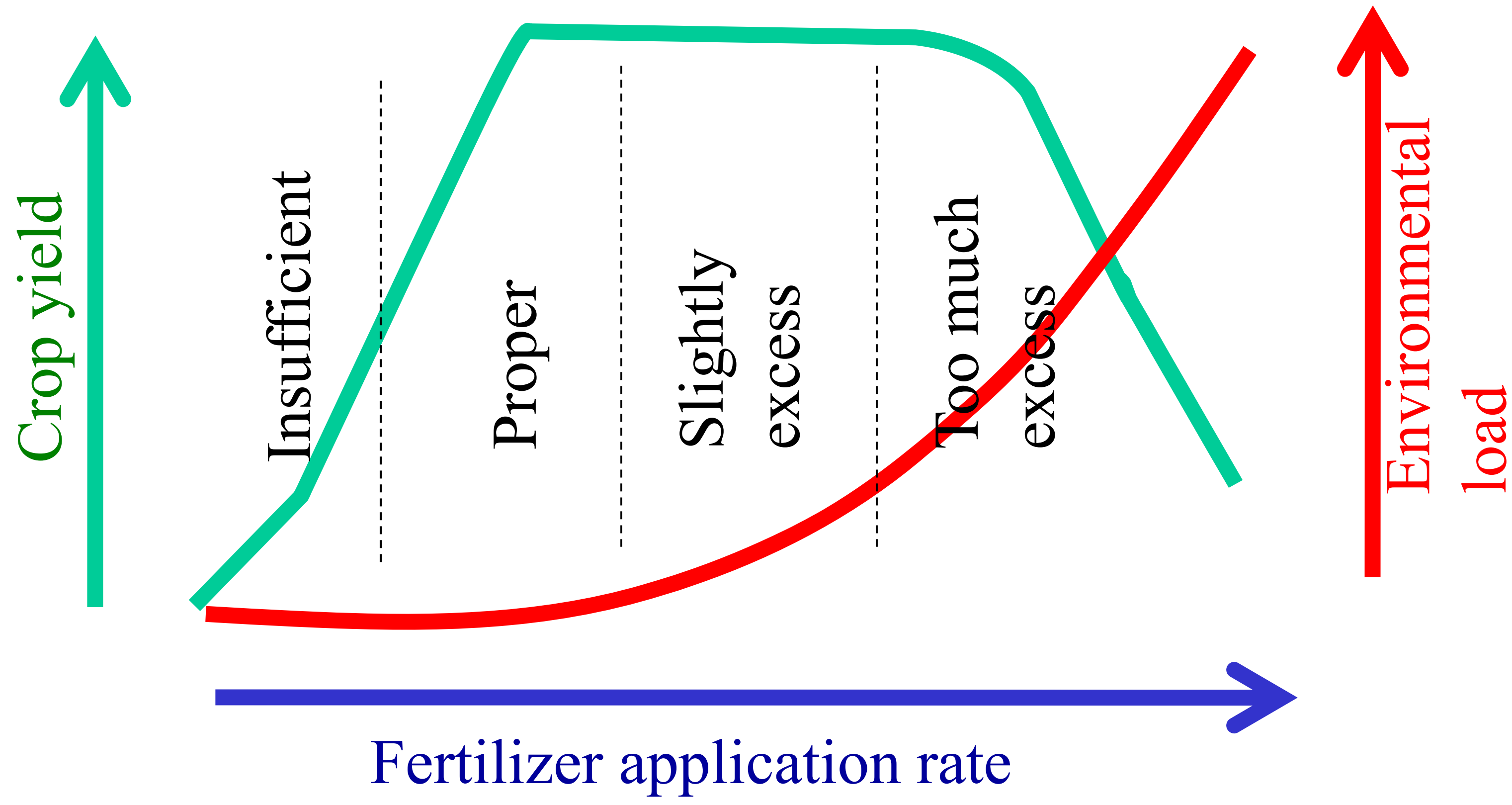
Crop yield and nutrient level



P

N, K, Ca, Mg, trace elements

Crop yield and environmental load



Disorder in crop growth caused by nutrition status of soil (2)

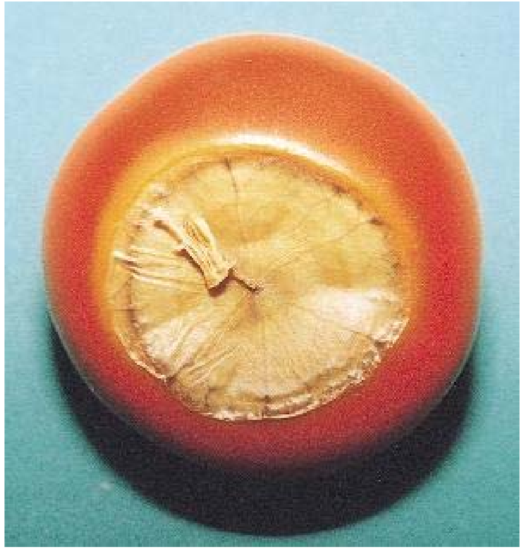
- Calcium deficiency of vegetables

  （Imbalance in basic cations）

- Decrease in quality of vegetables

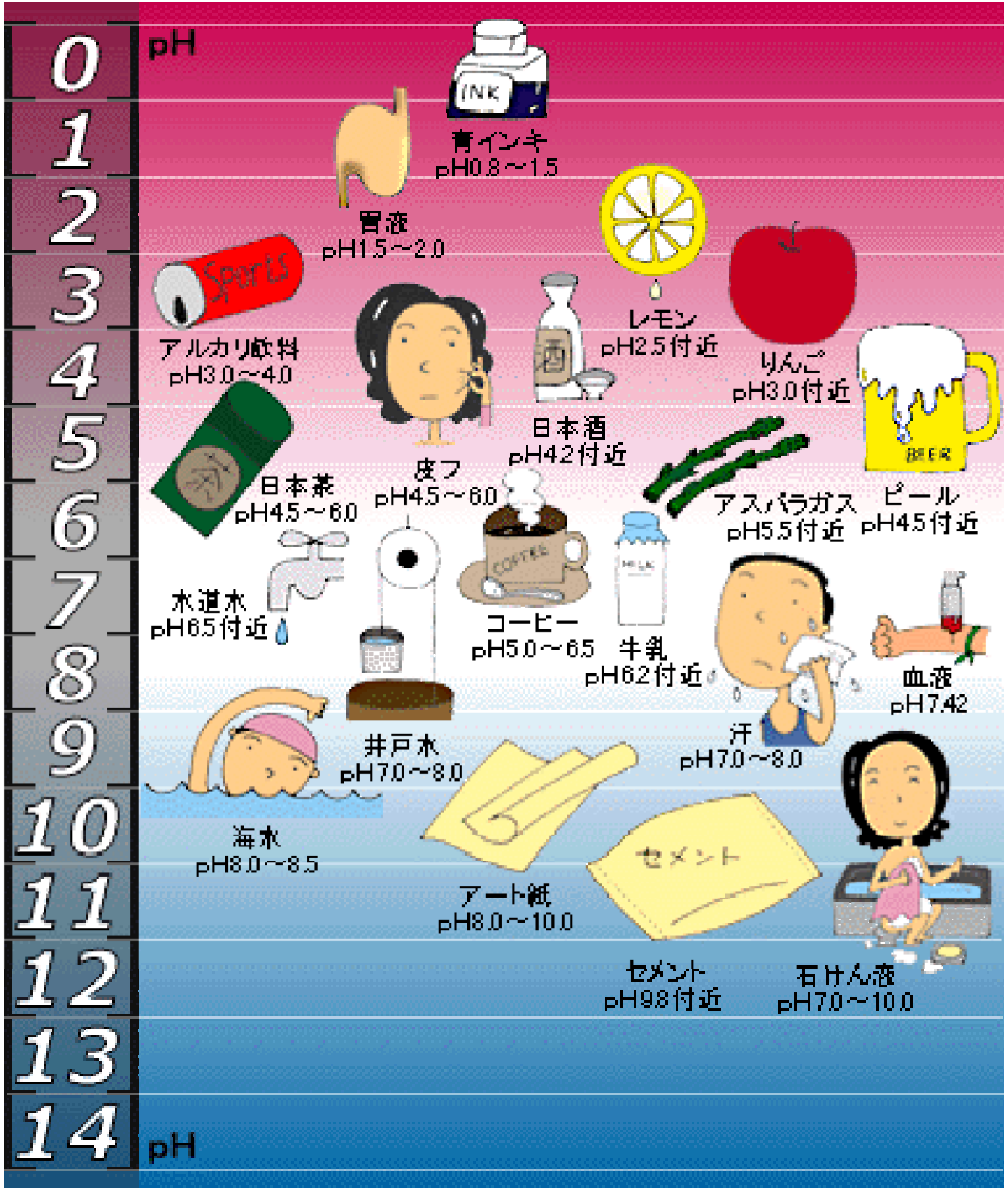
  Lowering in sugar and vitamins

  （accumulation of nitrate）



pH
in daily life

＝ −log (H^+)



Cited from

Horiba Home page

pH and crop growth (vegetables, root crops)

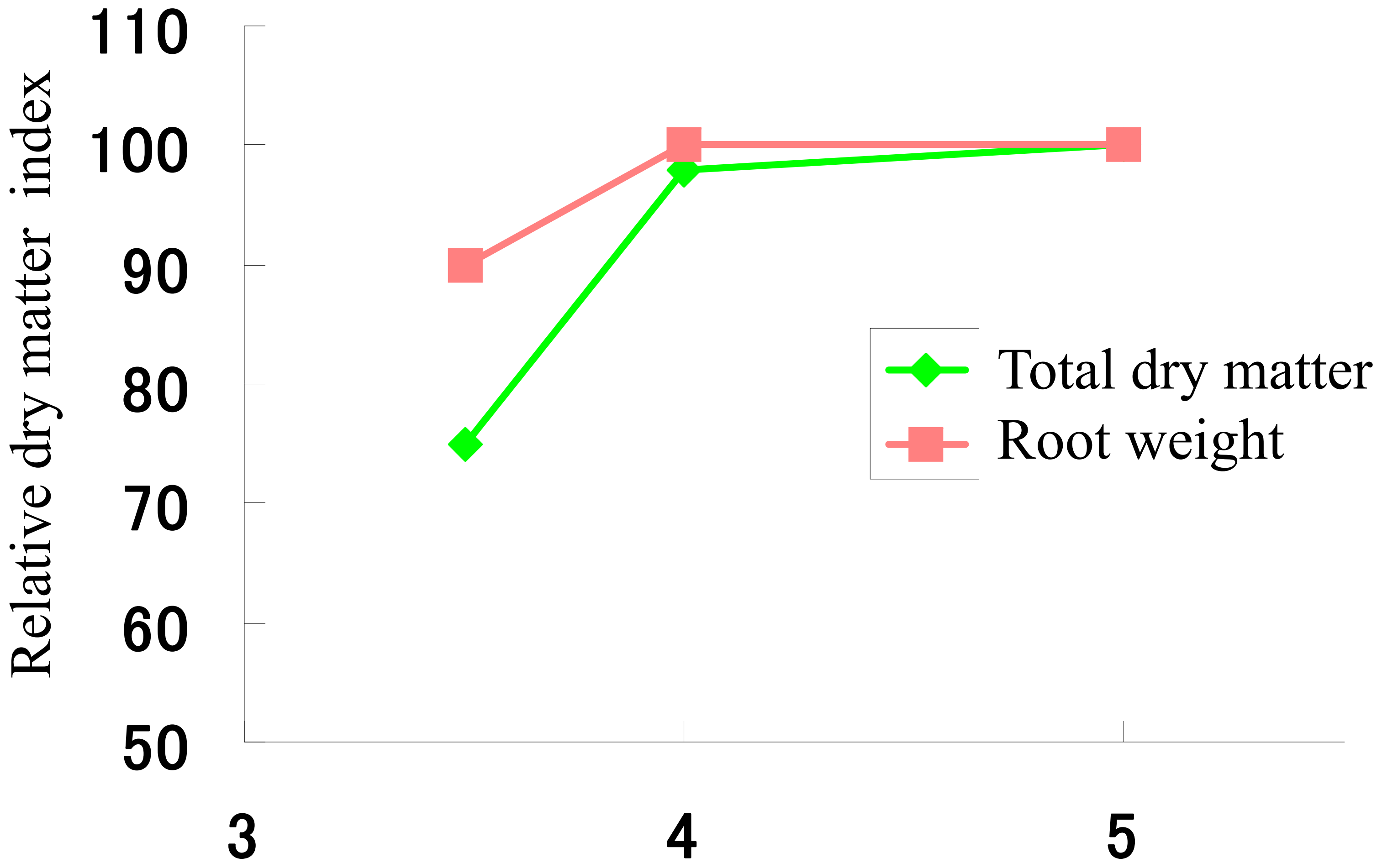
Low pH tolerance	Kind of crops
strong (4.0~5.0)	potato･taro
Little strong (4.5~6.0)	Sweet potato･radish･turnip･kidney bean･carrot･cucumber･parsley
Little weak (5.5~6.5)	tomato･egg plant･cabbage･broccoli･celery･green pea･melon
Weak (6.0~7.0)	spinach･onion･leek･burdock･asparagus･red pepper･lettus

pH and crop growth (grain・pasture)

Low pH tolerance	Kind of crops
strong (4.0~5.0)	rice ・ tea ・ tobacco
Little strong (4.5~6.0)	wheat ・ thimothy
Little weak (5.5~6.5)	Azuki bean ・ clover ・ milk vetch
Weak (6.0~7.0)	beet ・ barley ・ rye

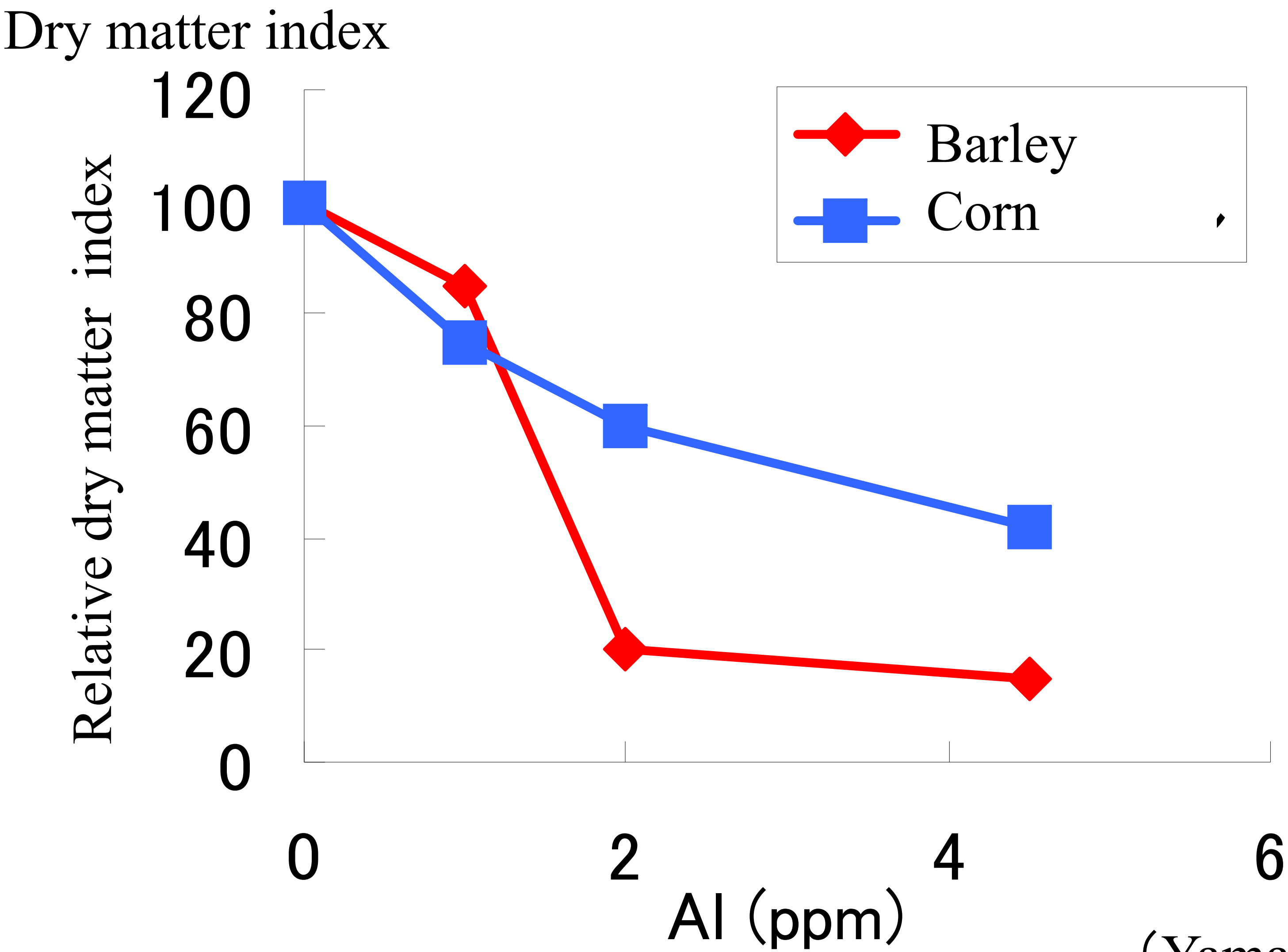
pH and dry matter production

Average of 49 plants



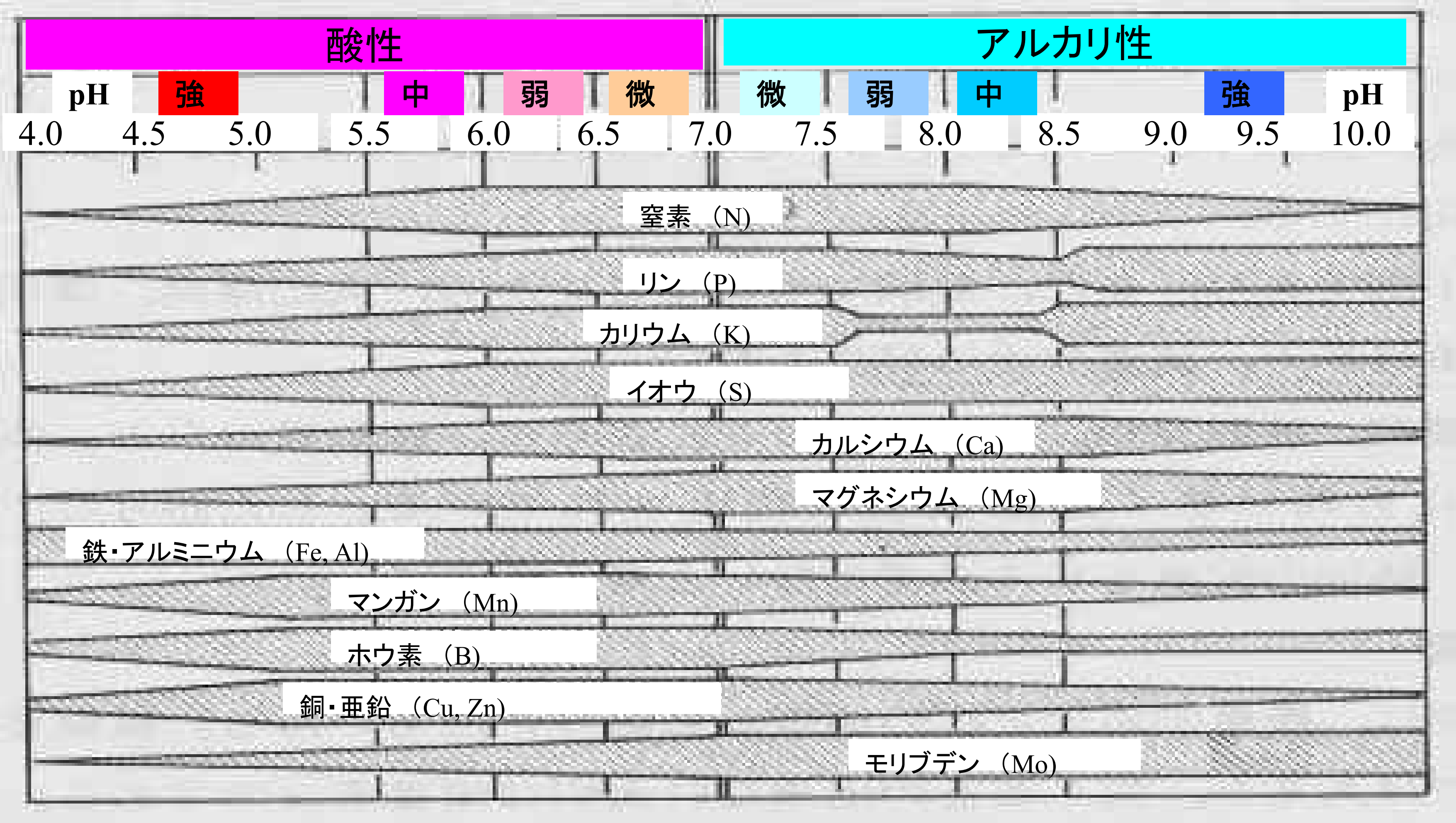
（Tanaka, Hayakawa 1974）

Damage by Al in hydroponic culture



(Yamane 1971)

Soil pH and availability of nutrients



Soil acidity and crop growth (1)

A) damage by hydrogen ion

B) damage by Al ion

C) deficiency in Ca and Mg

Soil acidity and crop growth (2)

D） phosphate deficiency

binding of Al and phosphate

E） Boron deficiency

Mo deficiency

－－－→serious in legume plants

F） excess damage by Mn

Mn is soluble at low pH

Soil acidity and crop growth (3)

G) suppress organic matter decomposition

mineralization of N and P increase on improvement of soil acidity

H) change in microbial flora

Fungi prefer acid, bacteria and actinomycetes prefer alkaline pH.

Soil acidity and crop growth (4)

I) Suppress nitrogen fixation

optimum pH 6.5～7.5

J) Suppress nitrification

On liming, nitrification ability increases remarkably.

Improvement of soil acidity（1）

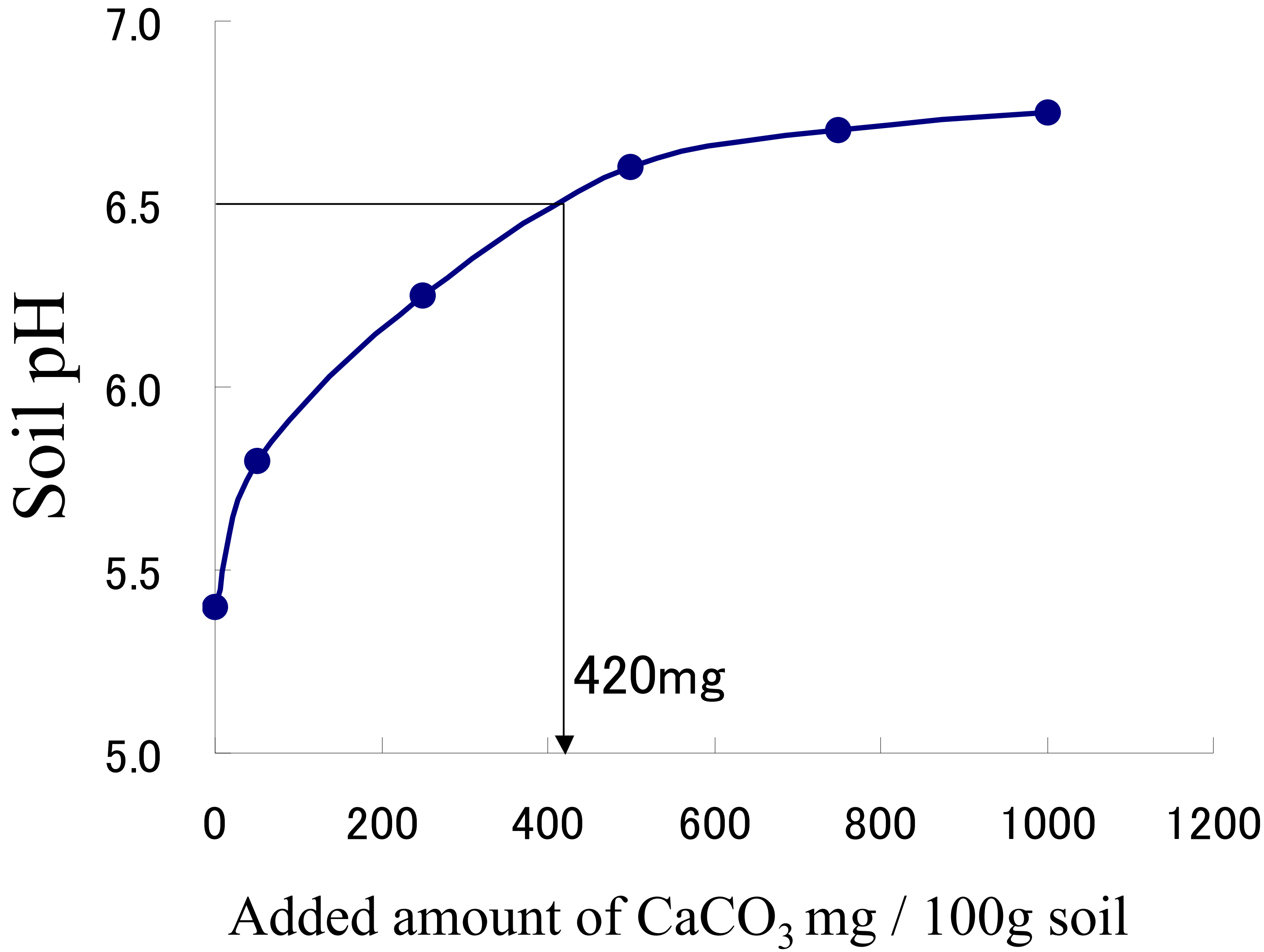
- **Calcite, Lime ($CaCO_3$)**

  3 times amount of exchangeable acidity （y_1）

  Buffer curve method

- **Gypsum ($CaSO_4$)**

  Al^{3+} in subsoil can be replaced by Ca^{2+} due to high solubility of gypsum



Lime requirement determination by buffer curve method

Calculation of lime requirement (example)

Goal pH 6.5 → $CaCO_3$ 420 mg / 100g soil

= 4.2g / kg = 4.2 kg / t

Amount of soil in 1 ha up to 15 cm depth

= 100m × 100m × 0.15m = 1500 m^3

≒1500 Mg = 1500 t （bulk density ≒ 1）

Lime requirement / 1 ha is

4.2 × 1500 = 6300 kg

Improvement of soil acidity（2）

- Large application of phosphate material

  because phosphate solubility is low under low pH

- Supply of organic matter

  to give buffering capacity to soil

If soil pH becomes too high,

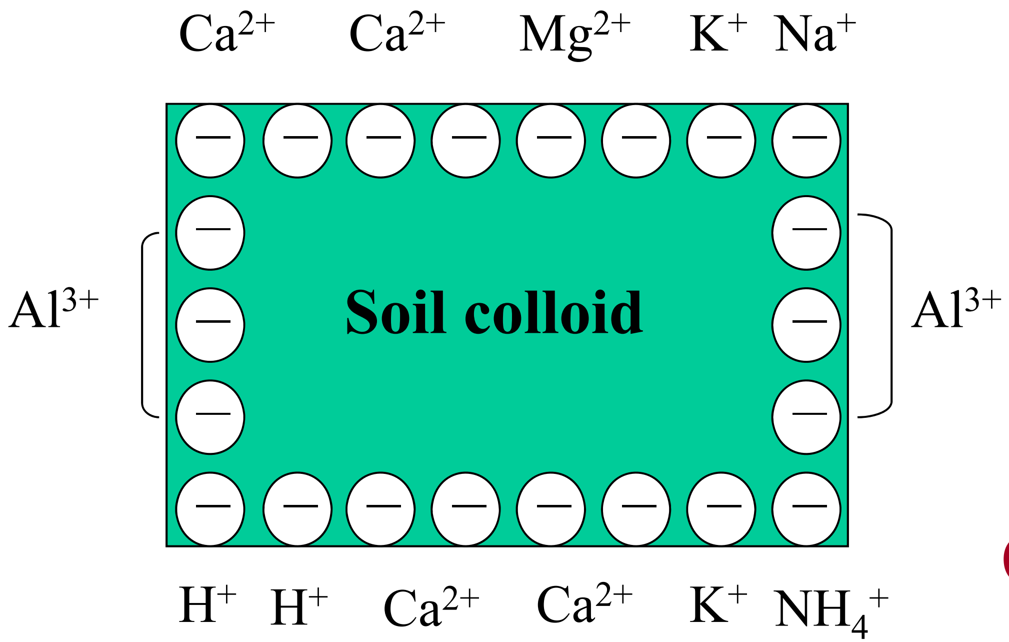
Nutrient deficiency occurrs.

Phosphate, calcium, magnesium,
boron, iron, manganese, zinc

Mechanisms of soil acidification

- **Due to CO_2 in rain water**
- **Al in acidic soil**
- **Fertilizer application**
- **Acid rain**
- **Acid sulfate soil**

Cation retention by soil colloid



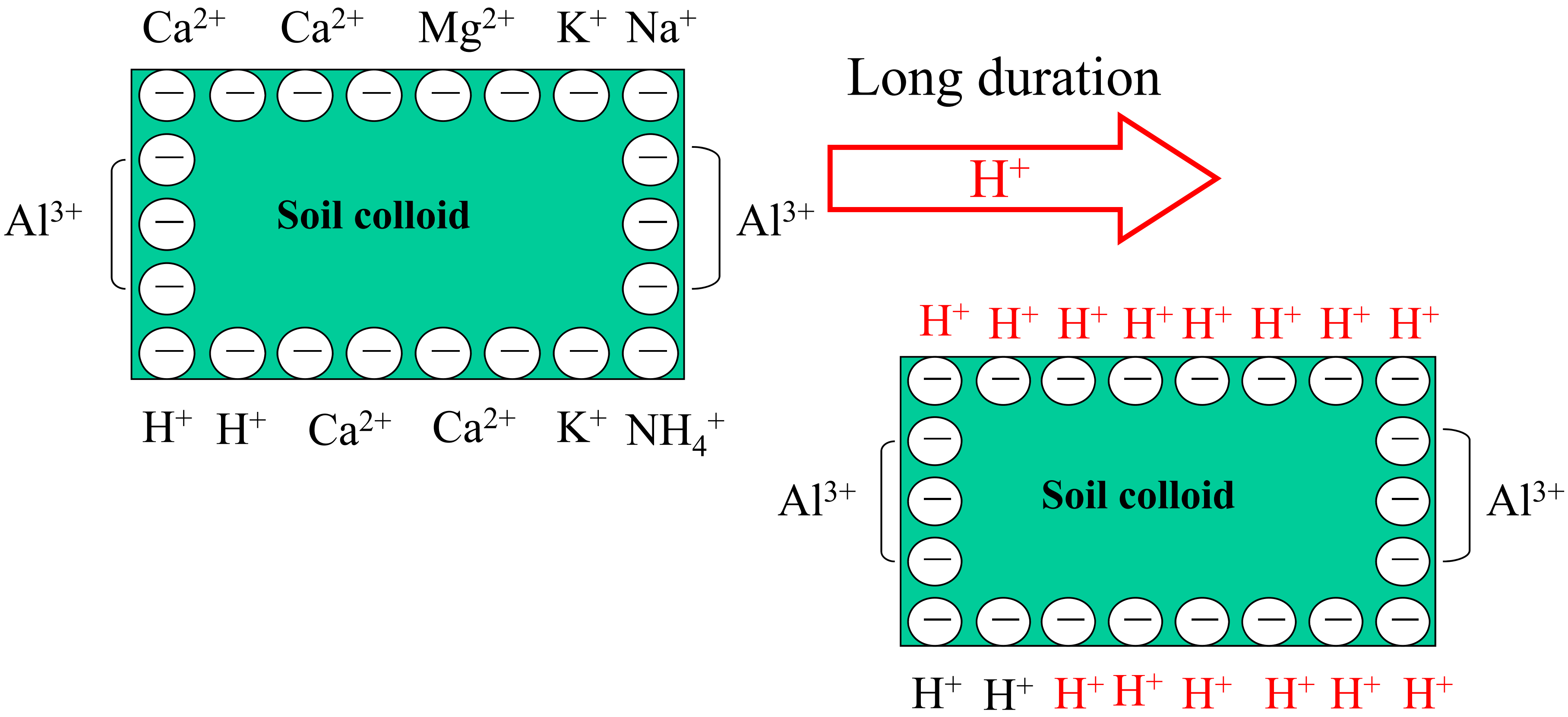
（Humus and clay）

Exchangeable ability of cations：

$H^{+}>Al^{3+}>Ca^{2+}>Mg^{2+}>K^{+}>Na^{+}$

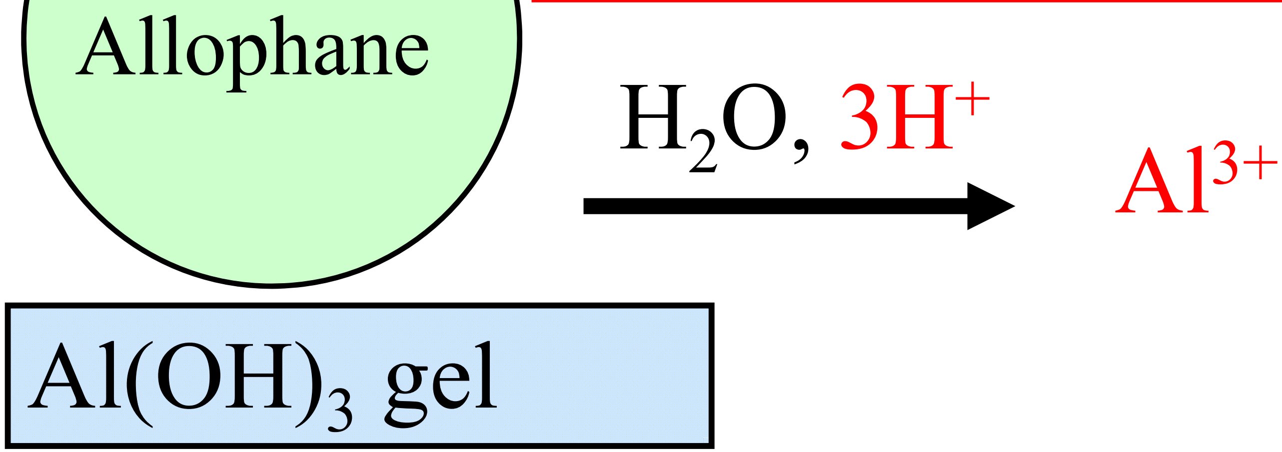
Soil acidification by rain water

$$CO_2 + H_2O \rightarrow H^+ + HCO_3^-$$



Ca^{2+}, Mg^{2+}, K^+, Na^+ leaching

Liberation of Al^{3+} in acidic soil

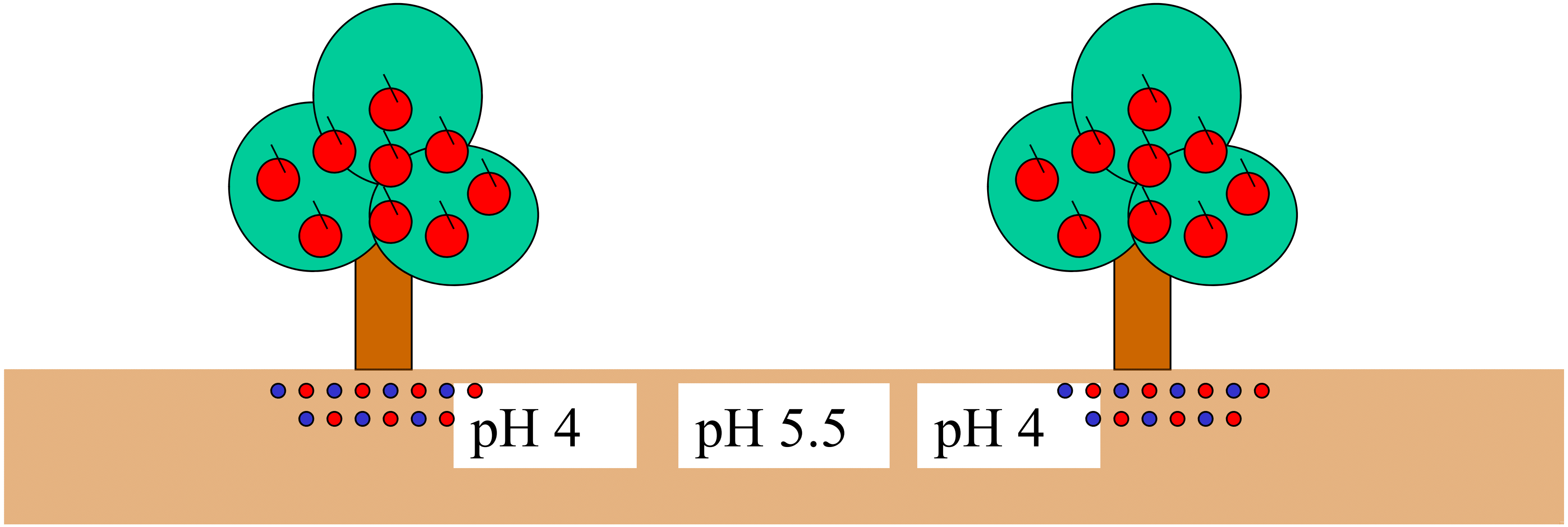


$$Al^{3+} + H_2O = Al(OH)^{2+} + H^+$$

log K = - 4.97（as strong as acetic acid）

log K of acetic acid = - 4.76 (25℃)

Soil acidification by fertilizer



$(NH_4)_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$

NH_4^+ is absorbed by plants,、

H^+ is supplied from soil colloids, root exudates, and H_2CO_3

Physiologically acidic fertilizers

- Ammonium sulfate $(NH_4)_2SO_4$
- Ammonium chloride NH_4Cl
- Potassium sulfate K_2SO_4
- Potassium chloride KCl

NH_4^+ and K^+ are absorbed, but SO_4^{2-} and Cl^- are not absorbed and remain in soil.

Physiologically neutral fertilizers

- Urea $(NH_2)_2CO$
- Ammonium nitrate NH_4NO_3
- Ammonium phosphate $(NH_4)_2HPO_4$
- **Compost works the same**

All constituents are absorbed or decomposed

Acid rain

- $SO_2 + H_2O \rightarrow H_2SO_3$
- $H_2SO_3 + (1/2)\ O_2 \rightarrow 2H^+ + SO_4^{2-}$

- N_2O, NO, NO_2

  $+ m\ H_2O + (n/2)\ O_2 \rightarrow H^+ + NO_3^-$

Acid sulfate soil

- Pyrite is accumulated stably in sediments.
- Pyrite is oxidized by air on land reclamation and sulfuric acid is formed.
- $FeS_2 + nO_2 + H_2O \longrightarrow FeSO_4 + H_2SO_4$
- Paddy field on reclaimed land, dressed soil, peat land have this problem.

Fixation of phosphate at low soil pH

- Al^{3+} + PO_4^{3-}
  → $AlPO_4$ ～$Al(OH)_2H_2PO_4$
  (variscite),（hardly soluble）
- Fe^{3+} + PO_4^{3-}
  → $FePO_4$ ～$Fe(OH)_2H_2PO_4$
  (strengite)（hardly soluble）

How Soil Diagnosis is carried out in Japan

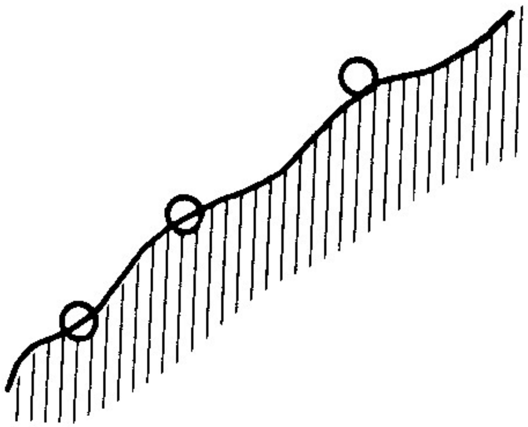
Method of soil sampling

Case 1: flat and homogeneous field

Collect from 5 places
in a field

Method of soil sampling

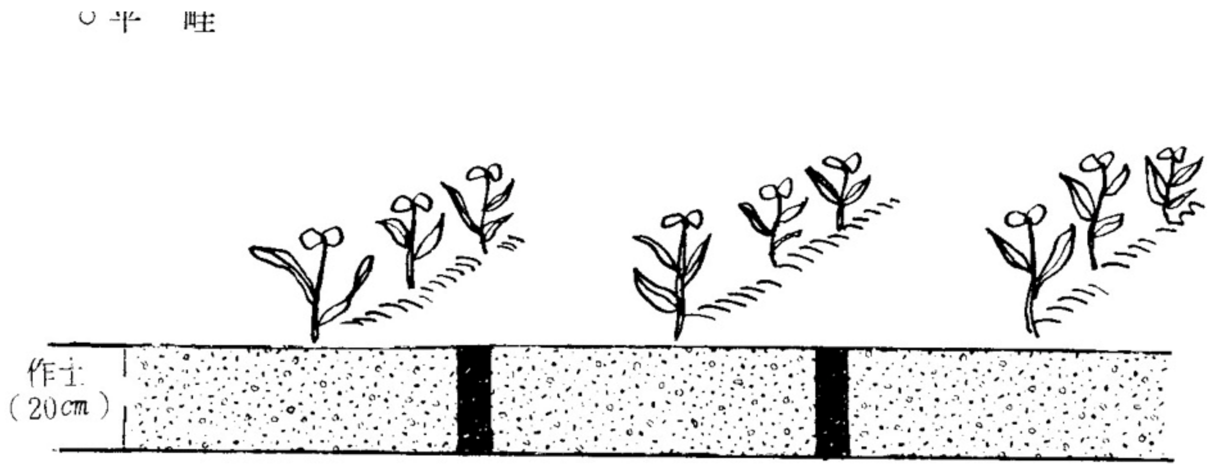
Case 2: Slopes



Separate into upper, middle, and lower portion. Collect 3 – 4 samples from each portion.

Method of soil sampling

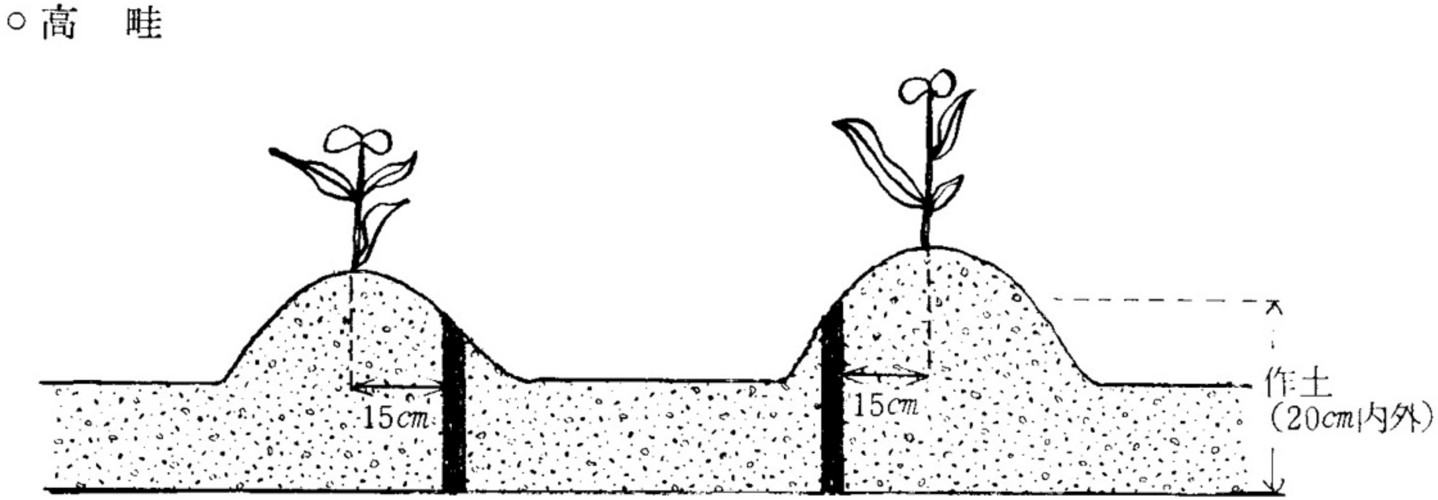
Case 3: Flat furrow



Central portion
between the row

Method of soil sampling

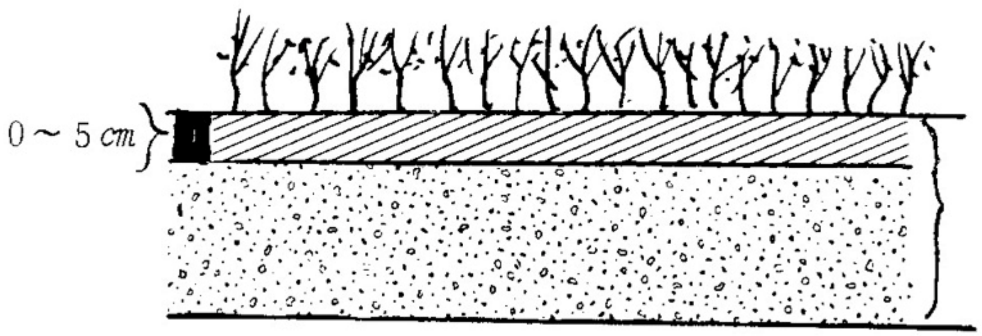
Case 4: High furrow



15 cm apart from the center of the row

Method of soil sampling

Case 5: pasture grass field

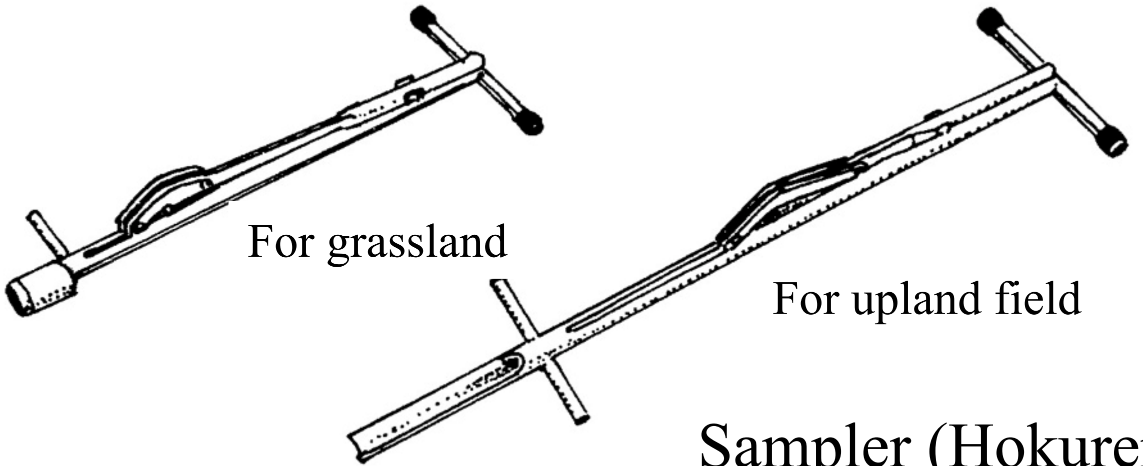


5 cm deep sample from the root mat. Refrain from mixing the withered grass.

Method of soil sampling

Necessary Tools

1. Sampler (Hokuren type)
2. Analysis order sheet
3. Plastic bags
4. Plastic bucket
5. Rubber band
6. Felt pen
7. Memopad with a ballpoint pen
8. others

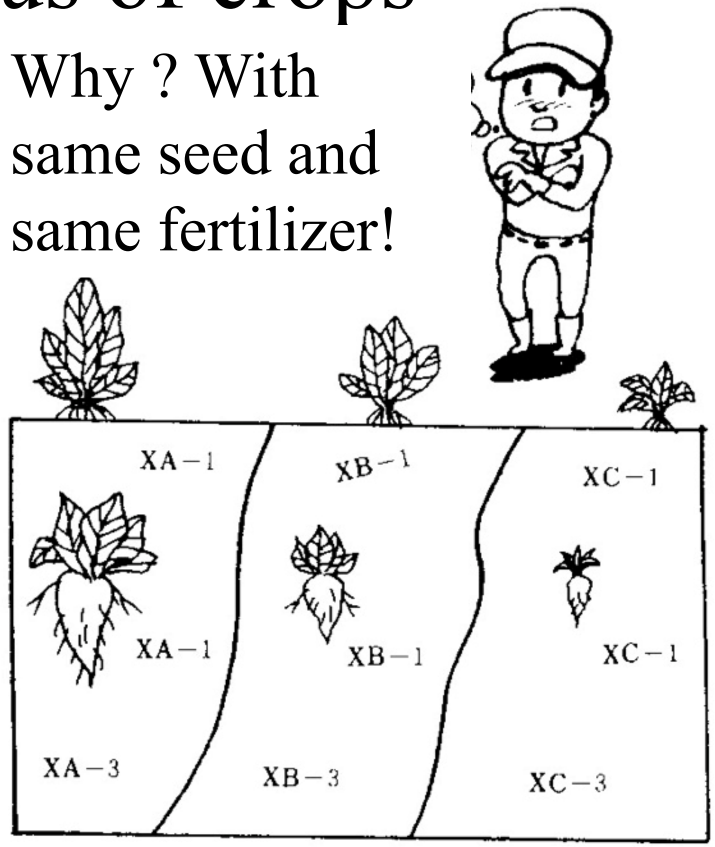


Sampler (Hokuren type)

Attention 1
in soil sample collection

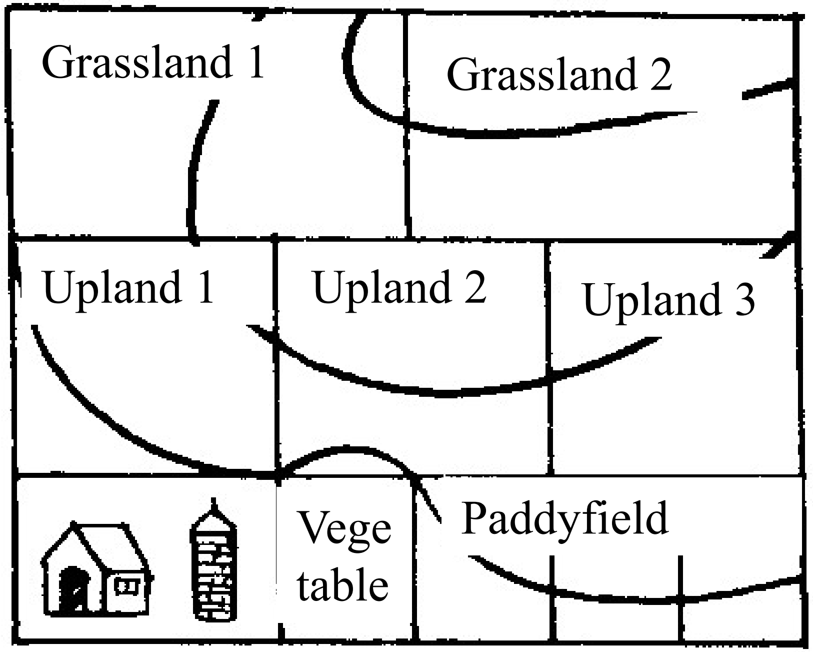
Growth status of crops

Why ? With
same seed and
same fertilizer!

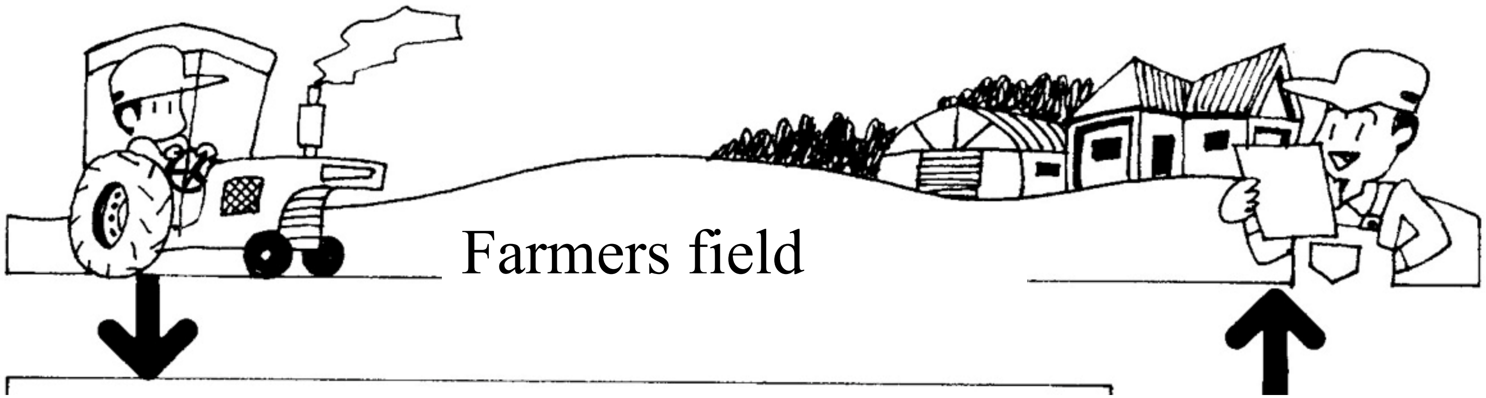


Attention 2
in soil sample collection

Field division

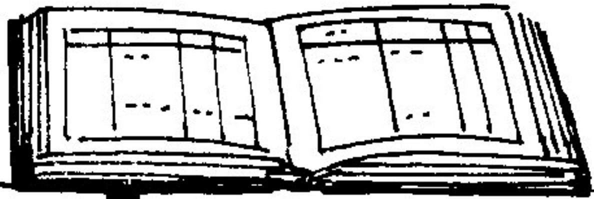


Flow sheet of soil diagnosis 1



Flow sheet of soil diagnosis 2

1. Refer to record book



1. Field division
2. History of Land improvement, soil improvement
3. Recent record of growth, yield, quality
4. Fertilizer management

Mr.Hosono explains his farm managements

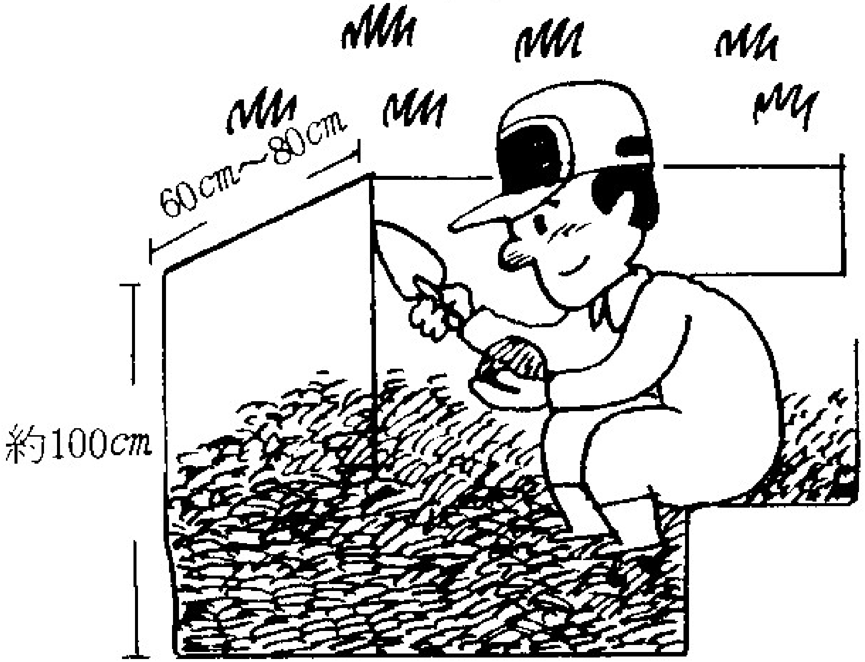
Scene of Soil Diagnosis Practice
(JICA Soil Diagnosis Course)

Field

Laboratory

Flow sheet of soil diagnosis 3

Soil profile survey



- •Depth of plowed layer
- •Texture of plowed and sub-layer soils
- •Soil color
- •Sand and stone
- •Volcanic ash
- •Wetness

What soil profile survey tells you:

- What factor is limiting the plant growth (gravel, volcanic ash, clay, compaction of soil material, acidity, salt accumulation)
- Content and thickness of humus
- Drainage, water retention, dry or wet.
- Different soil layers composing the soil profile → History of soil

Andosoil profile in Obihiro Univ. Agr. & Vmed.

Kuroboku soil

Plowed layer

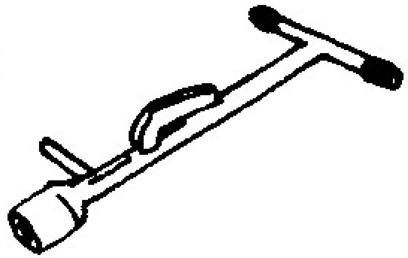
Tarumae d
volcanc ash

Eniwa loam

Alluvial soil

Flow sheet of soil diagnosis 4

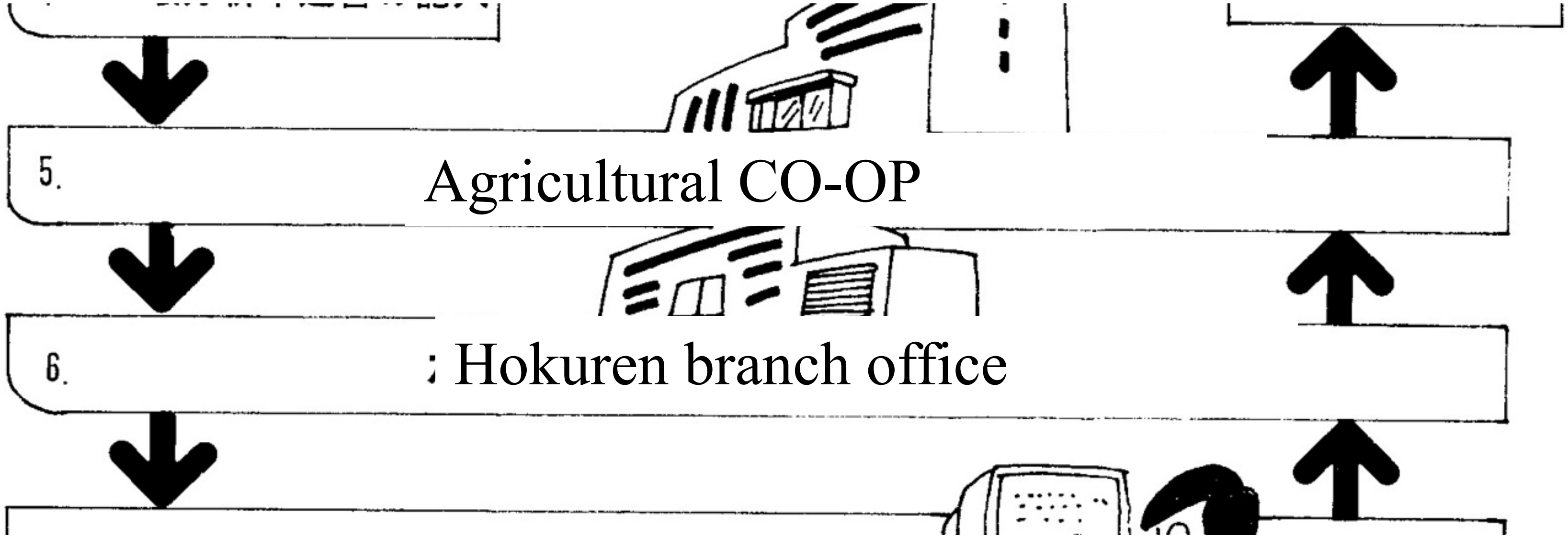
3. Collect soil samples



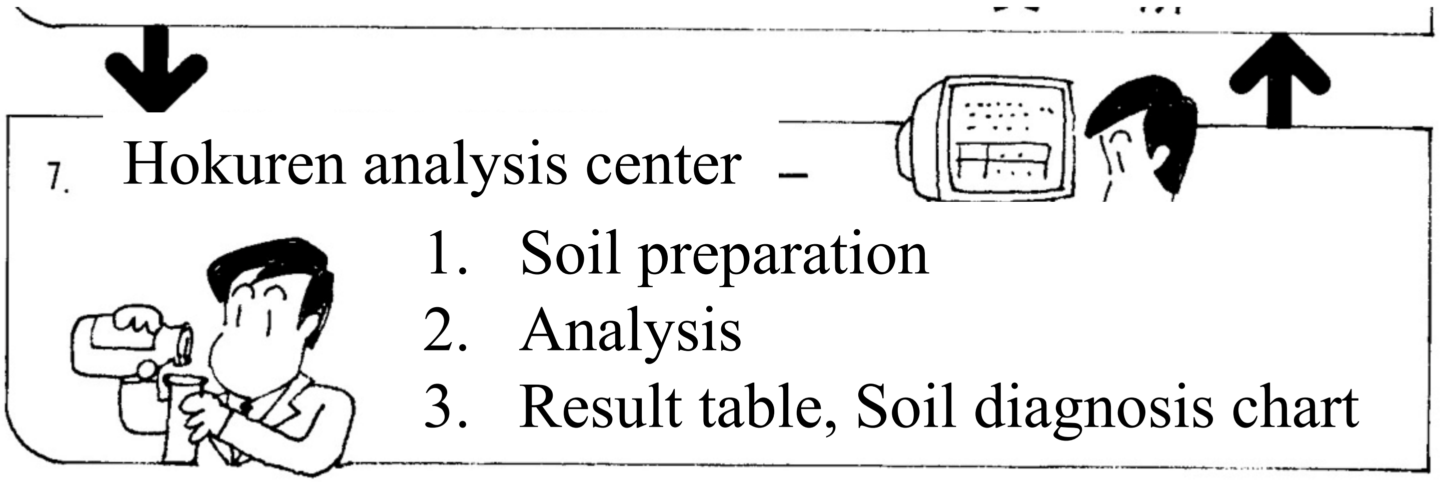
4. Fill the analysis order

5. Agricultural CO-OP

Flow sheet of soil diagnosis 5



Flow sheet of soil diagnosis 6



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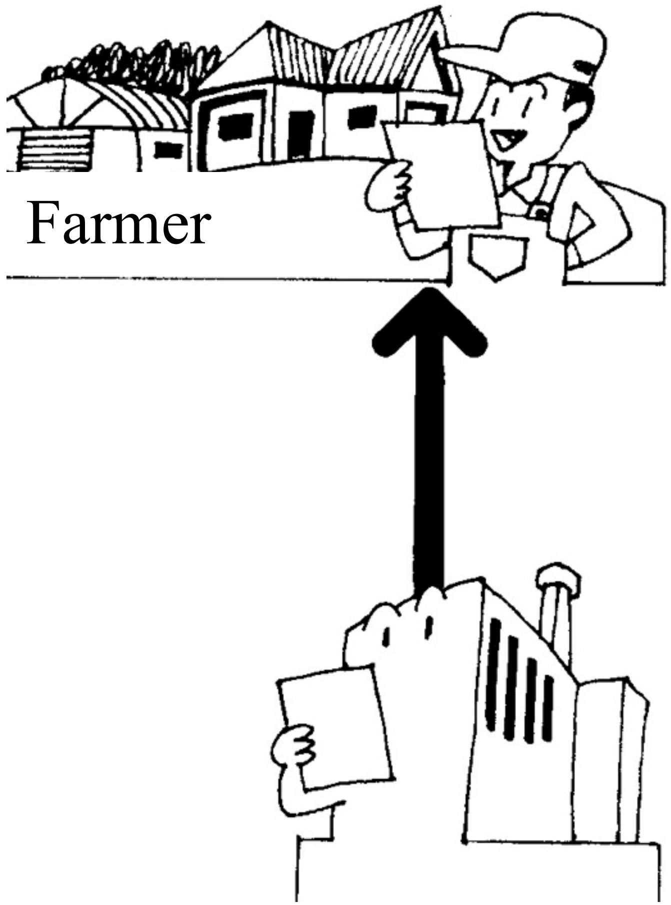
Flow sheet of soil diagnosis 7



Guidance and advice to farmers according to soil diagnosis result

Drying soil samples

Sieve soil samples (2mm)

Soil samples after preparation