Method of Soil Diagnosis

The year 2015 was International Year of Soils

2015
International
Year of Soils

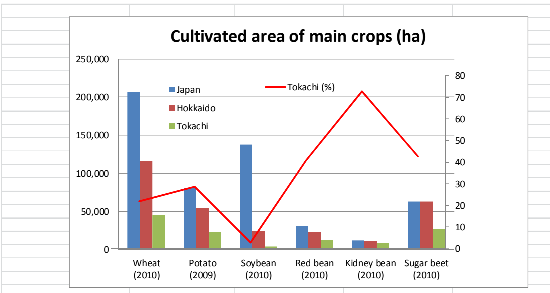
Why Soil Year 2015?

- 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.

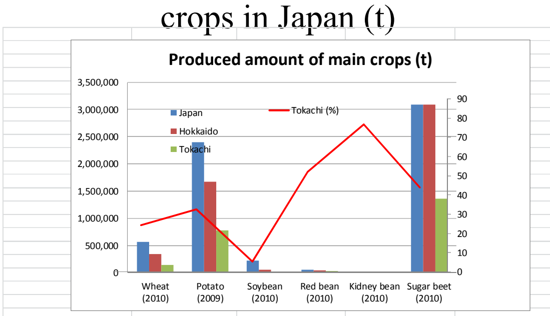
Why Soil Year 2015?

- 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.

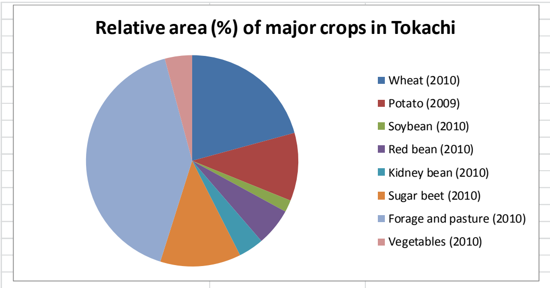
Cultivated area of major upland crops in Japan



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

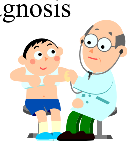
Improve drainage

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

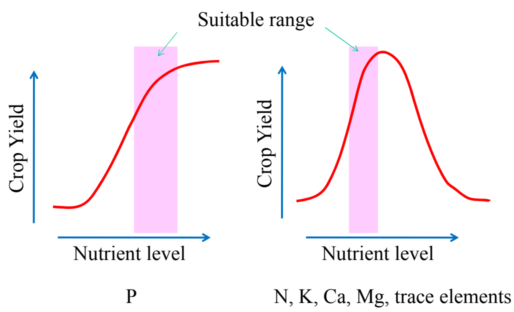
Present nutrient content in soil

should be known.

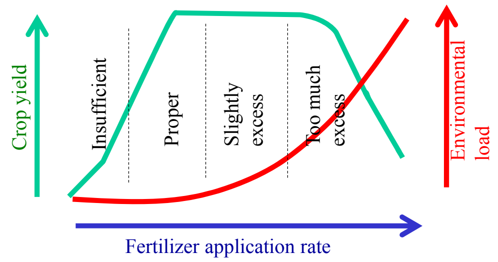
Disorder in crop growth caused by nutrition status of soil

- 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



Crop yield and environmental load



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

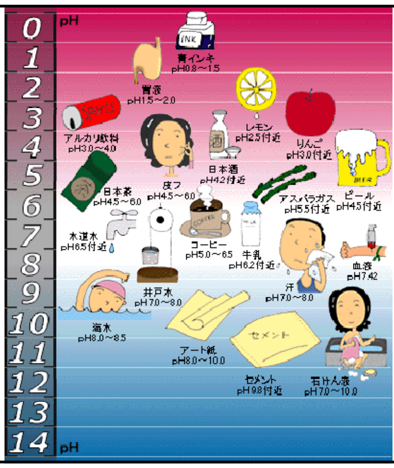
- Calcium deficiency of vegetables
  (Imbalance in basic cations)
- Decrease in quality of vegetables
  Lowering in sugar and vitamins
  (accumulation of nitrate)

pH in daily life

$= -\log(H^+)$

Cited from

Horiba Home page



pH and crop growth (vegetables, root crops)

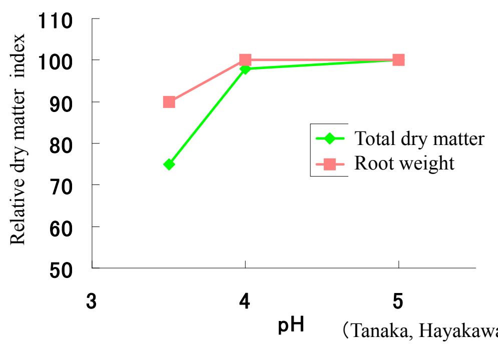
Low pH tolerance	Kind of crops
strong (4.0~5.0)	potato･taro
Little strong (4.5~6.0)	Sweet potato･radish･turnip･kidney bean･carrot･cucumber･parsley
Little weak (5.5~6.5)	tomato･egg plant･cabbage･broccoli･celery･green pea･melon
Weak (6.0~7.0)	spinach･onion･leek･burdock･asparagus･red pepper･lettus

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

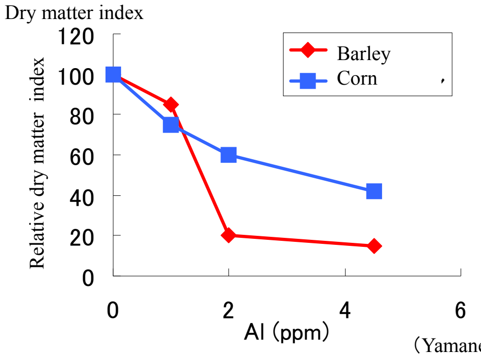
pH and dry matter production

Average of 49 plants



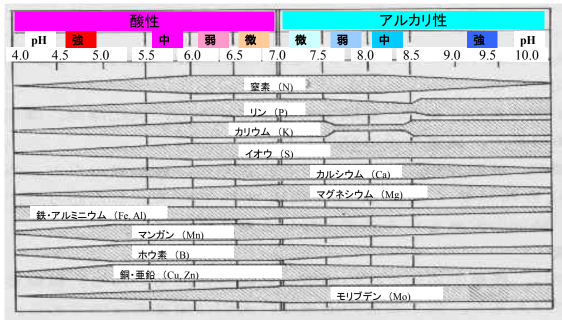
(Tanaka, Hayakawa 1974)

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

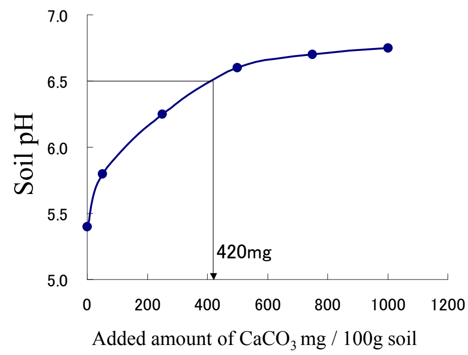
optimum pH 6.5～7.5

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,

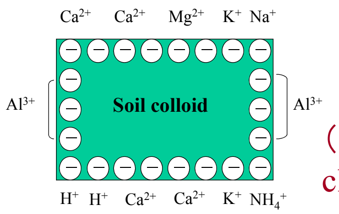
Nutrient deficiency occurrs.

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



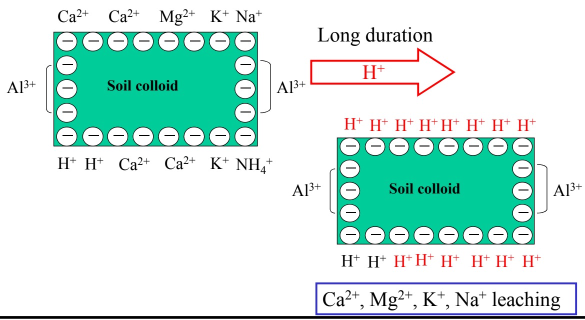
(Humus and clay)

Exchangeable ability of cations:

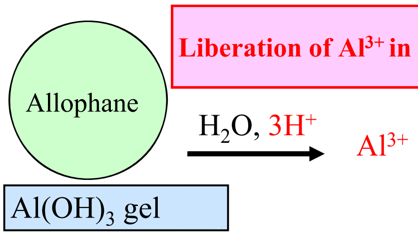
$H^+ > Al^{3+} > Ca^{2+} > Mg^{2+} > K^+ > Na^+$

Soil acidification by rain water

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



Liberation of Al^{3+} in acidic soil

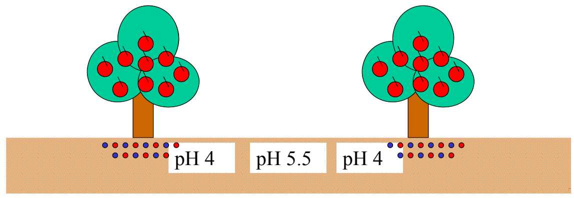


$Al^{3+} + H_2O = Al(OH)^{2+} + H^+$

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

log K of acetic acid = - 4.76 (25℃)

Soil acidification by fertilizer



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

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.
- $FeS_2 + nO_2 + H_2O \rightarrow FeSO_4 + H_2SO_4$
- Paddy field on reclaimed land, dressed soil, peat land have this problem.

Fixation of phosphate at low soil pH

- $Al^{3+} + PO_4^{3-}$
  $\rightarrow$ $Al PO_4 \sim Al(OH)_2H_2PO_4$
  (variscite), (hardly soluble)
- $Fe^{3+} + PO_4^{3-}$
  $\rightarrow$ $Fe PO_4 \sim Fe(OH)_2H_2PO_4$
  (strengite) (hardly soluble)

How Soil Diagnosis is carried out in Japan

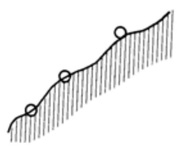
Method of soil sampling

Case 1: flat and homogeneous field

Collect from 5 places in a field

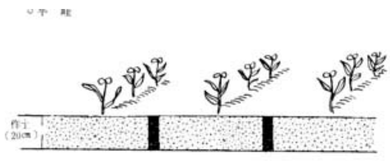
Method of soil sampling

Case 2: Slopes



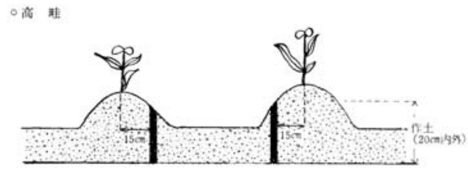
Separate into upper, middle, and lower portion. Collect 3 – 4 samples from each portion.

Method of soil sampling
Case 3: Flat furrow



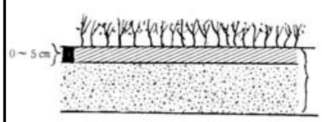
Central portion
between the row

Method of soil sampling
Case 4: High furrow



15 cm apart from the
center of the row

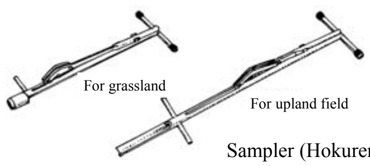
Method of soil sampling
Case 5: pasture grass field



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

Method of soil sampling
Necessary Tools

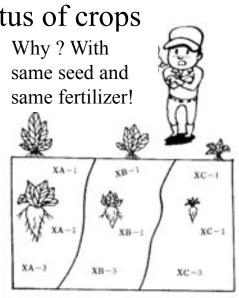
1. Sampler (Hokuren type)
2. Analysis order sheet
3. Plastic bags
4. Plastic bucket
5. Rubber band
6. Felt pen
7. Memopad with a ballpoint pen
8. others



Sampler (Hokuren type)

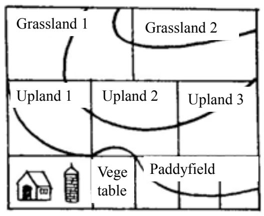
Attention 1
in soil sample collection

Growth status of crops

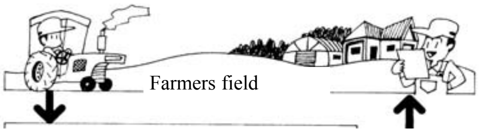


Attention 2
in soil sample collection

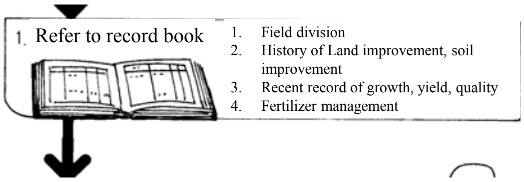
Field division



Flow sheet of soil diagnosis 1



Flow sheet of soil diagnosis 2



Mr.Hosono explains his farm managements

Scene of Soil Diagnosis Practice

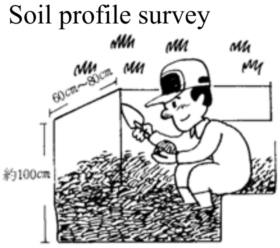
(JICA Soil Diagnosis Course)

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

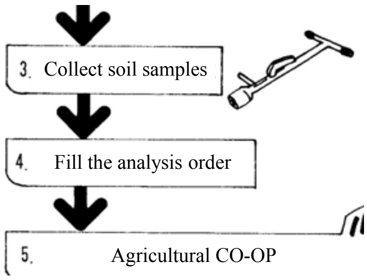
Plowed layer

Tarumae d volcanc ash

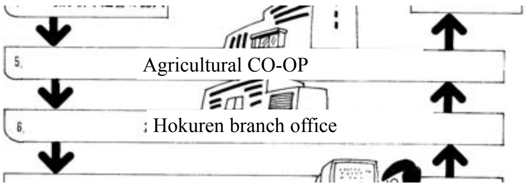
Eniwa loam

Alluvial soil

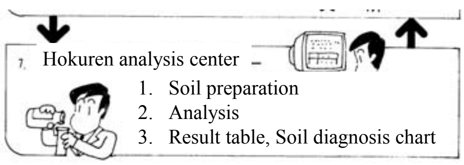
Flow sheet of soil diagnosis 4



Flow sheet of soil diagnosis 5



Flow sheet of soil diagnosis 6



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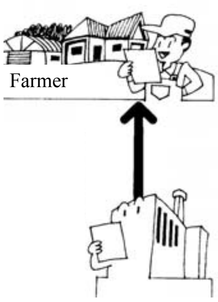
Soil Analysis Laboratory

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

Various Analysis Items and their significance

pH(H_2O)

- Concentration of free form H^+ in soil solution
- $pH = -\log(H^+)$
- Add 25 ml of water to 10g of soil.
- Shake 30 minutes.
- Measure the pH of turbid suspension using pH meter.

Factors affecting soil pH(H_2O)

- Fertilizer application
- Nutrient absorption by crops
- Seasonal change in climate, precipitation
- Partial pressure of CO2
- Activity of soil microbes
- Decomposition of soil organic matter
- Saturation degree of soil bases
- Leaching of soil bases
- Nitrification　(NH_4^+ , NO_3^-)

pH meter & EC meter

pH(KCl)

- Reflect the concentration of H^+ and Al^{3+} adsorbed electrostatically to clay and humus.
- pH(KCl) decreases when degree of saturation by basic cations is low.
- Add 25 ml of 1 M KCl to 10g of soil.
- Shake 30 minutes.
- Measure the pH of turbid suspension using pH meter.

Meaning of soil pH(KCl)

- Highly correlated with Al saturation degree of soil.
- pH(KCl) lower than 5.2 means
  - → occurrence of exchangeable Al^{3+}
  - → Inhibition of plant growth by Al^{3+}
- $Al^{3+} + H_2O \rightarrow Al(OH)^{2+} + H^+$
- $Al(OH)^{2+} + H_2O \rightarrow Al(OH)_2^{+} + H^+$

pH(0.01M $CaCl_2$)

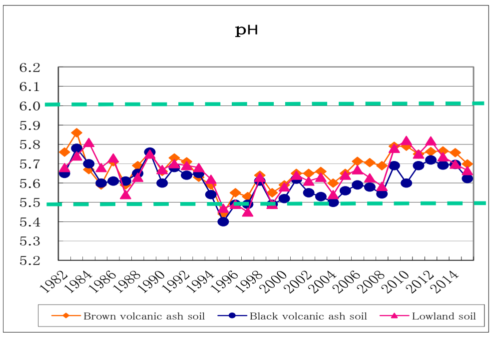
- Masking the effect of seasonal change and farm management
- To reflect the actual root zone environment more accurately, soil pH under dilute electrolyte concentration is more appropriate.

Meaning of soil pH

< 5.0	Very acidic
5.0 – 5.5	Acidic
5.5 – 6.0	Weakly acidic
6.0 – 6.5	Slightly acidic
6.5 – 7.0	Neutral
7.0 – 7.5	Slightly alkaline
7.5 – 8.0	Weakly alkaline
8.0 – 8.5	Alkaline
8.5 <	Very alkaline

Change in soil pH in Tokachi

Tokach Federation of Agricultural Co-operatives, Institute



Effect of pH on plant growth

- H^+ ion inhibits the function of root (pH < 4)
- Increase in Al^{3+} ion (Inhibit growth at >1 ppm level)
- Inhibit absorption of N, P, K, Ca, Mg, B, Mo and symptom of deficiency (in acidic range)
- Excess in Cu, Zn, Mn, Fe (in acidic range)
- Deficiency in Cu, Zn, Mn, Fe (in alkaline range)

Exchangeable Acidity

- Weigh 10 g of air dried soil in to a flask or bottle.
- Add 25 mL of 1N KCl.
- Shake for 1 hour.
- Filter through a filter paper (Advantec No.6).
- Take 10 mL of the filtrate into a flask and titrate with 0.1 N NaOH.
- Consumed mL is multiplied by 12.5.
- Obtained value is Y_1.

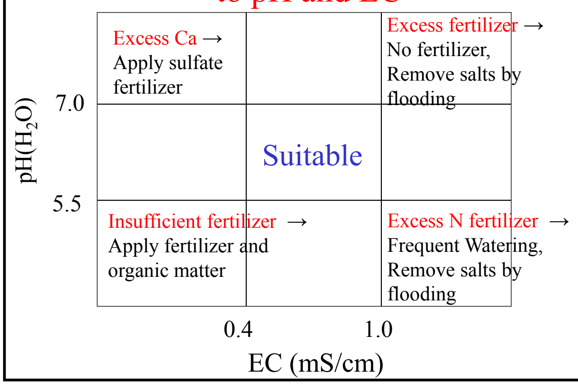
Electric conductivity（EC）

- Reflect total concentration of water soluble ions in soil solution
- Add 50 ml of deionized water to 10g of soil, shake 30 min. Measure EC of turbid suspension using EC meter.
- Unit is S/m, mS/cm or µS/cm, S: Siemens
  (1S/m=10 mS/cm = 10^4 µS/cm)

Meaning of soil EC

- High correlation with nitrate NO_3^- content
- Malnutrition under low EC(< 0.1 mS cm^{-1})
- Growth damage at high EC (> 1 mS cm^{-1})
- Adjust fertilizer application rate according to EC

Greenhouse soil diagnosis according to pH and EC



Application rate of basal fertilizer (N, K) according to soil EC（dS m^{-1}） in upland field

Soil Type	< 0.3	0.4-0.7	0.8-1.2	1.3-1.5	1.6 <
Humic andosoil	Standard rate	2/3	1/2	1/3	No fertilizer
Sandy・Fine textured	Standard rate	2/3	1/3	No fertilizer	No fertilizer
Sand dune/ immature	Standard rate	1/2	1/4	No fertilizer	No fertilizer

Humus

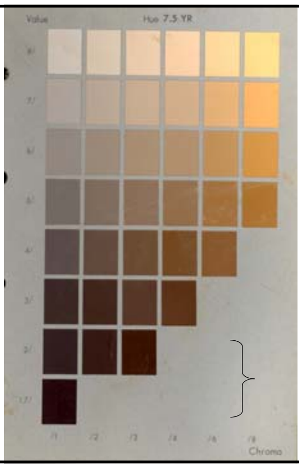
- Humus = Soil organic matter

Method of determination

- Rapid estimation by soil color
- Tyurin method（Potassium dichromate oxidation/ Titration）
- Dry combustion method（Instrumental analysis）

Standard Soil Color Chart Hue 7.5YR

Relationship between soil color and organic matter content

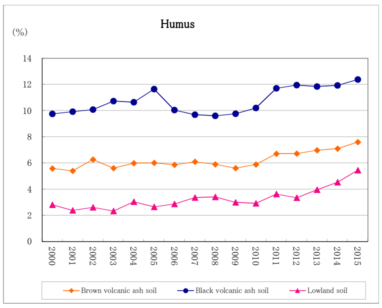


Importance of humus

- Soils with high humus content are generally fertile and easily manageable.
- Exception → Andosoil (Kuroboku in Japan)
- Supply nutrients (especially N)
- Hold soil moisture
- Hold nutrients（Cation Exchange Capacity）
- Formation of Soil Aggregate Structure

Change in soil humus in Tokachi

Tokach Federation of Agricultural Co-operatives, Institute



Nitrogen Analysis

- Nitrogen is the most important constituent of fertilizer.

Inorganic nitrogen

- Ammonium nitrogen

  Extracted by 1N KCl, 2N KCl
- Nitrate nitrogen

  Extracted by Water, 1N KCl, 2N KCl
- Determine by steam distillation/ titration or colorimetry
- Rapidly available to crops

Available nitrogen

- Potential amount of inorganic nitrogen formation
- After incubating 4 weeks at 30 ℃, total amount of formed inorganic nitrogen is determined.
- Incubation under upland or paddy condition.
- Problem: Time consuming method

Phosphate buffer (pH7) extraction method (Rapid estimation method for available nitrogen)

- Extracted nitrogen content or absorbance at 420 nm of the extracted solution showed high correlation with available nitrogen estimated by incubation method.

Hot water extractable nitrogen

- Another measure of available nitrogen
- Soil + water (1:10)
- Autoclaved (105 ℃/modified to 121 ℃, 1 hour)
- Filtered
- Extracted solution is digested by Kjeldahl method
- Nitrogen is determined by colorimetry

Adjustment of N application rate according to hot water extractable nitrogen

Hot water N (mg / 100 g)	N application rate (kg / 10 a)
1, 2	24
3, 4	20
5, 6	16
7, 8	12
9, 10	8
Higher than 11	8

Change in hot water extractable N in Tokachi

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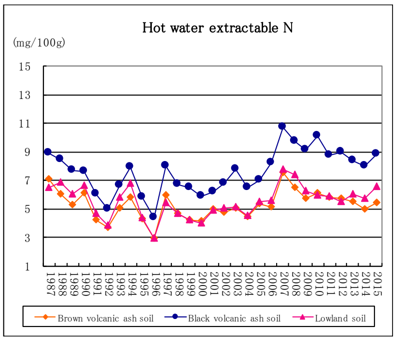


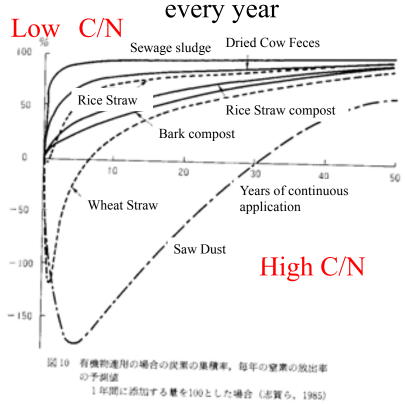
Total Nitrogen

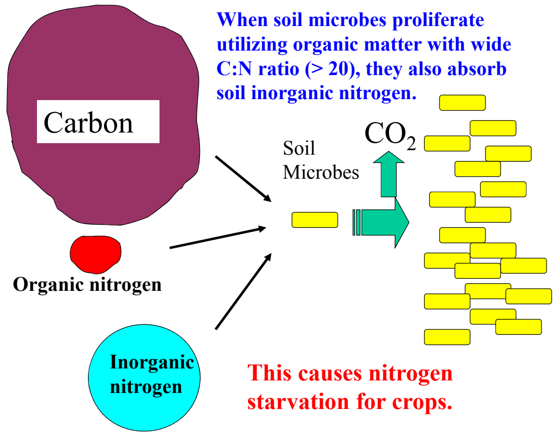
- Kjeldahl digestion (conc H_2SO_4 + K_2SO_4 + Catalyst(Cu, Hg, Se))

  Organic N → NH_4^+
- Instrumental (Dry combustion method)
- C/N is calculated
- C/N is related to the pattern and rate of nitrogen mineralization

Kjeldahl digestion apparatus

Release of N from organic matter applied to soil every year





Expected N release (kg) from 1t of organic matter (dry matter) during the following 1 year

Type of Organic Matter	Released N (kg)
Sewage sludge	70 (maximum)
Dried cow feces	31
Mature compost	19.9
Intermediately mature compost	19.5
Bark compost	19.5
Rice straw	6.5
Rice husk	5.4
Wheat straw (after long term application)	3.3
Saw dust (after long term application)	2.1

Adjustment of Fertilizer Application Rate according to Organic Matter Amendment (/ 1 t)

Organic Matter	N (kg)	P_2O_5 (kg)	K_2O (kg)
Crop residue compost	1	1	4
Bark compost	0	2	2
Cow feces + straw compost	2	4	7
Cow feces + bark	2	3	5
Chicken manure + bark	3	12	9
Municipal refuse compost	3	3	4
Food company garbage compost	10	7	3
Sewage sludge compost	13	15	1

Available Phosphate

- Limited resources of phosphate.
- Deficiency is common in most of soils.

Available phosphate

- Soil phosphate which is readily absorbed by plants.
- Various extraction methods has been proposed and correlation between crop growth has been examined.
- Suitable method differs depending on soil types and crops.

Various methods for Available phosphate

- Truog method (for neutral - acidic soils)
- Bray Method (No.1, No.2, No.2 modified)
  (for neutral – highly acidic soils)
- Olsen method
  (for high pH – $CaCO_3$ affected soils)
- 2.5% acetic acid extraction method
  (for Ca type phosphate)
- Mehlich 3 method
  (for soil with pH 5.2 – 8.2)

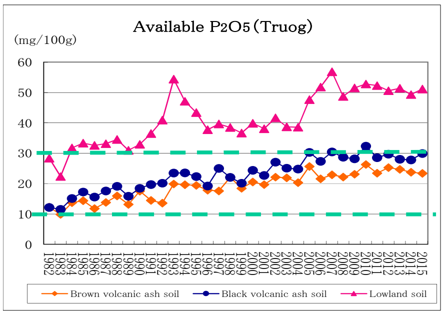
Flow Injection Analysis of CEC and available phosphate

Truog method

- 0.001 M H_2SO_4 (with 0.3% ammonim sulphate)
- Soil : Extractant 1 : 200
- Shake 30 min
- Colorimetry (Molybdenum blue method)
- Calcium form phosphate
- Applied to upland field, vegetable field, orchard field, paddy nursery soil in Japan

Change in available P_2O_5 (Truog) in Tokachi

Tokach Federation of Agricultural Co-operatives, Institute



Bray No2 modified method

- 0.03M NH_4F + 0.1M HCl
- Soil : Extractant 1:20 (grassland soil)
  1:10 (paddy soil)
- Shaking time 1 minute
- Ca form phosphate, and partially Al form + Fe form phosphate are extracted.
- Applied to Paddy soil and Grassland soil in Japan

Olsen method

- To 5g of soil, 0.5 M $NaHCO_3$ 100ml
  and 1 g of Active Charcoal were added.
- Shake 30 minutes
- Applied to soils with alkaline pH

Mehlich 3 method

- 1 g of soil is extracted with 10 mL of extractant solution (0.2M CH_3COOH, 0.25M NH_4NO_3, 0.015M NH_4F, 0.013M HNO_3, and 0.001M EDTA) by shaking during 5 min. Extacts are filtered through Whatman 42 paper. P determined by colorimetry (Molybdenum blue method).
- Mehlich 3 test often measures more P than Bray 1-P on high pH, $CaCO_3$ affected soils.

2.5% acetic acid extraction

- 1 g of soil is extracted with 100 mL of 2.5% acetic acid once, then with 50 mL of ammonium chloride two times.
- Calcium form phosphate is extracted
- Applied to wheat field soil
- Developed in Japan, but not yet so popular.

Available Phosphate（Truog）and application rate of P-fertilizer to upland crops

Available P_2O_5 mg/100g	Diagnosis	application rate of P-fertilizer
0 - 5	Insufficient	150 %
5 - 10	Slightly insufficient	130 %
10 - 30	Suitable	Standard rate
30 - 60	Slightly high～High	80%
> 60	Excess	50%

Available Phosphate（Truog）and application rate of P-fertilizer to vegetable field

Available P_2O_5 mg/100g	Diagnosis	application rate of P-fertilizer
<10	Insufficient	120 %
10 - 20	Slightly insufficient	Standard rate
20 - 50	Suitable	Standard rate
50 - 100	Slightly high～High	50 – 80%
> 100	Excess	No application

Exchangeable bases and cation exchange capacity

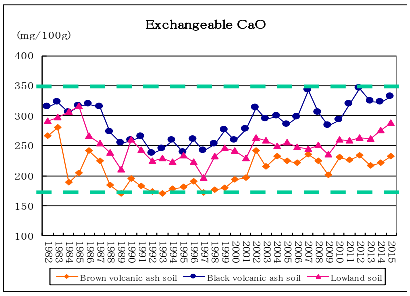
Extraction apparatus for CEC

Exchangeable bases (Ca, Mg, K)

- Exchangeable bases are extracted with 1M ammonium acetate and determined.
- Atomic absorption spectrophotometer and flame photometer are used for determination.
- Exchangeable cations are readily available to crops.

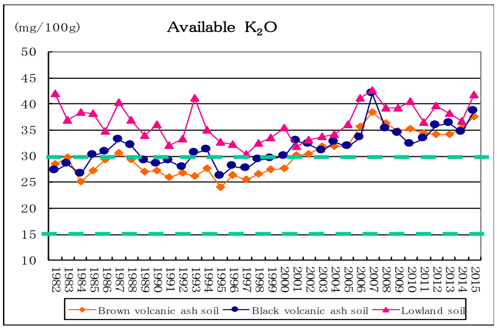
Change in exchangeable CaO in Tokachi

Tokach Federation of Agricultural Co-operatives, Institute



Change in exchangeable K_2O in Tokachi

Tokach Federation of Agricultural Co-operatives, Institute



Contents of exchangeable K_2O and adjustment of K fertilizer to upland crops

Exch. K_2O mg/100g	Diagnosis	K fertilizer application Values in ( ) are for potato
0 - 8	Insufficient	150 % (130 %)
8 - 15	Slightly insufficient	130 % (110 %)
15 - 30	Suitable	Standard rate
30 - 50	Slightly high	60% (50 %)
50 - 70	High	30% (20 %)
> 70	Excess	0% (0 %)

Cation Exchange Capacity (CEC)

- Capacity of Soil to hold cations electrostatically
- Due to minus charge on clay-minerals and humus
- Soil is first saturated with NH_4^+ by pH7 1M ammonium acetate, then eluted with 1 M KCl.
- Eluted NH_4^+ is determined.

Standard Value for CEC

- Fundamental data for soil improvement and fertilizer management.
- Sand-dune immature soil 3-10 $cmol_c$/kg
- Gray lowland soil･Light colored andosoil 15-25 $cmol_c$/kg
- Humic andosoil 20-30 $cmol_c$/kg

To increase CEC

- Soil dressing using clayey soil
- Organic matter amendment for many years

- Increasing CEC will be a hard work for farmers

Macro elements

- C, H, N, O
- P, K, Ca, Mg, S

are applied by fertilizers.

Trace Elements

- Fe, Cl, B, Mn, Cu, Zn, and Mo are essential trace elements for plants
- Cu and Zn are extracted with 0.1N HCl (1:5)
- Boron is extracted with hot water.

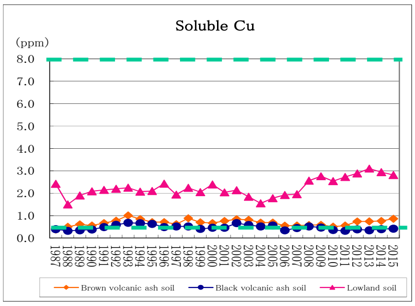
Atomic Absorption Spectrometer

Soil diagnosis standard for trace elements

Items	Standard Value	Remarks
Soluble Cu (Cu) in 0.1N HCl	0.5～8.0 ppm	Wheat(def.) Azuki(excess)
Soluble Zn (Zn) in 0.1N HCl	2～40ppm	Corn・wheat (deficiency)
Hot water soluble B (B)	0.5～1.0ppm	Beet (deficiency)

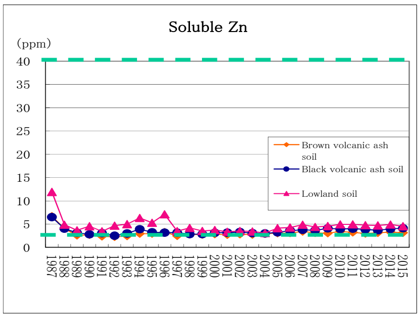
Change in soluble Cu in Tokachi

Tokach Federation of Agricultural Co-operatives, Institute



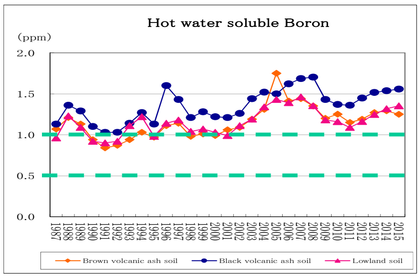
Change in soluble Zn in Tokachi

Tokach Federation of Agricultural Co-operatives, Institute



Change in hot water soluble B in Tokachi

Tokach Federation of Agricultural Co-operatives, Institute



Soil types and disorder in trace elements

Deficiency	Type of soils
Cu	High pH soil, humic andosoil
Zn	Sandy soil, High pH soil, peaty paddy soil
B	Sandy soil, High pH soil, peaty soil

Phosphate absorption coefficient

- Indicator for phophate absorption by soil
- Add 50ml of ammonium phosphate (pH 7.0, 13.44g P_2O_5 /l) to 25 g of dried soil. Shake 24 hours, filtered, and phosphate concentration in the filtrate is determined.
- Absorbed amount of phosphate is calculated from the difference between blank and sample.
- Expressed by absorbed amount (mg) of P_2O_5 by 100 g of soil.

Significance of phosphate absorption coefficient

- Indicator for identifying Kuroboku soil. (＞1500 mg P_2O_5/100g)
- Estimate the rate of phosphate application.
- Instead of chemical determination, near-infrared analysis is also used.

Near-infrared analyser

Other useful elements

- Na for sugar beet
- Si for rice
- Al for tea

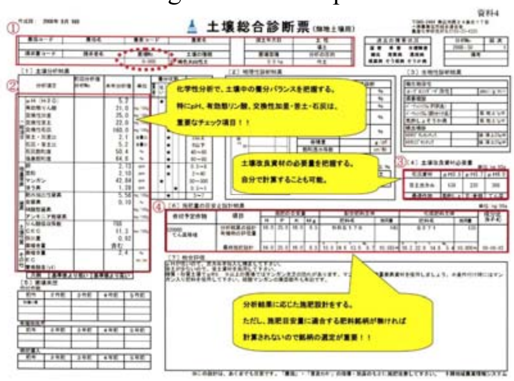
Are useful for limited types of plants.

Other items for soil diagnosis

- Particle size analysis
- Penetrometer
- Enzyme activity (α-Glucosidase)
- Nematodes

Data processing

Soil diagnosis chart of Tokachi federation of Agricultural Cooperatives



Application of soil diagnosis is beneficial for

- Proper fertilization
  - Save fertilizer cost
  - Secure healthy growth and high yield
  - Prevent environmental pollution by excess fertilizer.
  - Maintain soil fertility
  - Prevent soil deterioration

Use of Soil Diagnosis in Tokachi District

- 24.1 % of farmers are practicing soil diagnosis annually.
- 47.1 % occasionally.
- 23.1 % have some experience.
- 5.7 % have no experience of soil diagnosis.
- Results of soil diagnosis are used to calculate the application rates of fertilizers and soil improving materials.

Laboratory and facililties

Outlook of the laboratory

Entrance of soil analysis laboratory of Tokachi Federation of Agricultural Co-operatives

Residual pesticide analysis

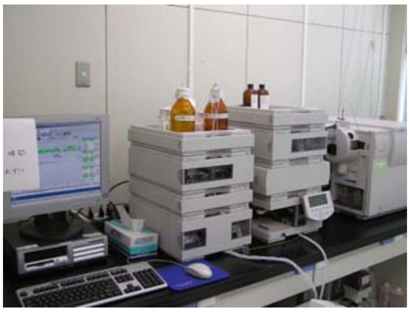
Friezed samples of agricultural products for pesticide analysis

Pesticide extraction room

HPLC with auto-sampler

GC-MS Apparatus

LC-MS Apparatus



ECD Gas-chromatograph

High Performance Liquid Chromatography (HPLC)