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 $CaCl_2$)

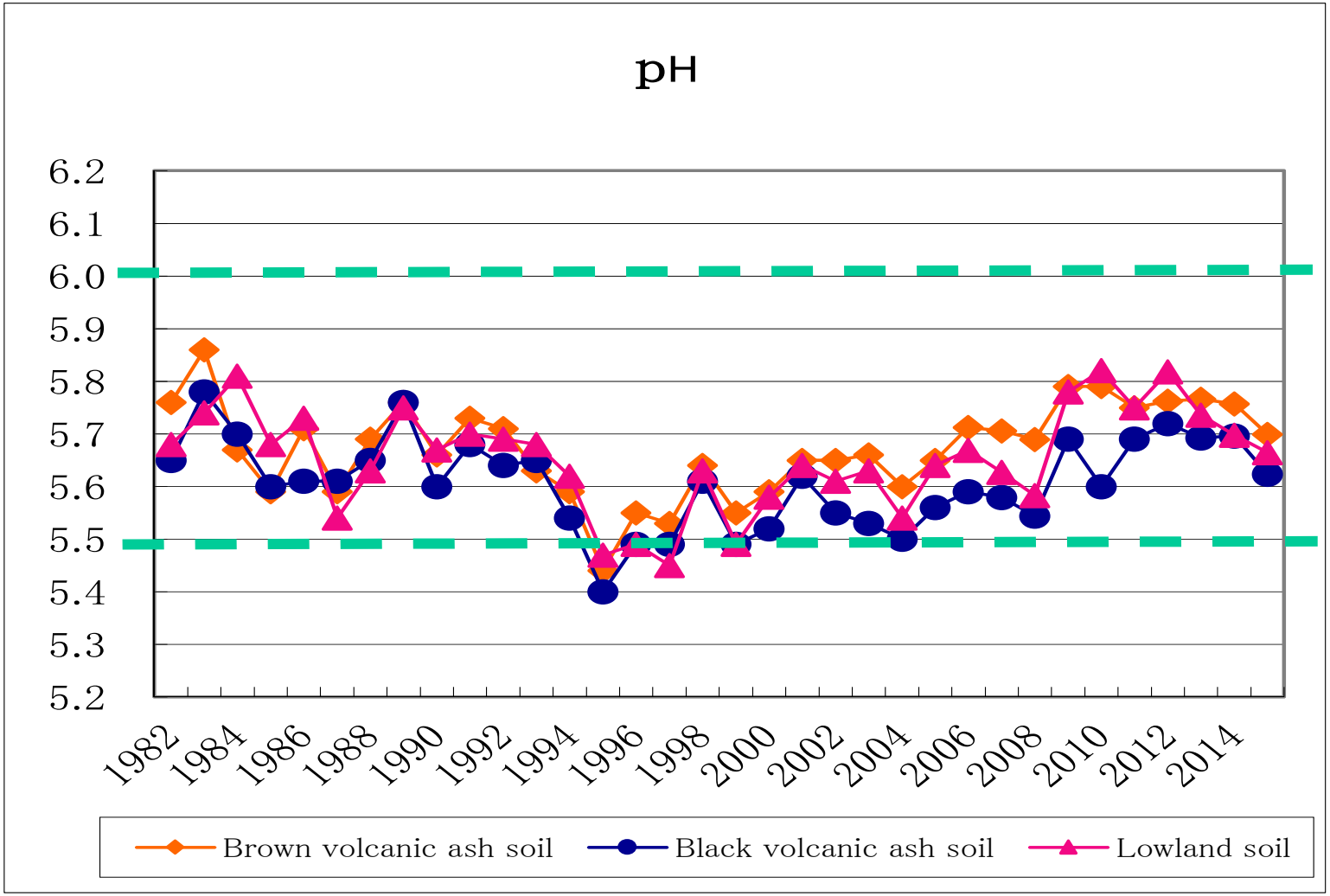
- Masking the effect of seasonal change and farm management
- To reflect the actual root zone environment more accurately, soil pH under dilute electrolyte concentration is more appropriate.

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）

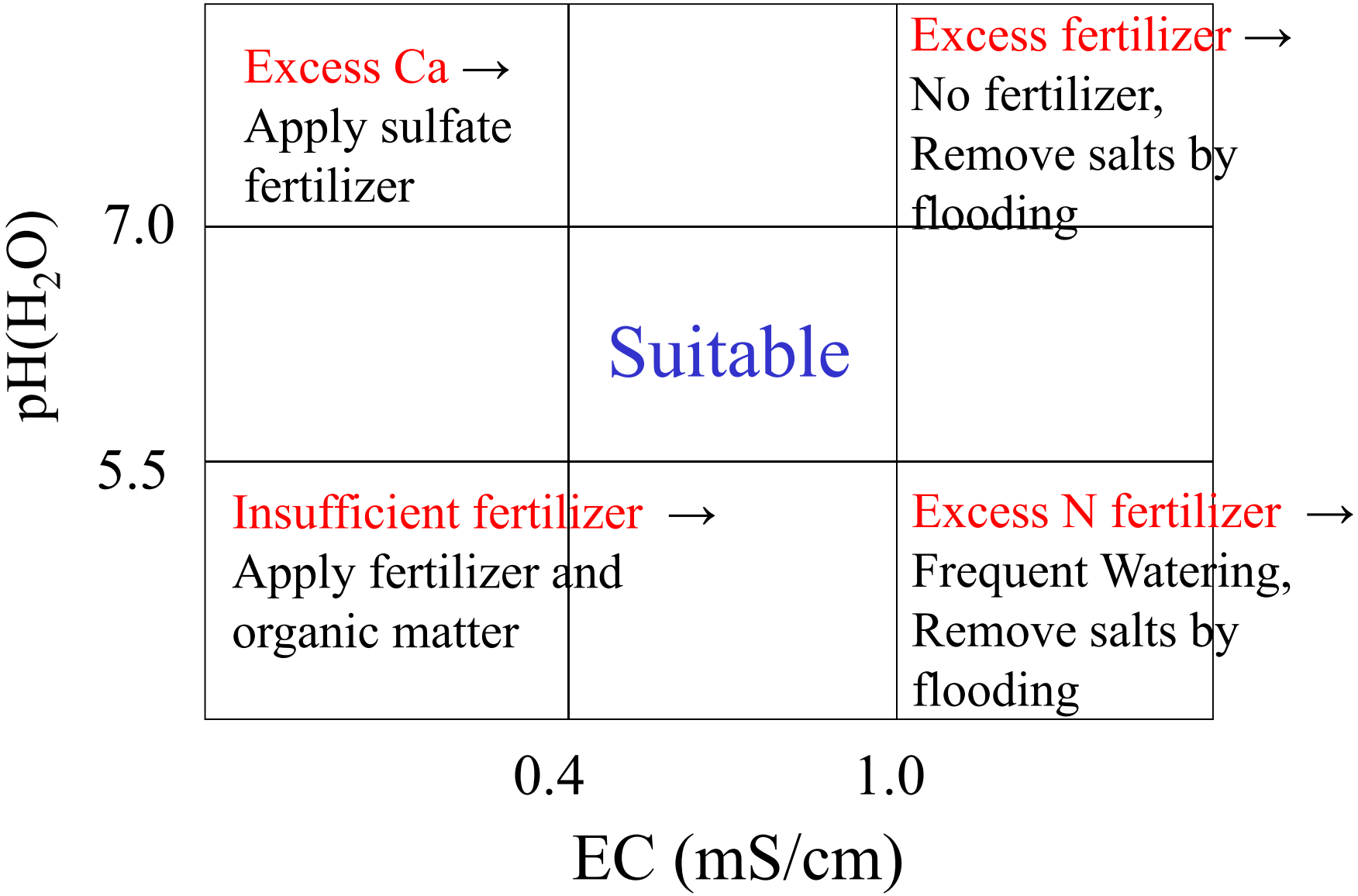
- Reflect total concentration of water soluble ions in soil solution
- Add 50 ml of deionized water to 10g of soil, shake 30 min. Measure EC of turbid suspension using EC meter.
- Unit is S/m, mS/cm or μS/cm, S: Siemens

  （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

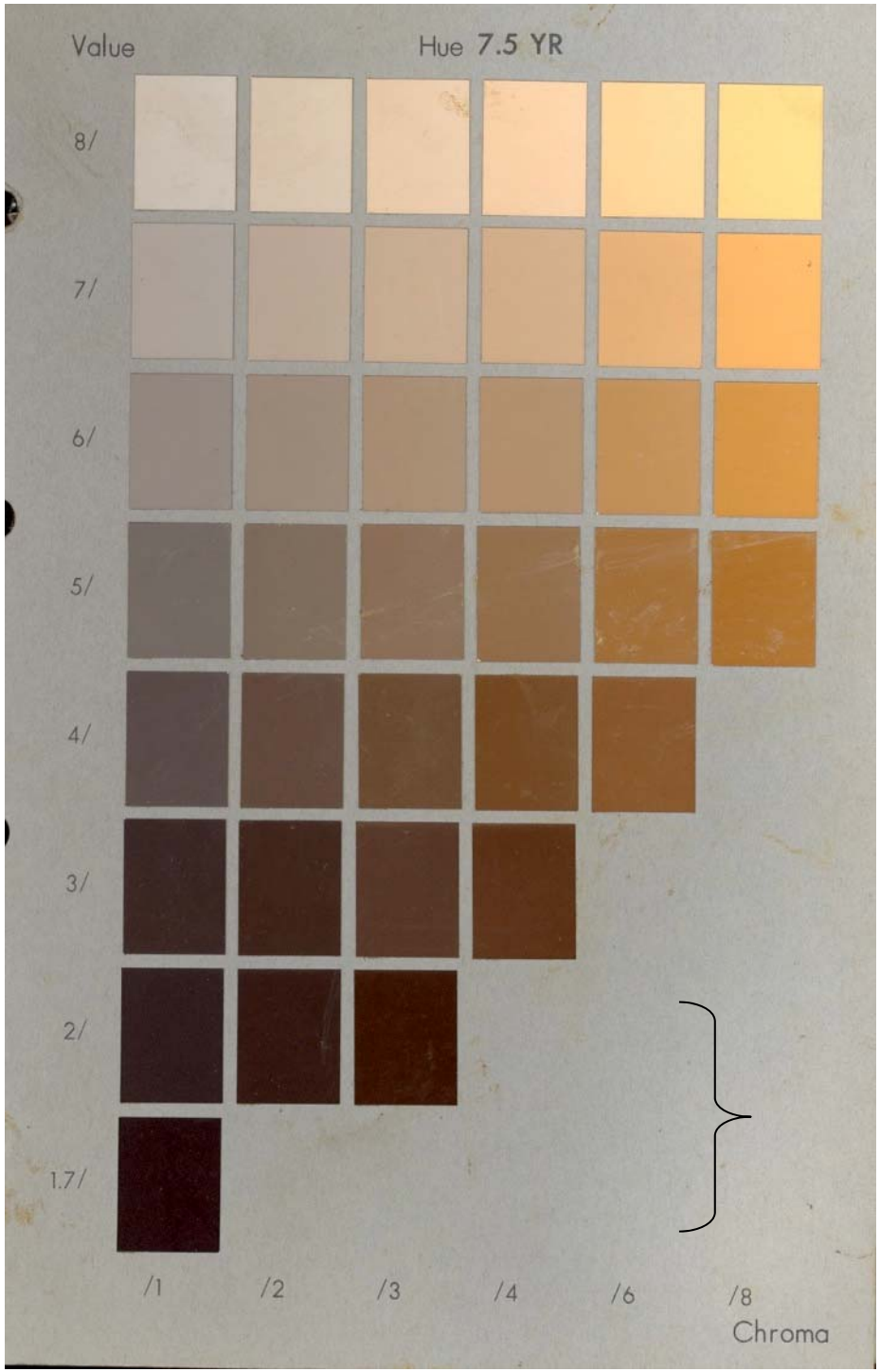
- Humus = Soil organic matter

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

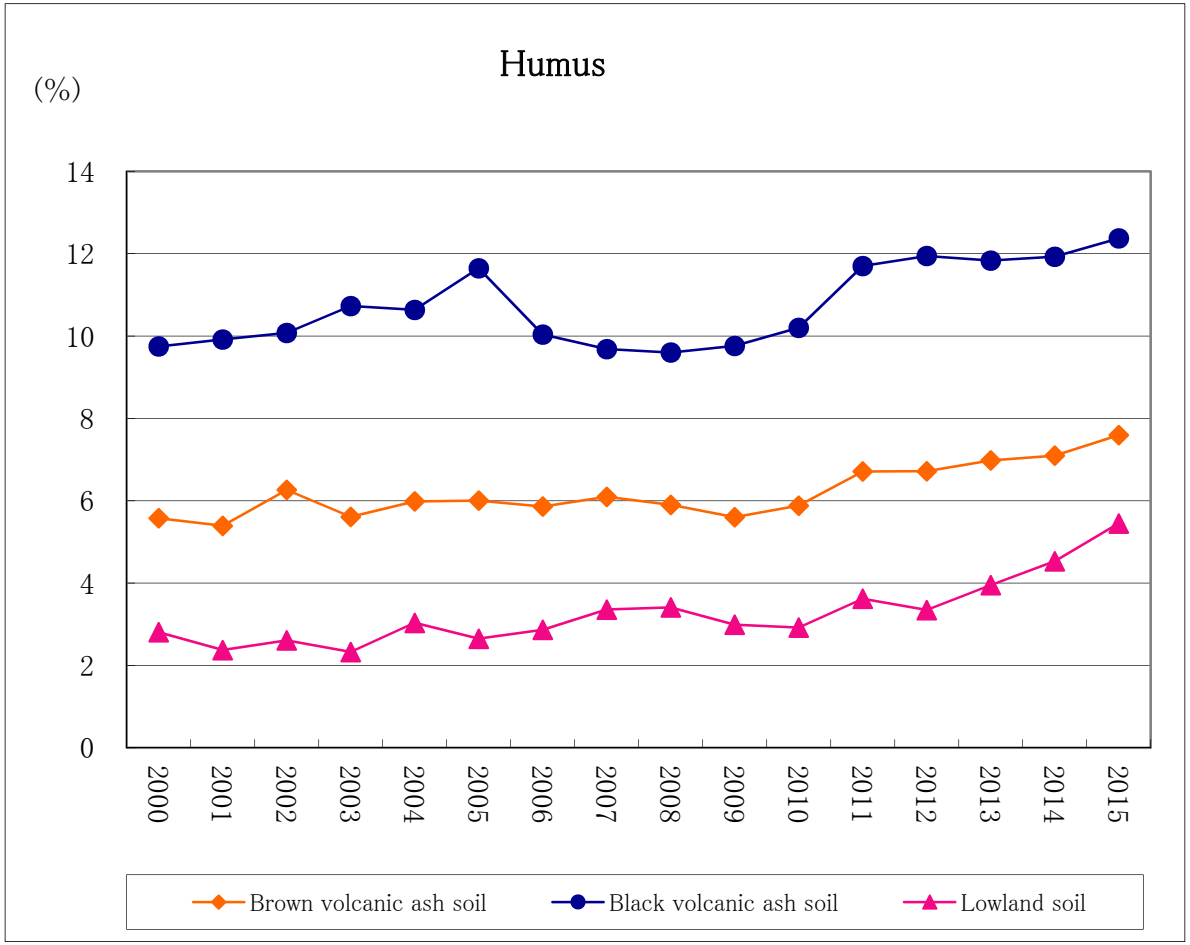


Importance of humus

- 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

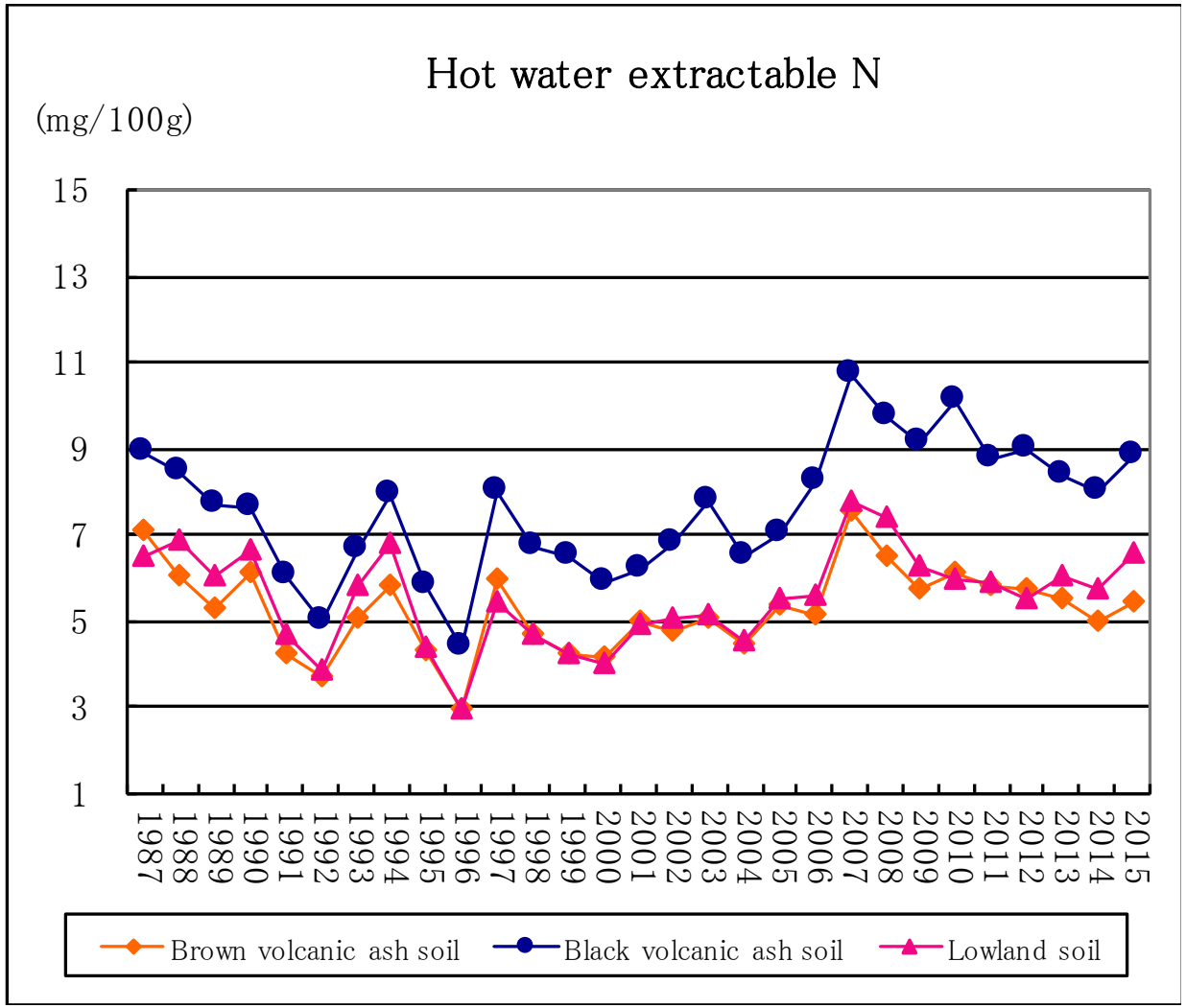
- Another measure of available nitrogen
- Soil + water (1:10)
- Autoclaved (105 ℃/modified to 121 ℃, 1 hour)
- Filtered
- Extracted solution is digested by Kjeldahl method
- Nitrogen is determined by colorimetry

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

Tokach Federation of Agricultural Co-operatives, Institute



Total Nitrogen

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

  Organic N $\rightarrow$ 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

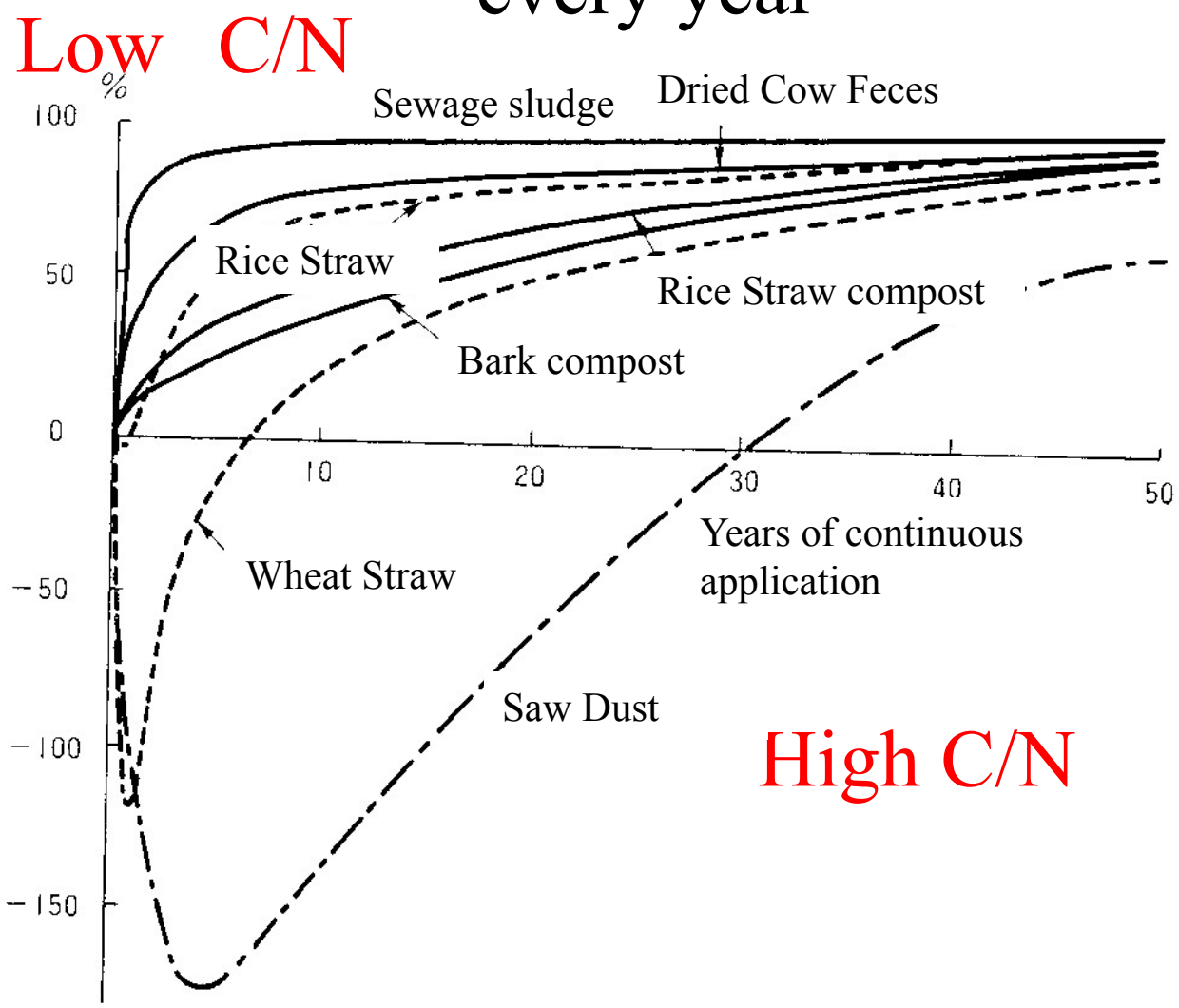
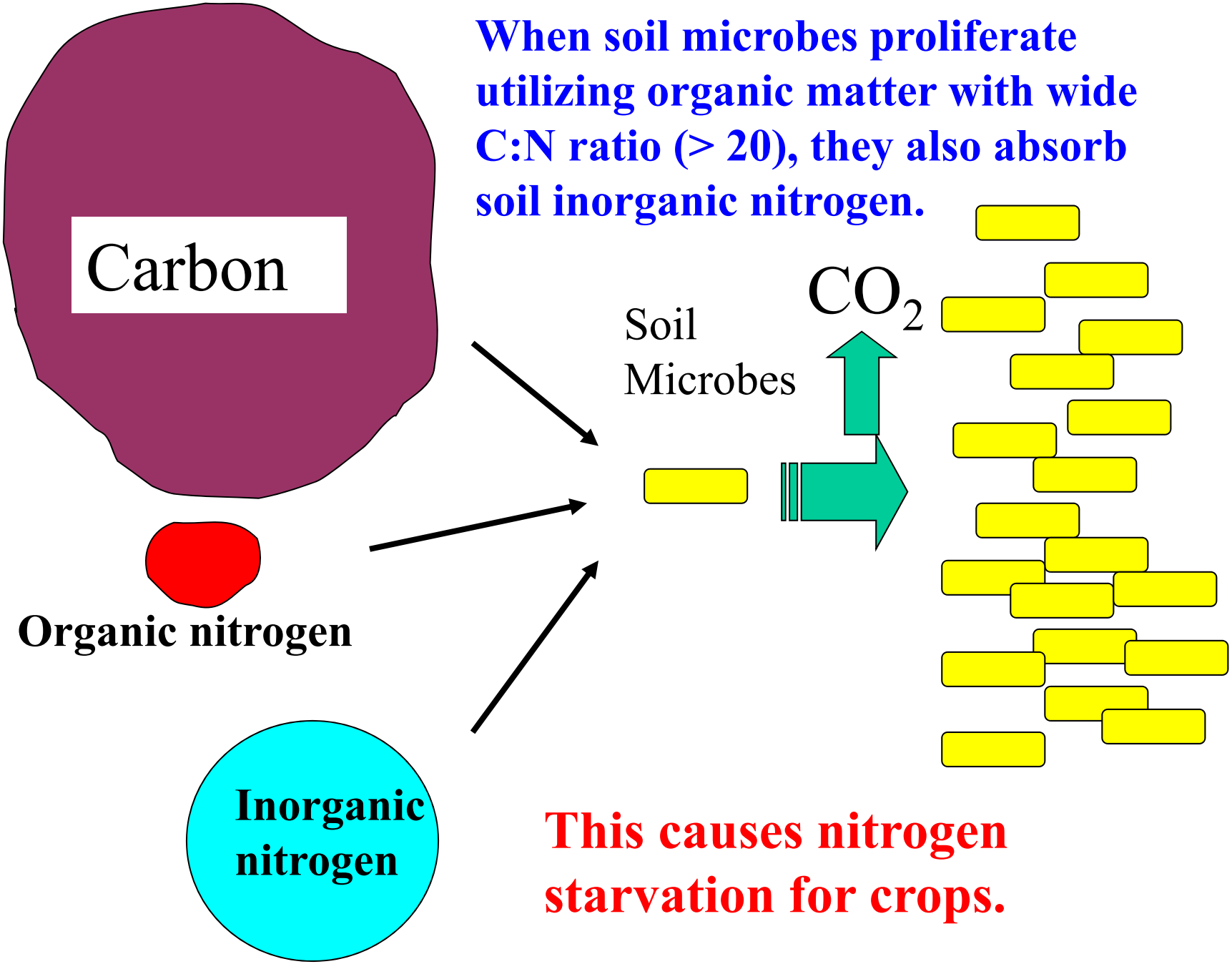


図 10　有機物連用の場合の炭素の集積率，毎年の窒素の放出率の予測値
1 年間に添加する量を100とした場合（志賀ら，1985）


When soil microbes proliferate utilizing organic matter with wide C:N ratio (> 20), they also absorb soil inorganic nitrogen.
Carbon
Soil Microbes
CO_2
Organic nitrogen
Inorganic nitrogen
This causes nitrogen starvation for crops.

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)

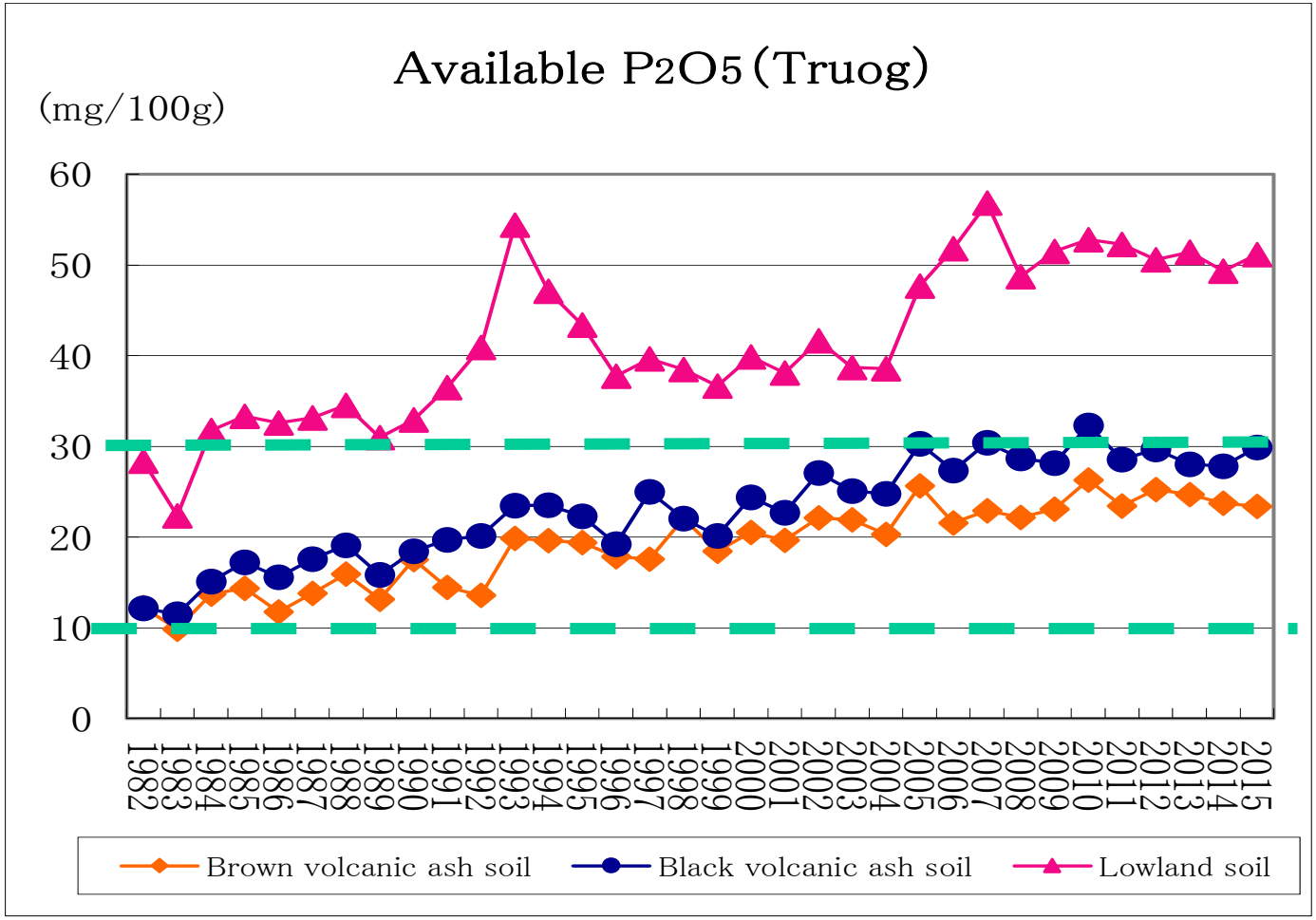
Flow Injection Analysis of CEC and available phosphate

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

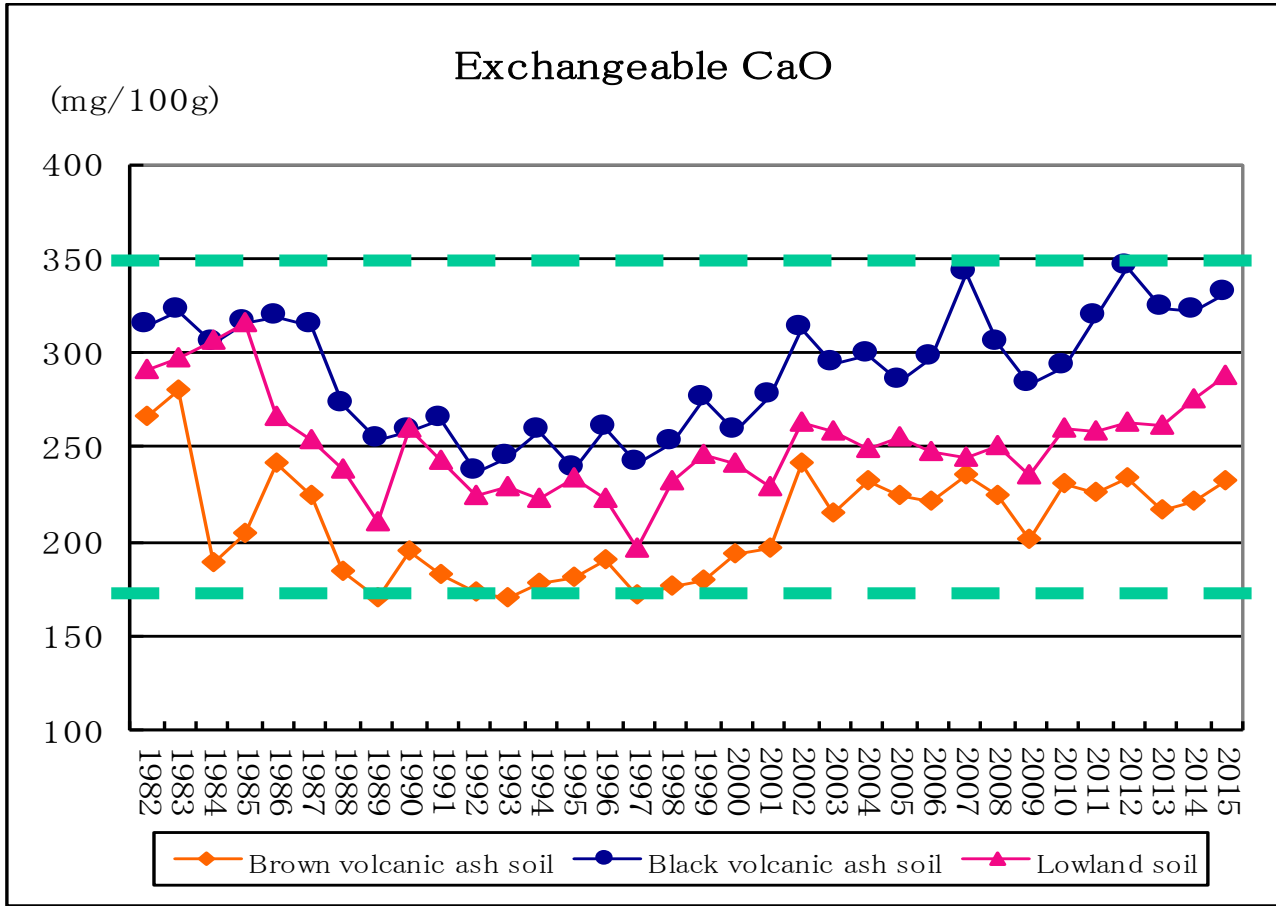
Extraction apparatus for CEC

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.

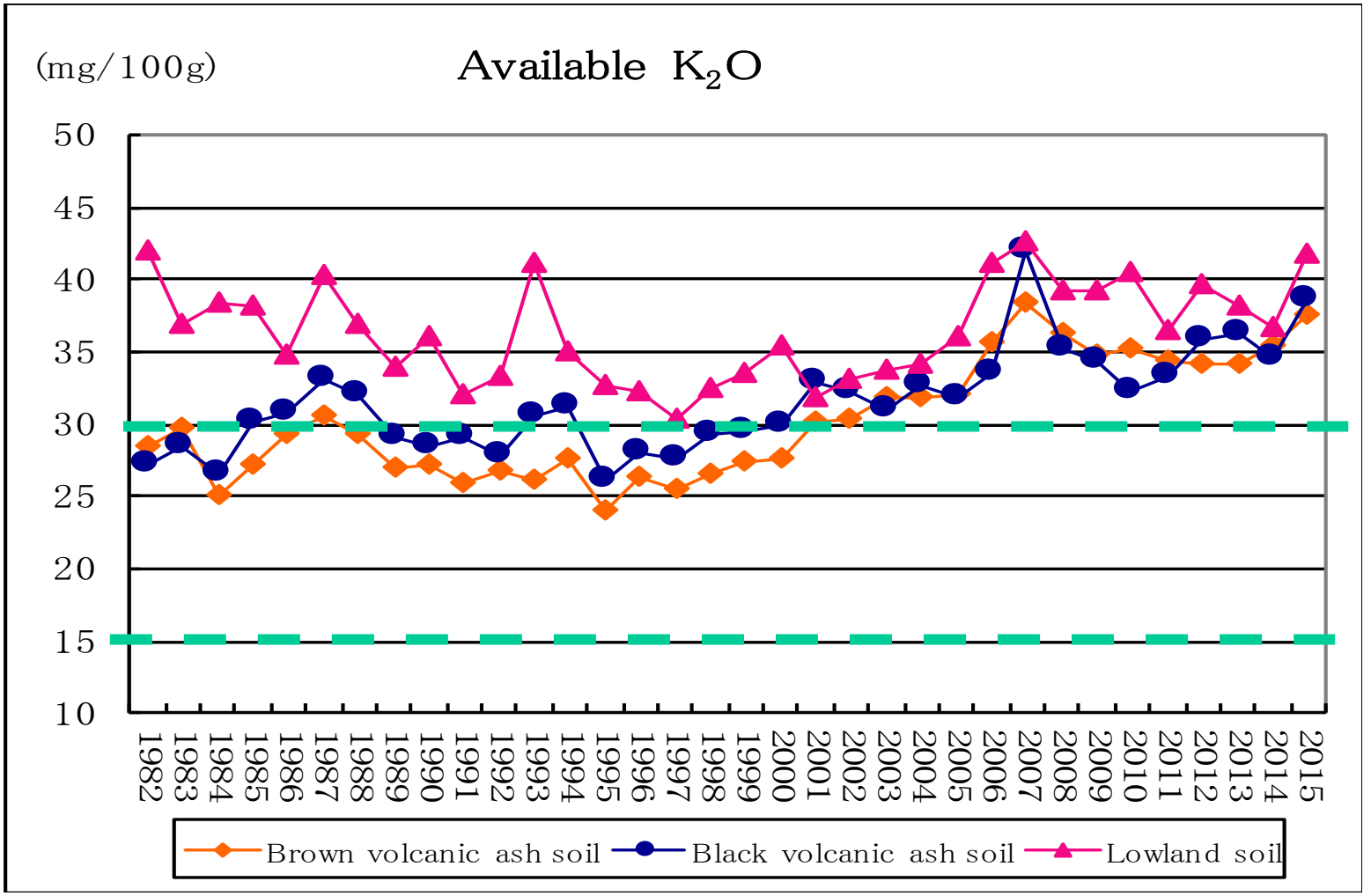
Change in exchangeable CaO in Tokachi

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.

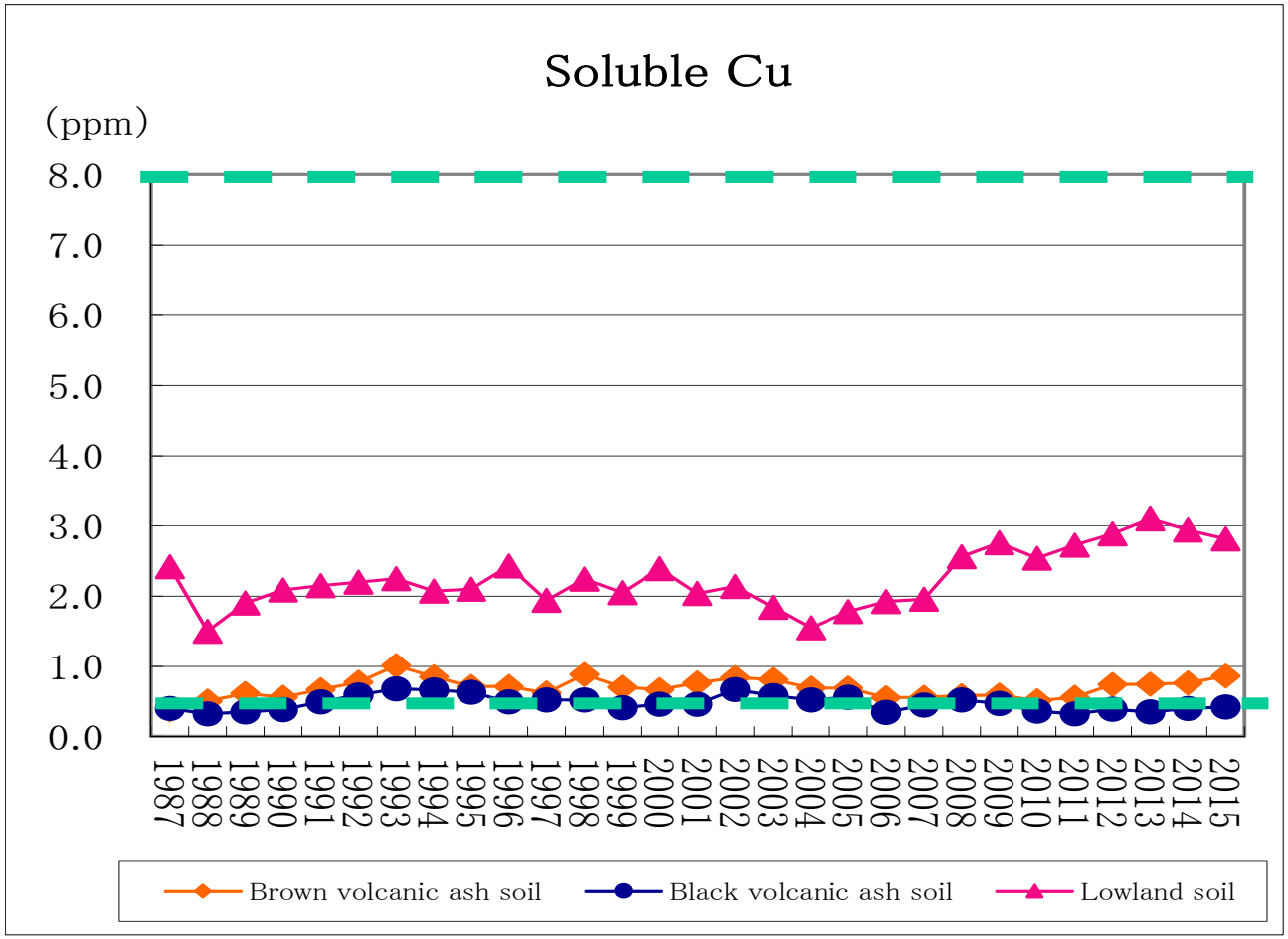
Atomic Absorption Spectrometer

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）

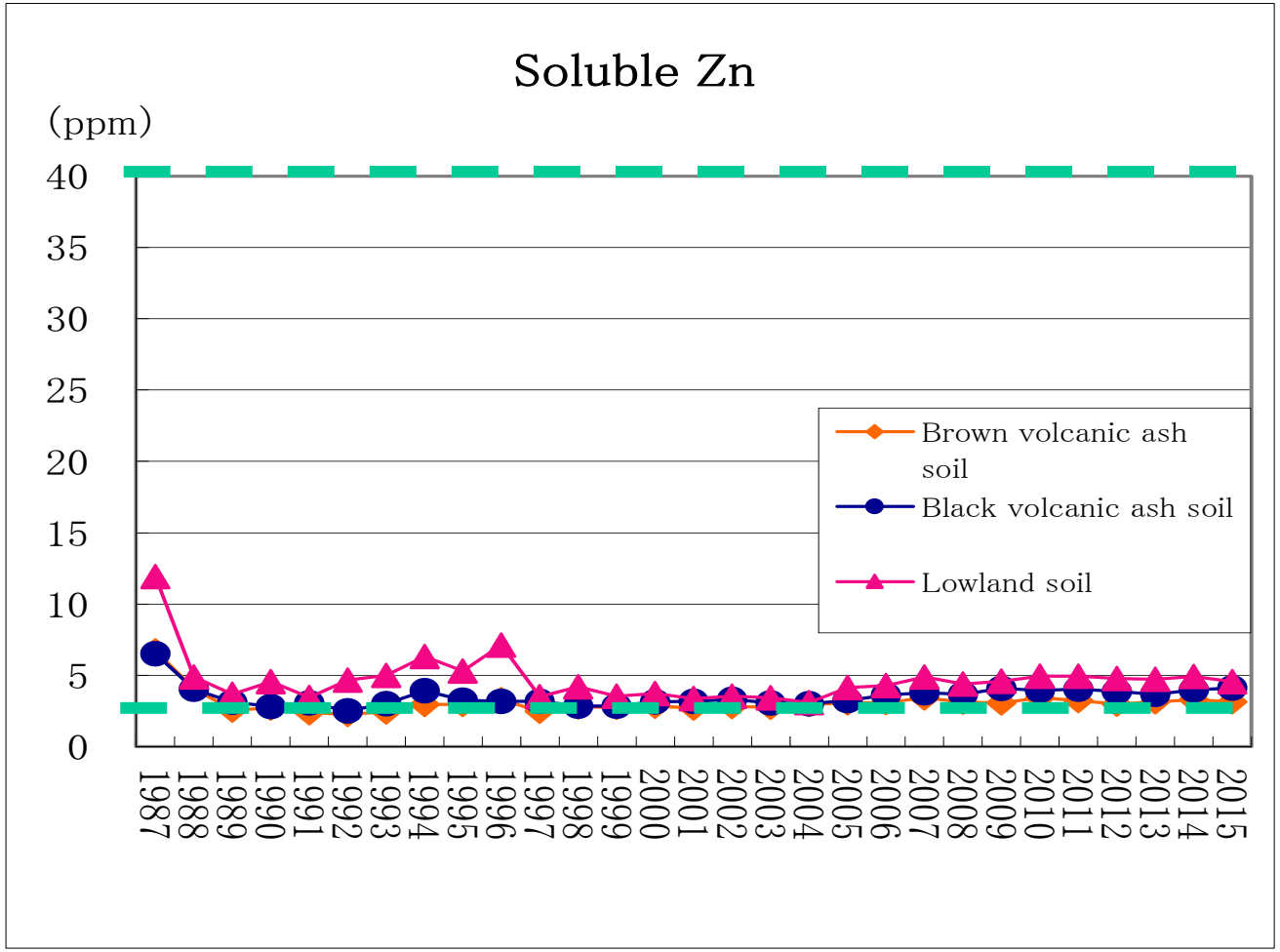
Change in soluble Cu in Tokachi

Tokach Federation of Agricultural Co-operatives, Institute



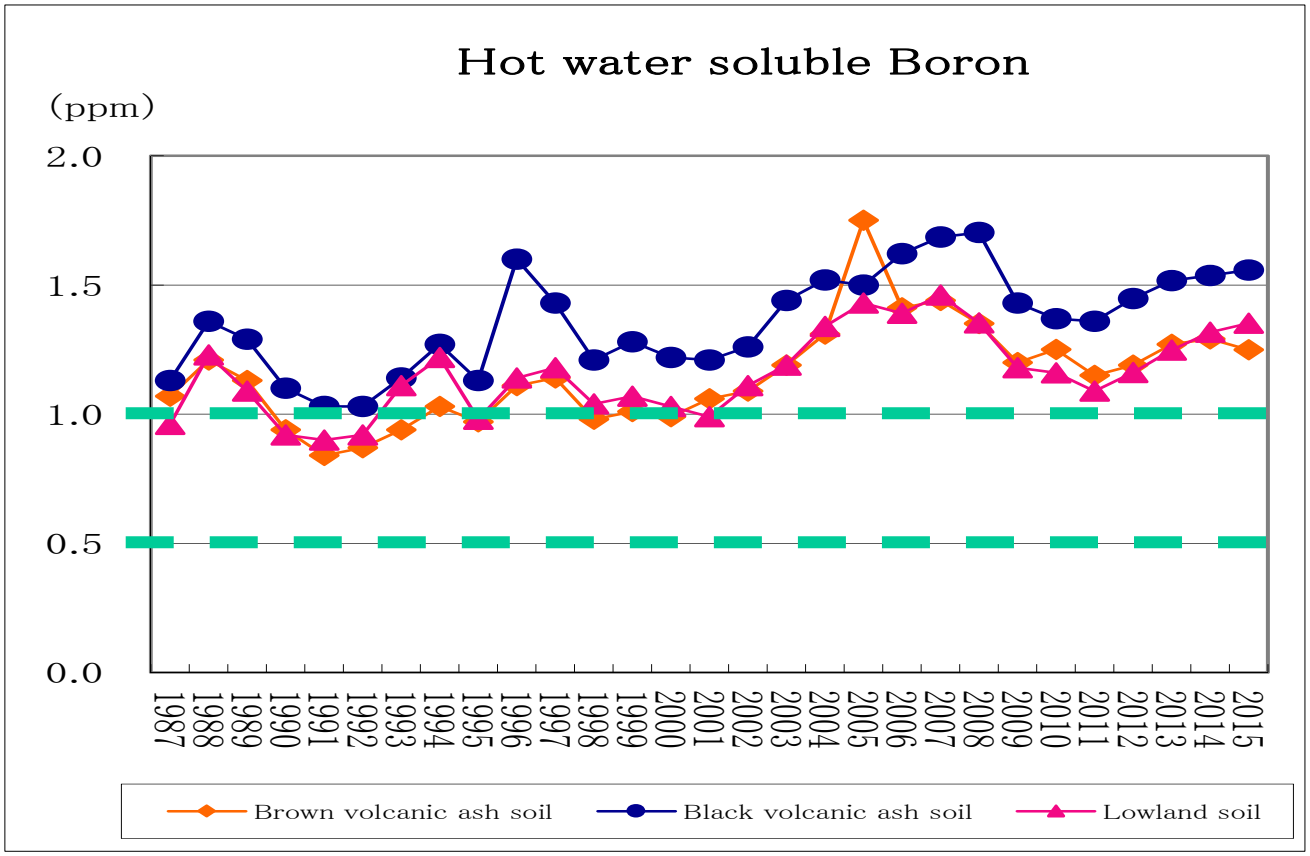
Change in soluble Zn in Tokachi

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

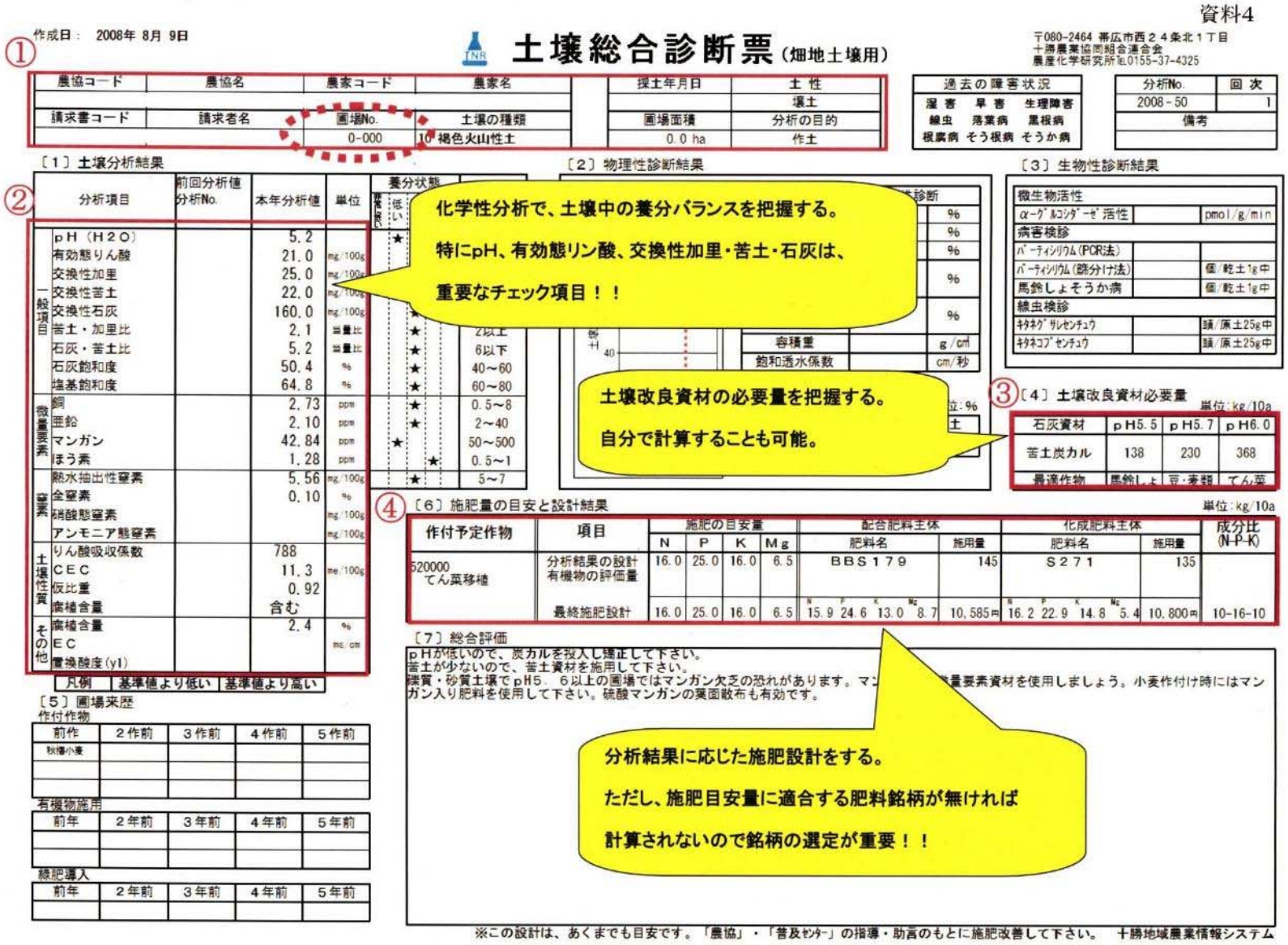
Are useful for limited types of plants.

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



資料4

作成日： 2008年 8月 9日

土壌総合診断票（畑地土壌用）

〒080-2464 帯広市西２４条北１丁目
十勝農業協同組合連合会
農産化学研究所 TEL0155-37-4325

農協コード	農協名	農家コード	農家名	採土年月日	土性
					壌土
請求書コード	請求者名	圃場No.	土壌の種類	圃場面積	分析の目的
		0-000	10 褐色火山性土	0.0 ha	作土

過去の障害状況			
湿害	旱害	生理障害	
線虫	落葉病	黒根病	
根腐病	そう根病	そうか病	

分析No.	回次
2008-50	1
備考	

〔1〕土壌分析結果

	分析項目	前回分析値 分析No.	本年分析値	単位	養分状態	
一般項目	pH（H2O）		5.2		★	
	有効態りん酸		21.0	mg/100g		
	交換性加里		25.0	mg/100g		
	交換性苦土		22.0	mg/100g		
	交換性石灰		160.0	mg/100g		
	苦土・加里比		2.1	当量比	★	2以上
	石灰・苦土比		5.2	当量比	★	6以下
	石灰飽和度		50.4	%	★	40～60
	塩基飽和度		64.8	%	★	60～80
微量要素	銅		2.73	ppm	★	0.5～8
	亜鉛		2.10	ppm	★	2～40
	マンガン		42.84	ppm	★	50～500
	ほう素		1.28	ppm	★	0.5～1
窒素	熱水抽出性窒素		5.56	mg/100g	★	5～7
	全窒素		0.10	%		
	硝酸態窒素			mg/100g		
	アンモニア態窒素			mg/100g		
土壌性質	りん酸吸収係数		788			
	CEC		11.3	me/100g		
	仮比重		0.92			
	腐植含量		含む			
その他	腐植含量		2.4	%		
	EC			ms/cm		
	置換酸度(y1)					

凡例 | 基準値より低い | 基準値より高い

化学性分析で、土壌中の養分バランスを把握する。
特にpH、有効態リン酸、交換性加里・苦土・石灰は、
重要なチェック項目！！

〔2〕物理性診断結果

容積重		g/cm³
飽和透水係数		cm/秒

〔3〕生物性診断結果

微生物活性		
α-ｸﾞﾙｺｼﾀﾞｰｾﾞ活性		pmol/g/min
病害検診		
ﾊﾞｰﾃｨｼﾘｳﾑ(PCR法)		
ﾊﾞｰﾃｨｼﾘｳﾑ(菌分け法)		個/乾土1g中
馬鈴しょそうか病		個/乾土1g中
線虫検診		
ｷﾀﾈｸﾞｻﾚｾﾝﾁｭｳ		頭/原土25g中
ｷﾀﾈｺﾌﾞｾﾝﾁｭｳ		頭/原土25g中

土壌改良資材の必要量を把握する。
自分で計算することも可能。

〔4〕土壌改良資材必要量

単位：kg/10a

石灰資材	pH5.5	pH5.7	pH6.0
苦土炭カル	138	230	368
最適作物	馬鈴しょ	豆・麦類	てん菜

〔5〕圃場来歴

作付作物

前作	2作前	3作前	4作前	5作前
秋播小麦				

有機物施用

前年	2年前	3年前	4年前	5年前

緑肥導入

前年	2年前	3年前	4年前	5年前

〔6〕施肥量の目安と設計結果

単位：kg/10a

作付予定作物	項目	施肥の目安量 N	P	K	Mg	配合肥料主体 肥料名	施用量	化成肥料主体 肥料名	施用量	成分比 (N-P-K)
520000 てん菜移植	分析結果の設計 有機物の評価量	16.0	25.0	16.0	6.5	BBS179	145	S271	135	
	最終施肥設計	16.0	25.0	16.0	6.5	N 15.9 P 24.6 K 13.0 Mg 8.7	10,585円	N 16.2 P 22.9 K 14.8 Mg 5.4	10,800円	10-16-10

分析結果に応じた施肥設計をする。
ただし、施肥目安量に適合する肥料銘柄が無ければ
計算されないので銘柄の選定が重要！！

〔7〕総合評価

pHが低いので、炭カルを投入し矯正して下さい。
苦土が少ないので、苦土資材を施用して下さい。
礫質・砂質土壌でpH5．6以上の圃場ではマンガン欠乏の恐れがあります。マン…量要素資材を使用しましょう。小麦作付け時にはマンガン入り肥料を使用して下さい。硫酸マンガンの葉面散布も有効です。

※この設計は、あくまでも目安です。「農協」・「普及ｾﾝﾀｰ」の指導・助言のもとに施肥改善して下さい。 十勝地域農業情報システム

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)