SOIL AND PLANT TISSUE TESTING METHODS AND INTERPRETATIONS OF THEIR RESULTS for British Columbia Agricultural Soils

Neville Gough, PAg. BCMAF 1996

FOREWORD

Organizations that advise farmers have expressed great interest in the continued dispensation of sound fertilizer and soil fertility management recommendations. To ensure the continuation of good advice members of these organizations suggested, at a meeting held in Richmond in June 1989, that the following actions were needed: that modified and newly developed analytical methods, interpretations of their results and recommendations be assessed before their implementation; that the assessment of the suitability of these analytical procedures and judgement on the soundness of the interpretations for B.C.'s soils and climate be made by a body - the British Columbia Agricultural Soil and Plant Tissue Testing Council; that the council be selected from laboratory staff, extension and research personnel, and that the decisions of the council not be binding. All agreed that an important first step in maintaining and enhancing quality recommendations would be the publication of a reference manual that contained presently used analytical methods for soil and tissue, interpretations of the results of the analyses and fertilizer recommendations. This manual is the result of such a suggestion.

The primary purpose of this manual is to provide in one source brief descriptions of laboratory operations. Detailed description of a specific procedure and the reason or philosophy for a given recommendation should be obtained from the laboratory identified with each procedure.

The manual is organized in two parts. Part I describes soil sampling of fields, soil sample preparation, methods of soil nutrient analysis, interpretations of soil test values, and fertilizer recommendation when available.

Part II presents the preparation of plant samples for analysis, analytical methods for the determination of nutrient levels, and interpretation of the values obtained.

This reference manual of standard soil and plant analytical methods, interpretations of analytical results and recommendations can be an asset to those giving advice on soil management practices. With the information provided, advisors should be able to choose the soil test procedures and interpretations that are best suited for their soils and cropping conditions. The fertilizer recommendations that have resulted from soil test calibration procedures can be varied to provide various fertilizer economic interpretations. Of course, some raw data from the calibration procedures will be required for the determinations. Knowing the analytical procedure used for a plant nutrient determination is quite important to the advisor but equally important are the plant parts and their stages of maturity that were used to establish the interpretative values. This information is provided in this manual. The same set of plant conditions used to establish the interpretative or critical values should be used when the diagnosis of a deficient nutrient is being made. The probability of a correct diagnosis is then very high.

The compiler appreciates the cooperation of the supervisors of Griffin Laboratories Corp.; Norwest Laboratories; Soilcon Laboratories Inc.; Pacific Soil Analysis Inc. and members of the Soil Fertility Working Group consisting of R. Bertrand, G. Kowalenko, A. Bomke and G. Neilsen. The comments of Geoff Hughes-Games were also helpful in the preparation of this manual. Nona Bennett deserves special thanks for typing this document.

CONTENTS

FOREWORD

•

.

PAGE

r

, 11

Soils - Part 1A

Title

Sample Collection and Preparation - Griffin Labs.	1
Sample Preparation - Pacific Soil Analysis	2
Incorporated (PSAI)	

Analytical Procedures

1.	Organic Matter and Carbon Determination				
	1.1	O.M. by loss on ignition - Griffin Labs.	3		
	1.2	O.M. by dry combustion, inductance furnace - Norwest Soil Research	4		
	1.3	Total carbon by dry combustion, Leco inductance	5		
	1.4	Organic Carbon by Walkley - Black wet oxidation method PSAI	6		
2.	Bulk	Density			
	2.1	Weight of a volume of dried and sieved scooped soil - Griffin Labs.	7		
3.	Soil	Reaction (pH)			
	3.1	1:2 v/v soil:water suspension - Griffin Labs	8		
	3.2	1:2 v/v soil:water slurry - Norwest Soil Research	9		
	3.3	1:1 v/v soil:distilled watter slurry - PSAI	10		
	3.4	1:2 v/v soil:CaCl ₂ slurry - PSAI	11		
4.	Elec	trical Conductivity (Water-Soluble Salts)			
	4.1	1:2 v/v soil:water suspension - Griffin Labs.	13		
	4.2	Saturated soil paste extract – Griffin Labs.	13		
	4.3	1:2 v/v soil:water suspension - Norwest Soil Research	14		
	4.4	Saturated soil paste extract - PSAI	15		
5.	Lime	Requirements			
	5.1	Shoemaker, McLean and Pratt buffer method - Griffin Labs.	16		
	5.2	Shoemaker, McLean and Pratt buffer method - Norwest Soil Research	20		

CONTENTS (cont'd.)

5

2

~~ \

6.	Nitra	ate and Ammonia	
	6.1	Nitrate extractable by 0.015 N NH ₄ F + 0.25 N HOAc Griffin Labs.	21
	6.2	Nitrate and ammonium extractable by 1 M KC1 - Norwest Soil Research	26
	6.3	Total nitrogen on semi-micro Kjeldahl digest - PSAI	27
	6.4	Nitrate and ammonium extractable by 0.5 N K ₂ SO $-$ PSAI	28
7.	Extra	actable Phosphorus	
	7.1	Phosphorus extractable by 0.015 N NH ₄ F + 0.25 N HOAc - Griffin Labs.	29
	7.2	Phosphorus extractable by 0.03 N NH_4F +	31
		0.025 N HCl - Norwest Soil Research	
	7.3	Phosphorus extractable by the Bray-IP extract - PSAI	32
	7.5	Phosphorus extractable by the Weblich extract $-$ PSAT	34
	1.5	thospholds extractable by the Menilen Extract - PSAI	74
8.	Extra	actable Potassium, Calcium, Magnesium, Sodium	
	8.1	K, Ca, Mg, Na extractable by 0.015 N NH4F + 0.25 N H)Ac - Griffin Labs.	35
	8.2	K, Ca, Mg, Na extractable by 1 M NH ₄ Ac - Norwest Soil Research	37
	8.3	K, Ca, Mg, Na extractable by 1 N NH ₄ Ac - PSAI	38
	8.4	K, Ca, Mg, Na extractable by Morgan extract - PSAI	39
9.	Extra	actable and Total Sulphur	
	9.1	Sulphur extractable by 0.015 N NH ₄ F + 0.25 N HOAC - Griffin Labs.	40
	9.2	Sulphate extractable by 0.01 M CaCl ₂ - Norwest Soil Research	41
	9.3	Sulphate extractable by CaCl ₂ - PSAI	42
	9.4	Total sulphur by Leco Analyzer - PSAI	4 3
10.	Extrac	table Zinc, Iron, Manganese, Copper	
	10 1	DTPA_TRA extractable Zn Fe Mn Cu _ Criffin Labo	<i>h.a</i>
	10.2	DTPA-TEA extractable Zn , re, rm, $Cn = 0$ IIIII Labs, DTPA-TEA extractable Zn , Re Mn $Cn = 0$	44 45
		Norwest Soil Research	-72
	10.3	0.1 N HCl extractable Zn. Fe. Mn. Cu - PSAT	46

CONTENTS (cont'd.)

.

ll. Boron	PAG	E	
11.1	Hot water soluble boron by azomethine-H method - 47		
11-2	Hot water soluble boron by azomethine-H method - 49		
11-3	Norwest Soll Research Hot water soluble boron by azomethine-H method - PSAI 51	ł	
	Soils - Part IB		
	Soil Test Interpretations and Fertilizer Recommendations		
Table l	Lime requirement and soil-SMP buffer pH values relationship for scooped mineral soils - Griffin Labs.	18	
Table 2	Lime requirements and soil-SMP buffer pH values relationship for scooped organic soils - Griffin Labs.	19	
Table 3	Recommended phosphorus (P ₂ O ₅) applications based on 5 soil test phosphorus (P) values for Vancouver Island, Lower Mainland, Okanagan, Kootenays, Kamloops, Williams Lake and Quesnel - Griffin Labs.		
Table 4	Recommended phosphorus (P ₂ O ₅) applications based on soil 5 test phosphorus (P) values for McBride, Prince George, Vanderhoof, Smithers - Griffin Labs.		
Table 5	Recommended phosphorus (P ₂ 0 ₅) applications based on soil test phosphorus (P) values for the Peace River - Griffin Labs.	53	
Table 6	Recommended potassium (K ₂ O) applications based on soil test potassium (K) values for Vancouver Island and the Lower Mainland - Griffin Labs.	5 4	
Table 7	Table 7Recommended potassium (K20) applications based on soil test potassium (K) values for the Okanagan, the Kootenays, Kamloops, Williams Lake and Quesnel - Griffin Labs.		
Table 8	Recommended potassium (K ₂ 0) applications based on soil test potassium (K) values for McBride, Prince George, Vanderhoof, Smithers and Peace River - Griffin Labs.	5 6	
Table 9	Magnesium (Mg) recommendations for several crops and all areas based on magnesium soil test values - Griffin Labs.	57	
Table 10	Sulphur recommendations for all crops and areas based on soil sulphur levels - Griffin Labs.	58	

v

CONTENTS (cont'd.)

•

• ¥ 1.

-

2

		PAGE		
Table 16	Leaf analysis guide for diagnosing nutrient status of peach trees - Griffin Labs.	81		
Table 17	Leaf analysis guide for diagnosing nutrient status of apricot trees - Griffin Labs.	8 2		
Table 18	Leaf analysis guide for diagnosing nutrient status of 83 pear trees - Griffin Labs.			
Table 19	Critical leaf nutritional concentrations for filbert trees - Griffin Labs.			
	List of Figures			
Fig. 1	AutoAnalyzer arrangement for nitrate and/or nitrite determination in soil and plant extracts.	25		
Fig. 2	AutoAnlalyzer arrangement for ammonium determination in plant digests.	71		
	Appendix	85		

.

SOILS

PART I-A

SAMPLE COLLECTION AND LABORATORY PREPARATION

Griffin Laboratories

INTRODUCTION

The soil sample submitted to the laboratory for analysis and ultimately a fertilizer recommendation should be representative from the field from which it was collected. Poor sampling will result in incorrect fertilizer recommendation regardless of the accuracy of the analysis. A representative soil sample is usually a composite of several samples for seldom does a sample from one site estimate satisfactorily the fertility of a field. Field fertility can also be estimated through multiple samples taken systematically on a grid pattern. This method is known as intensive point sampling.¹ The laboratory issues a guide on the soil sampling of fields.

PROCEDURE

The procedure² recommends the delineation of the field into areas that are reasonably uniform with respect to drainage, soil type, slope and past fertilization. A minimum of ten and preferably twenty to forty samples from each area, and taken to a depth of 15-20 cm, should be mixed thoroughly in a clean plastic pail and a subsample sent to the laboratory.

The sample submitted for analysis should be dry unless the laboratory states otherwise. Air drying should commence soon after collection so that biological activity might be arrested.

In the laboratory the soil sample is put into a soil box and given a laboratory number. If the sample were large it would be subsampled prior to boxing. The sample is then placed in a forced air oven and allowed to dry at 55° C. After drying, the sample is crushed with a block of wood and put through a 2 mm hand sieve.

⁽¹⁾ Dow, A.I. and James, D.W. 1973. Intensive Soil Sampling. Washington Agricultural Experiment Station, Bulletin 781.

⁽²⁾ Van Lierop, W. 1985. Soil Sampling. B.C.M.A.F. Soil, Feed and Tissue Testing Laboratory.

SAMPLE PREPARATION

.

•

Pacific Soil Analysis

All soil samples are air dried, pinned and sieved through a 2 mm sieve.

1.1 <u>Griffin Laboratories</u> - (Loss on Ignition)

INTRODUCTION

The ignition method was adapted from Ball¹ and Davies². Ball developed the procedure from experimentation with non-calcareous soils. Davies concluded from his research that the presence of calcium carbonate in soil does not affect the magnitude of the ignition loss at temperatures of 450° C. An exception may be those soils having gibbsite in their clay fraction. Griffin treats all soils similarly.

DETERMINATION

Apparatus

Muffle furnace (Thermolyne Programmable) Coors porcelain crucibles Forced - draft oven

Procedure

Measure a 2.5 ml scoop of soil into a porcelain crucible and dry for 5 hours at 105° C. Transfer crucible to a muffle furnace and ignite soil at 450° C for 16 hours. The percentage organic matter is the ratio of the weight loss during ignition to the weight of soil dried at 105° C X 100.

⁽¹⁾ Ball, D.F. 1964. Loss-on-ignition as an estimate of organic matter and organic carbon in non-calcareous soils. J. Soil Sci. 15:84-92

⁽²⁾ Davies, B.E. 1974. Loss-on-ignition as an estimate of soil organic matter. Soil Sci. Soc. Amer. Proc., Vol. 38:150

۰.

1.2 <u>Norwest Soil Research</u> - (dry combustion, inductance furnace)

Organic matter is determined by measuring the carbon content of the soil using an induction furnace. The liberated carbon dioxide is measured by an infrared detector. Organic matter is calculated by multiplying carbon content by a factor of 1.78.

4

1.3 <u>PSAI</u> - (Total carbon by dry combustion, Leco inductance furnace)

٠

्•

1.4 <u>PSAI</u> (Organic carbon by Walkley - Black wet oxidation method)

2. BULK DENSITY

2.1 Griffin Laboratories (Scooped Sample)

INTRODUCTION

The bulk density values of mineral soil samples as prepared by the method described below may be lower than found in corresponding settled fields but are comparable to values found in freshly tilled soils that are about to be seeded, fertilized or limed¹. Bulk density or volume-weight determined in the manner presented below has its highest use in the conversion of volume based soil test values.

DETERMINATION

Apparatus

Forced draft oven.

Procedure

Mineral and Organic Soils

Dry a 2.5 ml scoop of soil at 105° C for 5 hours and determine the weight of the soil. Calculate the bulk density as the ratio of soil weight dried at 105° C to volume of soil.

Mehlich, A. 1972. Uniformity of expressing soil test results, a case for calculating results on a volume basis. Comm in Soil Science and Plant Analysis 3(5), 417-424.

· ·

3.1 Griffin Laboratories - (1:2 v/v soil:water suspension)

INTRODUCTION

The pH of mineral and organic soils is measured potentiometrically in 1:2 volumes of soil and water mixture after it has been stirred. As soil-water ratio affects soil pH values, the ratio is maintained for all samples. A mixture of 25 ml of soil and 50 ml of distilled water is chosen for pH determination because the mixture when placed in a 4.0 oz. dixie cup easily covers the tips of the electrodes.

DETERMINATION OF pH

Apparatus

pH meter pH indicating electrode (calomel) pH reference electrode (glass) Container - 4.0 oz. dixie cups A single electrode might be substituted for the calomel and glass electrodes.

Procedure

Mineral and Organic Soils

Put 2 scoops of soil sample that were dried at 55°C into a 4.0 oz. dixie cup (1 scoop equals 12.5 ml). Add 50 ml of distilled water to the dixie cup, stir, allow to stand for 30 minutes, then stir again. Adjust pH meter using buffer solutions. Read the pH of the sample by inserting the electrodes in the soil-water suspension. Rinse the electrodes with distilled water between each sample.

3.2 Norwest Soil Research - (1:2 v/v soil:water slurry)

pH is determined in a 1:2 v/v soil:water slurry). Measurement of pH by electrode.

.

5

3.3 <u>PSAI</u> - (1:1 v/v soil:distilled water slurry)

Soil pH is determined potentiometrically using a Radiometer pH meter on a 1:1 soil to distilled water slurry.

3.4 <u>PSAI</u> - (1:2 v/v soil: CaCl₂ slurry)

Soil pH is determined potentiometrically using a Radiometer pH meter on a 1:2 soil to ${\rm CaCl}_2$ slurry.

4. ELECTRICAL CONDUCTIVITY (WATER-SOLUBLE SALTS)

Griffin Laboratories

INTRODUCTION

An aqueous extract from a saturated soil paste and the electrical conductivity value of the extract have been used to define soil salinity since 1954^1 . Extractions of other soil/water ratios have been used to estimate soil salinity. These ratios are not as well related to field soil moisture as the saturated soil paste². Increasing the proportion of water to soil usually causes a decrease in salt concentration. At Griffin Laboratories a 1:2 soil/water mixture is used for the determination of E.C. and the value obtained is multiplied by a conversion factor of 2 to give an approximate equivalent saturated paste value.

Traditionally electrical conductivity (E.C.) has been expressed in units of millimhos per centimeter (mmhos/cm). More recently equivalent units of decisiemen per meter (dS/m), or millisiemen per centimeter (mS/cm) have been used. All of these units represent the reciprocal of the electrical resistance of the soil solution and the values are indexes of the salt content of the soil.

DETERMINATION

Apparatus

Conductivity meter - Solu-Bridge Pipette type conductivity cell 40 oz. dixie cup 18 X 250 mm test tubes

Bower, C.A. and Wilcox, L.V. 1965. Soluble Salts. In C.A. Black et al; eds. Methods of soil analysis. Part 2. Chemical and microbiological properties. Agronomy 9. Am. Soc. Agron., Madison, Wis.

⁽²⁾ Hogg, T.J. and Henry, J.L. 1984. Comparisons of 1:1 and 1:2 suspensions and extracts with the saturation extract in estimating salinity in Saskatchewan soils. Can. J. Soil Sci. 64: 699-704.

Examination

4.1 1:2 Soil-Water Suspension (Short Method)

Calibrate the conductivity meter. Insert the conductivity meter pipette into the soil-water mixture remaining from the pH determination. Record the reading. Convert the reading from the 1:2 ratio solution to a saturated paste equivalent by multiplying by two.

Note: If the actual value is greater than 0.50 mmhos/cm, the determination must be repeated using the saturated paste.

4.2 Saturated Paste (Saturation Extract)

Measure about 2 tablespoons of sample into a 40 oz dixie cup. Add distilled water with stirring until soil is just saturated. The surface of the soil should just glisten when the cup is tapped on the bench several times. Allow 1/2 hour for paste to reach equilibrium, add more distilled water if necessary. Filter paste through Whatman No. 2, 5.5 cm filter paper into 18 X 250 mm test tube, using Buchner funnels under vacuum. Pour extract into a clean paper cup, draw extract into micro-conductivity cell and read the conductivity on the Solu-Bridge.

4. ELECTRICAL CONDUCTIVITY (water-soluble salts)

4.3 Norwest Soil Research - (1:2 v/v soil:water suspension)

Electrical conductivity is measured on water phase from 1:2 v/v soil:water slurry using an EC meter. The result is converted into saturated extract equivalent by multiplying result by a factor of 2.

4. ELECTRICAL CONDUCTIVITY (WATER-SOLUBLE SALTS)

4.4 <u>PSAI</u> - (saturated soil paste extract)

Electrical conductivity is measured on a saturated paste extract.

5. LIME REQUIREMENTS

5.1 Griffin Laboratories - (Shoemaker, McLean and Pratt buffer method)

INTRODUCTION

The lime requirement (LR) of a soil, as measured by most buffer-pH methods, is the amount of liming material required to raise the pH of a plough layer to a desired level.

The lime requirements of mineral soils having 1:2 v/v soil-water pH values that are lower than the desired pH are determined from the relationships between soil - buffer (Shoemaker, McLean, Pratt (SMP))¹ pH values and incubation lime requirement values². Lime requirements of organic soils with water pH values (1:2 v/v soil-water ratio) less than 5.2 are also determined from soil-SMP buffer pH values and incubation lime requirement values³. Lime requirement values in terms of calcium carbonate to achieve pH 5.5, 6.0 and 6.5 for mineral soils and 5.4 for organic soils are given in Part IA.

A volume of soil rather than a weighed sample is used in the laboratory to determine LR although the LR rate obtained through calibration is an absolute measure of the amount of acidity that will be neutralized by calcium carbonate in a given weight of soil. A very high correlation co-efficient between LR of weighed 10 gm samples and the LR of corresponding scooped 10 ml volumes converted to 10 gm sample equivalents allowed the use of a volume measure⁴. Scooping of soils is less time consuming than weighing and is the main reason for its use.

- (2) Tran, T.S. and Van Lierop, W. 1982. Lime requirement determination for attaining pH 5.5 and 6.0 of coarse-textured soils using buffer-pH methods. Soil Sci. Soc. Am. J. 46: 1008-1014.
- (3) Van Lierop, W. 1983. Lime requirement determination of acid organic soils using buffer-pH methods. Can. J. Soil Sci. 63: 431-423.
- (4) Van Lierop, W. 1989. Effect of assumptions on accuracy of analytical results and liming recommendations when testing a volume or weight of soil. Commun. in Soil Sci. Plant Anal., 20(21), 121-137.

Shoemaker, H.E., McLean, E.O. and Pratt, P.F. 1961. Buffer methods for determining lime requirement of soils with appreciable amounts of extractable aluminum. Soil Sci. Soc. Am. Proc. 25: 274-277.

DETERMINATION

Apparatus

pH Meter - Readable to 0.02 pH unit pH indicating electrode (calomel) pH reference electrode (glass)

Reagents

Shoemaker, McLean, Pratt (SMP) buffer - Dissolve in about 800 ml of distilled water using a magnetic stirrer: 1.8 g paranitrophenol, 30 g potassium chromate, 2.0 g calcium acetate, 53.1 g calcium chloride dihydrate, 10 ml of triethanolamine stock solution*. Make to one liter and adjust the pH to 7.5 in either 15% NaOH or 3M HCl.

Verify the buffering capacity of the SMP mixture by titrating 10 m1 of buffer with 0.1M HC1; its capacity should be 0.14 ± 0.003 meq HC1/ pH.

EXAMINATION

A. Mineral Soils

Weigh 10 gm or scoop 10 ml of air dried soil that was ground and passed through a 2mm sieve, into an appropriate container and add 10 ml of distilled water. Stir the soil-water mixture 5 or 6 times with a glass rod during a 30 minute period. Determine soil pH using a checked and calibrated pH meter. Rinse soil particles adhering to the electrodes back into the container with a minimal volume of water. Add 20 ml of SMP buffer to the soil-water mixture when the soil pH is lower than the desired pH and stir with a glass rod. Shake the sample (about 150 cycles/min.) for 15 minutes and then let stand for 15 minutes before reading soil-buffer pH. Measure soil-buffer pH carefully (\pm 0.02 pH unit). Soil lime requirements are obtained from soil-buffer pH values using Table 11 or regression equations given below it in Section IB.

B. Organic Soils

Organic soils are treated as the mineral soils are but lime requirement is determined when soil pH (water) is less than 5.2. Soil lime requirement is obtained from Table 12 or the regression equation below it in Section IB.

^{*} Make a 200 ml stock solution of triethanolamine (TEA) in water by weighing out 56.05 g of TEA and transferring it to a 200 ml volumetric flask and make to volume with distilled water.

Table 1

Relationship between soil-SMP buffer pH values and lime requirement rates to achieve soil pH 5.5, 6.0 and 6.5 for scooped mineral soils.

Soil-SMP B	uffer	Line	Requirer	ent**
pH		5.5	6.0	6.5
6.7		1.0	1.8	2.2
6.6		1.2	2.2	3.0
6.5		1.4	2.6	3.8
6.4		1.7	3.1	4.6
6.3		2.1	3.6	5.5
6.2		2.6	4.2	6.3
6.1		3.1	4.9	7.3
6.0		3.7	5.6	8.2
5.9		4.4	6.4	9.1
5.8		5.2	7.3	10.1
5.7		6.1	8.2	11.1
5.6		7.0	9.1	12.1
5.5		8.1	10.2	13.2
5.4		9.2	11.3	14.2
5.3		10.4	12.5	15.3
5.2		11.6	13.7	16.4
5.1		13.0	15.0	17.6
5.0		14.4	16.4	18.8
4.9		15.9	17.8	19.9
4.8		17.5	19.3	21.1

Scooped Mineral Soils*

Scooped Mineral Soils

$Y(5.5) = 3.988 X^2 - 54.54 + 187.4$	Y = Tonnes CaCO ₃ /ha for surface
	soil of 20 cm.
$Y(6.0) = 3.129 X^2 - 45.17 X + 164$	X = Soll - buffer pH
Y (6.5) = 1.189 X - 23.55 X + 107	

- * For LR determination purposes, mineral and organic soils contain 20% or less, and more than 20% organic matter respectively.
- ** LR rates are expressed in tonnes (1,000 kg) of finely ground limestone, having a neutralizing value of 100% CaCO₃ equivalent, for a furrow depth of 20 cm (2.0 million litres/ha).

Table 2

٠

.

Relationship between soil-SMP buffer pH values and lime requirement rates to achieve soil, pH 5.4 for scooped organic soils.

Soil-SMP Buffer	Lime Requirements
рН	5.4
6.0	0.0
5.9	1.1
5.8	2.3
5.7	3.4
5.6	4.6
5.5	5.7
5.4	6.9
5.3	8.0
5.2	9.2
5.1	10.3
5.0	11.5
4.9	12.7
4.8	13.8
4.7	15.0
4.6	16.1
4.5	17.3
4.4	18.4
4.3	19.6
4.2	20.7
4.1	21.9
4.0	23.1
3.9	24.2
3.8	25.4

SCOOPED ORGANIC SOILS*

Scooped Organic Soils

Y(5,4) = 69.3 - 11.56X

Y = Tonnes $CaCO_3/ha$ for a plow layer depth of 20 cm X = Soil - Buffer pH

5. LIME REQUIREMENTS

.

,*

5.2 Norwest Soil Research - (Shoemaker, McLean and Pratt buffer method)

Lime requirement is determined using the buffer method of Shoemaker, McLean and Pratt and calculations by Van Lierop and Tran.

6.1 <u>Griffin Laboratories</u> - (extractable nitrate)

INTRODUCTION

Nitrate-nitrogen, in most cases, is readily extracted from soil and a solution of 0.25 N acetic acid + 0.015 N ammonium fluoride - the Kelowna extractant - should extract all the nitrate. As the Kelowna extractant is used to extract simultaneously several plant available nutrients, the addition of NO_3 -N to the list reduces the number of extractants used by the laboratory. The concentration of the nitrate is determined colorimetrically as nitrite using an automated copper-cadmium reduction procedure^{1,2}.

PREPARATION OF SAMPLE EXTRACT

Reagents

Extracting Solution: 0.25 N HOAC + 0.015 N NH₄F Stock solutions containing 20 fold concentrations are prepared by dissolving 300 ml glacial acetic acid (5N; sol'n A) and 11.112 g NH₄F (0.30N; Sol'n B) each to a liter. These solutions should be transferred to plastic containers and stored in the refrigerator. Mix and dilute 125 ml each of solutions A and B to 2.5 1 shortly before extracting soils 1,2. This solution is the Kelowna extractant and contains 0.25 N acetic acid and 0.015 N ammonium fluoride.

Extraction

Measure (scoop) 2.5 ml of dried soil, ground to pass a 2 mm mesh sieve, into a container and add 25 ml of the Kelowna extractant (1:10 V/V). Swirl the contents for 5 minutes. Filter and use the extract to determine soil nitrate.

Van Lierop, W. 1986 Soil nitrate determination using the Kelowna multiple element extractant. Comm. in Soil Sci. Plant Anal 17(12), 1311-1329

 ⁽²⁾ Van Lierop, W. 1985. Nitrate and nitrite in soils. Soil Notes.
B.C. Ministry of Agri. and Food, Leaflet #2.

DETERMINATION

Reagents

(a) Ammonium Chloride for Cadmium Reduction Columns

Dissolve 40 g of ammonium chloride in 800 ml of distilled water and adjust the pH of the mixture to 8.5 using ammonium hydroxide. Add 0.5 ml of Brij-35 and make to 1 liter.

(b) Color Reagent

Dissolve, by heating if necessary, 10 g sulfanilamide into 750 ml of distilled water containing 100 ml of conc. phosphoric acid. Subsequently add 0.5 g of N-(1 naphthyl) ethylenediamine dihydrochloride, 0.5 ml Brij-35, dissolve, and make to 1 liter.

(c) Standards

Stock Nitrate Solution:

Dissolve 0.722 g of oven dried potassium nitrate in distilled water and dilute to 1 liter. This solution contains 100 ug $NO_3-N/m1$. Add 1 ml of chloroform and store in a refrigerator.

Stock Nitrite Solution (100 ug $NO_2-N/m1$): Dissolve 0.493 g $NaNO_2$ in distilled water and dilute to one liter.

Apparatus

(a) Reduction Column Preparation

- (i) Cadmium metal is filed with a rasp-cut file and particles sized. Those which pass a 20 but are held on a 40 mesh sieve are utilized in the reduction column.
- (ii) New or used cadmium particles (10 g) are cleaned with 50 ml of 6M HCl for 1 minute. Decant the HCl and wash the cadmium particles further with another 50 ml of 6 M HCl for 1 minute.
- (iii) Decant the HCl and wash the cadmium particles several times with distilled water.
 - (iv) Decant the distilled water and add 50 ml of 2% CuSO₄ 5H₂O. Wash the cadmium with distilled water until no blue color remains in the wash solution.

- (v) Fill the reductor columns with ammonium chloride reagent and transfer the prepared cadmium particles to the column using a dropping pipette. Ensure that no air bubbles are trapped in the column while filling. Although a commercial reductor can be utilized (Technicon part #189-000), a 14-inch length of 0.081" I.D. tygon tubing (a purple/purple peristaltic pumping tube) is used in the laboratory.
- (vi) The reductor column should be conditioned by passing 100 ug $NO_3-N/m1$ for 5 minutes followed by 100 ug $NO_2-N/m1$ for 10 minutes before utilization.
- (vii) Reduction efficiency can be checked by analyzing 10 ug N/m1 nitrite and nitrate standards. Peak heights are identical at 100% recovery.
- (b) Technicon Auto Analyzer

Operating Notes

- (i) The wash receptacle on the sampler should contain the Kelowna extractant.
- (ii) Nitrate standards should be prepared in the Kelowna extractant.
- (iii) When samples containing between 0-1 ug NO₃-N/ml are analyzed, the dilution loop can be omitted to increase the sensitivity. The resample line should then be connected directly to the sampler.
- (iv) Distilled water for the dilution loop should contain 1 ml of Brij-35 per liter.
- (v) Nitrite is analyzed by eliminating the reductor column and standardizing the colorimeter with a suitable standard. In order to obtain the exact nitrate values in soils the nitrite concentration should be subtracted. However, for routine analysis it is assumed that nitrite concentrations in soils are negligible.

EXAMINATION OF SAMPLE EXTRACT

Starting Analysis

(a) Ensure the adequacy of reagent supplies. This is very important as exposing the reductor column to air will destroy its reduction capability.

- (b) Place lines in their respective containers and start the proportioning pump. At this stage a length of 0.081" diameter tubing should be used instead of the reduction column.
- (c) When the ammonium chloride reagent reaches the end of fitting A2 (Fig. 1) connect the reductor column being careful to avoid air bubbles.
- (d) Allow the system to stabilize.

Stopping Analysis

- (a) Momentarily stop the proportioning pump to remove the reduction column. Clamp the ends of the reduction column and connecting lines to prevent loss of ammonium chloride reagent or air entering the reduction column. Replace the reduction column with a section of 0.081" diameter tubing.
- (b) Start the proportioning pump and place all reagent lines in distilled water containing 1 ml Brij-35/liter.
- (c) Run the rinsing cycle for 10 minutes to clean the manifold, stop pump and remove platen.
- (d) Ease tension on the pumping tubes by releasing one of the manifold blocks.

Range: 0.5-25 ugN/ml





NOTE: Figures in Parentheses Signify Flow Rates in mL/MIN.

★ 0.034 Polyethylene

FIGURE ----AUTOANALYZER ARRANGEMENT FOR NITRATE AND/OR NITRITE DETERMINATION IN SOIL AND PLANT EXTRACTS

۰÷

6.2 <u>Norwest Soil Research</u> - (extractable nitrate and ammonium)

Available nitrogen (ammonium and nitrate) are determined by extraction with lM potassium chloride at an extraction ratio of 1:10 w/v. Ammonium is measured by Technicon using sodium phenate/hypochlorite/potassium sodium tartrate colour reaction. Nitrate is determined by cadmium reduction and colour reaction with sulphanilamide and naphthylethylene diamine.

•

6.3 <u>PSAI</u> - (Total Nitrogen)

Total Nitrogen is determined colorimetrically using a Technicon AutoAnalyzer on a semi-micro Kjeldahl digest.

.

·*

6.4 <u>PSAI</u> - (extractable nitrate and ammonium)

Available ammonia and nitrate are determined colorimetrically on a 0.5 N $\rm K_2SO_4$ extract.

.

7. PHOSPHORUS (P)

7.1 Griffin Laboratories - (extractable phosphorus by Kelowna extractant)

INTRODUCTION

Phosphorus is extracted from dry soil samples with 0.25N acetic and 0.015 N ammonium fluoride¹ (Kelowna extractant). The Kelowna extractant was chosen to extract P over previously used Olsen and Bray - P-1 extractants. It was found to be equal to the Olsen but more accurate than the Bray P-1 in predicting P availability on a wide range of soil pH values¹. In addition the Kelowna extractant is capable of simultaneously extracting other plant nutrients in amounts that are directly related to their availabilities.

PREPARATION OF SAMPLE EXTRACT

Reagents

Extracting Solution: 0.25 N HOAC + 0.015 N NH₄F

To prepare two stock solutions A and B, dissolve 300 g glacial acetic acid in double distilled water and dilute to 1 liter (Sol'n A) and 11.112 g of NH_4F also in double distilled water and dilute to 1 1 (Sol'n B). Mix 50 ml of solution A with 50 ml of solution B and dilute to 1 liter. This dilution is the Kelowna extractant and contains 0.25N acetic acid and 0.015 N ammonium fluoride.

Extraction

Transfer a 2.5 ml scoop of dried soils, ground to pass a 2mm mesh sieve into each container on a shaking tray. Add 25 ml of extracting solution to each soil sample (soil:solution ratio = 1:10 v/v). Shake soil-solution mixtures for 5 minutes at about 180 oscillations per minute. Filter into test tubes.

DETERMINATION

(a) Apparatus

Inductively coupled argon plasma spectrophotometer - ARL 34000.

(b) Standardization of ICP

The plasma is ignited about 30 minutes prior to standards being entered. The instrument is standardized (with a full set of standards) each time it is used rather than normalized (which uses only the high and low from each group of elements). Standards are multi-element in non-interfering groups. For example, Ca, Mg and Na; and B, Cu, Fe, Mn and Zn are two groups. S,K and P are done as single elements. The spectral line used for the determination of P has a wave length of 178.29 nm.

Van Lierop, W. 1989. Determination of available phosphorus in acid and calcareous soils with the Kelowna multi-element extractant. Soil Sci. Vol 146, No₄, 284-291.
(c) Examination of Sample Filtrate

Sample solutions are drawn into the machine using a standard Meinhard nebulizer. There is a 30 second pre-flush period, followed by three 10 second integration periods. Sample uptake is approximately 2.5 ml/min.

(d) Calculation of Results

The ICP computer averages integration and plots them on a curve made from standard readings. Results are then printed for millivolt intensity, concentration of solution (ppm), final results (which uses dilution ratio entered for each sample) and standard deviation for 3 integrations. P is reported to clients as ug/ml instead of ppm.

7.2 <u>Norwest Soil Research</u> - (extractable phosphorus by 0.03 N NH₄F+ 0.025 N HCl)

Determined by extraction with 0.03 N ammonium fluoride/0.025 N hydrochloric acid at a 1:10 w/v extraction ratio. Phosphorus measured colorimetrically by Technicon autoanalyzer using ammonium molybdate/antimony potassium tartrate/ascorbic acid reagent.

٠

.,•

ſ,

×

7.2 <u>PSAI</u> - (extractable phosphorus by Bray - IP)

. ·

.

•

7.3 <u>PSAI</u> - (extractable phosphorus by Olsen extract)

۳

۰**۱**

7.4 <u>PSAI</u> - (extractable phosphorus by Mehlich extract)

`

8. POTASSIUM, CALCIUM, MAGNESIUM, SODIUM, SULPHUR

8.1 <u>Griffin Laboratories</u> - (extractable K, Ca, Mg, Na by the Kelowna extractant)

INTRODUCTION

Potassium, calcium, magnesium, and sodium are extracted simultaneously from dry soil samples with the Kelowna extractant. Levels of K removed with this multi-element extractant at 1:10 v/v soil-extractant ratio for 5 minutes at about 180 oscillations per minute generally produce concentrations that are 20% less than the concentrations extracted with 1N NH₄Ac, pH 7.0 at 1:10 v/v soil solution ratio and 1 minute extraction time¹. Sodium values tend to be similar for both extractants.

PREPARATION OF SAMPLE EXTRACT

Reagents

Extracting Solution: 0.25 N HOAc + 0.015 N NH4F

Prepare two stock solutions by dissolving and diluting with double distilled water 300 g of glacial acetic acid and 11.112 g of NH_4F each to 1 liter. Mix 50 ml of acetic acid solution and 50 ml of the ammonium fluoride solution and dilute to 1 liter. This solution is the Kelowna extractant and contains 0.25 N acetic acid and 0.015 N ammonium fluoride.

Extraction

Transfer a 2.5 ml scoop of dried soils, ground to pass a 2 mm mesh sieve into each container on a shaking tray. Add 25 ml of extracting solution to each soil sample (soil:solution ratio = 1:10 v/v). Shake soilsolution mixtures for 5 minutes at about 180 oscillations per minute. Filter into test tubes.

Van Lierop, W. 1989. Extraction of potassium and sodium from acid and calcareous soils with Kelowna multiple element extractant. Can. J. Soil Sci. 69:235-242.

DETERMINATION

۰,

Extractable K, Ca, Mg and Na are determined with the ARL Model 34000 inductively coupled argon plasma spectrophotometer at spectral lines of 766.49, 317.93, 279.08, 589.59, nm respectively. Concentrations are reported in ug/ml. For the standardization of the apparatus, examination of the filtrate and calculation of results by the ICP see the procedure on soil phosphorus analysis.

8. POTASSIUM, CALCIUM, MAGNESIUM, SODIUM

8.2 Norwest Soil Research - (extractable K, Ca, Mg, Na by 1 M NH4Ac)

Exchangeable calcium, magnesium, potassium, and sodium are determined by extraction with 1M neutral ammonium acetate at 1:5 w/v extraction ratio. The individual cations are measured by atomic absorption spectrophotometry.

8. POTASSIUM, CALCIUM, MAGNESIUM, SODIUM

^

8.3 <u>PSAI</u> - (extractable K, Ca, Mg, Na by ammonium acetate)

Available Ca, Mg, K, Na are determined by Perkin-Elmer Atomic Absorption spectrophotometer on 1:5 soil to ammonium acetate.

8. POTASSIUM, CALCIUM, MAGNESIUM, SOLIUM

8.4 PSAI - (extractable K, Ca, Mg, Na by Morgan extract)

Available Ca, Mg, K, Na are determined by Perkin-Elmer Atomic Absorption spectrophotometer on 1:5 soil to Morgan extract.

9.1 Griffin Laboratories - (extractable sulphur by the Kelowna extractant)

Introduction

, ι

Sulphur is extracted from dry soil samples with the Kelowna extractant levels of S removed with this multi-element extractant at 1:10 v/v soil-extractant ratio for 5 minutes at about 180 oscillations per minute are approximately twice as much as amounts removed by the previously used 0.1M Ca Cl₂ at a 1:2 v/v soil-solution ratio and 30 minute extraction time and analyzed by the hydriodic-hypophosphorus, formic acid mixture reduction procedure.

PREPARATION OF SAMPLE EXTRACT

Reagents

Extracting Solution: 0.25 N HOAC + 0.015 N NH4F

Prepare two stock solutions by dissolving and diluting with double distilled water 300 g of glacial acetic acid and 11.112 g NH_4F each to 1 liter. Mix 50 ml of acetic acid solution and 50 ml of the ammonium fluoride solution and dilute to 1 liter. This solution is the Kelowna extractant and contains 0.25 N. acetic acid and 0.015 N ammonium fluoride.

Extraction

Transfer a 2.5 ml scoop of dried soils, ground to pass 2 mm mesh sieve into each container on a shaking tray. Add 25 mL of extracting solution to each soil sample (soil:solution ratio = 1:10 v/v). Shake soil-solution mixtures for 5 minutes at about 180 oscillations per minute. Filter into test tubes.

DETERMINATION

Extractable S is determined with the ARL Model 34000 inductively coupled argon plasma spectrophotometer at a spectral line of 180.73 nm. Concentrations are reported in ug/ml. For the standardization of the appartus, examination of the filtrate and calculation of results by the ICP see procedure on soil phosphorus analysis.

9.2 Norwest Soil Research - (extractable sulphate by 0.01 M CaCl₂)

Sulphate is determined by extraction with 0.01 M calcium chloride at a 1.2 w/v extraction ratio. The sulphte is measured turbidmetrically.

•

۰.

9.3 PSAI - (extractable sulphate by CaCl₂)

Available sulphate-sulphur is determined using the HI-Bismuth reducable method on a 1:2 soil to calcium chloride extract.

9.4 PSAI - (total sulphur)

Total sulphur is determined on a LECO Sulphur Analyzer.

10. ZINC, IRON, MANGANESE, COPPER

10.1 Griffin Laboratories - (DTPA-TEA extractable Zn, Fe, Mn, Cu)

INTRODUCTION

Diethylene triamine pentacetic acid (DTPA), a chelating agent, extracts simultaneously plant available zinc, iron, manganese and copper¹ and their concentrations are determined by emmission spectroscopy.

PREPARATION OF SAMPLE EXTRACT

Reagents

Extracting Solution: DTPA

The DTPA extracting solution is prepared so as to contain 0.005M DTPA, 0.01 M CaCl₂ and 0.1M TEA and is adjusted to pH 7.30. Ten litres of this solution is prepared by dissolving 149.2 g of reagent grade triethanalamine (TEA), 19.67 g DTPA and 14.7 g CaCl₂.2H₂O in 200 ml of distilled water. The mixture is diluted to 9 litres. Adjust the pH to 7.30 + 0.05 with 6 M HCl and dilute to 10 litres.

Extraction

Scoop 8.5 ml of air dried soils, ground to pass a 2 mm mesh sieve, into 50 ml erlenmeyer flasks. Add 17 ml of DTPA extracting solution. Shake for 2 hours and then filter suspension through Whatman No. 42 filter paper. Collect the filtrate and analyze for zinc, iron, manganese and copper.

DETERMINATION

Extractable Zn, Fe, Mn and Cu are determined with the ARL Model 34000 inductively coupled argon plasma spectrophotometer at spectral lines of 213.94, 259.94, 257.61 and 324.75 um respectively. Concentrations are reported in ug/ml. For the standardization of the apparatus, examination of the filtrate and calculation of results by the ICP, see the procedure on soil phosphorus analysis.

^{1.} Lindsay, W.L. and W.A. Norvell 1978. Development of a DTPA soil test for zinc, iron, manganese and copper. Soil Sci. Am. J. 42: 421-428

10. ZINC, IRON, MANGANESE, COPPER

10.2 Norwest Soil Research - (DTPA - TEA extractable Zn, Fe, Mn, Cu)

Zinc, iron, copper and manganese are determined by extraction with DTPA-TEA solution at an extraction ratio of 1:2 w/v. Individual cations are measured by atomic absorption spectrophotometry.

10. ZINC, IRON, MANGANESE, COPPER

10.3 PSAI - (0.1 N HCl extract)

t

•

.

Available Cu, Zn, Fe and Mn are determined by A.A. on a 1:5 soil to 0.1 N HCl extract.

...

11. BORON

11.1 Griffin Laboratories

INTRODUCTION

The boron extracted by boiling soil in water for 5 minutes is of the free form and is not complexed with organic matter. Significantly higher quantities of boron might be obtained with longer boiling times. Such boron is usually held in organic matter¹. The concentration of boron is measured spectrophotometrically as the yellow colored complex formed with azomethine-H².

PREPARATION OF SAMPLE EXTRACT

Apparatus

Vortex stirer Taylor tubes

Extracting Mineral and Organic Soil Samples

Weigh 7.5 g of dried mineral or 3.75 g of dried organic soils into Taylor tubes. Add 15 ml of double distilled water into the tubes and stir them using a Vortex stirer. Boil samples for exactly 5 minutes on an aluminum block at 140°C. After boiling for 5 minutes transfer samples to a cold water bath. Add about 2.5 cc of activated carbon to the sample. Stir the samples using a vortex stirrer. Filter the samples through Whatman No. 42, 11 cm filter papers into 16 X 100 cm test tubes. All glassware should be weathered in HCl and rinsed thoroughly.

DETERMINATION

Apparatus

Colorimeter - L.K.B Model 2074 Calculating Absorption Meter

Reagents

(i) Buffer-EDTA Complexing Solution:

Dissolve 1,000 g of ammonium acetate and 60 g of ethylenedinitrilo-tetra acetic acid disodium salt (EDTA) in 1600 ml of double distilled water. Next slowly add 500 ml of glacial acetic acid.

- 1. Gupta U.C. 1967. A simplified method for determining hot water-soluble boron in podzol soils. Soil Sci. 103: 424-428
- John, M.K., Chuah, H.H., and Neufeld, J.H. 1975. Application of improved azomethine-H method to the determination of boron in soils and plants. Anal. Lett. 8(8) 5590568

(ii) Azomethine - H (Color Developer):

Dissolve 0.45 g of azomethine-H and 1.00 g ascorbic acid in about 80 ml of double distilled water. Make up to final volume of 100 ml with double distilled water.

(iii) Standards:

. .

For a 100 ppm stock solution, dissolve 0.5716 gm of dried boric acid into about 800 ml of double distilled water. Make to a final volume of 1000 ml.

EXAMINATION OF SAMPLE EXTRACT

To 0.50 ml of sample, blank and standard solutions of 0.25 ppm to 1.50 ppm pipetted into L.K.B. polystyrene tubes add 1 ml of buffer - EDTA complexing solution and 1 ml of azomethine-H reagent. The reaction mixture is stirred thoroughly then allowed to stand for 20 minutes. Absorbance at 416 nm is measured with L.K.B. colorimeter. Results are printed out on the teletype.

11. BORON

11.2 Norwest Soil Research -(hot water soluble boron - azomethine-H method)

Boron is determined by hot water extraction at an extraction ratio of 1:4 w/v. Boron is measured colorimetrically by azomethine-H with a technicon autoanalyzer.

11. BORON

+

* •

11.3 <u>PSAI</u> - (hot water soluble boron - azomethine-H method)

Available boron is determined colorimetirically on a hot water soluble extract using the azomethine-H method.

SOILS

PART I-B

INTERPRETATION OF SOIL TEST RESULTS

AND FERTILIZER RECOMMENDATION TO PRODUCE

MAXIMUM ECONOMIC YIELD FOR FIELD VEGETABLES, TREE FRUITS, BERRIES AND GRAPES

TRANT P	
TADLE	
	_

			·····		P20	5 Recommended (Rec)	kg/	ha		
Soil Test	L	Crop Group* 1		Crop Group 2		Crop Group 3		Crop Group 4	Cn	op Group 5
ug/ml 0-15 cm "Kelowna" extractar	2t	Tree Fruits: Apple, Apricot, Cherry, Peach, Pear, Pium		Barley, Oats, Rye, Wheat (Spring & Winter)		Grasses, Flax, Repessed, Canola, Mustard, Alsike clover, Birds foot trefoil, Crimson clover, Red clover, Grass-Legume (10-502)		Alfalfa, White clover, Sweet clover, Peas, Beans (bush & pole), Lettuce, Spinach, Corn, Soybeans, Cucumbers, Eggplant, Marrow, Muskmellon, Pumpkins, Squash Grass-legume (>50%)	Co Ber Pai Bu Bu Sw Ga Ga Fr	le Crops, hts, Carrots, rsnip, Radishes, rnips, Asparagum, lbs, Celery, set Corn, Onions, rlic, Peppers, apes, Small wits, Potatoes
	Bat,	, Bec,	Rat,	Bec,	Bat,	Rec,	Rat	. <u>Rec</u> .	Rat,	Bec.
5	٧٦.	PI	VI.	120	VI.	140	VI.	170	VI.	200
10	L	P1	L-	100	L-	120	L-	140	L-	170
15	L+	P1	L	80	Ē	100	Ľ	120	Ē	144
20	M	P1	L+	60	Ľ+	80	L+	100	L+	100
25	M+	21	M-	40	M-	60	M-	80	H	80
30	Н-	0	м	30	M	60	H	60	M	60
40	н	Ō	H+	20	M+	30	M+	40	M+	50
50	H+	Ö	H	15	H	20	H	30	H-	40
75	H+	0	H	15	X	20	н	30	н	40
100	8+	0	H+	15	H+	20	H+	30	H+	40
999	VH	0	vu	0	1/10	<u> </u>	1/12	~	1.017	0

Recommended Phosphorum (P205) Applications based on Soil Test Phosphorum (P) Values for Vancouver Island, Lover Mainland, Okanagan, Kootenays, Kamloops, Williams Lake and Quesnel

P1 - A phosphorus recommendation is made only for orchards that are about to be planted. The P_{205} is applied as 11-55-0 at a rate of 150 g/100 1 of soil that is placed in the planting hole of young trees. $P_{205} \ge 0.44 = P$ or $P \ge 2.29 = P_{205}$.

* Crop Group - A number of crops that have similar P requirements.

Soil Test Rating (Rat.)

- VL Large economical response to fertilizer nutrient.
- L Moderate economical response.
- M Small economical response.
- H No immediate response. The suggested rate of fertilization is intended to maintain soil phosphorus fertility.
- VH No response.

	P ₂ 0 ₅ Recommended (Rec.) kg/ha									
Soil Test P		Crop Group* 1	<u> </u>	Crop Group 2		Crop Group 3		Crop Group 4	Cx	rop Group 5
ug/ml 0-15 cm "Kelowna" extractant	:	Barley, Oats Rye, Grasses, Grass seed		Grass-Legume, (10-50%) Wheat		Flax, Rapeseed, Canola, Mustard, Alfalfa (estab- lished), Alsike clover, Birdsfoot trefoil, Crimson clover, Red clover, established Grass- Legume (>50%)		Beans, Sweet corn, Cucumbers, Lettuce, Marrow, Musicaelons, Peas (processing), Pumpkins Spinach, Squash, Corn, Egg- plants, Alfalfa (new), White clover, Sweet clover, Vetch, Soy- beans, new Grass-Legume (>501)	Sa Tu Co Ca Ra Ce Ga Pe	all Fruits, arf, Potatoes, timeral & Organic), ble Crops, Beets, arrots, Parsnips, dishes, Turnips, paragus, Bulbs, blery, Egsplants, arlic, Hops, Onions, ppers, Rhubarb, matoes
	Rat	, Bec.	Rat,	Bec.	Rat	. Rec.	Ba	t, Rec,	Rat.	Rec,
5	VL.	80	VL.	100	VL.	120	VL.	140	VL.	160
10	VL	80	VL	90	VL.	100	VI.	130	VL.	140
15	L-	70	L-	80	L-	90	L-	120	L-	120
20	L	60	L	70	L	80	L	100	L,	100
25	L+	50	Ľ+	60	L+	70	L+	90	L+	90
30	M	40	M-	50	M	60	M	80	M	80
40	M	30	M	40	M	50	M	70	M	70
50	M+	20	M+	30	M+	40	Н+	60	M+	60
60	H-	15	H	20	H	30	H-	40	Н	50
75	H	15	н	20	H	30	н	40	H	50
100	H+	15	H+ .	20	H+	30	H+	40	H+	50
999	VH	0	VH	0	УН	0	VH	0	VH	0

Recommended Phosphorus (P₂0₅) Applications based on Soil Test Phosphorus (P) Values for McBride, Prince George, Vanderhoof and Smithers

Soil Test Rating (Rat.)

VL - Large economical response to fertilizer nutrient.

L - Moderate economical response.

M - Small economical response.

H - No immediate response. The suggested rate of fertilization is intended to maintain soil phosphorus fertility.

VH - No response.

 $P_2O_5 \ge 0.44 = P \text{ or } P \ge 2.29 = P_2O_5$

* Crop Group - A number of crops that have similar P requirements.

		·····			P205 R	ecommended (Rec.)	kg/ha	and a the second se	<u> </u>	
Soil Test P	Cr	op Group* 1	C	rop Group 2	Cr	op Group 3	Crop	Group 4	Crop	Group 5
ug/ml 0-15 cm	G rass seed, Grasses, Barley, Oats, Rye, Wheat		Flax, Rape- seed, Mustard, Canola, Grass- Legume (10-50X legume)		Peas(dry), Soy- beans, Alfalfa (established), Alsike clover, Birdsfoot Trefoil, Crimson clover, Red clover, esta- blished Grass- Legume (>50%)		Beans, Sweet corm, Gucumbers, Lettuce, Marrow, Muskmelons, Peas (processing), Pumpkins, Spinach, Squash, Corn, Egg plants, Alfalfa (new), White clover, Sweet clover, Vetch, Soybeans New Grass-Legume (>50%)		Small Fruits, Turf, Potatoes, (Organic & Irrigated) Cole Crops, Beets, Carrots, Parsnips, Radisbes, Turaips, Asparagus, Bulbs, Celery, Egglants, Garlic, Hops, Onions, Peppers, Rhubarb.	
	Rat,	Rec,	Rat,	Rec,	Rat,	Rec.	Rat,	Bec,	Rat.	Rec,
5	VL.	80	VL.	100	VL:	120	VL.	140	VL.	160
10	VL.	80	VL.	90	VL.	100	VL.	130	VL.	140
15	L-	70	L	80	L-	90	L-	120	L-	120
20	L	60	L	70	L	80	L	100	L	100
25	L+	50	L+	60	L+	70	L+	90	L+	90
30	M	40	M	50	M	60	M	80	M	80
40	м	30	м	40	M	50	M	70	M	70
50	M+	20	M+	30	M+	40	н	60	M+	60
60	Н-	15	Н-	20	H	30	H	40	H	50
75	H	15	н	20	н	30	н	40	н	50
100	H+	15	R+	20	H+	30	H+	40	H+	50
999	VH	0	VH	0	VH	0	VH	G	VH	0

Recommended Phosphorus $(P_{2}O_{5})$ Applications based on Soil Test Phosphorus (P) Values for the Peace River

Soil Test Rating (Rat.)

VL - Large economical response to fertilizer nutrient.

L - Moderate economical response.

M - Small economical response.

H - No immediate response. The suggested rate of fertilization is intended to maintain soil phosphorus fertility.

VH - No response.

P205 x 0.44 = P or P x 2.29 = P205

* Crop Group - A number of crops that have similar P requirements.

· .

					K20 Re	commended (Rec.) kg/ha	*****			
oil Test K	Cro	Crop Group* 1 Crop Group 2		rop Group 2	Cro	Crop Group 3 Crop Group 4			Crop Group 5		
K ug/ml 0-15 cm "Kelowna" extractant	Tre App Che Pea	e Pruits: le, Apricot, rry, Peach, r, Plum	Ba R) (S	nriey, Oats, re, Wheat, Spring £ Minter)	Gra Rap Can	sses, flax, eseed, ola, Hustard	Alfal Peas, pole Spins Alsi foot clove Sweet	fa, White clover, , Beans (bush &), Corn, Lettuce, ach, Grass-Legume, te clover, Birds- trefoil, Crimson er, Red clover, : clover, Soybeans	Turf, Beets Parsn Turni Bulbs Husks plant Onion Marro Grape Potat Squas	Cole Crops, , Carrots, ip, Radishes, ps, Asparagus, , Celery, elons, Egr- s, Cucumbers, s, Garlic, w, Peppers, , Small Fruits, oes, Pumpkis, h. Tomatoes	
	Rat,	Bec.	Rat,	Rec,	Rat.	Rec.	Ret.	Rec.	Rat.	Rec.	
25	L	K1	VL.	150	VL.	200	VL.	200	VL.	250	
35	L	K1	L-	100	L-	150	VL.	200	VL	250	
50	L+	K1	L	80	L	100	L-	200	٧L	250	
65	M-	K1	L+	60	L+	80	L	150	Ն-	250	
80	M	K1	M-	40	M-	60	L+	100	L	200	
100	M+	К1	M	30	м	40	M	80	ն+	150	
125	M+	К1	M+	30	H+	40	M	60	M	100	
150	н-	0	н	20	н	20	м	60	M	80	
175	н	0	H-	20	н-	20	н-	40	M+	60	
190	H+	0	H	20	H	20	н	40	н-	40	
220	VH	0	н	20	H	20	н	40	н	40	
250	VH	0	Н+	20	H+	20	H+	40	H+	40	
9999	VN	0	VH	A	VU	0	VII	0	570	0	

Recommended Potassium (K_20) Applications based on Soil Test Potassium (K) Values for Vancouver Island and the Lower Mainland

Soil Test Rating (Rat.)

VL - Large economical response to fertilizer nutrient.

L - Moderate economical response.

M - Small economical response.

H - No immediate response. The suggested rate of fertilization is intended to maintain soil potassium fertility.

4

VH - No response.

K1 - 250 lb. K2 0/ac gre recommended for soils testing low or medium in K.

 $K_{2}0 \ge 0.83 = K \text{ or } K \ge 1.20 = K_{2}0$

* Crop Group - A number of crops that have similar K requirements.

Recommended Potassium (K₂O) Applications based on Soil Test Potassium (K) Values for the Okanagan, the Kootenays, Kamloops, Williams Lake and Quesnel

<u> </u>			**************************************		K20 Re	commended (Rec.) kg/ha				
oil Test K	Cro	op Group* 1		Crop Group 2	Cı	rop Group 3	Cro	p Group 4	Crop Group 5		
K ug/ml 0-15 cm "Kelowna" extractant	Tro Apj Cho Per	ee Fruits: ole, Apricot, erry, Peach, ar, Plum	84 R; (;	arley, Oats, ye, Wheat, Spring & Winter)	Gra Raj Car	uses, Flax, pesced, pola, Mustard	Alfa Alsi foot clov Swee Beau Corn Gras	lfa, White clover, ke clover, Birds- trefoil, Crimson er, Red clover, t clover, Soybeans, t clover, Soybeans, s (bush & pole), , Lettuce, Spinach, s-legume	Turf, Beets, Parsnij Turnip Bulbs, Muskme: plants, Onions, Marrow, Grape, Potato Squash	Cole crops, Carrots, p, Badishes, s, Asparagus, Celery, lons, Egg- , Cucumbers, , Garlic, , Peppers, Small Fruits, es, Pumpkin, , Tomatoes	
	Rat,	Rec.	Rat,	Bec.	Rat,	Rec.	Rat,	Rec.	Rat,	Bec.	
25	L-	K1	VI.	150	VL.	200	VI.	200	VL	250	
35	L	K1	L-	100	L	150	VL	200	VL.	250	
50	L+	K1	L	80	L	100	L	200	VL.	250	
65	M-	K1	L+	60	ե+	80	L	150	L-	250	
80	M	K1	M	40	M	60	L+	100	L	200	
100	M+	K1	M	30	M	40	M	80	Ľ+	150	
125	M+	К1	M+	30	M+	40	м	60	M	100	
150	н⊸	0	H-	20	H-	20	Н+	60	м	80	
160	H	0	H	20	H	20	H	40	H+	60	
175	H+	0	H+	20	H+	20	H	40	H-	40	
190	VH	0	VH	0	VK	0	H+	40	H	40	
220	VH	0	VH	0	VH	0	VH	0	н	40	
250	VH	0	VH	0	VH	0	VN	0	VH	0	
9999	VH	0	VH	0	VH	n	VH	0	VH	0	

Soil Test Rating (Rat.)

VL - Large economical response to fertilizer nutrient.

L - Moderate economical response.

M - Small economical response.

H - No immediate response. The suggested rate of fertilization is intended to maintain soil fertility.

VH - No response.

K1 - 250 1b. K20/ac are recommended for soils testing low or medium in K.

 $K_20 \ge 0.83 = K \text{ or } K \ge 1.20 = K_20$

* Crop Group - A number of crops that have similar K requirements.

		<u></u>			K20 R	commended (Rec.)	Kg/ha		<u>, , , , , , , , , , , , , , , , , , , </u>		
Soil Test K	Cru	op Group* 1	(Crop Group 2	Cı	rop Group 3	Crop	Group 4	Crop Group 5		
ugʻal 0-15 cm "Kelowna" extractant	Gri	Grasses		Barley, Oats, Wheat, Rye, Grass-legume (10-50% legume), Flax, Rape seed, Canola		Alfalfa, Alsike clover, Birds foot trefoil, Crimmon clover, Red clover, White clover, Sweet clover, Vetch Soybeans, Grans legume (>50%)		Beans, Corn, Lettuce, Spinach, Peas, Potatoes (non irrigated)		Small Fruits, Turf, Potatoes (irrigated organ- ics), Cole Crops, Beets, Carrots, Parsnips, Radisbes, Turnips, Asparagus, Bulbs, Celery, Corn, Cucumbers, Egglants, Garlic, Marrow, Musk- melons, Onions, Pepperi Pumpkins, Rhubarb, Squash, Tomatoes	
	Rat.	Rec.	Rat,	Rec.	Bat.	Rec.	Rat.	Rec.	Rat,	Rec,	
25	L	100	VL.	125	VL.	150	٧L	200	VL.	250	
35	Ē	80	L-	100	L-	125	L-	150	le-	200	
50	- L+	60	Ē	80	r.	100	- L	125	ī.	150	
65	M	40		60		80	м	100		125	
80	M	30	M	50	Ň	60	M	80	M	100	
100	 M+	30	 M+	50	 ₩+	50	 M+	60	M Star	80	
125	H-	20	H-	30	H	40	M+	40	 M4	60	
150	н	15	н	30	н	40	К	40	H .	40	
175	H+	15	 H+	30		40	 H+	40		40	
999	VH	0	VH	0	VH	0	11. VH	40	NH VH	10	

Recommended Potassium (K₂O) Applications based on Soil Test Potassium (K) values for McBride, Prince George, Vanderhoof, Smithers and Peace River

TABLE 8

Soil Test Rating (Rat,)

VL - Large economical response to fertilizer nutrient.

L - Moderate economical response.

M - Small economical response.

H - No immediate response. The suggested rate of fertilization is intended to maintain soil fertility.

VH - No response.

 $K_{2}0 \times 0.83 = K \text{ or } K \times 1.20 = K_{2}0$

* Crop Group - A number of crops that have similar K requirements.

Table 9

Magnesium (Mg) recommendations for several crops and all areas based on magnesium soil test values:

Soil Test Mg ug/ml	Crop G	roup A*	Crop Group B**			
0-15 cm "Kelowna" extractant	Rating	Recommended Mg kg/ha	Rating	Recommended Mg Kg/ha		
0-25	VL	40	VL.	40		
26-50	L	25	М	25		
51-100	М	25	Н	0		
101-150	Н	0				
151-250	VH					

Soil Test Rating

- VL Large economical response to fertilizer nutrient
- L Moderate economical response
- M Small economical response
- H No immediate response
- VH No response
- * Crops having similar Mg requirements asparagus, beans, bulbs, celery, corn (sweet), cucumbers, eggplants, garlic, hops, lettuce, marrow, onions, peas, peppers, pumpkins, rhubarb, spinach, squash, rapeseed, canola, muskmellons, grape, blueberry, cranberry, loganberry, raspberry, strawberry, broccoli, brussel sprouts, cabbage, cauliflower, kale, kohlrabi, beets, carrots, parsnips, radishes, turnips, tomatoes, legumes, mustard, soybeans.
- ** Crops having similar Mg requirements apple, apricot, cherry, peach, pear, plum, grass, flax, rye, airport green, golf green, landscaping lawn, bowling garden, turf farm, potatoes, cereals.

Sulphur (S) recommendations for all crops and areas based on soil sulphur levels.

Soil Test S ug/ml 0-15 cm Expected Response Recommended "Kelowna" to Fertilizer S extractant Rating Nutrient kg/ha 0-10 VL 30 Large economical response 11-20 Moderate economical response 20 L 21-35 Μ Small economical response 10 26-35 Н No immediate response 0 36+ VL No response 0

Recommended Boron (B) Applications for all Crops and Areas based on Soil Test Boron

			B Recommended kg/h		
Soil Test B	Crop Group A	Crop Group 8	Crop Group B ₂	Crop Group C	Crop Group D
ug/ml	Beans	Turf farm	Apricot, Peach	Blueberry, Cranberry,	Cherry, Apple, Pear
U~15 CM Hot water extractant	Gucunde FS	Airport green Landscape lawn Blowling green Potatoes Marrow, Peas Pumpkins, Squash Cereals, Grass Rye	Plum, Prune-plum, Grape	Loganberry, Raspberry, Strawberry, Carrots, Parsnips, Radisbes, Asparagus, Bulbs, Celery, Corn, Eggplants, Garlic, Onions, Hops, Lettuce, Huskmelons, Peppers, Rhubarb, Spiusch, Tomstoes, Flax, Canols, Rapeseed, Hustard, Soybeans	Cole Crops, Kale, Kohlrabi, Beets, Turaips, Alfalfa, Alsike clover, Birdsfoot trefoil, Crimson clover, Red clover, White clover, Sweet clover, Vetch
<0.20	1	1	3	3	5
0.21-0.40	0	1	2	2	4
0.41-0.60	0	0	1	1	3
0.61-0.80	0	0	0	1	3
0.81-1.00	0	0	0	• 0	2
<1.00	0	0	0	0	0

-1811-18-

,

Zinc (Zn) and Copper (Cu) recommendations for all crops and areas based on soil test values.

Soil Test ug/ml O-15 cm DTPA		
<u>ext</u>	ractant	Recommendations
Zn Cu	<1.0 <0.3	10 kg/ha Zn as zinc sulphate 5 kg/ha Cu as copper sulphate

•

PLANT MATERIAL

PART II A

SAMPLE COLLECTION AND LABORATORY PREPARATION

Griffin Laboratories

INTRODUCTION

The main purposes of plant tissue analysis are to diagnose nutrient deficiency and toxicity and to guide fertilizer and soil management practices. To provide reference levels of nutrient concentrations required to accomplish the above purposes, the plant part selected for analysis should reflect the nutritional status (health) of the plant for most or all of the growing season¹.

PROCEDURE

1. Sampling

(a) Representative Samples

The sample submitted to the laboratory must be representative of the field from which it was collected. It is important to select a specific part at a definite location on the plant at a definite stage of growth.

When the purpose for sampling is the diagnosis or verification of deficiency or toxicity symptoms, the sample should represent the range of symptoms related to the nutritional disorder. A comparison of chemical analyses of a similar plant part from a normal plant can aid in the interpretation. Plant tissue from healthy and unhealthy plants should be of the same stage of maturity.

(b) Sample Size

The size of the sample to be taken depends on the condition of the field and the crop grown. When large variations occur an intensive sampling procedure is necessary in order to represent the nutrient content of the plant in question. The plant sample submitted to the laboratory should be an amount that would provide enough material for chemical analysis.

^{1.} Ulrich, A. 1976. Plant analysis as a guide in fertilizing crops in soil and plant-tissue testing in California. University of California Bulletin 1879.

2. Sample Preparation

(a) Removal of contamination

Distilled water is used to clean very dirty leaves. Normally leaves submitted are not washed.

(b) Drying

If leaves have been washed the sample is put into the oven set at 55° C for a minimum of 60 to 72 hours, depending on the type of sample received.

(c) Grinding

After drying, plant sample is ground to pass through a 20^{MMA} sieve. A Wiley Mill is used for this purpose. The ground samples are stored in coin envelopes.

1. DRY MATTER

1.1 Griffin Laboratories

PROCEDURE

The wet weight of the sample should, preferably, be determined in the field soon after collection. If weighing in the field is not possible, protect the samples from high temperatures.

The plant sample is weighed before and after drying at 100°C for 16 hours.

1. DRY MATTER

1.2 <u>PSAI</u>

٠

All foliar samples are oven dried at $70^{\circ}C$, and later moisture corrected to $100^{\circ}C$.
2.0 CALCIUM, POTASSIUM, MAGNESIUM, PHOSPHORUS, IRON, ZINC, MANGANESE, COPPER, BORON, SULPHUR

2.1 Griffin Laboratories

INTRODUCTION

The plant sample is ashed by wet oxidation. A mixture of nitric and perchloric acids is used. The concentrations of the elements are determined on the inductively coupled argon plasma spectrophotometer.

PREPARATION OF SAMPLE DIGEST

(a) Reagents

A mixture of conc. nitric and perchloric acids (3 + 1).

(b) Apparatus

Oxford pipette Aluminum block digest or Taylor tube

(c) Digestion

The ground plant sample, if kept in storage after drying, is again dried at 100° C overnight prior to being ashed. 0.5 g of the sample is placed into a 50 ml Taylor tube and 8 ml of (3+1) nitric - perchloric acid mixture is added to the sample. The sample is left to pre-digest overnight in the aluminum block which is placed on top of the heating unit. The rheostat of the heating unit is set so that it will reach 203° C in 1-1/2 to 2 hours after being switched on by a timer clock. When the sample is completely digested, a clear whitish solution is obtained. After digestion, the Taylor tube is removed from the aluminum block and allowed to cool. Dilute digestate to 25 ml with distilled water. Set the rheostat on the heating unit so that the temperature of the aluminum block will reach 120° C and then warm the digestate for 5-10 minutes to dissolve the solid. The digestate is ready for analysis.

DETERMINATION

(a) Apparatus

Inductively coupled argon plasma spectrophotometer - ARL 34,000.

(b) Standardization of ICP

The plasma is ignited about 30 minutes prior to standards being entered. The instrument is standardized (with a full set of standards) each time it is used rather than normalized (which uses only the high and low from each group of elements). Standards are multi-element in non-interfering groups. For example, Ca, Mg and Na; and B, Cu, Fe, Mn and Zn are two groups. S, K and P are done as single elements. The spectral lines used for the determination of Ca, K, Mg, P, Fe, Zn, Mn, Cu, B and S are 317.93, 766.49, 279.08, 178.29, 259.94, 213.86, 257.61, 324.75, 249.68 and 180.73 nm respectively.

(c) Examination of Sample Digestate

Sample solutions are drawn into the machine using a standard Meinhard nebulizer. There is a 30 second pre-flush period, followed by three 10 second integration periods. Sample uptake is approximately 2.5 ml/min.

(d) Calculation of Results

The ICP computer averages integration and plots them on curve made from standard readings. Results are then printed for millivolt intensity, concentration of solution (ppm), final results (which uses dilution ratio entered for each sample) and standard deviation for the 3 integrations.

2.2 Norwest Soil Research

٠.

Phosphorus, potassium, calcium, magnesium, sodium, sulphur, zinc, copper, manganese and boron are all measured after digesting the plant tissue in perchloric acid/nitric acid mixture.

Calcium, magnesium, sodium, zinc, copper and manganese are measured in the extract by atomic absorption spectroscopy.

Phosphorus is measured by colorimetry with a technicon autoanalyzer using ammonium molybdate, antimony potassium tartrate and ascorbic acid.

Boron is measured with a technicon autoanalyzer by colour reaction with azomethine-H.

Sulphur is measured turbidimetrically using barium chloride.

2.0 CALCIUM, POTASSIUM, MAGNESIUM, PHOSPHORUS, IRON, ZINC, MANGANESE, COPPER, BORON

2.3 <u>PSAI</u>

-

Foliar samples are digested by the Parkinson and Allen method to determine, P, K, Ca, and Mg.

Samples are dry ashed to 500° C to determine total Cu, Zn, Fe, Mn and B.

3.0 AMMONIUM-NITROGEN

3.1 Griffin Laboratories

INTRODUCTION

Nitrogen in organic matter is converted to ammonium-nitrogen by digestion with sulphuric acid, hydrogen peroxide and selenium as the catalyst. The ammonium sulphate formed because of the oxidation of carbonized material is reacted with a buffer mixture, salicylate-prusside solution and hypochlorite in that order¹. The high pH of the reactions, maintained by the buffer, is necessary for maximum color development. The ammonium-nitrogen is determined colorimetrically.

PREPARATION OF SAMPLE DIGEST

(a) Apparatus

Constricted digestion tubes Vortex mixer Aluminum block digestor

(b) Reagents

Hydrogen peroxide Conc. sulphuric acid Reagent grade selemium oxide pellets

(c) Digestion Procedure

Weigh 0.25 g of plant tissue that was originally dried at 100° C or 65° C into constricted digestor tubes. Add 2 selenium pellets, 5 ml of concentrated sulphuric acid and mix with the vortex mixer. Add 1 ml of hydrogen peroxide and wait for 10-15 minutes. Digest at 400°C for 75 minutes. Cool for 15 minutes and fill to 75 ml with distilled water.

DETERMINATION OF AMMONIUM-NITROGEN

(a) Apparatus

Technicon AutoAnalyzer - Figure 2

1. Wall, L. and Gehrke, C. 1975. An automated total protein nitrogen method. Journal of the AOAC Vol. 58 No. 6.

1. Preparation of Apparatus (AutoAnalyzer)

Plug in the manifold, turn on the colorimeter and allow them to warm up for 20 minutes. Latch the platen into place on the proportioning pump and pump water through the system for 10 minutes. Place reagent lines into their respective reagent bottles. The salicylate line goes in last at approximately 5 minutes after the others have been pumping. Allow all reagents to run for 10 minutes allowing the system to equilibrate.

(b) Reagents

Diluent water. Distilled water containing 1.0 ml Brij-35/1 Stock sodium potassium tartrate solution - 20% Stock sodium hydroxide. 20% solution Stock buffer solution. 0.5M. Dissolve 134 g Na₂HPO₄.7H₂O in 800 ml of distilled water, add 20 g NaOH and dilute to 1 1 with water and mix.

Working buffer solution. 0.1M sodium phosphate, 5% sodium potassium tartrate and 5.4% NaOH. Add 250 ml of 20% sodium potassium tartrate solution to 200 ml stock buffer solution and mix. With swirling add 250 ml 20% NaOH and 1.0 ml Brij-35, dilute to 1 1 with water, and mix.

Sulphuric acid-sodium chloride solution. 0.75% H₂SO₄ - 10% NaC1. Dissolve 100 gm NaC1 in 600 ml distilled water. Add 7.5 ml H₂SO₄ and 1.0 ml Brij-35, diltue to 1 l with water and mix.

Sodium salicylate - sodium nitroprusside solution. 15% - 0.03%. Dissolve 150 g NaC₇H₅O₃ and 0.30 g Na₂Fe(CN)₅NO.2H₂O in 600 ml distilled water, filter into 1 l flask and add 1.0 ml Brij-35, dilute to volume with water, and mix.

Sodium hypochlorite. Dilute 6.0 ml sodium hypochlorite solution to 100 ml with distilled water. Add 2-4 drops of Brij -35 and mix. Any commercial bleach solution (eg. Clorox) containing 5.25% available chlorine is satisfactory.

Nitrogen stock solution. Dissolve 4.714 g of dried ammonium sulphate in 1 1 of distilled water (1000 ppm N.). Working standard solutions: 0 to 125 ppm N.

(c) Examination of Sample Digest

Pour the digested samples into 5 ml Technicon AutoAnalyzer sample cups and place them in the sample tray. On the first tray alternate 5 blanks with 4 standards to adjust colorimeter. Keep track of the standard calibration setting (daily record). An increase in standard calibration setting may be caused by a worn out dialysis membrane. Run 1 blank and 1-125 ppm standard every 20 samples. After recorder shutdown, remove salicylate line first and place it in distilled water. Rinse the system with the 30% Brij 35 solution.



TECHNICON INDUSTRIAL SYSTEMS / TARRYTOWN, NEW YORK 10591 A DIVISION OF TECHNICON INSTRUMENTS CORPORATION

5.

3. AMMONIUM-NITROGEN

3.2 Norwest Soil Research

Ammonium nitrogen is determined by Kjeldahl digestion using a sulphuric acid/potassium sulphate/copper sulphate/selenium digestion mixture. Ammonium produced is measured by steam distillation followed by titration with standard sulphuric acid.

3.0 AMMONIUM-NITROGEN

3.3. <u>PSAI</u>

< **1**

.

Foliar samples are digested by the Parkinsen and Allen method.

4.0 NITRATE-NITROGEN

4.1 Griffin Laboratories

INTRODUCTION

Nitrate-nitrogen is removed from plant tissue by briefly boiling it with the Kelowna extractant. A short period of boiling removes nitrates not easily leached by shaking the material with water. The concentration of the nitrate is determined colorimetrically as nitrite using an automated copper-cadmium reduction procedure^{1,2}.

PREPARATION OF SAMPLE EXTRACT

(a) Apparatus

50 ml Erlenmeyer Hot plate

(b) Reagents

Extracting Solution: 0.25 N HOAC + 0.015 N NH₄F

Stock solutions containing 20 fold concentrations are prepared by dissolving 300 ml glacial acetic acid (5N; sol'n A) and 11.112 g NH₄F (0.30N; Sol'n B) each to a liter. These solutions should be transferred to plastic containers and stored in the refrigerator. Mix and dilute 125 ml each of solutions A and B to 2.5 l shortly before extracting soils. This solution is the Kelowna extractant and contains 0.25 N HOAC + 0.015 N NH₄F^{1,2}.

(c) Extraction

Weigh 0.1 g of ground sample that was originally dried at $100^{\circ}C$ into 50 ml Erlenmeyer flasks. Add 10 ml of 0.25 N HOAC + 0.15 N NH₄F solution and bring to a boil on a hot plate. Filter through No. 42 Whatman paper for the determination of nitrate-nitrogen.

Van Lierop, W. 1986 Soil nitrate determination using the Kelowna multiple element extractant. Comm. in Soil Sci. Plant Anal 17(12), 1311-1329

⁽²⁾ Van Lierop, W. 1985. Nitrate and nitrite in soils. Soil Notes.B.C. Ministry of Agri. and Food, Leaflet #2.

DETERMINATION

Reagents

- (a) Ammonium Chloride. Dissolve 40 g of ammonium chloride in 800 ml distilled water and adjust the pH of the mixture to 8.5 using ammonium hydroxide. Add 0.5 ml of Brij-35 and make to 1 liter.
- (b) Color Reagent. Dissolve, by heating if necessary, 10 g sulfanilamide into 750 ml distilled water containing 100 ml of concentrated phosphoric acid. Subsequently, add 0.5 g of N-(1-napthyl) ethylenediamine dihydrochloride, 0.5 ml Brij-35, dissolve, and make to 1 liter.
- (c) Nitrogen Stock Solution. Dissolve 0.722 g of oven dried potassium nitrate in distilled water and dilute to 1 liter. This solution contains 100 ug NO_3-N/ml . Add 1 ml of chloroform and store in a refrigerator.

Working Standard. Generally after the linearity of the colorimeter has been verified utilization of a single standard should be sufficient to ensure analytical accuracy.

A standard containing 10 ug $NO_3-N/m1$ with the colorimeter adjusted to read half scale seems to satisfy this requirement. Pipette 10 ml of the 100 ug NO_3-N stock standard into a 100 ml volumetric flask, add 5 ml each of stock extracting solutions A and B, make to volume and mix thoroughly. This standard will contain 10 ug NO_3-N in 0.25N HOAc and 0.015 N NH_4F .

Apparatus

- (a) Reduction Column Preparation
 - (i) Cadmium metal is filed with a rasp-cut file and particles sized. Those which pass a 20 but are held on a 40 mesh sieve are are utilized in the reduction column.
 - (ii) New or used cadmium particles (10 g) are cleaned with 50 ml of 6M HCl for l minute. Decant the HCl and wash the cadmium particles further with another 50 ml of 6 M HCl for 1 minute.
 - (iii) Decant the HCl and wash the cadmium particles several times with distilled water.
 - (iv) Decant the distilled water and add 50 ml of 2% CuSO₄.5H₂O. Wash the cadmium with distilled water until no blue color remains in the wash solution.

- (v) Fill the reductor columns with ammonium chloride reagent and transfer the prepared cadmium particles to the column using a dropping pipette. Ensure that <u>no air</u> bubbles are trapped in the column while filling. Although a commercial reductor columnn can be utilized (Technicon 189-0000), a 14-inch length of 0.081" I.D. tygon is used in Griffin laboratory.
- (vi) The reductor column should be conditioned by passing 100 ug $NO_3-N/m1$ for 5 minutes followed by 100 ug $NO_2-N/m1$ for 10 minutes before utilization.
- (vii) Reduction efficiency can be checked by analyzing 10 ug N/ml nitrate and nitrite standards. Peak heights are identical at 100% recovery.
- (b) Technicon AutoAnalyzer

Operating Notes

- (i) The wash receptable on the sampler should contain Kelowna extractant.
- (ii) Nitrate standards should be prepared in Kelowna extractant.
- (iii) When samples containing between 0-1 ug NO₃-N/m1 are analyzed, the dilution loop can be omitted to increase the sensitivity. The resample line should then be connected directly to the sampler.
- (iv) Distilled water for the dilution loop should contain 1 ml of Brij-35 per liter.
- (v) In order to obtain the exact nitrate values in plant tissue the nitrite concentration should be subtracted.
- (c) Examination of Extract

1. Starting Analysis

- (a) Ensure the adequacy of reagent supplies. This is very important as exposing the reductor column to air will destroy its reduction capability.
- (b) Place lines in their respective containers and start the proportioning pump. At this stage a length of 0.081" diameter tubing should be used instead of the reduction column.
- (c) When the ammonium chloride reagent reaches the end of filling A2 (Fig. 1) connect the reductor column being careful to avoid air bubbles.
- (d) Allow the system to stabilize.

4.0 NITRATE-NITROGEN

4.2 Norwest Soil Research

Weigh 1 g of sample dried at 60° C. To a 50 ml Erlenmeyer flask add 20 ml 1N KCl stopper and shake. Filter. The concentration of nitrate in the filtrate is determined colorimetrically as nitrite using an automated copper-cadmium reduction procedure.

Table: 13Leaf Analysis Guide for Diagnosing
Nutrient Status of Apple Cultivars

Crop: Apple: Red Delicious, Newtown, Golden Delicious, McIntosh, Spartan, Winesap.

Plant Part/Growth Stage: Collect leaves at mid-summer from the middle third terminal growth (present year's growth), that is growing upward and outward at 30 to 60 degrees.

Leaf Type	Tree Age	Nutrient	Low	Adequate	<u>High</u>
Red Delicious,	11 yrs.+	Nitrogen %	1.8	2.1-2.5	2.7
Newtown	0-10 yrs.	(N)	1.8	2.1-2.8	3.0
Golden Delicious	mature		1.5	1.8-2.0	2.3
McIntosh	11 yrs.+		1.6	1.9-2.3	2.5
	0-10 yrs.		1.6	1.9-2.6	2.8
Spartan	11 vrs.+		1.5	1.8-2.2	2.4
	0-10 yrs.		1.5	1.8-2.5	2.7
Winesap	11 yrs.+		1.6	1.9-2.3	2.5
All Cultivars	mature	Phosphorus %		0.15	
	1-2 yrs.			0.20-0.30	
	All yrs.	Potassium % (K)		1.0	
	All yrs.	Calcium % (Ca)	1.0	1.3	1,5
	All yrs.	Magnesium % (Mg)	0.26	0.27	0.37
	All yrs.	Zinc (Zn) ug/g	< 21	21-25	26
	All yrs.	Iron (Fe) ug/g	< 45	45-99	100
	All yrs.	Boron (B) ug/g	21-30	31-60	61-80
	All yrs.	Manganese ug/g (Mn)	<25	25-60	61

Low- Large economical response to fertilizer nutrient.Adequate- Desirable level for good plant growth and high fruit quality.High- Quality of fruit might not be affected but nutrient application
might be uneconomic.

Table: 14Leaf Analysis Guide for Diagnosing
Nutrient Status of Cherry Trees

Crop: Cherry

Plant Part/Growth Stage: Collect leaves at mid-summer from the middle third terminal growth (present year's growth) that is growing upward and outward at 30 to 60 degrees.

Tree Age	Nutrient		Low	Adequate	High
11 yrs. +	Nitrogen (N)	z	1.6	1.9-2.7	3.3
0-10 yrs.			1.6	1.9-3.0	3.6
Mature trees	Phosphorus (P)	2		0.15	
1-2 yrs.				0.20-0.46	
All yrs.	Potassium (K)	%		1.0	
All yrs.	Calcium (Ca)	z	1.5	1.8	2.1
All yrs.	Magnesium (Mg)	X	0.36	0.37-0.46	0.47
All yrs.	Zinc (Zn) ug/	'g	<17	17-26	27
All yrs.	Iron (Fe) ug/	g	<45	45-99	100
All yrs.	Boron (B) ug/	B	21-30	31-60	61-80
All yrs.	Manganese ug/ (Mn)	g	<20	20-300	301

Low - Large economical response to fertilizer nutrient.

Adequate - Desirable level for good plant growth and high fruit quality.

High - Quality of fruit might not be affected but nutrient application might be uneconomic.

PLANT MATERIAL

£

ې و

WIE 24

PART II B

PLANT TISSUE ANALYSIS INTERPRETIVE GUIDES

Table: 15Leaf Analysis Guide for DiagnosingNutrient Status of Prune-Plum Trees

Crop: Plum

ć.

~

Plant Part/Growth Stage: Collect leaves at mid-summer from the middle third terminal growth (present year's growth), that is growing upward and outward at 30 to 60 degrees.

Tree Age	Nutrient		Low	Adequate	<u> </u>
11 yrs. + 0-10 yrs.	Nitrogen (N)	%		1.9-2.5	
Mature trees	Phosphorus (P)	2		0.15	
1-2 yrs.				0.20-0.30	
All yrs.	Potassium (K)	2		1.0	
All yrs.	Magnesium (Mg)	2	0.26	0.27-0.36	0.37
All yrs.	Zinc (Zn) ug/	g	<17	17-26	27
All yrs.	Iron (Fe) ug/	g	<45	45-99	100
All yrs.	Boron (B) ug/	g	21-30	31-50	51-60
All yrs.	Manganese ug/: (Mn)	g	<20	20-60	61

Low	- Large economical response to fertilizer nutrient.
Adequate	- Desirable level for good plant growth and high fruit quality.
High	- Quality of fruit might not be affected but nutrient application
	might be uneconomic.

Table: 16Leaf Analysis Guide for Diagnosing
Nutrient Status of Peach Trees

Crop: Peach

Plant Part/Growth Stage: Collect leaves at mid-summer from the middle third terminal growth (present year's growth), that is growing upward and outward at 30 to 60 degrees.

Tree Age	Nutrient		Low	Adequate	High
11 yrs. +	Nitrogen (N)	%	2.0	2.6-3.2	3.8
0-10 yrs.			2.0	2.6-3.5	4.1
Mature trees	Phosphorus (P)	2		0.15	
1-2 yrs.				0.20-0.30	
All yrs.	Potassium (K)	2		1.2	
All yrs.	Calcium (Ca)	8	1.6	2.2	2.8
All yrs.	Magnesium (Mg)	2	0.36	0.37-0.46	0.47
All yrs.	Zinc (Zn) ug/g	5	<17	17-26	27
All yrs.	Iron (Fe) ug/g	5	<45	45-99	100
All yrs.	Boron (B) ug/g	5	21-30	31-50	51-60

Low - Large economical response to fertilizer nutrient.
 Adequate - Desirable level for good plant growth and high fruit quality.
 High - Quality of fruit might not be affected but nutrient application might be uneconomic.

81.

<u>د</u> ۴

. 9

Table: 17Leaf Analysis Guide for DiagnosingNutrient Status of Apricot Trees

Crop: Apricot

. •

> Plant Part/Growth Stage: Collect leaves at mid-summer from the middle third terminal growth (present year's growth), that is growing upward and outward at 30 to 60 degrees.

Tree Age	Nutrient		Low	Adequate	High
11 yrs. +	Nitrogen (N)	8	2.0	2.6-3.2	3.8
0-10 yrs.			2.0	2.6-3.2	4.1
Mature trees	Phosphorus (P)	2		0.15	
1-2 yrs.				0.20-0.30	
All yrs.	Potassium (K)	2		1.2	
All yrs.	Magnesium (Mg)	z	0.26	0.27-0.36	0.37
All yrs.	Zinc (Zn) ug	s/g	<17	17-26	27
All yrs.	Iron (Fe) ug	:/g	<45	45-99	100
All yrs.	Boron (B) ug	s/8	21-30	31-50	51-60
All yrs.	Manganese ug	:/g	<25	25-200	201

Low - Large economical response to fertilizer nutrient.

Adequate

- Desirable level for good plant growth and high fruit quality.

High

 Quality of fruit might not be affected but nutrient application might be uneconomic.

Table: 18 Leaf Analysis Guide for Diagnosing Nutrient Status of Pear Trees

Crop: Pear

١.

Plant Part/Growth Stage: Collect leaves at mid-summer from the middle third terminal growth (present year's growth), that is growing upward and outward at 30 to 60 degrees.

Tree Age	Nutrient	Low	Adequate	<u>High</u>
11 yrs +	Nitrogen (N) 9	1.6	1 9-2 3	25
0-10 yrs.		1.6	1.9-2.5	2.7
Mature trees	Phosphorus % (P)		0.15	
1-2 yrs.			0.20-0.30	
All yrs.	Potassium % (K)		1.0	
All yrs.	Magnesium (Mg)	0.26	0.27-0.36	0.37
All yrs.	Calcium (Ca) 🎗	1.0	1.3	1.5
All yrs.	Zinc (Zn) ug/g	<15	15-24	25
All yrs.	Iron (Fe) ug/g	<45	45-99	100
All yrs.	Boron (B) ug/g	21-30	31-60	61-80
All yrs.	Manganese ug/g (Mn)	<25	25–60	61

Low- Large economical response to fertilizer nutrient.Adequate- Desirable level for good plant growth and high fruit quality.High- Quality of fruit might not be affected but nutrient application
might be uneconomic.

<u>د</u> د

к.

por a

Table 19Leaf Analysis Guide for DiagnosingNutrient Status of Filbert Trees

Crop: Filbert

*** **

F. F.

Plant Part/Growth Stage: Collect leaves at mid-summer from branches growing upward and outward at about 45 degrees around the edge of immature or mature trees at shoulder height or higher.

Nutrient Critical Concentration

Nitrogen (N)	2.2%
Phosphorus (P)	0.14%
Potassium (K)	0.8%
Sulphur (S)	0.14%
Calcium (Ca)	1.44%
Magnesium (Mg)	0.27%
Copper (Cu)	9 ug/g
Zinc (Zn)	20 ug/g

APPENDIX

Data to Support Interpretations and Recommendations:

.:

¥

I	Fertilizer Rates vs Actual Yield, Relative Yield or Yield Responses
II	Soil Test Values vs Fertilizer Rates that Maximized Yield or Profit
III	Soil Test Values vs Relative Yield (for Soil Test Interpretations)
IV	Critical Tissue Nutrient Level Data
v	Nutrient Levels vs Tissue Sampling Times over the Growing Period as Related to Crop Yields
VI	Comparison of Extractants (To Predict Nutrient Availability)
VII	Regression Equations for Relationships of Extractants

م جيني جيني