Appendix 4. Solution Concentrations

System Name	Abbreviation	Definition
Molar	M	gram-molecular weight (mole
Molal	M	of solute) per liter of solution gram-molecular weight (mole
		of solute) per kilogram of solvent
Formal	F	gram-formula weight of solute
Normal	N	per liter of solution gram-equivalent weight of solute per liter of solution
Weight per volume, percent	w/v, %	number of grams of solute × 100 per volume of solvent (mL).
Volume percent	Volume % or v/v %	Volume of solute × 100 per volume of solution.
Weight percent	wt % or w/w %	Weight of solute × 100 weight of solution.
Parts per million	ppm	milligrams of solute or milligrams per liter of solution kilogram
Parts per billion	ppb	micrograms of solute or micrograms per liter (kilogram) of solution.

Appendix 5. Some Useful Relationships

1 g = 1000 mg = 1,000,000 μg	ppm = μg/g (solid per liquid)
1 μg = 0.001 mg = 0.000001 g	ppm = μL/L (liquid per liquid)
1 L = 1000 mL	ppm × 2 = 1lbs/A
1 mL = 0.001 L	ppm × 10^{-4} = %
ppm = μg/mL (solid per liquid)	1% = 1 gm/100 ml
ppm = mg/L (solid per liquid)	1% = 10,000 ppm

Appendix 6. Concentration Normality, Amount of Concentrated Acids, and Bases to Make of 1 N Solution (1-L)

Acid or Base	**Chemical Properties**				**Solution**
	Specific	**Percent**	**Grams**	**Approximate**	**Needed**[1]
	Gravity	**by Weight**	**per Liter**	**Normality (*N*)**	**(mL)**
Acetic acid	1.05	99.0	1042.0	17.45	58
Ammonium	0.90	28.3	255.0 (NH_3)	15.0	67
hydroxide					
Hydrochloric acid	1.19	38.0	451.6	12.4	81
Hydrofluoric acid	1.16	50.0	577.5	28.8	35
Nitric acid	1.42	72.0	1024.0	16.2	62
Phosphoric acid	1.69	85.0	1436.0	44.0	23
Perchloric acid	1.66	70.0	1165.0	11.6	86
Sodium hydroxide	1.53	50.0	762.7	19.0	53
Sulfuric acid	1.84	96.0	1742.0	35.5	28

[1]To make up 1-L of 1 *N*

Appendix 7. Soil pH Levels and Associated Conditions

Soil pH	Indications	Associated Conditions
< 5.5	Soil is deficient in Ca and /or Mg, and should be limed	Poor crop growth due to low cation exchange capacity and possible Al^{3+} toxicity. Expect P deficiency.
5.5 – 6.5	Soil is lime-free, should be closely monitored.	Satisfactory for most crops
6.5 – 7.5	Ideal range for crop production.	Soil cation exchange capacity is near 100% base saturation.
7.5 – 8.4	Free lime ($CaCO_3$) exists in soil.	Usually excellent filtration and percolation of water due high Ca content on clays. Both P and micronutrients are less available.
>8.4	Invariably indicates sodic soil.	Poor physical conditions. Infiltration and percolation of soil water is slow. Possible root deterioration and organic matter dissolution.

Source: Hach Company, USA (1992).

Appendix 8. Summarized Soil Test Methods for Fertility Evaluation

Parameter	**Olsen P**	**AB-DTPA**	**NH_4OAc**	**DTPA**	**Hot water**
Property/		NO_3-N, P, K,	K, Mg, Na, Ca	Zn, Cu, Fe, Mn	B
Nutrient(s)		Zn, Cu, Fe, Mn			
Sample size (g)	2.5	10	5	10	10
Volume-extractant (mL)	50	20	25	20	20
Extracting solution	0.5 M $NaHCO_3$	1 M $NH_4HCO_3^+$	1 N NH_4Oac	0.005 M $DTPA^+$	H_2O
	at pH 8.5	0.005 M DTPA	pH 7.0	0.01 M TEA^+	
		(pH7.6)		0.01 M $CaCl_2$ (pH7.3)	
Shake/boil (minutes.)	30	15	5	120	5
Shaking action and speed: All use reciprocating, 180+ oscillations/minutes., except for B					
Extraction method	Colorimetry, at 880nm (Molybdenum blue)	P: Colorimetry, K: Flame emission Zn, Cu, Fe, Mn: AAS	K& Na: Flame emission Mg & Ca: AAS	AAS	Colorimetry, at 430 nm (Azomethine-H)
Soil nutrient conc.,	P, 2 – 200	P, 2 – 100; K, 5 – 750;	K, 50 – 1000;	Zn, 0.5 – 20	B, 1 – 10
no dilution (ppm)		Zn, 0.5 – 35	Ca, 500 – 2000;		
			Mg, 50 – 500;		
			Na, 10 – 250		
Primary reference	Olsen *et al.* (1954)	Soltanpour & Schawb (1977)	Schollenberger& Simon (1945)	Lindsay & Norvell (1978)	Berger & Truog (1939)

Source: Soil and Plant Analysis Council (1992). AAS = atomic absorption spectrophotometer.

Appendix 9. Generalized Guidelines for Interpretation of Soil Analysis Data

Nutrient /Organic Matter	Soil Test	Low	Marginal	Adequate
		---------- % ----------		
Organic matter	Walkley- Black	<0.86%	0.86 – 1.29%	>1.29
		----------ppm----------		
Nitrate	AB-DTPA	<11	11 – 20	>20
Phosphate	$NaHCO_3$	<8	8 – 15	>15
	AB-DTPA	<4	4 – 7	>7
Potassium	NH_4OAc	<100	100-150	>150
	AB-DTPA	<60	60 – 120	>120
Zinc	DTPA	<0.5	0.5 – 1.0	>1.0
	AB-DTPA	<1.0	1.0 – 1.5	>1.5
Copper	DTPA	<0.2	0.2 – 0.5	>0.5
	AB-DTPA	<0.2		>0.5
Iron	DTPA	<4.5		>4.5
	AB-DTPA	<2.0	2.1 – 4.0	>4.0
Manganese	DTPA	<1.0	1.0 – 2.0	>2.0
	AB-DTPA	<1.8		>1.8
Boron	Hot water	<0.5	0.5 – 1.0	>1.0
	HCl	<0.45	0.45 – 1.0	>1.0

DTPA= diethylene triamine pentoacetric acid. AB = ammonium bicarbonate.

$NaHCO_3$ = Sodium bicarbonate.

Sources: FAO (1980); Soltanpour (1985); Ludwick (1995); Martens and Lindsay (1990); Johnson and Fixen (1990); Soil and Plant Analysis Council (1992); Matar *et al.* (1988).

Appendix 10. Suggested Plant Tissue Sampling Procedures for Selected Dryland Crops1

Growth Stage	Plant Part to Sample	Plants Sampled
	Wheat and Barley	
Seeding stage (< 30 cm tall)	All the aboveground portion	50 – 100
Before head emergence	Flag leaf	25 – 50
	Corn	
Seedling stage (< 30 cm tall)	The entire aboveground shoot. The entire	20 – 30
Prior to tasselling	leaf fully developed below the whorl	15
From tasselling to silking	The entire leaf at the ear node (or	
	immediately above or below it)	15 – 25
	Sorghum	
Prior to or at heading	Second or 3rd leaf from top of plant	15 – 25
	Soybean or other Beans	
Seedling stage (<30 cm tall)	All the above ground portion	20 – 30
Prior to or during	Two or three fully developed	20 – 30
initial flowering	Leaves at the top of the plant	
	Peanut	
Maximum tillering	Recently matured leaflets	25
	Alfalfa, Clover and other Legumes	
Prior to or at 1/10th	Mature leaf blades taken about	40 – 50
bloom stage	One-third of the way down the plant	
	Food Legumes including Chickpea and Lentil	
Vegetative growth stage	Whole shoots	40 – 50
Bloom initiation	Recently matured leaf	50 – 200

[1]When specific guidelines are unknown; the general *rule of the thumb* is to sample *upper mature* leaves at flower imitation.

Sources: Jones *et al.* (1971, 1991); Reuter and Robinson (1986); Tandon (1993).

Appendix 11. Generalized Interpretation of Nutrient Concentrations in Cereal Plant Tissues Sampled at Boot Stage (Feekes Stage 10.1)

	Nutrient Concentration in Dry Tissue			
Nutrient	**Deficient**	**Low**	**Sufficient**	**High**
	----------%----------			
Nitrogen (winter grains)	<1.25	1.25 – 1.74	1.75 – 3.00	>3.00
(spring grains)	<1.50	1.50 – 1.99	2.00 – 3.00	>3.00
	<0.15	0.15 – 0.19	0.20 – 0.50	>0.50
Phosphorus	<1.25	1.25 – 1.49	1.50 – 3.00	>3.00
Potassium		<0.20	0.20 – 0.50	>0.50
Calcium (wheat, oats)		<0.30	0.30 – 1.20	>1.20
(barley)		<0.15	0.15 – 0.50	>0.50
Magnesium Sulfur		<0.15	0.15 – 0.40	>0.40
	----------ppm----------			
Manganese	<5	5 – 24	25 – 100	>100
Zinc		<15	15 – 70	> 70
Copper		<5	5 – 25	> 25

Source: Walsh and Beaton (1973).

Appendix 12. Classification Criteria for Salt-Affected Soils

Soil	ECe[1]	Exchangeable Sodium Percentage (ESP)	Sodium Adsorption Ratio (SAR)
	--dS/m--		
Normal	<4	<15	<15
Saline	=4	<15	<15
Sodic	<4	>15	=15
Saline-Sodic	=4	>15	=15

[1]EC in saturated paste extract

Source: Bohn *et al.* (1985).

Appendix 13. Soil Salinity Classification

Soil Texture	Degree of Salinity (Electrical Conductivity)[1]				
	None	Slight	Moderate	Strong	Very Strong
	---------- dS/m ----------				
Coarse sand to sandy loam	<1.2	1.2 – 2.4	2.5 – 4.4	4.5 – 8.9	>9.0
Loamy fine sand to loam	<1.3	1.3 – 2.4	2.5 – 4.7	4.8 – 9.4	>9.5
Silt loam to clay loam	<1.4	1.4 – 2.5	2.6 – 5.0	5.1 – 10.0	>10.1
Silty clay loam to clay	<1.5	1.5 – 2.8	2.9 – 5.7	5.8 – 11.4	>11.5

[1]EC in 1:1 soil/water suspension

Source: Hach Company (1992).

Sesame (*Sesamum indicum*)		Sugarbeet (*Beta vulgaris*)	0.56
Red pepper (*Capsicum annum*)		Cotton (*Gossypium hirsutum*)	0.56 – 0.93
	0.093	Asparagus (*Asparagus officinalis*)	0.93 – 1.39

Source: Keren and Bingham (1985).

Appendix 16. Mesh Sizes of Standard Wire Sieves

Sieve Opening	**Standard Mesh Number**		
(mm)	**US**	**British**	**French**
2.00	10	8	34
1.00	18	16	31
0.500	35	30	28
0.420	40	36	–
0.250	60	60	25
0.210	70	72	–
0.149	100	–	–
0.125	120	120	22
0.063	230	240	19
0.053	270	300	–

Appendix 17. Equivalent Weights

Symbol/Formula	Equivalent Weight		Common Name
	----g----		
Ions			
Ca^{++}	20.04		Calcium ion
Mg^{++}	12.16		Magnesium ion
Na^{+}	23.00		Sodium ion
K^{+}	39.10		Potassium ion
Cl^{-}	35.46		Chloride ion
SO_4^{--}	48.03		Sulfate ion
CO_3^{--}	30.00		Carbonate ion
HCO_3^{-}	61.01		Bicarbonate ion
PO_4^{---}	31.65		Phosphate ion
NO_3^{-}	62.01		Nitrate ion
Salts			
$CaCl_2$	55.50		Calcium chloride
$CaSO_4$	68.07		Calcium sulfate
$CaSO_4 \cdot 2H_2O$	86.09		Gypsum
$CaCO_3$	50.04		Calcium carbonate
$MgCl_2$	47.62		Magnesium chloride
$MgSO_4$	60.19		Magnesium sulfate
$MgCO_3$	42.16		Magnesium carbonate
NaCl	58.45		Sodium chloride
Na_2SO_4	71.03		Sodium sulfate
Na_2CO_3	53.00		Sodium carbonate
$NaHCO_3$	84.01		Sodium bicarbonate
KCl	74.56		Potassium chloride
K_2SO_4	87.13		Potassium sulfate
K_2CO_3	69.10		Potassium carbonate
$KHCO_3$	100.11		Potassium bicarbonate
Chemical Amendments			
S	16.03		Sulfur
H_2SO_4	49.04		Sulfuric acid
$Al_2(SO_4)_3 \cdot 18H_2O$	111.07		Aluminum sulfate
$FeSO_4 \cdot 7H_2O$	139.01		Iron sulfate (ferrous)

Conversion of milliequivalents per liter to parts per million:

ppm = milliequivalents/liter × equivalent weight.

Appendix 18. Preservation Methods and Holding Times for Water Samples

Determination	Container	Preservation	Maximum storage
Acidity	P, G(B)	Refrigerate	24 h
Alkalinity	P, G	Refrigerate	24 h
BOD	P, G	Refrigerate	6 h
Boron	P	$HN0_3$ to pH <2	28 d
Bromide	P, G	None required	28 d
Carbon, organic, total	G (B)	Analyze immediately; or refrigerate and add HCl, H_3PO_4, or H_2SO_4 to pH <2	7 d
Carbon dioxide	P, G	Analyze immediately	0.25 h
COD	P, G	Analyze as soon as possible, or add H_2SO_4 to pH <2; refrigerate	7d
Chloride	P, G	None required	N.S.
Color	P, G	Refrigerate	48 h
Conductance	P, G	Refrigerate	28 d
Hardness	P, G	Add $HN0_3$ or H_2SO_4 to pH <2	6 months
Metals, general	P(A), G(A)	Filter immediately, add HNO_3 to pH <2	6 months
Chromium VI	P(A), G(A)	Refrigerate	24 h
Mercury	P(A), G(A)	Add $HN0_3$ to pH <2, 4°C,	28 d
Ammonia	P, G	Analyze as soon as possible or add H_2SO_4 to pH <2, refrigerate	7 d
Nitrate	P, G	Analyze as soon as possible; refrigerate	24 h
Nitrate + nitrite	P, G	Add H_2SO_4 to pH <2, refrigerate	1-2 d
Organic, Kjeldahl-N	P, G	Refrigerate, add H_2SO_4 to pH <2	7d
Odor	G	Analyze as soon as possible; refrigerate	6 h
Dissolved Oxygen	G, BOD	Analyze immediately	0.25h
pH	P, G	Analyze immediately	0.25h
Phosphate	G (A)	Refrigerate	48h
Phosphorus total	P, G	Add H_2SO_4 to pH <2, Refrigerate	28d
Salinity	G	Use wax seal	6 month
Solids	P, G	Refrigerate	7d
Sulphide	P, G	Refrigerate; add 4 drops 2N zinc acetate/100ml; add NaOH to pH>9	28 d
Temperature	P, G	Analyze immediately	0.25h
Turbidity	P, G	Refrigerate in dark	24h

*For determinations not listed, use glass or plastic containers; preferably refrigerate during storage and analyze as soon as possible.

P = plastic (polyethylene or equivalent); G = glass; G (A) or P (A) = rinsed with 1 + 1 HNO3; G (B) = glass, borosilicate; G(S) = glass, rinsed with organic solvents or baked

Refrigerate = storage at 4°C ± 2°C; in the dark

N.S. = not stated in cited reference; stat = no storage allowed; analyze immediately.

Appendix 19. Relationships between EC (saturation extract basis), and leaching fraction under conventional irrigation management

Water class	Electrical conductivity	Salt concentration	Type of water
	dS/m	mg/L	
Non-saline	< 0.7	< 500	Drinking and irrigation water
Slightly saline	0.7 - 2	500 -1500	Irrigation water
Moderately saline	2 -10	1500 - 7000	Primary drainage water and groundwater
Highly saline	10 -25	7000 - 15000	Secondary drainage water and groundwater
Very highly saline	25 - 45	15000 - 35000	Very saline groundwater
Brine	> 45	> 45000	Seawater