Hands-on Exercise 1: Reading and Interpreting Soil Analysis Reports, Nutrient Budgeting, and Selecting Mineral and Organic Matter Soil Amendments

for the student

INTRODUCTION

In this exercise you will be asked to read and interpret a sample soil analysis report and practice formulating a basic fertility program for meeting short- and long-term soil fertility and plant nutrition goals. Using the Step-by-Step Instructions from Demonstration 2 and the reference materials listed below, you will generate a basic soil fertility management plan in which you will: define any potential limiting nutrients and/or soil chemical imbalances; calculate application rates of needed soil amendments to make necessary adjustments to soil chemical properties; select any needed supplemental fertilizers, and; develop a basic nitrogen budget for a hypothetical organic production system.

NOTE: It is **CRITICAL** that one confirms the specific "optimal" levels used in this unit with those used by your local testing service. The optimal levels presented in this unit are examples of those used by many A & L National Agricultural Laboratories.

PLEASE INCLUDE THESE COMPONENTS IN YOUR SOIL FERTILITY MANAGEMENT PLAN:

- A description of the relevant agronomic characteristics of the sampled soil
- The identification of any potentially limiting and/or excess nutrients found in the soil
- The selection of the type, quantities and costs of soil amendments that may be used to address limited or imbalanced soil nutrient levels
- The selection of the type, quantities and costs of supplemental fertilizers that may be used to address limited or imbalanced soil nutrient levels
- Development of a nitrogen budget for your crop(s) including suggested application rates of compost, selected cover crop species and their seeding rates (see appendix 4, Nitrogen Budgeting Worksheet)
- A summary of your findings including a timeline for the implementation of both short- and long-term elements of your soil fertility management plan

PREPARATIONS AND MATERIALS

- Sample soil analysis report
- Step-by-Step Instructions from Demonstration 2 (pp. 31–34)
- Calculator
- Appendix 2, Nutrient Budgeting Worksheets
- Appendix 4, Nitrogen Budgeting Worksheet Exercise
- Appendix 5, Supplemental Fertilizer Worksheet
- Appendix 6, Optimal Nutrient Levels of Major Cations Based on CEC
- Appendix 7, Nutrient Content of Common Fertilizers and Amendments
- Appendix 8, Fertilizer Solutions Chart
- Appendix 9, Approximate Pounds/Acre of Nutrients Removed by Common Crops
- Agricultural supply catalogues with listing of soil amendments (see Resources section)

Assessment Questions

1. What are the effects of excess nitrogen on crops and in the environment?

2. Give examples of raw organic matter.

3. Explain the difference between compost and other sources of organic matter.

4. Which nutrients affect pest and disease susceptibility?

5. In general, what is the minimum fertility program for sustainable production?

6. Explain the concepts of Cation Exchange Capacity and Cation Saturation Ratios (CSR).

7. What are several advantages of optimum soil cation balance?

8. What are the three primary sources of nitrogen factored into a nitrogen budget for an organic farming system?

Assessment Questions Key

1. What are the effects of excess nitrogen on crops and in the environment?

   Elongated cells with thinner cell walls, excess growth and vigor, increased susceptibility to pests and diseases, poor storage quality. Excess nitrogen released into the environment may lead to the eutrophication of aquatic ecosystems and the contamination of ground water.

2. Give examples of raw organic matter.

   Leaves and leaf litter, crop stubble, manures, sawdust, plant and animal remains, cover crops and other undigested/undecomposed organic matter

3. Explain the difference between compost and other sources of organic matter.

   Compost is aerobically decomposed organic matter; most other sources are raw organic materials that require digestion in the soil medium. Raw organic matter may take 3–6 weeks+ to break down and release nutrients, resulting in the temporary depression of soil nitrogen levels and the possibility of plant nitrogen deficiencies.

4. Which nutrients affect pest and disease susceptibility?

   They all do. Excess nitrogen and imbalances of phosphorus, potassium, and/or calcium are generally more suspect in pest and disease problems.

5. In general, what is the minimum fertility program for sustainable production?

   Replacement of nutrients removed by the crop.

6. Explain the concepts of Cation Exchange Capacity and Cation Saturation Ratios (CSR).

   The clay and humus particles in the soil have a negative charge. Positively charged ions (e.g., of Ca, Mg, K, Na, H, etc.) are adsorbed to the surfaces of clay and humus, where the can be exchanged with other cations in the soil solution, on plant roots or held tightly, depending on conditions. CSR is the ratio of Ca, Mg, K, and Na on the exchange sites, and is a major factor in soil fertility and structure.

7. What are several advantages of optimum soil cation balance?

   Optimum soil tilth, aeration, drainage, nutrient availability, biological activity, organic matter breakdown, and minimized toxic elements

8. What are the three primary sources of nitrogen factored into a nitrogen budget for an organic farming system?

   Compost, the estimated nitrogen release (ENR) from soil organic matter, and the nitrogen contributed by nitrogen-fixing cover crops

Resources

SUGGESTED READINGS

A and L Western Agricultural Laboratories, Inc. Reference Guides: "Soil Sampling" and "Soil Analysis" 1311 Woodland Ave. #1 Modesto, CA 95351. 209.529-4080.

The two four-page pamphlets above provide an overview of basic soil sampling procedures and the soil properties measured in an A and L soil analysis report. Available from www.al-labs-west.com/index.html.

Gaskell, Mark, Jeff Mitchell, Richard Smith, Steven Koike, and Calvin Fouche. 2000. *Soil Fertility Management for Organic Crops*. Publication 7249. Oakland, CA: University of California Division of Agriculture and Natural Resources.

A brief four-page overview of soil fertility for organic production systems. Available on-line in PDF format from anrcatalog.ucdavis.edu.

PRINT RESOURCES

A and L Western Agricultural Laboratories, Inc. *Agronomy Handbook: Soil And Plant Analysis.* Modesto, CA: California Laboratory.

A concise and practical handbook designed to be used in association with A and L soil analysis testing services. Provides an overview of general properties of soils and recommendations on the management of all essential soil and plant nutrients. Includes useful tables on crop removal estimates, crop deficiency symptoms, nutrient composition of common fertilizers and amendments comprehensive section on plant analysis.

Albrecht, William A., and C. Walters (editors). 1975. *The Albrecht Papers, I, II and III*. Raytown, MO: Acres USA.

Provides an overview of William Albrecht's agronomic research and outlines the rationale behind his suggestions of base cation saturation ratios.

California Fertilizer Association. 2001. *The Western Fertilizer Handbook, Ninth Edition*. Thomson publications.

This handbook presents fertilization, nutrient management, and related topics based on the fundamentals of biological and physical sciences.

Magdoff, Fred, and Harold Van Es. 2000. *Building Soils for Better Crops. Second Edition*. Handbook Series Book 4, Sustainable Agriculture Network. Beltsville, MD: National Agricultural Library.

An introductory overview of organic management of soil fertility covering the basics of soil organic matter, physical, and chemical properties of soil, ecological soil and crop management. Practical and accessible information. Available from www.sare.org.

Miller, P. R., W.L. Graves. et al. 1989. *Cover Crops for California Agriculture*. Leaflet 21471. Oakland, CA: University of California Division of Agriculture and Natural Resources.

A concise overview of the common cover crops use in California agriculture. Addresses annual and perennial cropping systems.

Sprague, H., ed. 1964. *Hunger Signs in Crops*. New York: David Mckay Company.

Discusses the visual signs of nutrient deficiencies in various crops.

Traynor, J. 1980. *Ideas in Soil and Plant Nutrition*. Bakersfield, CA: Kovak Books.

UC Division of Agriculture and Natural Resources. 1998. *Cover Cropping in Vineyards*. Publication 3338. Oakland, CA: University of California Division of Agriculture and Natural Resources.

A technical introduction to the use of cover crops in California vineyards. Covers agronomic and economic aspects of cover crop use.

Young, G. 1999. "Training Manual for Soil Analysis Interpretation in Northern California." Master's Thesis, California State University, Sonoma.

A thesis project developed for teaching farmers and extension agents how to read and interpret soil analysis reports. Includes summaries of studies of fertilizer use trends in northern California and those linking over fertilization with pest and disease problems. Emphasizes the research and recommendations of William Albrecht.

WEB RESOURCES

Alternative Farming Systems Information Center, USDA

www.nal.usda.gov/afsic/

Technical information on organic farming, sustainable agriculture, community supported agriculture. Access to National Agricultural Library to research journal article abstracts and order articles.

Appropriate Technology Transfer for Rural Areas (ATTRA)

www.attra.org/

A national sustainable farming information center. Information on sustainable farming production practices, alternative crop and livestock enterprises, innovative marketing.

List of web sites on soil quality, with over 50 links and references on soil fertility

Bob Lippert's Frequently Asked Questions Regarding Soil Testing, Plant Analysis, and Fertilizers, Department of Crop and Soil Environmental Science, Clemson University

hubcap.clemson.edu/~blpprt/bobweb/bobweb.html

Commercial Organic Nutrient Recommendations, University of Maine Soil Testing Service and Analytical Lab

anlab.umesci.maine.edu/handout/organ01.HTM

Evaluating Microbiology of Compost (Vicki Bess, *BioCycle*, May 1999; Vol. 40, Issue 5)

www.jgpress.com

Fertilizer Recommendations for Horticultural Crops

www.hortnet.co.nz/publications/guides/fertmanual/dguide1.htm

Information and photos of specific crop nutrient deficiencies

Interpreting Missouri Soil Test Reports, University of Missouri-Columbia

muextension.missouri.edu/xplor/agguides/soils/g09112.htm

Interpreting Soil Test Results for Commercial Crops, University of Maine Soil Testing Service and Analytical Lab

anlab.umesci.maine.edu/combk/comm0.HTM

Nutrient Management for Commercial Fruit and Vegetable Crops in Minnesota, University of Minnesota

www.extension.umn.edu/Documents /D/C/DC5886.html

Ohio Agronomy Guide, Bulletin 472: Soil Fertility

www.ag.ohio-state.edu/~ohioline/b472/fertile.html

Organic Materials Review Institute

www.omri.org

A list of materials compatible in organic farming, brand name review, technical information.

Peaceful Valley Farm Supply

www.groworganic.com

A catalogue of tools and supplies and technical support for organic farmers and gardeners.

Philosophy of Soil Testing, National Corn Handbook, Purdue University

www.agcom.purdue.edu/AgCom/Pubs /

Selecting an Analytical Laboratory, Colorado State University

www.ext.colostate.edu/pubs/crops/00520.html

Soil Fertility Test Interpretation: Phosphorus, Potassium, Calcium, Magnesium, Rutgers Cooperative Extension Service

www.rce.rutgers.edu:80/ag/

Soil Sampling for High Yield Agriculture

www.back-to-basics.net/efu/pdfs/sampling.pdf

An illustrated overview of basic soil sampling techniques.

Soil Test Explanation, Colorado State University

www.ext.colostate.edu/pubs/crops/00502.html

Soil Test Interpretations, New Mexico State University

www.cahe.nmsu.edu/pubs/_a/ /a-122.html

Soil Testing and Nutrient Management, A Basic Guide for Interpreting Soil Test Values, Woods End Agricultural Laboratory

www.woodsend.org/brinton2.pdf

Soil Testing Handbook for Professionals in Agriculture, Horticulture, Nutrient and Residuals Management, 3rd Edition. University of Maine Soil Testing Service and Analytical Lab

anlab.umesci.maine.edu/handbk/part0.htm

Something to Grow On: Nutrient Management, the Key to Successful Nursery Crop Production, Cornell University

www.hort.cornell.edu/department/faculty/good/growon/index.html

UC Sustainable Agriculture Research and Education Program (UC SAREP)

www.sarep.ucdavis.edu/

Sustainable agriculture news, technical information, grant programs, Biologically Integrated Farming Systems (BIFS) program.

www.sarep.ucdavis.edu/soil/websites.htm

Understanding the Numbers on Your Soil Test Report, University of Arkansas

www.uaex.edu/Other_Areas/publications/

Understand Your Soil Test: Calcium, Magnesium, Boron, Copper, Chlorine, Molybdenum, University of Nebraska

www.ianr.unl.edu/pubs/Soil/g165.htm

USDA National Organic Program.

www.ams.usda.gov/nop/

Regulations on certification, materials, and labeling for organic producers and processors.

Appendix 1: Sample (blank) Soil Analysis Report

(Numbers refer to headings in Lecture 2 Outline)

ACME Agricultural Laboratories, Inc. Sample/Lab Number: _____

1	% Organic Matter		_____ %
2	ENR		_____
	PHOSPHORUS		
3a	P1		_____ ppm Weak Bray
3b	P2		_____ ppm Reserve
4	Potassium	K	_____ ppm
5	Magnesium	Mg	_____ ppm
6	Calcium	Ca	_____ ppm
7	Sodium	Na	_____ ppm
8	pH		_____ Soil
9	pH		_____ Buffer Index
10	Hydrogen	H	_____ meq/100 g
11	CEC		_____ meq/100 g
	PERCENT BASE SATURATION		
12a	Potassium	K	_____ % K
12b	Magnesium	Mg	_____ % Mg
12c	Calcium	Ca	_____ % Ca
12d	Hydrogen	H	_____ % H
12e	Sodium	Na	_____ % Na
13	Nitrate Nitrogen	NO_3^-	_____ ppm
14	Sulfate Sulfur	SO_4^-	_____ ppm
	MICRONUTRIENTS/TRACE ELEMENTS		
15a	Zinc	Zn	_____ ppm
15b	Manganese	Mn	_____ ppm
15c	Iron	Fe	_____ ppm
15d	Copper	Cu	_____ ppm
15e	Boron	B	_____ ppm
16	Excess Lime Rate		_____
17	Soluble Salts		_____ mmhos/cm
18	Chloride	Cl	_____ ppm
19	Particle Size Analysis (Soil Texture: %Sand, %Silt, %Clay)		_____

Appendix 2: Nutrient Budgeting Worksheets

REPORT NO.

NAME DATE SAMPLED SOIL DEPTH SAMPLED: 0 -12 "

FIELD I.D. CROP SOIL TEXTURE

% ORGANIC MATTER PH CO_3 HCO_3 CATION EXCHANGE CAPACITY (CEC)

SOIL CATIONS	CALCIUM (Ca)	MAGNESIUM (Mg)	POTASSIUM (K)	SODIUM (Na)	HYDROGEN (H)	
A ppm tested						
B ppm optimal range				na	na	
C Conversion factor ppm to lbs/acre (to 13–14")	x 4	x 4	x 4.8	na	na	
D = B x C lbs/acre optimal range				na	na	
E = A x C lbs/acre tested				na	na	
F = D - E lbs/acre of nutrient required				na	na	
G VL Low Med Hi VH						
H % CSR tested (cation saturation ratio)						
I % CSR optimal	65 – 75%	5 – 10%	3 – 5%	0 – 5%	0 – 20%	
J Soil amendment to be used				na	na	
K Nutrient content by %				na	na	
L = F/K lbs/acre amendment required				na	na	
M = L/2000 or M = L/440 tons/acre or lbs/100 sq-ft of amendment needed				na	na	
N Price per unit				na	na	
O acre or sq ft				na	na	
P Total cost/amendment						**Total cost of amendments**

Appendix 2 (cont'd): Nutrient Budgeting Worksheets – Macronutrients

MACRONUTRIENTS	P1 (P_2O_5-P) Available	P2 ($NaHC0_3$-P) (Olsen method)	SULFUR (SO_4-S)	NITROGEN (NO_3-N)	
A ppm tested					
B ppm optimal range	30 – 40	12 – 15 (at pH of 7.0)	15 – 20		
C conversion factor ppm to lbs/acre (to 13–14")	x 9.2	x 9.2	x 12		
D = B x C lbs/acre optimal range	150 – 250	110 – 138	135 – 185		
E = A x C lbs/acre total present					
F = D - E pounds/acre of nutrinet required					
G VL Low Med Hi VH					
H % CSR tested	na		na		
I % CSR optimal	na		na		
J Soil amendment to be used					
K Nutrient content by %					
L = F/K lbs/acre amendment required					
M tons/acre or lbs/100 sq ft of amendment needed					
N Price per unit					
O acres or sq ft					
P Total cost /amendment					**Total cost of amendments**

Appendix 2 (cont'd): Nutrient Budgeting Worksheets – Micronutrients

MICRONUTRIENTS	ZINC (Zn)	MANGANESE (Mn)	IRON (Fe)	COPPER (Cu)	BORON (B)	
A ppm tested						
B ppm optimal range	1.1 – 3.0	9 – 12	11 – 16	0.9– 1.2	0.6– 1.2	
C conversion factor ppm to lbs/acre (to 13–14")	x 4	x 4	x 4	x 4	x 4	
D = B x C lbs/acre optimal range	4 – 12	36 – 48	44 – 64	3.6 – 4.8	2 – 4	
E = A x C lbs/acre total present						
F = D - E pounds/acre of nutrient required						
G VL Low Med Hi VH						
H % CSR tested	na	na	na	na	na	
I % CSR optimal	na	na	na	na	na	
J Soil amendment to be used						
K Nutrient content by %						
L = F/K lbs/acre amendment required						
M = L/2000 or M = L/440 tons/acre or lbs/100 sq ft of amendment needed						
N Price per unit						
O acres or sq ft						
P Total cost/amendment						**Total cost of amendments**

Appendix 3: Example of a Nitrogen Budget

NITROGEN REMOVAL		1) 150 lbs N/acre (spinach) (Estimated total N lost to crop removal)
NITROGEN CONTRIBUTIONS		
Soil Organic Matter Estimated Nitrogen Release (ENR) Example ENR: 110 lbs/ac	• Use 60–80% of Estimated Nitrogen Release (ENR) on Soil Test for annual and perennial crops, respectively. • 110 lbs/acre (110 x .60) = 66 lbs/acre of actual N	2) 66 lbs N/acre (Estimated nitrogen released in the first year from soil organic matter)
Compost * Moist compost is ~35% moisture by weight. This needs to be subtracted from the total compost weight. (0.35 x total compost weight = amount to subtract from total to get dry weight)	• Average application rate: 5–7 tons/acre/year of compost • ~1 % nitrogen content • 10,000–14,000* lbs x .01 = 65–91 lbs actual N • with ~50% available in the first year = 32.5–45 lbs N	3) 32.5–45 lbs N/acre (Estimated nitrogen released N released in the first year from compost)
Legume Cover Crops	• Estimated N fixation by Bell Beans = 100 lbs/ acre • Estimated % N Available in first season after incorporation = 50% • 100 lbs X .50 = 50 lbs estimated lbs of actual N available in first season after incorporation	4) 50 lbs. N/acre (Estimated N contribution of fabaceous cover crops)
Total Available Nitrogen	• 66 lbs + 45 lbs + 50 lbs = 161 total lbs of actual N/acre	5) 161 lbs N/acre (Estimated total available nitrogen/acre)
Calculating Additional Nitrogen Needs	• Line 1 (Total N lost to crop removal) – Line 5 (Total Available Nitrogen) • 150 lbs – 161 lbs = 11 lbs N/acre surplus. No supplemental N needed Note: Seasonal environmental conditions (e.g., cool and wet soils) may create growing conditions that may depress mineralization and N availability, thereby creating a demand for supplemental fertilizer despite the presence of adequate quantities of N in the soil. This relatively low excess should not lead to losses to the environment if nutrient release is properly timed with crop demand.	

Appendix 4: Nitrogen Budgeting Worksheet

NITROGEN REMOVAL *(See appendix 5 for crop removal estimates)* NITROGEN CONTRIBUTIONS		1) _____ lbs.N/acre (Estimated average total N lost to crop removal)
Soil Organic Matter Estimated Nitrogen Release (ENR) *(See soil analysis report for ENR figures)*	• Estimated Nitrogen Release (ENR) on Soil Test _____ x 60–80% (for annual and perennial crops, respectively)	2) _____ lbs.N/acre (Estimated nitrogen released in the first year from soil organic matter)
Compost * Moist compost is ~35% moisture by weight. This needs to be subtracted from the total compost weight. (0.35 x total compost weight = amount to subtract from total to get dry weight)	• Application rate: _____ tons/acre/year of compost • Average N content of compost = _____% • _____ lbs. compost* x %N of compost = _____ lbs. actual N applied • Average N available in the first year = 50% • _____ lbs. actual N applied x .050 = ENR of compost	3) _____ lbs N/acre (Estimated nitrogen released N released in the first year from compost)
Legume Cover Crops *(See Unit 1.6 for estimating N contribution of cover crops)*	• Estimated N fixation by cover crop = _____ lbs/ acre • Estimated % N Available in first season after incorporation = 50% • _____ lbs. X .50 = _____ lbs. estimated lbs of actual N available in first season after incorporation	4) _____ lbs. N/acre (Estimated N contribution of fabaceous cover crops)
Total Available Nitrogen	• _____ lbs. + _____ lbs. + _____ lbs. = _____ total lbs of actual N/acre	5) _____ lbs. N/acre (Estimated total available nitrogen/acre)
Calculating Additional Nitrogen Needs	• Line 1 _____ (Total N lost to crop removal) – Line 5 _____ (Total Available Nitrogen)	6) _____ lbs. N/acre (Total needed supplemental nitrogen in lbs./acre)

***** Note on the accuracy of the above mineralization figures: The C:N ratio of organic matter, climate and weather patterns, the presence of lignins and tannins on the orginic matter, soil biological activity, soil moisture, and the placement of the organic matter amendments in the soil profile are all influencial factors in determining the mineralization rate of organic matter. Therefore , the accuracy of the mineralization rates listed in the Nitrogen Budgeting Worksheet above must be understood in this light and represent only rough estimates.

Appendix 5: Supplemental Fertilizers Worksheet

POTENTIAL LIMITING NUTRIENTS	FERTILIZER	APPLICATION METHOD	APPLICATION RATE	FREQUENCY OF APPLICATION	TOTAL VOLUME NEEDED	COST/ACRE
TOTAL						

Appendix 6: Optimum Nutrient Levels (in ppm) of Major Cations Based on CEC

CEC of Soil	Ca 65%	Ca 75%	Mg 10%	Mg 15%	K 3%	K 5%	Na <5%
2	260	300	24	37	23	39	23
3	390	450	37	55	35	59	35
4	520	600	49	73	47	78	46
5	650	750	61	92	59	98	58
6	780	900	73	110	70	118	69
7	910	1050	85	128	82	137	81
8	1040	1200	98	146	94	157	92
9	1170	1350	110	165	105	176	104
10	1300	1500	122	183	117	196	115
11	1430	1650	134	201	129	216	127
12	1560	1800	146	220	140	235	138
13	1690	1950	159	238	152	255	150
14	1820	2100	171	256	164	274	161
15	1950	2250	183	275	176	294	173
16	2080	2400	195	293	187	314	184
17	2210	2550	207	311	199	333	196
18	2340	2700	220	329	211	353	207
19	2470	2850	232	348	222	372	219
20	2600	3000	244	366	234	392	230
25	3250	3750	305	458	293	490	288
30	3900	4500	366	549	351	588	345
35	4550	5250	427	641	410	686	403
40	5200	6000	488	732	468	784	460

TOTAL EXCHANGE CAPACITY	CALCIUM LEVEL should be between these levels	MAGNESIM LEVEL should be between these levels	POTASSIUM LEVEL should be above first and near or below second	SODIUM LEVEL should be below this

Sample calculations:

FOR ANY CEC:	PPM OPTIMUM	MINUS	PPM TESTED	EQUALS	PPM NEEDED
CEC	ppm Ca (optimum)		ppm Ca (tested)		ppm needed
11	1430 –1650	-	950	=	480 – 700
CEC	ppm Mg (optimum)		ppm Mg (tested)		ppm needed
11	134 – 201	-	287	=	0

To calculate pounds or tons of amendments, multiply amount needed (ppm) by 4 to get pounds per acre-foot. Then divide amount needed in pounds by percent of element in the amendment. Ex:ample: Limestone, 32% Ca; 700 ppm needed x 4 = 2800 pounds/acre foot divided by .32 = 8,750 pounds divided by 2000 pounds = 4.4 tons/ac ft.. To calculate pounds per 1000 square feet (1 foot deep), divide pounds needed (8,750) by 44 = 200 pounds/1000 sq feet.

Appendix 7: Nutrient Content of Common Fertilizers and Amendments

MATERIAL	% N–P–K	% Ca–Mg–S	MICRO-NUTRIENT	TOTAL LBS NUTRIENTS per 100 lbs	COST per 100 lbs	COST PER LB. OF NUTRIENT	COMMENTS
SYNTHETIC MINERALS							
Ammonium sulfate	21-0-0	0-0-24		45			SOL-AC
Urea	46-0-0	—		46			SOL-AC
Calcium nitrate	15-0-0	19-0-0		34			SOL
Ammonium nitrate	34-0-0	—		34			SOL-AC
Super phosphate	0-20-0	25-0-0		50			SOL
Diammonium phosphate	18-48-0	—		66			SOL-AC
Nutricote	14-14-14	—		34			SOL-AC
Osmacote	14-14-14	—		34			SOL-AC
N–P–K Blend	—						SOL
Potassium sulfate	0-0-50	0-0-18		68			SOL
MINED MINERALS							
Rock Phosphate	0-25-0	25-0-0	+	50			SR
Sulfate of potash	0-0-50	0-0-18	+	68			SR
Greensand	0-2-7	—-	+	9			SR
Sulfur	0-0-0	0-0-90	+	90			SR-AC
CALCIUM AMENDMENTS							
Shell limestone	—-	39-1-0	+	40			SR
Dolomite	—-	20-10-0	+	30			SR
Gypsum	—-	22-0-16	+	38			SR
Hydrated (Ag) lime	—-	70-0-0		70			SOL
Mined limestone	—-	36-1-0	+	37			SR
Hardwood ash	0-2-5	20-2-0	+	29			SOL
ORGANIC MATTER FERTILIZERS & AMENDMENTS							
Fish emulsion	4-2-2	1-0-0	+	9			SOL-RAW
Fish powder	12-1-1	1-0-0	+	15			SOL-RAW
Blood meal	13-0-0	—-	+	13			SR-RAW
Cottonseed meal	7-2-2	—-	+	11			SR-RAW
Bat guano	10-4-1	1-0-0	+	16			SR-RAW
Chicken manure	3-2-1	3-0-0	+	9			SR-RAW
Steer manure	1-1-1	—-	+	3			SR-RAW
Bonemeal	2-15-0	20-0-0	+	37			SR
Mushroom waste	1.5-1-1.5	3-0-0	+	7			SR-RAW
Agricultural compost	1.5-1-1.5	2-0-0	+	6			SR
N–P–K Organic Blend	7-5-7	1-0-0	+	20			SR

SOL Soluble, quick acting, leaches out easily RAW Requires digestion before plant uptake SR Slow release, less leaching AC Acidifies soil

Appendix 8: Fertilizer Solutions Chart

	** Nitrogen Source, at least 4%	** Phosphorus Source, at least 3%	** Potassium Source, at least 3%	Solution Grade / Injectable	Foliar / Sprayable	Significant Magnesium	Significant Sulfur	Significant Calcium	Contains multiple trace minerals	Corrects specific mineral deficiencies	Pelleted or Granulated	* Fast Release = Immediate to 1 month	* Mid release = 1 to 4 months	* Long term release = 4+ months	For correcting low pH	For correcting high pH	Contains significant amounts of humus or humic acids	Used where nematodes are a problem	Contributes to microbial activity
Alfalfa Meal												●				●			●
Azomite								●					●						●
Bat Guano, High N	●			●	●						●								●
Blood Meal	●							●				●							
Bone Meal		●					●					●							
Brix Mix					●		●	●			●								
4-4-2	●	●								●		●							●
6-6-6	●	●	●							●		●							●
7-5-7	●		●				●			●		●							●
8-5-1	●	●								●		●							●
7-7-2 BioGro Fish Pellets	●	●						●		●		●							
9-3-5 BioGro Fish Pellets	●	●	●					●		●		●							
Calcium 25					●			●			●								
Chicken Manure, Composted		●						●				●				●			●
Compost, New Era, Grover's, Cranford's			●					●					●	●	●	●	●		●
Corn Gluten Meal	●											●							
Cottonseed Meal	●											●							
Feather Meal	●												●						
Fish Powder	●			●	●						●								●
Fish Meal	●	●										●							●
Fish Emulsion	●				●			●			●								●
Fish, Eco-Hydrolyzed Liquid	●			●	●			●			●								●
Fish & Kelp, Eco-Growth Liquid				●	●			●			●					●			●
Greensand			●					●					●						●
Kelp, Acadian Liquid			●	●	●			●			●								●
Kelp, Algit								●				●							●
Kelp, Soil Min			●					●					●						●
Kelp, Eco Cold-Processed Liquid				●	●			●			●					●			●
Kelp, Algamin				●	●			●			●								●
Kelp, Maxicrop			●	●	●			●			●								●
Gypsum, Solution Grade				●	●		●	●			●				●				
Gypsum, Mined							●	●					●		●				
Humate, Activate 80								●					●			●			
Lime, Oystershell								●	●				●	●					
Lime, Solution Grade				●	●			●				●		●					
Micronized-Cranfords Compost				●	●				●			●				●			●
Micronized Humate-Micro-Hume				●	●				●			●				●			●
Micronized Nutri Min				●	●				●			●							●
Micronized Soft Rock Phosphate		●		●	●			●	●			●							●
Micronized Shrimp Shell Meal		●		●				●	●			●					●		●
Neem cake	●												●				●		
Omega 6-6-6	●	●	●	●	●							●							●
Omega 1-5-5		●	●	●	●							●							●
Phytamin 800	●			●	●							●							●
Soft Rock Phosphate		●						●	●					●					●
Seabird Guano, High N	●	●		●	●							●							●
Seabird Guano, High P		●		●	●							●							●
Shrimp Shell Meal	●	●						●	●					●				●	●
Sulfate of Potash, Soluble			●	●	●		●					●							●
Sulfate of Potash, Standard			●				●				●			●					●
Sul Po Mag			●			●	●							●					
Sul Po Mag, Soluble			●	●	●	●	●					●							
WestBridge BioLink 5-5-5	●	●	●	●	●							●							
Worm Castings								●						●		●			●

Use Appendix 8 (previous page) as a reference to help you choose fertilizers. Remember, though, that this type of chart has inherent limitations. This chart will be updated with each catalog publication, as new information becomes available. * The time period mentioned in these categories represents the approximate length of time these fertilizers will last in your soil. Release period will vary, depending upon soil temperatures and biology. **Please note: Fertilizers that do not show a dot for a particular analysis (N-P-K) may still contain smaller amounts of these.

Appendix 9: Approximate Pounds/Acre of Nutrients Removed by Common Crops

CROP	YIELD	NITROGEN	PHOSPHATE	POTASH	CALCIUM	MAGNESIUM	SULFUR
GRAINS							
Corn	200 bu	300	120	260	42	30	32
Rice	150 bu	150	60	160	24	17	18
Soybeans	60 bu	330	72	144	102	14	27
Wheat	74 bu	158	54	120	20	18	17
HAY - LEGUMES							
Alfalfa	10 tons	600	140	500	280	50	50
Vetch	5 tons	275	75	225	120	25	25
HAY - GRASSES							
Coastal Bermuda	10 tons	500	120	350	75	45	60
Timothy	5 tons	180	68	220	40	24	14
FRUITS AND VEGETABLES							
Apples	21 tons	175	75	320	100	40	40
Cabbage	30 tons	195	72	240	72	30	66
Celery	50 tons	260	110	500	130	40	70
Cucumbers	20 tons	180	60	300	160	40	32
Grapes	10 tons	55	20	100	10	7	11
Lettuce	20 tons	140	46	200	56	14	16
Onions	15 tons	90	41	80	24	9	36
Oranges	30 tons	270	60	270	210	52	30
Peaches	15 tons	116	30	150	101	24	21
Pears	20 tons	118	48	174	102	28	25
Potatoes	25 tons	150	75	250	10	12	8
Spinach	15 tons	150	45	90	36	15	12
Tomatoes	30 tons	120	36	210	15	15	21
Turnips	12 tons	154	34	168	65	12	22
Mixed Vegetable Average		130	54	218	78	21	29

From Soil and Plant Analysis, A&L Western Laboratories, 1974; Western Fertilizer Handbook, 1980; Nutrient Deficiencies & Toxicities in Crop Plants, 1993.