BULLETIN 458

FERTILIZING FRUIT CROPS

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CONTENTS

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FERTILIZING FRUIT CROPS

Fertilizer applications to fruits are made to supplement plant nutrient elements naturally occurring in the soil in order to maintain an optimum supply in the rooting zone. Application of fertilizers, except for this purpose, is wasteful and may have deleterious effects on both the crop and the environment. Improperly applied nutrients may cause excessive growth, or create nutrient imbalances which can greatly complicate management practices.

The best guide to nutrient requirements of a fruit plant is an intimate knowledge of its growth characteristics along with a thorough knowledge of the planting. Careful and frequent assessment of growth and fruiting characteristics must be combined with foliar and soil analysis if the grower is to develop the most effective fertilizer program for a given crop.

Soils of suitable fruit sites in Ohio more frequently are limited in the supply of nitrogen than in any other element. Hence, in many instances only nitrogen need be applied. Thus, fertilizer recommendations for fruit crops typically are based on nitrogen needs. Other nutrient elements are known to be needed in specific fruit plantings in Ohio. If these elements are needed for good growth and production, they should be added.

Although soil fertility practices are of major importance, they do not offer the total answer to successful fruit growing. The performance of the fruit plant is dependent upon many factors. Even with proper fertilization, unsatisfactory production may occur due to poor pest control, inadequate soil moisture, mechanical injury, or improper cultural practices.

SOIL TYPES AND THEIR CHARACTERISTICS

There are more than 350 different soil types in Ohio. They vary widely in their chemical and physical characteristics. These differences are caused by climate, vegetation, parent material, relief, drainage and time. Poor drainage and excess water on the soil surface or in the soil profile are major problems in about half of Ohio's cropland. Soils on the steeper slopes are usually well drained; soils on nearly level areas may be imperfectly drained, and soils in depressed areas are usually poorly drained.

Most Ohio fruit plantings are located on medium fertility, alluvail, and terrace soils developed from glacial materials. The land is generally sloping or rolling and higher than the surrounding terrain. However, this does not insure that certain soil problems including poor drainage will not exist. In the overall management of a fruit planting, it is wise to learn as much as possible about the soil properties before setting the plants. Data can be obtained from several sources such as the Agronomy Guide, published by the Ohio Cooperative Extension Service, The Division of Lands and Soil, Ohio Department of Natural Resources, or USDA Soil Survey Reports, published by The Soil Conservation Service. These reports are available at county Cooperative Extension Service and Soil and Water Conservation District offices.

SOIL REACTION AND LIMING

Soil pH

The chemical reaction of a soil may be termed acid, neutral, or akaline. Soil acidity or alkalinity is measured by the pH scale. The neutral point is a pH of 7.0. Below this such as pH 5.0, the scale indicates an acid condition, and above as pH 8.0, an alkaline condition. These values are based on a logarithmic scale, hence, each whole number is 10 times greater than the one preceding it. Thus, a pH 5.0 is 10 times more acid than pH 6.0 or, a pH 8.5 is 10 times more alkaline than pH 7.5.

Table 1: Lime Requirement to Increase Soil pH to Four Levels[1]
(In Terms of T/A Ag-Ground Limestone, T.N.P. 90 + 6⅔ inch Plow Depth)

Lime Test Index	Desired pH Levels — Mineral Soils 7.0	6.5	6.0	Organic Soils 5.2
	Tons per Acre—Ag-Ground Limestone			
70	0	0	0	0
69	0.3	0.3	0.2	0.2
68	1.2	1.0	0.8	0.6
67	2.1	1.8	1.4	1.1
66	2.8	2.4	1.9	1.5
65	3.7	3.1	2.6	2.0
64	4.6	3.9	3.2	2.4
63	5.5	4.6	3.8	2.9
62	6.3	5.3	4.3	3.4
61	7.1	6.0	4.9	3.8
60	8.0	6.7	5.5	4.2
59	8.9	7.5	6.1	4.8
58	9.7	8.1	6.6	5.2
57	10.6	8.9	7.2	5.6
56	11.4	9.6	7.8	6.1
55	12.3	10.4	8.5	6.6
54	13.2	11.1	9.1	7.0
53	14.0	11.7	9.6	7.4
52	14.9	12.5	10.2	7.8
51	15.8	13.2	10.8	8.4
50	16.7	14.0	11.4	8.8
49	17.6	14.7	12.0	9.2
48	18.4	15.5	12.6	9.6

[1]From 1972-73 Agronomy Guide, Ohio Extension Bul. 472.

Lime Test Index

As mentioned previously, the soil pH test measures active soil acidity or alkalinity. To ascertain the lime requirement of a soil, a test for total acidity should be made. This is indicated by the Lime Test Index. As shown in Table 1, the lower the Lime Test Index is below 70, the higher the lime requirement. The amount required will also vary according to the soil pH level desired (7.0, 6.5 or 6.0) and the depth to which applied. Table 1 shows the adjustments to a depth of 6⅔ inches for the desired pH. If a pH change to a greater depth is wanted, the appropriate figures from Table 1, for your situation, can be multiplied by the factor in Table 2 to ascertain the amount of lime needed to adjust the pH to a greater depth. Lime should be incorporated at these greater depths if a more rapid response is desired.

Table 2: Adjustments in Liming Ratio for Depth of Plowing[1]

Plowing Depth (in)	Multiplying Factor
3⅓	.50
Base 6⅔	1.00
7	1.05
8	1.20
9	1.35
10	1.50
11	1.65
12	1.80
13	1.95
14	2.10

[1]From 1972-73 Agronomy Guide, Ohio Extension Bul. 472.

Liming

For continued high production, it is essential to make proper use of both lime and fertilizer. Liming materials are applied to raise the soil pH and to supply calcium or magnesium. Indiscriminate applications can have adverse effects. Do not apply lime until the need has been established. Raising the pH of an excessively acid soil can produce the following beneficial effects:

1. Increase the availability of phosphorus, calcium, magnesium, and molybdenum.

2. Reduce the concentrations of available manganese, iron, and aluminum.
3. Increase microbiological activity which in turn hastens release of nitrogen, phosphorus, potassium, boron, and other elements from decaying organic matter.
4. Improve soil structure and tilth.
5. Increase production per acre.

For best growth and production of most fruit plants, the soil pH should be between 5.5 and 6.5, but for management reasons 6.0 to 6.5 is ideal. This range is also desirable for good cover crop development. One exception is the blueberry, which does best on acid soils in the pH range of 4.0 to 5.0. For this crop, it is sometimes beneficial (practiced on a small scale) to apply materials such as sulfur or aluminum sulfate to acidify the soil.

Liming Materials

Materials used for correcting soil acidity include all calcium and magnesium products sold for agricultural purposes in the carbonate, oxide, hydroxide or silicate forms, or any of their combinations.

Table 3: Equivalent Amounts of Liming Materials[1]
(Based on T.N.P. and Fineness)

Grade	T.N.P	Fineness % Passing Mesh Size 100	60	20	8	Lbs. to equal 1 ton of Agr'l Ground Limestone 90 or higher T.N.P	% of Ag-Ground to Apply
AGRICULTURAL LIMESTONE AND/OR SLAG (air cooled)							
Hydrated	160+	90	95	98	100	1000	50
Hydrated	130-140	90	95	98	100	1200	60
Ag-Superfine	90+	80	95	100	100	1600	80
	80-89	"	"	"	"	1800	90
	70-79	"	"	"	"	2000	100
Ag-Pulverized	90+	60	70	95	100	1700	85
	80-89	"	"	"	"	1900	95
	70-79	"	"	"	"	2100	105
Ag-Ground (Base)	90+	40	50	70	95	2000	100
	80-89	"	"	"	"	2300	115
	70-79	"	"	"	"	2600	130
Ag-Fine Meal	90+	30	40	60	85	2500	125
	80-89	"	"	"	"	2800	140
	70-79	"	"	"	"	3100	155
Ag-Coarse Meal	90+	20	30	50	80	2900	145
	80-89	"	"	"	"	3200	160
	70-79	"	"	"	"	3700	185
Ag-Fine Screenings	90+	10	20	45	80	3400	170
	80-89	"	"	"	"	3800	190
	70-79	"	"	"	"	4300	215
Ag-Coarse Screenings	90+	5	15	40	80	4000	190
	80-89	"	"	"	"	4300	215
	70-79	"	"	"	"	4800	240
AGRICULTURAL GRANULATED SLAG (water cooled)							
Ag-Granulated Slag	90+	5	15	55	95	2000	100
	80-89	"	"	"	"	2300	115
	70-79	"	"	"	"	2600	130

[1]From the 1972-73 Agronomy Guide, Ohio Extension Bul. 472.

High calcic liming materials have 90 percent or more of the total calcium and magnesium as calcium oxide and contain 35 percent or more of calcium oxide equivalent. Dolomitic, or high magnesic liming materials, contain 10 percent or more of magnesium oxide equivalent and should be used on soils low in magnesium. Fused calcium magnesium silicate, a common by-product of the steel industry, is sold as agricultural slag. Two kinds are available (air cooled and water quenched or granulated slag), either of which can be a suitable liming material. Slag must have the same degree of fineness as limestone when sold as a liming material.

Liming materials have a wide range of total neutralizing power (TNP). This is due to variations in calcium and/or magnesium content as well as to impurities. If a material's TNP is less than 90, an adjustment should be made to account for this lower level when determining the amount required to affect the pH adjustment.

The effectiveness of any liming material depends upon its particle size. The finer it is ground, the greater the reacting surface and the more rapid the effects upon the pH level. Extremly coarse materials, larger than 8-mesh, react so slowly that they are not recommended.

A comparison of the commonly available liming materials used in Ohio is presented in Table 3. The choice of which liming material to use will depend upon those that are readily available, cost per TNP unit, method of spreading, magnesium level in the soil, and how rapid a pH correction is desired. For example, a soil low in magnesium that needs the pH raised should be limed with dolomitic limestone. If a rapid change of soil pH is required, then a hydrated lime is preferred over ag-ground limestone. Also, only half as much hydrated lime as ag-ground limestone is required to get the same degree of pH change. Throughout the state, ag-ground limestone is the most widely used form in correcting soil pH and, in most cases, will have the lowest cost per TNP unit applied.

Liming Applications

It is very important to initiate a soil pH control program one or two years prior to establishing a fruit planting. Collect soil samples, have them analyzed, and apply required lime before setting the plants. Liming recommendations of the Ohio soil testing laboratory are based on a broadcast application over the entire planting site. This will result in the desired pH adjustment in the upper 6⅔ inches of soil. It is important that the entire area be treated as crop roots will eventually permeate the entire soil mass. If acid subsoils are indicated in preplanting soil tests, adjust the pH to a depth of 18 inches.

Liming may be done any time of year and is a service of many fertilizer dealers. Following application, it is advisable to incorporate lime into the soil for a more speedy reaction. In instances where pH correction to or beyond plow depth is desired, half of the lime required may be applied before plowing and half afterwards.

After the pH has been adjusted to the desired range and soil depth, it should be monitored periodically in the established planting to determine if futher liming is needed. Both calcium and magnesium, the major plant nutrients in lime, are lost through cropping as well as by erosion and leaching. The use of acid-forming fertilizers also contributes to the need for periodic liming.

FERTILIZER MATERIALS

Inorganic Fertilizers

Materials classed as inorganic fertilizers may contain only one essential plant nutrient, or a mixture of two or more. The label on the product states the percentages of nitrogen (N), phosphorus (P) or phosphorus pentoxide (P_2O_5) and potassium (K) or potassium oxide (K_2O) the material contains. Thus, the analysis on a bag of mixed fertilizer may read 0-16-16, which means that it contains 0% N, 16% P_2O_5 and 16% K_2O. The percentages are always in this order in the analysis formula.

It is important to know the analysis and the classes of various basic fertilizer materials for making sound management decisions. Tables 4, 5, 6 and 7 list the analyses of many of the various fertilizer materials.

Organic Fertilizers

The term organic fertilizer is commonly applied to plant or animal waste products which contain one or more of the nutrient elements. Synthetic organic fertilizers are those organic fertilizer compounds that are synthetically produced but are chemically identical to natural organic fertilizer compounds. A common example of a synthetic organic fertilizer is urea. Natural organic fertilizers include materials such as bone meal, blood meal, tankage, and animal manures.

The natural processes of decay that must take place to release the nutrients in organic fertilizers generally cause these nutrients to be released more slowly than those of inorganic materials. In the microbial decomposition of many of the organic fertilizers, especially those containing small amounts of nitrogen, nitrogen from the soil is tied up in the decaying process. This nitrogen, along with the nitrogen that was present in the undecomposed organic fertilizer, will become available to the plants only after a significant amount of decomposition has occurred. In the case of sawdust, it may take several years, while alfalfa hay may take only a few weeks or months to break down.

Table 4: Analysis and Classes of Some Nitrogen (N)
(Fertilizer Materials[1])

Nitrogen Fertilizer Carriers	Formula	Form	Per Cent Nitrogen
INORGANIC:			
Ammonium nitrate	NH_4NO_3	Solid	33.5
Ammonium sulfate	$(NH_4)_2SO_4$	Solid	21
Anhydrous ammonia	NH_3	Gas[2]	82
Aqua ammonia	NH_4OH	Liquid	20-25
Calcium cyanamide	$CaCN_2$	Solid	21
Calcium nitrate	$Ca(NO_3)_2$	Solid	16
Nitrogen solutions	(Varies)	Liquid	20-50
Sodium nitrate	$NaNO_3$	Solid	16
SYNTHETIC ORGANIC:			
Urea	$CO(NH_2)_2$	Solid	45
Urea formaldehyde		Solid	38
NATURAL ORGANIC:			lb/T
Animal manure		Solid	10-20
Sewage sludge		Solid	5-10

[1] From the 1972-73 Agronomy Guide; Ohio Extension Bul. 472.
[2] Liquid under pressure

Table 6: Analysis of Some Ca, Mg and S Carriers[1] [2]

Material	Average Per Cent N	P	K	Ca	Mg	S
Ammonium Nitrate Limestone	20.5			7.3	4.4	
Magnesium Sulfate (Epsom Salts)					9.7	13
Calcium Sulfate (Gypsum)				22.3		17
Sulfate of Potash-Magnesia			22		11.2	22.7
Superphosphate						
(Normal)		18-20		20.4		12-14
(Concentrated)		30-50				1.4
Ammonium Sulfate	20.5					23.7
Potassium Sulfate		48-51				17-18
Elemental Sulfur						50-99
Ammonium Phosphate	11	48				2.2
Ammonium Phosphate (Sulphate)	16	20				15.4
Manganese Sulfate						14-17
Sulfuric Acid						32.7

[1] Liming materials also contain varying amounts of Ca and Mg.
[2] From the 1972-73 Agronomy Guide, Ohio Extension Bul. 472.

Table 5: Analysis of Phosphorus (P_2O_5) and Potash (K_2O) Fertilizer Carriers[1]

Fertilizer Material	Formula	Approximate Per Cent N	P_2O_5 Total	P_2O_5 Available (Citrate Soluble)	P_2O_5 Per Cent Available P_2O_5 Which is Water Soluble	K_2O
PHOSPHORUS CARRIERS						
20% superphosphate	$CaH_4(PO_4)_2$ and $Ca_2H_2(PO_4)_2$	0	21	20	85	0
Concentrated superphosphate	$CaH_4(PO_4)_2$	0	47	45	85	0
Ammonium phosphate	$NH_4H_2PO_4$ mostly	11	49	48	92	0
Diammonium phosphate	$(NH_4)_2HPO_2$	18	47	46	100	0
Phosphoric acid	H_3PO_4	0	54	54	100	0
Superphosphoric acid, Polyphosphate						
Rock phosphate	H_3PO_4 and $H_4P_2O_7$	0	76	76	100	0
	Fluoro-and chloroapatites					
	$3\ Ca_3(PO_4)_2 \cdot CaF_2$	0	34	3 to 8	0	0
POTASH CARRIERS						
Muriate of potash	KCL	0	0	0	0	60 to 62
Potassium sulfate	K_2SO_4	0	0	0	0	50
Potassium magnesium sulfate	$K_2SO_4 \cdot 2\ MgSO_4$	0	0	0	0	21
Potassium nitrate	KNO_3	13	0	0	0	44

[1] From the 1972-73 Agronomy Guide, Ohio Extension Bul. 472.

Table 7: Analysis of Various Micronutrient Carriers

Fertilizer Material	Formula	Average Content
Manganese Carriers		%Mn
Manganese Sulfate	$MnSO_4 \cdot H_2O$	32
Manganese Chelate	Na_2Mn Complex	12*
Iron Carriers		%Fe
Ferrous Sulfate	$FeSO_4 \cdot 7H_2O$	20
Ferric Sulfate	$Fe\ (SO_4)_3$	27
Iron Chelate	NaFe Complex	10*
Boron Charriers		%B
Sodium Borate (Borax)	$Na_2B_4\ O_7 \cdot 10H_2O$	11
Polybor; Solubor	$Na_2B_4O_{13} \cdot 4H_7O$	21
Copper Carriers		%Cu
Copper Sulfate	$CuSO_4 \cdot 5H_2O$	25
Copper Sulfate Monohydrate	$CuSO_4 \cdot H_2O$	35
Copper Chelate	Na_2Cu Complex	13*
Zinc Carriers		%Zn
Zinc Sulfate	$ZnSO_4 \cdot 7H_2O$	22
Zinc Sulfate	$ZnSO_4 \cdot H_2O$	36
Zinc Chelate	Na_2Zn Complex	14*
Zinc Oxide	ZnO	72-79
Molybdenum Carriers		%Mo
Ammonium Molybdate	$(NH_4)_2MoO_4$	49
Sodium Molybdate	$Na_2MoO_4 \cdot 2H_2O$	39

* Chelated forms of these nutrients may contain up to this amount. Their nutrient availability has been changed by complexing with an organic carrier.

Reference to commercial products or trade names are for educational purposes only. No discrimination is intended and no indorsement by the Cooperative Extension Service is implied for specific products or names.

An organic material may vary considerably in composition, depending upon its source. Thus, when such a material is applied as fertilizer, an unknown quantity of nitrogen, phosphorus, potassium, or other elements is actually applied. Organic materials do have definite advantages, but price per unit of plant food is not one of these advantages. However, as by-products of the growers farming operation, it may be necessary or desirable so as to utilize such waste products.

Plant roots absorb various nutrient elements only in certain forms, regardless of whether supplied as organic or inorganic material. For example, plants absorb nitrogen as nitrate and ammonium ions as well as certain water-soluble amines and nucleic acids whether they come from inorganic commercial fertilizer, manure, or other sources.

Table 8: Average Nitrogen Content of Certain Organic Materials[1]

Organic Material	Nitrogen (N) average lbs. per ton	Pounds of actual N needed to bring the N content to 2% per ton
Wheat Straw	12.2	27.8
Corn Cobs	7.4	32.6
Peanut Hulls	21.4	18.6
Sweet Clover Hay (damaged)	36.0	4.0
Peat Moss	50.0	20.0
Wood Chips (oak)	4.0	36.0
Sawdust	9.0	31.0
Bone Meal (raw)	60.0	...
Cottonseed Meal	120.0	...
Fish Meal	200.0	...
Chicken Manure	32.0	8.0
Dairy Cattle Manure	11.2	28.8
Fattening Cattle Manure	14.0	26.0
Hog Manure	10.0	30.0
Horse Manure	13.8	26.2
Sheep Manure	28.0	12.0
Activated Sewage Sludge	120.0	...
Dried Blood	260.0	...
Peruvian Guano	260.0	...

[1] The nitrogen value of organic waste products will vary significantly according to age, storage conditions, temperature, moisture content, etc.

DETERMINING FERTILIZER NEEDS

All fruit crops do not have the same nutritional requirements. Further, the fertilizer program in a given fruit planting may need to be varied from year to year and location to location. These conditions make it necessary for a grower to determine the fertilizer needs of a given planting on an annual or seasonal basis. Guides for determining such requirements are presented in the following sections.

Plant Indicators

Visual Symptoms

Deficiencies of the various nutrient elements produce characteristic visual symptoms in each plant species. If a given element is deficient to the point where visual symptoms occur, reductions in yield, growth, and vitality of the plant have already taken place. Accurately diagnosing specific nutritional deficiencies on the basis of visual symptoms can be difficult. Deficiency symptons of the plant combined with results of foliar analyses enable the grower to more accurately identify a nutrient deficiency problem. Multiple deficiencies or excesses frequently prevent typical deficiency symptoms from developing.

Nitrogen (N): Variations in the nitrogen content of a plant can be great, producing wide fluctuations in visual symptoms. In some instances, a prolonged excessively high level of nitrogen in the plant can result in deficiency symptoms of one or more nutrient elements. Inadequate nitrogen levels result in yellowing of the leaf, small terminal growth, and low fruit production. For further details, see Table 9.

Potassium (K): The second most likely nutrient to become deficient in Ohio fruit plantings is potassium. General foliage symptoms of potassium deficiency on apples and pears are: Older or lower leaves on current season's growth first show an olive-brown discoloration of leaf margins. As the symptoms become more intense, leaf margins turn a reddish brown color and may eventually die, giving a scorched, ragged appearance. Adjacent to

Table 9: Indices For Judging Nitrogen Status of Fruit Trees

Index Point	Low Nitrogen	Normal Nitrogen	Excessive Nitrogen
Terminal Shoot Growth	Bearing; Small diameter, less than 4 in. av. length Non-bearing; Less than 10 in. av. length	Av. 4-12 in. long Av. 10-24 in. long	Av. 12-20 in. long Av. 24-40 in. long
Leaf Size	Small, thin	Medium to average	Large, thick, often puckering at tip
Leaf Color	Uniformly pale, yellowish-green	Normal green	Very dark green
Fall Leaf Drop	Early; leaves show some red coloration in veins	Normal time; leaves green to light green	Late; leaves remain dark green until severe frost
Bark Color	Light brown to reddish brown	Gray to dark gray-brown	Greenish gray to gray
Fruit Set	Poor; June drop of young fruit usually heavy	Normal for the cultivar, apples 1 to 3 fruits set per cluster	May have little or no effect; or may reduce set somewhat
Fruit Size	Per tree av. is smaller than normal	Normal for the cultivar	Per tree av. is larger than normal
Fruit Overcolor	Highly colored often earlier than normal	Av. color for the cultivar at picking time	Poor color up to and after normal picking period
Fruit Undercolor	Yellow color develops earlier than normal for the cultivar	Yellow-green to yellow color develops normally for the cultivar	Green to greenish-yellow color at normal picking period for the cultivar
Fruit maturity	Somewhat earlier than normal for the cultivar	Normal picking dates for the cultivar	5 to 10 days later than normal for cultivar

this area, the leaf tissue will have an olive-brown to reddish-brown color while the remainder of the leaf becomes dark green. On grapes, early symptoms of potassium deficiency include interveinal and marginal chlorosis of leaves located at about the middle of the developing cane. As the symptoms progress in intensity, necrosis and crinkling of the leaves occur. The terminal leaves of shoots usually remain normal in color even though basal leaves may exhibit rather striking potassium deficiency symptoms. Black leaf is also a symptom on concord grapes Typical potassium deficiency symptoms on peaches, plums and tart cherries include a crinkling of the leaves along the leaf midrib. Interveinal chlorosis and shot-holing may be prevalent in addition to scorch, with some cultivars showing pronounced inward rolling of leaf margins. Only when an extreme deficiency occurs will terminal leaves show symptoms.

A high level of magnesium in the soil may depress the absorption of potassium by plant roots to the extent that potassium deficiency symptoms occur. It is unwise to apply very large amounts of magnesium carrying materials to Ohio soils without some background soil test information.

Magnesium (Mg): Deficiency symptoms of this nutrient element have been observed in Ohio fruit plantings, most notably in grapes. Magnesium deficiency can occur in plants on soils naturally low in available magnesium, or on soils with a high calcium-magnesium ratio, or on those that have received heavy applications of potassium fertilizers.

Deficiency symptoms become most apparent in the mid to latter part of the growing season. Symptoms first appear in the older leaves at the base of current season's growth, progressing towards the terminal as they become more severe. The most prominent symptoms is a yellowing of the leaf margins that progresses through the interveinal tissues towards the midrib. The veins and adjacent tissues remain green. When severe magnesium deficiency occurs, the yellowed areas may turn brown and die.

Phosphorus (P): Extremely rare in Ohio fruit plantings are symptoms of phosphorus deficiency, with the possible exception of strawberries. Fruit plants utilize a relatively small quantity of this element from the soil when compared with most agronomic and vegetable crops.

The most characteristic symptom of phosphorus deficiency is a dull, dark green color of leaves. In late season, affected leaves may become somewhat bronzed or reddish in appearance, especially around the midrib and secondary veins. Affected leaves mature and fall early in the fall. Other symptoms associated with phosphorus deficiency are abnormally small leaves with sharp petiole angles, small twig diameter, and reduced fruit bud formation. In strawberry leaves, the bronzing is often marginal.

Calcium (Ca): Definite foliar symptoms of calcium deficiency have not been reported in Ohio trees or small fruit plantings although low foliar levels are frequently observed. These symptoms could develop in plantings on soils with a pH below 5.5 with available calcium extremely low for a prolonged period of time. Few orchards or small fruit plantings are maintained under such soil conditions.

Calcium deficiency is most evident in the root zone where growth is greatly restricted and brown root tips result. Foliar symptoms include a discoloration and necrotic areas on the young leaves. Foliar symptoms may be followed by dying shoot tips and leaf symptoms occuring on leaves nearing maturity. Low levels of calcium in apple fruits have been related to certain physiological diseases such as bitter pit and cork spot. Bitter pit is evident as small, brown, soft dried pits of collapsed tissue. Most of the pitting occurs just beneath the apple skin and typically concentrated at the blossom half of the fruit. Rarely are they ever found on the shoulder toward the stem end of the apple.

Symptoms of bitter pit are seldom observed much before harvest time. Those few that do develop prior to harvest are sometimes referred to as tree pits, whereas those that develop after harvest are called storage pits. The maturity of bitter pit occurs as storage pits. Fruit placed directly in low temperature storage may not exhibit symptoms for several days or weeks in storage.

Bitter pit symptoms can and often are confused with other problems or disorders. One of the distinguishing characteristics is that symptoms will normally develop within a month or two after harvest. Fruit not showing symptoms by that time usually do not develop the disorder. While the pits will darken, become more depressed and more numerous, they remain dry, are relatively superficial, and are often corky. They may be associated with the lenticels of the fruit but are not confined to these natural openings or pores.

Cork spot, the symptoms of which are described under boron, has at times responded to calcium sprays.

Boron (B): It is uncertain as to what extent boron deficiency symptoms occur in Ohio orchards and small fruit plantings since the primary and most frequent deficiency symptoms appear in the fruit. Foliar levels of boron are frequently found to be in the low range in apples, peaches, and grapes. The most common boron deficiency symptom on apple fruits is referred to as corking. It consists of clusters of dead cells that are usually tan to brown in color. Corking may occur anywhere in the fleshy portion of the fruit, its location being affected by the cultivar and severity of the deficiency. In Yellow Transparent, corking may occur throughout the fruit, and when this happens early in the development of the fruit, they are stunted and deformed. In Cortland, corking occurs just beneath the surface of the fruit and in severe cases may cause bruised or water-soaked appearing patches on the surface. Corking in Rome Beauty, for instance, occurs in the area of the core.

Boron deficiency corking in apple fruit can be confused with other types of corking. A fruit analysis showing less than 10 ppm of boron is sometimes used to confirm the diagnosis. Boron deficient fruit may ripen and drop prematurely.

Corkspot, a physiological disorder that commonly occurs on York Imperial apples and occasionally on Red Delicious fruits, has also been attributed to a deficiency of boron. Cork spots generally appear in the outer portion of the flesh. The spots may start developing during the month of June as a dimple or depression. The spot is either greener or redder than the surrounding area. Corking occurs less frequently on other cultivars, and it is not known whether this condition is caused by the same factors.

Foliage symptoms occur only under extreme boron deficiency. These are manifested by dieback of new shoots or even small branches. Terminal buds fail to break and grow in the spring. Growth from laterial buds may extend beyond the dead tips with small, narrow leaves in tufts or rosettes.

Manganese (Mn) and Iron (Fe): Deficiencies of these two nutrient elements may occur under soil conditions of high pH, 7.0 or above, especially in parts of northwestern Ohio. Under these conditions the elements are rendered unavailable to plant roots. Blueberries on many upland soils with pH above 6.0 are prone to show iron deficiency (chlorosis) symptoms unless given special treatment.

Occasionally, one or two trees in an orchard may exhibit iron deficiency symptoms. On investigation, it is often found that these trees are located near the site of a pile of lime, building plaster, etc. where the calcium level of the soil is abnormally high. Trees on the edge of an orchard, where the roots come in contact with building foundations, may occasionally show iron deficiency symptoms.

Young, terminal leaves are the first to show the characteristic symptoms of iron or manganese deficiency. As the plant becomes more deficient, symptoms progress towards the base of the shoot, but the older leaves show symptoms only under severe deficiencies. Affected leaves exhibit a yellowing of the interveinal areas and later may become almost yellow, as in the case of iron chlorosis of blueberries. Manganese deficiency symptoms develop a leaf pattern similar to magnesium but will occur first in terminal instead of older leaves. Interveinal yellowing will also be more intense than in the case of magnesium deficiency.

Under acid soil conditions, especially below a pH of 5.0 to 5.5, manganese may become available in such large amounts as to be toxic to certain fruit plants, such as Delicious apples. Bark symptoms of manganese toxicity, commonly called "internal bark necrosis" or "apple measles", may be indistinguishable from those of boron deficiency. Pimples or measles first develop in July or August in the bark of two or three year old wood; very rarely in current season's growth. As these pimples enlarge, they crack open in the center accompanied by additional cracking and scaling of the bark around the base of the lesion. In severe cases, the bark of a branch may be almost completely covered with such lesions, causing death of laterial and terminal buds. Young trees have been known to die from severe effects of this nutritional disorder. Cutting across a lesion on a branch will show brown dead tissue extending slightly into the wood.

Zinc (Zn): Zinc deficiency of fruit crops in Ohio is rare. Zinc deficiency has, however, seriously curtailed growth of certain fruit and nut crops in other areas of the country.

The symptoms of zinc deficiency are short internodes, small narrow leaves, interveinal chlorosis, and shoot and branch dieback. In advanced stages, small, narrow terminal leaves are arranged in whorls giving rise to the typical "rosette" or little leaf symptoms of zinc deficiency. Except in severe cases, only a few shoots on an otherwise normal tree will show symptoms. The symptoms may disappear as the season advances.

Foliar Analysis

Chemical analyses of plant foliage (foliar analysis) is an important tool for establishing and maintaining a proper fertilizer program in fruit plantings. To be of greatest value, foliar analysis should be made on an annual basis. Such a system of analysis will indicate the nutrient status of the plants during a given year. Based on this analysis, adjustments can be made. In general, these adjustments are made in the following years program. However, for elements other than nitrogen, corrections can usually be made during the current year. Nutrient element levels in the plant will vary according to the fertilizers applied, soil pH, soil moisture level, soil and air temperatures, rainfall, the load of fruit on the plants, and the time of sampling.

Foliar analyses can be of value in diagnosing the cause or causes of abnormalities in plant growth or fruit development. For this, only a single analysis properly taken (Figure 1) may be needed. In other instances, a series of analyses may be necessary to arrive at a proper explanation. Paired comparisons, one from normal and one from the abnormal condition, is frequently helpful. Thus, foliar analyses, particularly if they are made over a period of years, can indicate an approaching deficiency of a nutrient element before the plant shows any visable symptoms. It is possible then, through proper corrective fertilizer applications, to prevent the deficiency from ever occur-

Table 10: Sufficient Nutrient Range for Peaches, Apples and Grapes Under Ohio Conditions[1]

Crop	N %	P %	K %	Ca %	Mg %	Mn ppm	Fe ppm	B ppm	Cu ppm	Mo ppm	Zn ppm
	Nutrient Element										
Peaches	2.8-3.2	.20-.30	1.4-2.2	1.8-2.4	.31-.40	35-150	50-150	25-50	10-20	.5-2.0	20-50
Apples	1.9-2.4	.19-.28	1.3-1.8	1.3-1.7	.24-.36	31-150	35-150	28-50	10-20	.5-1.5	20-50
Grapes	.9-1.3	.16-.30	1.5-2.5	1.0-1.8	.26-.45	30-150	30- 50	25-50	10-50	.3-1.5	30-50

[1] Leaf samples taken between July 15 and August 15 from mid-shoot leaves on current season's growth in accordance with instruction provided with the plan analysis kit, see Figure 1 of this bulletin.

ing in the plant. By the same token, it is possible to learn when an element may be increasing in the plant towards a level that will reduce fruit quality or bring about some other undesirable effect. When this condition is known, steps can be taken to alter the fertilizer program and cultural practices that influence the uptake of the element from the soil solution.

Grower use of foliar analysis is aimed at helping the grower reach optimum or maximum production within the limits of good nutrition. Other factors such as diseases, soil moisture, and insects will then become the limiting factors once desired nutritional levels (Table 10) are reached and maintained. Using foliar analyses only when nutritional problems are suspected will not yield the greatest grower returns.

It is necessary to have as much information as possible about the growth characteristics of the plants sampled if accurate interpretations of results are to be made. The questionnaire (Figure 2) that accompanies a leaf sample for analysis is very important to the interpreter making recommendations. The analysis data (Figure 3) alone are inadequate for determining the optimum fertilizer program.

The Ohio Cooperative Extension Service in cooperation with the Ohio Agricultural Research and Development Center made a foliar analyses program available to producers in 1964. This service is available on a fee basis to fruit growers and other crop producers in Ohio. County Extension offices have kits and detailed information on this program. In general, leaf samples should be taken between July 1 and August 15 from plants that represent conditions within the planting. These may be normal or abnormal. In either case, maximum benefit will be realized only if the sampling instructions are followed, the questionnaire filled out with utmost care and recommendations are incorporated into the orchard management program.

Soil Analysis

The first step in planting an orchard, once the site has been selected, is to test the soil. Possibly the most meaningful value of a soil test to fruit producers is the pH and lime test index. In addition, soil test results are helpful in determining fertilizer needs.

A complete soil analysis is of special importance when planning the development of any new fruit planting site. It is much easier and more desirable to adjust the soil pH and nutrient status prior to planting. Ideally, the initial soil samples and corrective actions should be done for a planting site a year or two prior to planting. This allows time for the needed soil amendments to produce their most desirable effects.

A soil analysis has its greatest value in established plantings when used in conjunction with foliar analysis. The soil analysis gives the relative amounts of certain elements available in the soil but not an indication of levels within the plant. With fruit trees, because of the vast depth and breadth of the root system, it is difficult to sample the soil to represent the area where the root system absorbs its nutrients. Thus, a poor correlation frequently exists between a soil test and a leaf analysis for a given nutrient.

This does not, however, rule out the use of soil testing as a basic tool in determining fertilizer needs of fruit crops and gaining a better understanding of the soil conditions in which the crop is growing. A soil analysis service is available in Ohio through each County Cooperative Extension Office. As with foliar analysis, a questionnaire must be filled out (Figure 4) and accompany the soil sample so that the interpreter can make sound recommendations. Results will be returned with recommendations (Figure 5).

KEEP THIS SHEET

Sample No. 05590

OHIO PLANT ANALYSIS LABORATORY

Ohio Cooperative Extension Service, The Ohio State University
and Ohio Agricultural Research and Development Center, Cooperating

Your Sample Identification: Field 1 South (Location) | 1 | 5 | 1 | 2 | (Location No) (Sample No) Date Sample Submitted: July 18

SAMPLING AND HANDLING INSTRUCTIONS FOR HORTICULTURAL CROPS

General Instructions:

1. Prior to taking sample(s), survey planting for uniformity. Plants selected for an individual sample should be similar in age, size, condition, vigor, leaf color, variety, and growth. Avoid areas where such differences exist unless you plan to take samples for comparative purposes. Do not sample plants which are insect-infested, diseased, physically injured, or have other obvious abnormalities not related to nutrition.

2. Sample(s) should represent either: A) the normal condition of the crop, or B) the abnormal condition of a problem area.

3. Follow the specific sampling instructions for crops listed on this and the next two pages.

4. Place sample in the mailer provided and record your sample identification on the instruction sheet and on the questionnaire. The surface of the sample should be dry when taken. **DO NOT PUT SAMPLE IN PLASTIC CCNTAINER SINCE IT MAY MOLD IN TRANSIT.**

5. Complete questionnaire, enclose it in the small envelope and send mailer to the Plant Analysis Laboratory, Ohio Agricultural Research and Development Center, Wooster, Ohio 44691.

Instructions For Specific Crops:

1. FRUIT CROPS

A. **FOR TREE FRUITS:** pick leaves mid-point on the current season's terminal growth. Walk diagonally across the block selected for sampling and pick 2 to 4 leaves from each alternate tree on left and right of sampler. Pick leaves within easy reach from all sides of the trees. If orchard consists of rows of several cultivars, select leaves by walking in an S shaped pattern down the rows. Remove leaves with a downward pull so that petioles remain attached.

B. **FOR GRAPES:** from a bearing primary shoot, select the youngest fully expanded leaf which is well exposed to light. On Concord this leaf is best identified as the youngest one on the shoot to attain full size, is changing from light to dark green, and has a brown pubescence instead of white on the lower surface. **SEND ONLY THE PETIOLE. DISCARD THE BLADE.**

C. **FOR STRAWBERRIES:** sample should represent a single cultivar. Obtain sample by walking diagonally across the rows selecting the youngest fully expanded leaf. **SEND WITH ENTIRE PETIOLE ATTACHED.**

CROP	TIME OF SAMPLING	PLANT PART	NUMBER OF UNITS TO SAMPLE
Apples, Peaches, Pears, Plums	July 1 – Aug. 15	Leaves	40 – 60
Grapes	July 1 – Aug. 15	Petioles	60
Strawberries (first year)	June 15 – July 1	Leaves	60
Strawberries (renewed planting)	July 15 – Aug. 15	Leaves	60

Fig. 1

RETURN THIS SHEET IN SMALL ENVELOPE

Horticultural Sample No. OFFICE USE 05590

OHIO PLANT ANALYSIS LABORATORY

Ohio Cooperative Extension Service, The Ohio State University
and Ohio Agricultural Research and Development Center, Cooperating

Name: Mr. Fruit Grower	Grower Name (If other than at left):
Street, Route: Rt. 1	County:
City: Wooster, Ohio 44691 (Zip Code)	Your Sample Identification: 1 5 1 2 (Location No / Sample No.)
Telephone Number:	

Fill in Blanks and Appropriate Boxes

OFFICE USE — Date Received

CROP AND SOIL HISTORY

[1] TYPE OF CROP: (1) Fruits (2) Greenhouse Vegetables (3) Outdoor Vegetables (4) Nursery-Deciduous (5) Nursery-Evergreen (6) Florist

OFFICE USE — CROP Apples — CULTIVAR (Variety) Red Delicious

OFFICE USE — PLANT PART SAMPLED: (1) As Directed ✓, (2) If Other, Describe

[0 4] [1 2] [6 2] DATE PLANTED:

[ ] [ ] [ ] DATE TRANSPLANTED:

[0 7] [1 8] [7 3] DATE SAMPLED:
Mo. Day Year

OFFICE USE — PREVIOUS CROP: (List) Apples

OFFICE USE — PLANT APPEARANCE: (Check) (1) Normal ___,
(2) Abnormal ✓, (Describe) Light Green

[8 0] PERCENTAGE OF PLANTS AFFECTED: (0 to 99%)

OFFICE USE — HERBICIDE APPLIED CURRENT CROP YEAR: Simazine

OFFICE USE — HERBICIDE APPLIED PREVIOUS CROP YEAR: Simazine

[1] SOIL: (1) Fine or Medium Texture (clay and silt) (2) Coarse Texture (sandy) (3) Organic (muck or peat) (4) Container, Bed, Bench or Pot Mixture

[3] SOIL MOISTURE PRIOR TO SAMPLING: (1) Excessive (due to poor drainage) (2) High (due to above average rainfall) (3) Normal (4) Low

CURRENT SOIL TEST DATA

5.4	pH
65	LIME TEST INDEX
16.4	CATION EXCHANGE CAPACITY (Meq/100g)
	AVAILABLE NUTRIENTS (Lbs./A)
12	Phosphorus
169	Potassium
1650	Calcium
2	ORGANIC MATTER
24	SOLUBLE SALTS
1	SOIL TEST BY: 1. O.S.U., 2. Other
73	DATE TESTED: 19 73
	SOIL TYPE (MAPPING) NUMBER

FERTILIZER AND/OR LIMESTONE APPLIED

[1] Rate — RATE: (1) Lbs./Acre (2) Lbs./Plant (3) Lbs./Cu. Yd. (4) Ppm

	PREVIOUS (LAST) YEAR OR CROP
45.0	Nitrogen (N)
0.0	Phosphorus (P_2O_5)
0.0	Potassium (K_2O)
00	Ag. Ground Limestone
	CURRENT YEAR OR CROP
55.0	Nitrogen (N)
0.0	Phosphorus (P_2O_5)
0.0	Potassium (K_2O)
00	Ag. Ground Limestone

Fig. 2

FORM #250312

OHIO PLANT ANALYSIS REPORT

OHIO COOPERATIVE EXTENSION SERVICE, THE OHIO STATE UNIVERSITY AND OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER, COOPERATING

PLANT ANALYSIS

ELEMENT	ANALYTICAL RESULTS	RANGE: DEFICIENT	LOW	SUFFICIENT	HIGH	EXCESS
N	1.56	XXXXXXXX				
P	00.19	XXXXXXXXXXXX				
K	00.84	XXX				
(%) Ca	01.56	XXXXXXXXXXXXX				
Mg	00.43	XXXXXXXXXXXXXXXXXXX				
Na	00.02	XXXXXXXXXXXXX				

ELEMENT	ANALYTICAL RESULTS	RANGE: DEFICIENT	LOW	SUFFICIENT	HIGH	EXCESS
Mn	0111	XXXXXXXXXXXXX				
Fe	0120	XXXXXXXXXXXXX				
B	0020	XXXXXXXX				
(ppm) Cu	0013	XXXXXXXXXXXXX				
Zn	0040	XXXXXXXXXXXXX				
Mo	01.99	XXXXXXXXXXXXXXXXXXXXX				
Al	0555	XXXXXXXXXXXXXXXXXXXXX				

COMMENTS AND RECOMMENDATIONS

NITROGEN IS LOW. INCREASE RATE OF APPLICATION TO 65 LB./ACRE. APPLY IN LATE FALL OR EARLY SPRING.

POTASSIUM IS DEFICIENT. APPLY 400 LBS. PER ACRE MURIATE OR SULFATE OF POTASH ANYTIME.

BORON IS LOW. APPLY 1 LB. BORAX OR ½ LB. POLYBOR PER TREE. SPREAD UNIFORMLY BENEATH TO SLIGHTLY BEYOND TREE BRANCHES.

GROWER NAME (If other than at right):

COUNTY:

TOWNSHIP:

RETURN ADDRESS:
PLANT ANALYSIS LABORATORY
OHIO AGRICULTURAL RESEARCH & DEVELOPMENT CENTER
WOOSTER, OHIO 44691

GROWER
MR. FRUIT GROWER
RD 1
WOOSTER, OHIO 44691

COUNTY AGRICULTURAL AGENT
200 VANOVER ST.
WOOSTER OHIO 44691

GROWER IDENT.: 1 S 1 2
DATE RECEIVED: 07/20/73
DATE RETURNED: 07/28/73

PLANT ANALYSIS SAMPLE NO. 0 0549

CROP & SOIL HISTORY		SOIL TEST DATA	FERT. & LIME APPL.
CROP APPLE		TYPE FINE/MEDIUM TEXT.	RATE, LBS./ACRE
CULTIVAR RED DELICIOUS		MOISTURE NORMAL	N P K
PLANT PART AS DIRECTED		PH 5.4	PREVIOUS CROP
PLANTED OR TRANSPLANTED 04/12/62		P 12 LBS./A	45.0 0 0
DATE SAMPLED 07/18/73		K 169 LBS./A	LIME 0 LBS.
PREVIOUS CROP APPLE		CA 1650 LBS./A	CURRENT CROP
PLANT APPEARANCE LIGHT GREEN	80 PCT.	OM 2 SALTS 24	55.0 0 0
HERBICIDE CURRENT SIMAZINE		BY OSU	LIME 0 LBS.
HERBICIDE PREVIOUS SIMAZINE		YEAR 1973	

Fig. 3

FERTILIZER RECOMMENDATIONS

Soil Applications

Pre-Planting

In addition to liming, it is often desirable to apply fertilizer to a planting site before setting the plants. This is especially true if soil tests indicate low levels of available phosphorus, potassium, magnesium or other elements. If the needed nutrient elements are applied one or two years ahead of planting in sufficient quantities, the soil should be at a much more desirable fertility level at planting time. The value of such pre-planting treatment can be enhanced if done in conjunction with the growing of green manure and cover crops on the site. Such a combination will improve both the nutrient level and the tilth of the soil, thus creating a more desirable rooting medium for the newly set plants. The type and rates of fertilizer applications will depend upon the soil test results and the kind of cover crop being grown.

Post-Planting

In general, fertilizers applied to the soil will have a longer lasting effect than those applied to the foliage. Early spring applications of nitrogen fertilizers, before new growth begins, are considered most satisfactory. For tree fruits, nitrogen should be applied at least 30 days before the average bloom date.

In the case of tree fruits, nitrogen fertilizers may be applied in late November or December if application in the spring is inconvenient. Summer or early fall applications of nitrogen to any of the tree fruits are not advisable. This may result in poor fruit over color and late growth which can increase the hazards of winter injury to wood and buds. If fertilizers are applied over foliage, it should be brushed or washed off immediately to avoid injury.

Elements other than nitrogen such as phosphorus, potassium or magnesium may be applied any time of the

Date *March 16, 1973*

Return This Sheet

THE OHIO STATE UNIVERSITY

Copy No. from Soil Bag

SOIL TESTING LABORATORY - COOPERATIVE EXTENSION SERVICE
1885 NEIL AVENUE - COLUMBUS, OHIO 43210
TELEPHONE (614) 422-5742

HORTICULTURAL SOIL TEST

Sample Information

Grower Name: *Mr. Fruit Grower*	Industry Name:
Street, Route: *Rd. 1*	Street, Route:
City: *Wooster* Ohio *44691* Zip Code	City: Ohio Zip Code

Write Appropriate Numbers in Boxes at Left

2	
1	SEND RESULTS TO: 1. Grower, 2. Industry, 3. Both
1 5 0 2	YOUR SAMPLE IDENTIFICATION (Field, Greenhouse, Orchard, Bed, Pot and/or Sample No.):
	SOIL TYPE NUMBER:
6 5	LAST LIMED: 19*65*
4.0	AMOUNT LIMED (Tons/A-use decimal ⊙, e.g. 2⊙5; lbs./1000 sq.ft. - No decimal):
9	DEPTH OF SAMPLING (Inches):
	CROP *Apples* CULTIVAR (VARIETY) *Red Delicious* PREVIOUS CROP *Apples*
1	STATUS: 1. Planted, 2. To be Planted, 3. For Transplanting
0 1	LOCATION: 01. Field, 02. Orchard, 03. Greenhouse, 04. Lawn or Garden, 05. Athletic Field, 06. Fairways, 07. Tees, 08. Greens, 09. Nursery-Field, 10. Nursery-Container, 11. Roadside, 12. Airport, 13. Sod Farm, 14. Other ______
	TYPE AND POSITION: 1. Pot Plants, 2. Plants in Raised Benches, 3. Plants in Ground Beds, 4. Flats or Paks
1 3 2	AGE (Months):
2	IRRIGATED: 1. Yes, 2. No
1	ORGANIC MATTER ADDED: 1. None, 2. Manure, 3. Peat Moss, 4. Peanut Hulls, 5. Corn Cobs, 6. Straw, 7. Wood Chips or Bark, 8. Sawdust, 9. Other ______
☐ Ton/A OR ☐ Inches	ORGANIC MATTER APPLIED:
	TEST REQUESTED (Check Boxes): Standard [1], Standard plus Ca and Mg [X], Organic Matter [X], Manganese [4], Zinc [5], Boron [6], Greenhouse [7], Lawn or Garden [8]

Fig. 4

LIME AND FERTILIZER RECOMMENDATIONS

SAMPLE ID 2 | CROP RED DELICIOUS APPLES | LOCATION ORCHARD

COMMENTS:

APPLY 142 LB. LIME/1000 SQ. FT. TO RAISE PH TO 6.5 IN PLOW LAYER (3.1 TONS/ACRE)

MAINTAIN ANNUAL NITROGEN AS NEEDED OR AS INDICATED BY FOLIAR ANALYSIS. A GENERAL RULE IS TO APPLY AT THE RATE OF 1/20 ACTUAL N PER TREE PER YEAR OF TREE AGE.

PHOSPHORUS AND POTASSIUM ARE SOMEWHAT BELOW THE DESIRED LEVELS. THE FOLLOWING APPLICATION IS SUGGESTED: APPLY 8-16-16 FERTILIZER TO TREE AREAS AT THE RATE OF ½ LB. PER TREE PER YEAR OF TREE AGE, OR ITS EQUIVALENT. FOR PRE-PLANT OR GENERAL APPLICATIONS BROADCAST FERTILIZER AT THE RATE OF 500-600 LB. PER ACRE.

NOTE: IF THE ABOVE APPLICATION OF A MIXED FERTILIZER IS MADE IT WILL ALSO SUPPLY GENERAL NITROGEN REQUIREMENTS AS SUGGESTED IN PARAGRAPH 2.

Mr. Fruit Grower
RD 1
WOOSTER, OHIO 44691
COUNTY WAYNE | RECEIVED SAMPLE 3/19/73 | DATE PRINTED 3/21/73 | REPORT NUMBER 6742 | PLAN

Sample Identification: Your Sample ID	Code Number	Lab Number	Sample Information: Soil Type	Plow Depth	Last Limed: Year	Last Limed: T/A	Analytical Results: Soil pH	Lime Test Index	Available Phosphorus P lb/A	Exchangeable: Potassium K lb/A	Calcium Ca lb/A	Magnesium Mg lb/A	Cation Exchange Capacity meq/100g	Percent Base Saturation (Computed): % Ca	% Mg	% K	Available: Manganese Mn lb/A	Iron Fe lb/A	Zinc Zn lb/A	Copper Cu lb/A	Boron B lb/A	Other: Nitrates NO_3 N lb/A	Organic Matter %	Soluble Salts mhos X10[5]
2		2640		9	65	4	5.4	65	12	169	1650	197	16.4	57.3	9.2	2.1							2.0	24
							Low		Low	Low	OK	OK											OK	OK

THE OHIO STATE UNIVERSITY SOIL TESTING LABORATORY A.S.C. OFFICE COPY
COOPERATIVE EXTENSION SERVICE, 1885 NEIL AVENUE - COLUMBUS, OHIO 43210

Fig. 5

year without causing ill effects. It is generally convenient to apply these fertilizers with the nitrogen, either separately or in a mixed analysis.

Incorporation of fertilizer materials into the soil will result in more rapid availability to the plants. This is especially true of elements other than nitrogen. This may not be practical in fruit plantings under a sod-management system.

Rates of Applications

The rates of fertilizer application suggested in this publication are general and should be adjusted by the grower according to specific situations. In this adjustment, the grower must consider leaf color, terminal growth, and fruiting characteristics of the previous season, as well as results of soil and/or foliar analyses.

In general, a satisfactory nutritional condition exists in mature trees when foliage is of moderate, dark-green color; yield is good; overcolor of fruits satisfactory; and the annual terminal growth is 6 to 12 inches. When these conditions exist from year to year, there is little need to make appreciable changes in the rate or nature of the fertilizer program unless recommended by foliar analysis. Annual terminal growth of 15 to 30 inches is considered satisfactory for nonbearing trees. Pears are an exception, and terminal growth should average only 12 to 16 inches for nonbearing trees to keep fireblight at a minimum. Should terminal growth exceed 12 inches on mature bearing trees, then the annual rate of nitrogen should be reduced or eliminated the following year.

Heavy pruning on trees of normal vigor will typically stimulate growth in a manner similar to over fertilization. Reduced rates of nitrogen fertilizer should accompany heavy pruning to prevent this excessive terminal growth.

Rates in the guidelines (Tables 11 and 12) are given in terms of actual nitrogen. See Table 4 for percent N for the different nitrogen fertilizer compounds.

Table 11: Tree Fruit Fertilization Guidlines

Adjust rate by tree characteristics (See Table 9) and/or foliar analysis recommendations

Kind of Fruit	Material and Rate of Application	Timing and Placement	Remarks
Apple	Basic rate of 1/20 lb. actual nitrogen per tree per year of tree age; apply annually	Spread beneath drip of branches in early spring	Suggested applications should be reduced or eliminated the spring following severe pruning. If tree age is unknown, follow guidelines under "All Trees"
Peach	Basic rate of 1/10 lb. actual nitrogen per tree per year of tree age under a sod cover crop management system; use half this rate under cultivation system; apply annually	Spread beneath drip of branches; apply in split application, half in very early spring and half after the crop is assured, but no later than mid-June	In "no crop" years, do not apply the second portion of the split application. Use, foliar analysis results to determine need for other nutrients. If tree age is unknown, apply 1/10 lb. N per inch of trunk diameter measured 1 foot above ground) for tree in a sod management system; 1/20 lb per inch of trunk diameter under a cultivation system.
Pear	Apply 1/20 lb. actual N per tree per year of tree age; application should be made every other year	Spread beneath drip of branches in early spring	Too much nitrogen results in excessive growth and increased fireblight. If three age is unknown, use a biennial N application following the guidelines under "All Tree Fruits"
Plum Cherry Apricot	Basic rate of 1/20 lb. actual nitrogen per tree per year of tree age; apply annually	Spread beneath drip of branches in early spring	If "no crop" year, use ½ of normal annual rate. Use foliar analysis results to determine need for other nutrients. If tree age is unknown, follow guidelines under "All Tree Fruits"
All Tree Fruits	Other fertilizer elements should be applied at rates suggested from foliar and/or soil analysis results or when deficiency symptoms have been identified If tree age is unknown, apply 1/20 lb. N per tree per inch of trunk diameter. Trunk diameter should be measured one foot above the ground	See appropriate fruit crop	Follow future foliar analysis recommendations

Example, **Trees of known age:** We have an apple orchard that is 8 years old. What would be the suggested nitrogen rate per tree?

1/20 lb. = 0.05 lb.

.05 lb. N per year of tree age
× 8 year-old trees
.40 lb. N per tree

If calcium nitrate (16%N) is to be used, then the amount per tree for 8-year-old apple trees would be

2.5 lbs. of calcium nitrate (16%) per tree
16 | 40.0

If ammonium nitrate (33%) is used instead of calcium nitrate then:

1.2 lbs. of ammonium nitrate (33%) per tree
33 | 40.0 would be needed

Example, **Trees of unknown age.** We have acquired an orchard of standard apple trees. We can tell that they are standard because they are large and the graft union is below ground. We don't know their age, however. We measure the trunk diameter one foot above the ground and fined that it is 11 inches. How much fertilizer should we apply?

1/20 lb. = 05 lb.

.05 lb. N per inch of tree diameter
× 11 inches tree diameter
.55 lb. N per tree

If calcium nitrate (16% N) is to be used, then the amount of N per tree for our apple trees with a trunk diameter of 11 inches would be:

3.4 lb. calcium nitrate (16% N) per tree would
16 | 55.0 be needed

Example, **Peaches without a crop:** We have a 12-year-old peach orchard under a cultivation system that lost all of its fruit buds during a severe freeze in January. How much fertilizer will these trees need?

1/20 lb. = .05 lb.

.05 lb. N per year of tree age
× 12 year old trees
.60 lb. N per tree (provided they had not lost their crop)

.60 lb. N per tree
× 0.5 (use ½ normal rate because of crop loss)
.30 lb. N per tree

If 12-12-12 is to be used, then the amount needed per tree in the the "no crop" year for the 12-year-old peach trees would be:

12-12-12 — 2.5 lbs. of 12-12-12 per
12 | 30.0 tree will be needed

Table 12: Small Fruits Fertilization Guidlines

Adjust rate by plant characteristics and/or foliar analysis recommendations

Kind of Fruit	Material and Rate of Application	Timing and Placement	Remarks
Grapes	In early spring, apply nitrogen carrying fertilizer to give 40 to 80 lbs. actual nitrogen per acre For new plantings 1/10 lb. of actual nitrogen per vine	Band in the row area in early spring Apply in a 3-ft. diameter circle around each vine	Watch closely for development of deficiencies such as potassium and magnesium; an excess of one may cause a deficiency of the other With the black plastic mulch system, the suggested rate should be worked into the ground prior to the laying of the plastic. Use a 1-1-1 ratio fertilizer in this case
Strawberries	New planting, apply 400 to 500 lbs. 12-12-12 fertilizer per acre, or equivalent; or 10 to 12 lbs. per 1000 sq. ft. At renewal, apply 30 to 40 lbs. actual N per acre	Broadcast over entire area Band over row area	Apply during site preparation and incorporate before setting plants. Apply immediately after harvest; brush or wash excess off plants
Blackberries Raspberries Other Bramble Fruits	50 to 150 lbs. of actual N per acre	Band in row area	Apply in spring before growth starts; avoid getting fertilizer on young growth and leaves as it may cause injury
Blueberries	¼ to ½ lb. of sulfate of ammonia around each plant; if iron chlorosis develops, apply iron chelate according to manufacturer's recommendations	Band in row area	Apply in spring before growth starts; avoid getting fertilizer on young growth and leaves as it may cause injury Iron Chlorosis: if yellow foliage develops, indicating iron deficiency, apply iron chelate according to directions on container

Foliar Sprays

Foliar applications of certain nutrient elements may be made to some fruit crops, especially apples and grapes. Application of all required nutrient elements by this method is, however not a common practice. Foliar sprays can be used to great advantage in correcting nutrient deficiencies. This is especially important when the deficiencies occur during the growing season and immediate correction is necessary. Foliar sprays such as calcium sprays for bitter pit on apple fruits are also used to prevent certain physiological disorders before they occur.

Nitrogen (N): Foliar applications of urea (45% nitrogen) have been used successfully on apples and strawberries in cases where additional nitrogen was needed at a critical time. Otherwise, they are not generally recommended. Late application on apples may adversely affect fruit quality.

A low bi-uret grade of urea should be used for foliar application. On apples and grapes, use at the rate of 5 pounds per 100 gallons (200 gallons per acre) starting with the first cover spray, and spacing the sprays about 10 days apart. Do not make more than 3 applications. On low-nitrogen, fruiting strawberry plantings, apply at the same rate as for apples, 5 pounds per 100 gallons (200 gallons per acre), in the spring at weekly intervals until the crop is harvested, or until a maximum of 3 sprays have been applied.

Magnesium (Mg): Magnesium deficiency has been observed on apple trees in Ohio. Foliar application of magnesium sulfate (Epsom salts) is effective in overcoming this deficiency. Magnesium sulfate is usually applied, starting at petal fall and continuing on a weekly schedule until 3 sprays have been applied. For dilute spraying, use 20 pounds of Epsom salts per 100 gallons of water (200 gallons per acre). For concentrate spraying, 40 pounds per acre of Epsom salts should be used. Do not exceed 40 pounds of this material per 100 gallons of concentrate spray.

Epsom salts should be applied as a special spray. **Do not mix** with pesticides as the effectiveness of the pesticides may be reduced and fruit injury could result.

Calcium (Ca): Foliar applications of calcium have been effective in reducing bitter pit in many apple cultivars susceptible to this disorder. On trees where bitter pit has been a problem, the following sprays are suggested. Use 3 pounds of calcium nitrate, or 2 pounds of calcium chloride per 100 gallons of spray plus a wetting agent. Four to 6 applications at 2 week intervals should be made, the last coming about 2 weeks before harvest. Regular and complete fruit coverage is necessary to get the calcium over the whole surface of the apple. Calcium sprays have been added to most pesticide mixtures without compatibility problems. Do not apply calcium sprays when the temperature is above 85°F.

Cork spot, another physiological disorder that occurs occasionally on Delicious and several other cultivars (called York spot on the cultivar York Imperial), will generally be reduced by the application of calcium sprays. Such corrective calcium sprays should be applied at a rate of 2 pounds of calcium chloride per 100 gallons of spray with a wetting agent. Calcium should be applied in the first 4 cover sprays.

Potassium (K): Should potassium deficiency symptoms occur during the season, then foliar sprays of either nitrate or sulfate of potash at 6-10 pounds per 100 gallons of water (200 gallons per acre) should be applied as a corrective measure. Appropriate soil applications should also be made since they have a more lasting effect.

Boron (B): Foliar sprays of Solubor at ½ pound per 100 gallons can be used as a method of preventing a boron deficiency. If a proven deficiency exists, then 2 Solubor sprays of 1 pound per 100 gallons should be applied; one in the late bloom stage and the other in the early post bloom period. These 2 sprays have generally reduced but not eliminated the incidence of cork spot. Soil applications of boron are also effective.

Manganese (Mn): Manganese deficiency occurs in certain fruit growing areas of Ohio. Its occurance is closely related to a high soil pH or extreme soil moisture conditions.

In mild cases of deficiency where a lightening of the interveinal leaf areas occur, corrective sprays are not necessary. Fruit size, yield, and quality appear to be unaffected. If the condition is severe, spray applications of manganese sulfate at the rate of 4 pounds per 100 gallons as needed plus 2 pounds of hydrated lime may be used as a corrective measure. Manganese chelates may also be used according to the manufacturer's recommendations.

Iron (Fe): In recent years the development of iron chelate compounds has made correction of iron deficiency relatively easy. These materials can be applied safely as foliar sprays. Any runoff will eventually benefit the crop through root uptake. Apply according to manufacturers recommendations.

Zinc (Zn): The most common corrective measure for zinc deficiency is the application of high concentrations of zinc sulfate as a dormant spray. Applications of 32% zinc sulfate at 14 pounds or 36% zinc sulfate at 12½ pounds or 22% zinc sulfate at 20 pounds per 100 gallons of water may be used. A rate of 2½ gallons per 100 gallons of water of liquid zinc sulfate can also be used. Such sprays are most effective if delayed as late as possible but applied prior to opening of the buds. **Caution:** Injury to the tree may result if the zinc is applied within 3 days preceding or following an application of oil.

Warning:

Do not mix nutrients with pesticides unless compatibilities are known. Micronutrients should not be applied to fruit crops except in cases of proven deficiency, or on the advise of trained technical persons. The range between enough and too much is very small for these trace elements. Many of them are more harmful in excess than in deficiency.

Fertilizing Newly Set Fruit Plantings

Fertilize plants, set in the fall, the following spring about the time growth begins. Spring-set plants should be fertilized following a drenching rain or irrigation. adjustments of soil fertility have been made in accordance with soil test recommendations, nitrogen should be the only element needed at this time. It should be applied at the rate of 1/10 pound of actual nitrogen per tree.

Starter solutions applied at planting time have given variable results with fruit plants. Generally, they have not proved themselves on the more fertile soils. On very poor soils and light sandy soils, starter solutions may be of value.

Fertilizer materials for newly set brambles are typically incorporated into the soil when the plant bed is prepared. On most sites, 8 to 10 pounds per 100 square feet, or 350 pounds per acre of 8-16-16 or similar analysis fertilizer will be beneficial. Should the plants not "grow-off" well, it is advisable to apply additional nitrogen in late May or early June. For this purpose, apply 1 to 2 ounces of a 33 percent nitrogen carrier or its equivalent per plant.

Table 13: Conversion Table for Applying Lime and Fertilizer

Pounds Fertilizer Per Acre Broadcast	Equivalent Pounds Per 1000 Sq. Ft. Broadcast	Tons of Liming Material Per Acre	Equivalent Pounds Per 1000 Sq. Ft.
100	2.29	½	23
200	4.58	1	45
300	6.87	1½	68
400	9.16	2	90
500	11.45	2½	113
600	13.74	3	135
700	16.03	3½	158
800	18.32	4	180
900	20.61	4½	203
1000	22.91	5	225
1100	25.19		
1200	27.48		
1300	29.77		
1400	32.06		
1500	34.35		
1600	36.64		
1700	38.93		
1800	41.32		

SPECIAL CONSIDERATIONS

Fertilizing Sod Cover

Most Ohio orchards as well as occasional grape, bramble and blueberry plantings are grown under a sod system of soil management. This provides a good working surface and reduces soil erosion. Thus, it is important to maintain the sod crop in a good state of growth while producing a heavy yield of quality fruit. Perennial grasses such as bluegrass, creeping red fescue, and ryegrass are suitable because of their shallow rooting and less competition to the fruit plants.

Fertilizing the sod should be based upon soil analyses, preferably made every 2 or 3 years, as well as on the condition of the sod. In general, a fertilizer application should provide 20 to 25 pounds of nitrogen per acre on most loam soils and the amount of phosphorus and potassium required. In most fruit plantings, the fertilizer ratio should be a 1-1-1 or a 1-2-2.

When the sod cover is fertilized, the rate is not usually sufficient to supply the nitrogen needs of the fruit crops. Therefore, it is necessary to supply an additional amount of nitrogen to the trees, or apply the mixed fertilizer at a rate higher than that required just for the sod. The grower's choice will depend upon the convenience and cost of two separate applications, the possibility of having a specific ratio mixed for his needs, and whether additional nitrogen may even be needed that particular year. Higher rates of nitrogen application are generally needed in orchards under sod cover management than those under cultivation.

Fertilizing and Mulching

Mulching was practiced more extensively in the past than it is today in Ohio fruit plantings. However, it is still followed in a number of orchards and small fruit plantings, especially during the first few years after establishment.

Organic mulches decay and supply a small amount of nutrient elements to the soils during the process. Materials high in protein such as legume hay will supply a considerable amount of nitrogen. Conversely, sawdust supplies very little nitrogen. In fact, during the early stages of decay, nitrogen may be tied up in the soil by bacteria and other decay causing organisms. As a result, a temporary nitrogen deficiency may result. Thus, when a mulch is first started, higher rates of nitrogen application may be needed to compensate for that removed from the soil by micro-organisms. The rate would seldom exceed 1½ times the normal application, and would apply to the first and second years only. Once the decay processes are well under way and nitrogen is being released into the soil, annual nitrogen application can usually be reduced or omitted. This would be true so long as the mulch was replenished each year.

Fertilizing Following Severe Pruning

On occasion it becomes necessary to subject fruit trees to rather severe pruning. Since such a treatment greatly alters the ratio of leaves to roots during the early part of the growing season, a reduction in the nitrogen rate is usually desirable. The more vigorous the growth of the tree the preceeding season, the greater the nitrogen reduction with the severity of pruning. In many cases nitrogen applications may be eliminated for one to two years following severe pruning of apple or pear trees. Often this is not the case with the stone fruit trees. Stone fruit trees of average vigor receiving severe pruning are usually benefited by half the normal rate of nitrogen application the first spring, followed by the normal rate thereafter.

Trees that are low in vigor and severely pruned will usually benefit from the normal rates of nitrogen application the first season. The rate of application in succeeding years will depend upon tree vigor, size of crop and other factors.

Fertilizing in No Crop Years

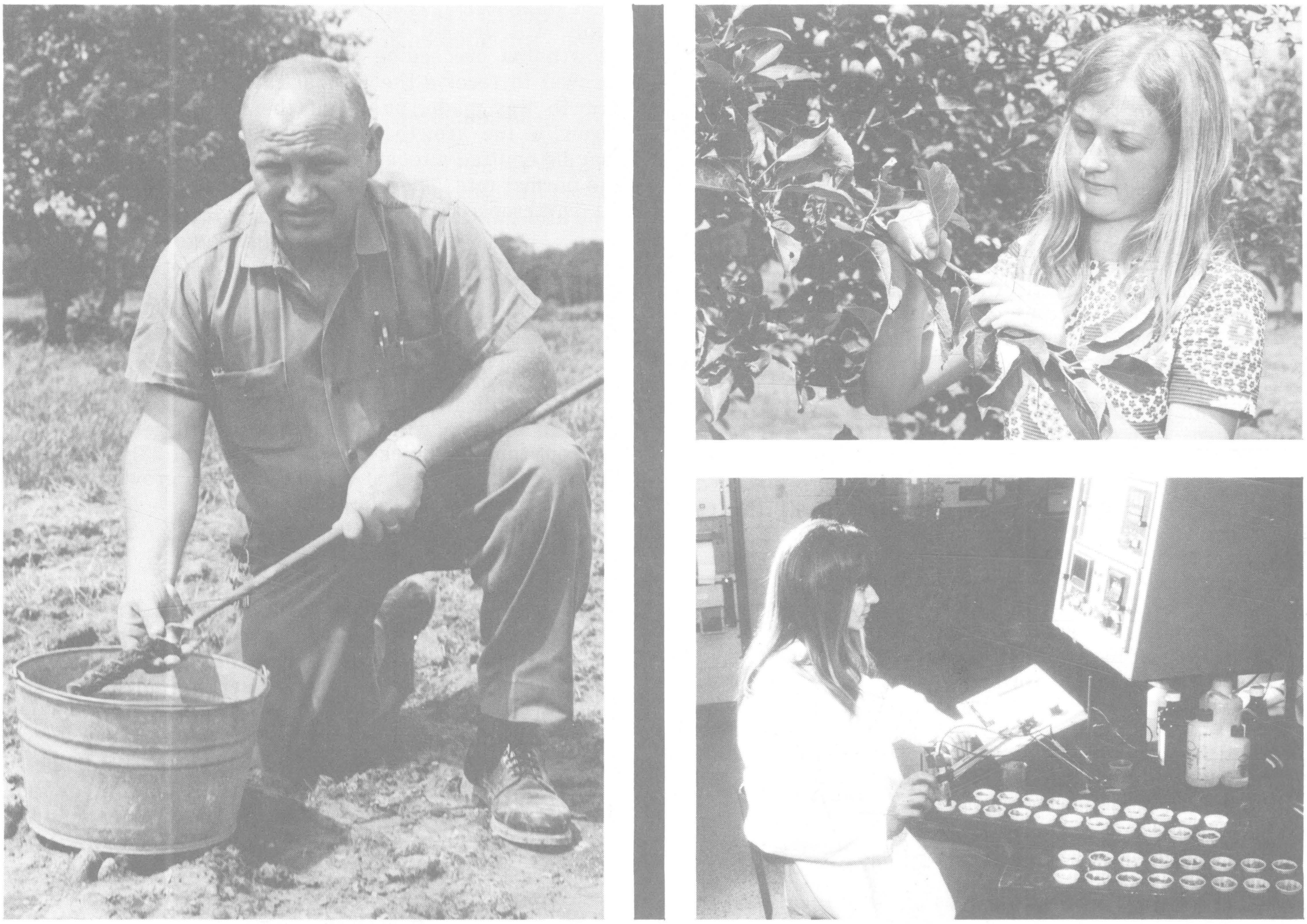
Fruit crops are, on occasion, lost due to winter injury or spring frost damage or for some other reason. In such years of no crop, the nitrogen requirements will be less than in a normal crop year. The amount of nitrogen to apply will depend largely upon the vigor of terminal growth the preceeding season. Trees of low vigor will do well to receive the normal rate. If average terminal growth was made, only half the normal rate need be given. If the growth was very vigorous, then nitrogen may be omitted altogether, or at best, applied at a fourth the normal rate. These general rules will apply to nearly all fruit crops.

Fertilizing Through Irrigation Systems

The application of fertilizers through irrigation systems is of relatively recent origin and specific recommendations are for the most part lacking. Three primary advantages of this method are: (1) saving in time and labor of application, (2) having the nutrient elements applied in solution with sufficient water to get them into the root zone for quick plant response, and (3) the ability to apply the fertilizer at any point in the growing season when it is needed.

For satisfactory irrigation application, a fertilizer material should be completely soluble, or nearly so. Today, most nutrient elements can be procured in soluble forms or in solutions for use through irrigation. The key to proper application is a metering (proportioning) device which will permit accurate flow of the fertilizer material into the irrigation line. Several such proportioning devices are available from irrigation supply companies. Some growers have devised their own metering systems that function quite accurately. The uniformity of application over the area will depend upon the lay-out of the irrigation system, sprinkler pattern, and the manner in which the material is injected into the irrigation line.

So far, the use of irrigation to apply fertilizers has been restricted largely to strawberries and other small fruits. However, there is no reason for not employing this method in tree fruits where irrigation systems are in use, except that other methods may be more practical.



Determining fertilizer needs by laboratory analysis of foliage and soil.