Soil and Crop Factors for
Fertilizer Recommendations

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CONTENTS

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General Information

Plant nutrients most commonly deficient in cultivated soils are nitrogen, phosphorus, and potassium. Commercial fertilizers contain one or more of these three elements. Other minerals required in large amounts by plants are calcium, magnesium, and sulphur. Calcium and magnesium are supplied in lime. Sulphur is contained in most fertilizers supplying phosphorus. The minor or trace elements for plants include iron, manganese, copper, zinc, boron, and molybdenum. Various plants differ greatly in their ability to utilize plant nutrients in soil and the ability of a single plant to use these nutrients differs greatly under many soil and climatic conditions.

There is no simple means of determining the type or amount of fertilizer that will give highest returns for a specific field and crop. General fertilizer recommendations are difficult in Oklahoma with extreme variations in soil characteristics, climate (particularly the amount and distribution of rainfall), and local adaptation of many types of crops. Treatment of a specific field to obtain high crop yields will vary from year to year due to natural variation in soils, crop growing conditions, and past management practices.

The principal factors that determine the kind and amount of fertilizer and the best method of application are:

1. **Characteristics and production capability of the soil type.** Drainage, presence or absence of excessive salts or alkali, organic matter content, soil texture, depth and physical condition all contribute to the ability of a soil to give profitable returns from fertilizer application. Deep, permeable soils in good physical condition have an advantage for increased profitable returns from fertilizers because of higher production

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capabilities. Use of lime on acid soils increases the efficiency of fertilizer materials.

2. **Characteristics of crop to be grown and climatic probabilities for good yields.** Particular crops vary considerably in requirement for various plant nutrients. Crops grown primarily for forage have different fertilizer requirements than these same crops grown for high grain yields. Most important cash crops give profitable returns from fertilizers used properly. The relative crop cash value influences the kinds of fertilizer and amounts that can be used profitably. In Oklahoma the amount and distribution of rainfall are governing factors in crop yields and the plant's ability to utilize the applied plant nutrients. A crop under irrigation has higher fertility requirements than in dry land conditions. Irrigated crops should be fertilized for maximum yields.

3. **Previous cropping, fertilization and management practices of the particular field.** The previous cropping and fertilizer history of a field gives reliable information on the fertility level of the soil and its productive ability. The growth of alfalfa, sweet clover, vetch, and other legumes in a rotation, if properly managed, contributes much to increasing the nitrogen level of the soil and there is no chemical soil test to measure this effect. Soil structure and physical condition of the soil are extremely important in Oklahoma. Maintaining organic matter and tilling the soil at proper soil moisture content are the best ways of maintaining desirable physical condition of the soil. Phosphorus- and potassium-containing fertilizers can be expected to give residual effects on succeeding crops, especially in cases of crop failure.

4. **Capabilities and limitations of the individual farmer or rancher concerned in terms of capital, equipment, farming system, his desires and his previous experience in fertilizer usage.** The farmer or rancher concerned is actually the main factor determining what a fertilizer recommendation should be. If his resources are limited, his best bet is to use the type and amounts of fertilizer materials that will give him the greatest return for limited investment. Fertilizer recommendations are ordinarily made for a crop within a rotation. Residual effects of fertilizer materials applied to crops that fail generally raise the fertility level of the soil and contribute to increased yields in following seasons of favorable rainfall. HOW the fertilizer is applied is as important as the kind and amount of fertilizer used. Soil fertility levels are easier to maintain under livestock systems of farming compared to straight cash crop farming. Good soil management practices are necessary to maintain and increase soil fertility levels; commercial fertilizers cannot do the job alone.

Soil tests, plant tissue tests, and deficiency symptoms are aids which may be used in evaluating some of the above factors. They support basic information but will not satisfactorily substitute for it. Therefore, it is necessary that all of this information be obtained and used in connection with these tests for sound, practical fertilizer recommendations. The increased use of fertilizers in the state, particularly the concentrated high analysis fertilizers, requires particular attention to these basic factors for efficient use of fertilizers and the proper expenditure of the farmer's capital.

Time and Method of Fertilizer Applications

The most efficient time of applying fertilizer materials is at seeding (starter) and at a time when the plant nutrients are readily used by the growing plant (top dressing and side dressing).

Proper fertilizer placement is of great importance particularly for stand establishment. Broadcasting of fertilizers for establishing stands of cultivated crops, small grains, and forage crops including grasses and legumes is wasteful and inefficient. Fertilizers in contact with the seed reduce the stand for most crops.

Banded fertilizer two to three inches below or to one side of the seed has proved best for most crops. For drill planted crops such as the small grains, it is preferable to drill the fertilizer in the row with the seed rather than broadcast the starter fertilizer.

Top dressing and side dressing established crops may be accomplished with any machinery that will deliver the fertilizer at a uniform rate without mechanically injuring the growing plant or its root system.

Fertilizer Analysis

The plant nutrient content of a fertilizer is given in percentage figures on each bag. These figures show the percentage of total nitrogen, available phosphorus as P_2O_5, and soluble potash as K_2O in the fertilizer. The first figure indicates the number of pounds of nitrogen in 100 pounds of the fertilizer; the second figure indicates the number of pounds of phosphorus as P_2O_5; and the third, the number of pounds of potassium as K_2O. For example, 100 pounds of a 10-20-10 fertilizer will supply 10 pounds of nitrogen, 20 pounds of P_2O_5 and 10 pounds of K_2O. Likewise, 100 pounds of superphosphate which is designated as 0-20-0 will supply 20 pounds of P_2O_5.

Value of Manure

Stated in fertilizer terms, one ton of fresh livestock manure is equivalent to about 100 pounds of 10-5-10 fertilizer. About half of the

nitrogen and potassium and about 10 percent of the phosphorus are in the liquid fraction. Farm manure is an excellent source of plant nutrients and organic matter. Regular additions of farm manure to crop land will do much to maintain soil fertility.

Rock Phosphate

The phosphorus contained in rock phosphate is relatively insoluble and becomes available to plants very slowly. To be effective rock phosphate must be finely ground and thoroughly mixed with the soil. Its availability is greatly increased by soil organic matter and soil acidity. Rock phosphate is not recommended for soils having less than 1.5 percent organic matter, neither is it recommended for soils with reactions higher than pH 6.0. Rock phosphate should usually not be applied at rates less than 500 to 1000 pounds per acre.

How to Take Soil Samples

The importance of obtaining representative soil samples for soil analyses cannot be over-emphasized. The most precise and accurate analytical procedure can be no better than the sample used.

In field sampling, soils that differ in appearance, crop growth, or previous treatment should be sampled separately if the area is of such size that it can be treated and fertilized separately.

In general, composite samples should not represent more than 10 to 15 acre areas within fields.

Subsoil samples give additional information of soil characteristics and are particularly important for evaluating needs of perennial crops.

Carefully taken, representative soil samples may be expected to be reliable indicators of the soil area sampled for a 12-month period following sampling, provided the soil does not receive lime or fertilizer treatments and is not cropped or subjected to severe erosion.

Interpretation of Test Results

Soil tests offer a partial means of evaluating the amounts of available plant nutrients in the soil. Soil tests are not perfect, and, therefore, will not predict in every case the best soil treatment. In any case, additional information must be available to properly evaluate soil test results in terms of the kind, amount, and method of applying fertilizers.

Soil tests, as they are carried out in the Oklahoma county soil testing laboratories, are tests for lime requirement, organic matter, available phosphorus, available potassium, and free carbonates in the soil. The following information concerning interpretation of soil test results is applicable to the testing procedures presently used in the Oklahoma county soil testing laboratories.

Lime Requirement

Acid soils result from soil loss of basic plant nutrients such as calcium, magnesium, and potassium. Many soil parent materials were low in content of these bases originally. Liming acid soils replenishes calcium and sometimes magnesium.

Iron and aluminum increase in solubility as soil acidity increases, in fact, the method of determining lime requirement in county soil testing laboratories is actually a measure of soluble iron in soils.

Soil texture is an important factor in determining the amount of lime required to furnish the soil with adequate amounts of calcium.

A precise measurement of soil reaction (pH) by determining active hydrogen concentration in soils is one of the most useful of soil testing procedures. Soil pH indicates indirectly a number of soil fertility characteristics.

1. Phosphorus is changed to forms relatively unavailable to plants in strongly acid soils and in alkaline calcareous soils.

2. The activity of desirable soil micro-organisms, particularly the nitrogen fixers and nitrifiers, is seriously depressed in strongly acid and strongly alkaline soils.

3. High amounts of active hydrogen in normal soils are usually reliable indicators of the lack of basic plant nutrients such as calcium, magnesium, and potassium.

Soil Reaction, Soil Texture, and Lime Requirements

		Lime Requirement in Tons per Acre		
Soil Reaction	pH Range	Sand	Sandy Loam, Loams and Silt Loams	Clay Loam and Clay Soil
Slightly acid	6.1 to 6.5	none	1	1 to 2
Moderately acid	5.5 to 6.0	1	1 to 2	2 to 3
Strongly acid	5.0 to 5.4	1 to 2	2 to 3	3 to 4
Very strongly acid	Below 5.0	2	3 to 4	4 to 5

Legumes are usually benefitted more by lime applications than are most grains and grasses. Soil organic matter, subsoil characteristics and previous liming history will influence the lime requirement.

Soil Organic Matter

No chemical soil test is available at present for accurately predicting the needs for nitrogenous fertilizer. The organic matter test is a measure of organic carbon in soils and indirectly indicates a measure of potential nitrogen supply because the nitrogen and organic carbon content of soil humus is somewhat constant.

The growth of alfalfa, sweet clover, and vetch in the rotation and the disposition of legume crops has an important influence on the available nitrogen in the soil. Such crops as corn require more nitrogen than can be supplied by normal release of nitrogen even from soils very high in organic matter. Other crops, such as oats and cool season grasses, require large amounts of nitrogen when soil organisms are inactive during cool portions of the year. Many factors other than soil organic matter content must be considered in determining how much nitrogen fertilizer is required for a specific crop.

Soil organic matter is a valuable soil component for improving soil physical condition. Effectiveness of organic matter in improving soil tilth is related to soil texture. A heavy textured clay soil containing only one percent organic material is definitely low. However, a very light sandy soil in Oklahoma that contains only one percent organic matter is medium to high.

Guides for the use of nitrogen fertilizers on specific crops and soil situations are included in the fertilizer recommendations published annually by the Oklahoma Experiment Station.

Levels of Organic Matter Needed to Produce Good Crop Yields on Well Drained, Medium Textured Soils

	Western Oklahoma	Central Oklahoma	Eastern Oklahoma
Cool Season Crops (Small Grains and Winter Forage Crops)	1.0 to 1.5%	1.5 to 2.0%	2.0 to 2.5%
Warm Season Crops (Sorghums, Cotton, Peanuts and Summer Forage Crops)	0.5 to 1.0%	1.0 to 1.5%	1.5 to 2.0%

Available Phosphorus

The test for available phosphorus is determined by extracting the soil with a dilute acid. Much of the phosphorus in the soil is in an organic form in organic matter and is not soluble.

Many crops can obtain a greater amount of soil phosphorus than can be extracted with this dilute acid and many other crops are not as efficient as the extracting solution in obtaining phosphorus.

Important crops including alfalfa, wheat, corn, oats, and most legumes respond to phosphorus fertilization on practically all agriculturally important soils in Oklahoma.

Phosphorus fertilizers may be expected to give good residual effects on following crops in case of a failure of the crop to which the fertilizer was applied.

Soil Fertility Levels of Available Phosphorus
Medium Textured, Well Drained Soils

Level	Available Phosphorus lbs./A*	Crop Response
Very low	0 to 10	Legumes, small grains, corn, cotton, sorghums and most cultivated crops and forages require phosphorus fertilization on soils having low available phosphorus.
Low	11 to 20	
Medium	21 to 40	Alfalfa, vetch and clovers, small grains, corn and cotton give good returns for phosphorus fertilizers applied to soils containing only moderate amounts of available phosphorus.
High	Over 40	

* Soil phosphorus extractable with .02 normal sulphuric acid

Available Potassium

Most medium and heavy textured soils of central and western Oklahoma are usually well supplied with this element. Light textured soils

Soil Fertility Levels of Available Potassium
For Medium Textured, Well Drained Soils

Level	Available Potassium lbs./A*	Crop Response
Very low	0 to 75	Alfalfa and most legumes, small grains, corn, cotton, sorghums and other cultivated crops and forages give good response to potassium fertilization on low potash soils.
Low	76 to 125	
Medium	126 to 200	Potassium fertilization is usually not recommended except for such high potash requiring crops as alfalfa, Ladino clover, barley, corn and cotton growing in special situations.
High	Over 200	

* Soil potassium extractable with 8.5 percent sodium nitrate solution.

and soils strongly acid in reaction are often deficient in available potassium.

Many crops have higher potassium requirement than others; alfalfa has a very high requirement for this element but also has an extensive root system to more efficiently utilize native soil potassium that is less available to other crops.

Potassium fertilizers may be expected to give good residual effects on following crops in case of crop failure when the fertilizer is applied.

Free Carbonates

The soil test for free carbonates is used to substantiate other soil tests and aid in their evaluation.

Comber test (soluble iron) may test positive in neutral and alkaline soils; the presence of free carbonates may indicate that lime is not needed though the iron test is positive.

Extractable phosphorus tests on alkaline soils may indicate high in presence of carbonates even though the actual amount of available phosphorus for most crops is low.

Plant Tissue Tests and Deficiency Symptoms

Growing plants tend to take up and accumulate amounts of plant nutrients in excess of the immediate needs of the plant. If the supply of nutrients from the soil is sufficient, there will be quantities of unassimilated or "unused" nutrients within the plant tissue. Low amounts in plants indicate that supply of nutrients from the soil may be limiting plant growth. Plants usually test low for a period of time before deficiency symptoms appear. This test is particularly useful for indicating nitrogen status in relation to the supply of soil nitrogen available to the plant.

Specific deficiencies of nutrient elements cause typical symptoms to appear in the growing plant. Recognition of these symptoms is a helpful aid in diagnosing nutrient deficiencies. Insects, plant diseases, and many types of plant injuries may cause the plant to exhibit abnormalities in appearance that are similar to deficiency symptoms.

Soil tests, plant tissue tests and deficiency symptoms will contribute information for diagnosing nutrient deficiencies in soils and plants. It is important to recognize the definite limitations in each of these procedures as well as their relative value. When used properly, these methods supplement each other and the use of more than one procedure will result in more complete and valid information from which to draw conclusions as to nutrient deficiencies in plants and soils.

General Fertilizer Recommendations

The following tables present general fertilizer recommendations for major crops grown in Oklahoma. The range in plant nutrient recommendations for soil test results is given for crops and soils conditions not under irrigation.

Crops must be fertilized to obtain the highest practical yield and quality when grown under irrigation. Nitrogen requirements are particularly high for most irrigated grain and forage crops compared to the same crops grown under dry land conditions. Higher rates of fertilizer are recommended for irrigated crops with the objective of minimizing the possibility of plant nutrient deficiencies limiting yields. Good soil physical condition, adequate drainage and low salt content are likewise necessary to give continued profitable crop returns with irrigation.

General Fertilizer Recommendations—Corn and Cotton

	Pounds of Plant Food to Apply per Acre				
		Phosphorus (P_2O_5)		Potassium (K_2O)	
		If soil test shows:		If soil test shows:	
Crop	Nitrogen (N)	Low to Very low	Medium to High	Low to Very low	Medium to High
Corn:					
Bottomland					
At Planting	10-20	40-60	20-40	20-60	0-20
Sidedressed N	30-80				
Upland					
At Planting	10-20	20-40	10-30	20-40	None
Sidedressed N	20-60				
Cotton:					
Eastern and Central Oklahoma					
At Planting	10-20	20-40	10-20	20-40	0-20
Western Oklahoma					
At Planting	10-15	20-30	0-20	15-30	0-10

How to Use This Table:

First, determine the soil type and production capability for the specific field concerned and the general plant food needs of the crop to be grown. Consider what the previous soil treatments have been and the capabilities and desires of the farmer. Use this basic information to decide the pounds of plant food needed within the ranges given in the above chart from soil test results. Example: 200 lbs. of 10-20-10 fertilizer at planting supplies 20 lbs. nitrogen, 40 lbs. P_2O_5 and 20 lbs. K_2O. 150 lbs. ammonium nitrate (33%) sidedressed to a crop supplies 50 lbs. of nitrogen.

General Fertilizer Recommendations—Sorghums and Wheat

Crop	Pounds of Plant Food to Apply per Acre				
		Phosphorus (P_2O_5)		Potassium (K_2O)	
		If soil test shows:		If soil test shows:	
	Nitrogen (N)	Low to Very low	Medium to High	Low to Very low	Medium to High
Sorghums:					
Grain					
At Planting	0-20	20-40	0-20	10-20	None
Forage					
At Planting	0-20	20-40	0-20	15-40	None
Sidedressed	0-40				
Wheat (grain):					
Central and Eastern Oklahoma					
At Planting	0-50*	30-60	0-30	20-40	None
Western Oklahoma					
At Planting	0-30*	20-40	0-20	20-30	None

* The nitrogen fertilizer may be applied all at planting; all topdressed in the spring or fall; or it may be split, i.e. 20 lbs. at planting and 30 lbs. topdressed.

General Fertilizer Recommendations—Barley, Oats, Soybeans & Peanuts

Crop	Pounds of Plant Food to Apply per Acre				
		Phosphorus (P_2O_5)		Potassium (K_2O)	
		If soil test shows:		If soil test shows:	
	Nitrogen (N)	Low to Very low	Medium to High	Low to Very low	Medium to High
Barley (grain):					
At Planting:	0-20	30-40	0-30	20-40	0-20
Topdressed	20-50				
Oats (grain):					
At Planting	10-30	20-40	0-20	10-40	None
Topdressed	20-50				
Soybeans:					
At Planting	10-20	30-40	20-30	10-20	None
Peanuts:					
At Planting	0-15	20-50	0-30	20-50	None

Barley is best adapted to high fertility soils; lime is usually required for high yields of this crop when grown on medium to highly acid soils. Oats required large amounts of nitrogen to produce high yields of forage and grain, particularly during wet, cold seasons and on poorly drained soils. Peanuts and soybeans frequently do not respond to direct fertilization. Increased yield and quality are frequently obtained with peanuts and soybeans when heavy fertilization is applied to the preceding winter cover crop as rye and vetch.

General Fertilizer Recommendations—Alfalfa & Sweet Clover & Sericea Lespedeza

Crop	Nitrogen (N)	Pounds of Plant Food to Apply per Acre			
		Phosphorus (P_2O_5)		Potassium (K_2O)	
		If soil test shows:		If soil test shows:	
		Low to Very low	Medium to High	Low to Very low	Medium to High
Alfalfa:					
At Establishment	0-15	40-80	30-60	30-60	None
Topdress annually		40-80	30-60	30-60	0-30
Sweet Clover and Sericea Lespedeza:					
At Establishment	0-10	40-60	10-40	20-30	None
Topdress annually on Sericea Lespedeza		30-40	0-30	10-20	None

Alfalfa requires well drained soils and has a high requirement for lime, phosphorus, and potassium. Established stands should be fertilized annually. Use of potash fertilizers may be lowered where subsoils are high in potassium. Twenty lbs. borax per acre is recommended for heavily fertilized stands showing bronzing or chlorosis of leaves.

Alfalfa and Sweet Clover are relatively efficient in utilizing the relatively insoluble phosphorus in rock phosphate.

Sericea Lespedeza is more tolerant of acid low fertility soils than sweet clover.

General Fertilizer Recommendations—Temporary Pastures

Crop	Nitrogen (N)	Pounds of Plant Food to Apply per Acre			
		Phosphorus (P_2O_5)		Potassium (K_2O)	
		If soil test shows:		If soil test shows:	
		Low to Very low	Medium to High	Low to Very low	Medium to High
Small Grains and common Ryegrass alone and with Vetch, Crimson or Sweet Clover:					
At Establishment	10-40	30-60	10-30	20-40	0-20
Established small grains used only for pasture, topdress	20-50				
Sudan Grass:					
At Establishment	10-40	20-40	10-20	10-20	0-20
Sidedress	20-60				

Barley is best adapted to high fertility soils and is more sensitive to acid soil conditions than other small grains. Oats require large amounts of nitrogen to produce high yields of forage. Sudan grass produces best on high fertility soils and gives good response to nitrogen fertilization.

General Fertilizer Recommendations—Permanent Pastures

Crop	Pounds of Plant Food to Apply per Acre				
		Phosphorus (P_2O_5)		Potassium (K_2O)	
		If soil test shows:		If soil test shows:	
	Nitrogen (N)	Low to Very low	Medium to High	Low to Very low	Medium to High
WARM SEASON GRASSES					
Bermuda					
Weeping Lovegrass					
Dallis Grass					
At Establishment	10-20	20-40	10-20	10-40	None
Topdress annually (no legumes)	30-60	20-40	0-20	10-40	None
Overseeded with:					
Hop Clover: (fall)					
Lespedezas: (spring)					
At Establishment	None	20-40	10-20	10-20	None
Topdress annually	None	20-40	10-20	10-20	None
Overseeded with:					
White, Ladino, Button and Crimson Clovers,					
Vetch: (fall)					
At Establishment	0-10	30-80	20-40	20-80	0-40
Topdress annually	None	20-40	20-40	20-40	0-20

Bermuda should be fertilized at planting for establishment on low fertility soils. Subsequent fertilization should be for the legumes in established stand of Bermuda. Double the annual rate of fertilizer may be applied biennially on established pastures. Rates of fertilizer application should be increased for deep, permeable prairie and bottomland soils because of higher soil productive capacity.

COOL SEASON GRASSES					
Smooth brome, Tall fescue, Orchard grass, and Perennial ryegrass seeded (fall) with Alfalfa, Vetch, White, Ladino Red or Crismon Clovers:					
At Establishment	10-30	40-80	20-40	20-60	0-20
Topdress annually	20-40	40-80	20-40	20-60	0-20

When these grasses are grown without legumes, annual applications of 30-60 lbs. of nitrogen are required. Potassium fertilization should be reduced when subsoils are well supplied with available potassium. Nitrogen may be applied where grasses are not making satisfactory growth in competition with the legumes.