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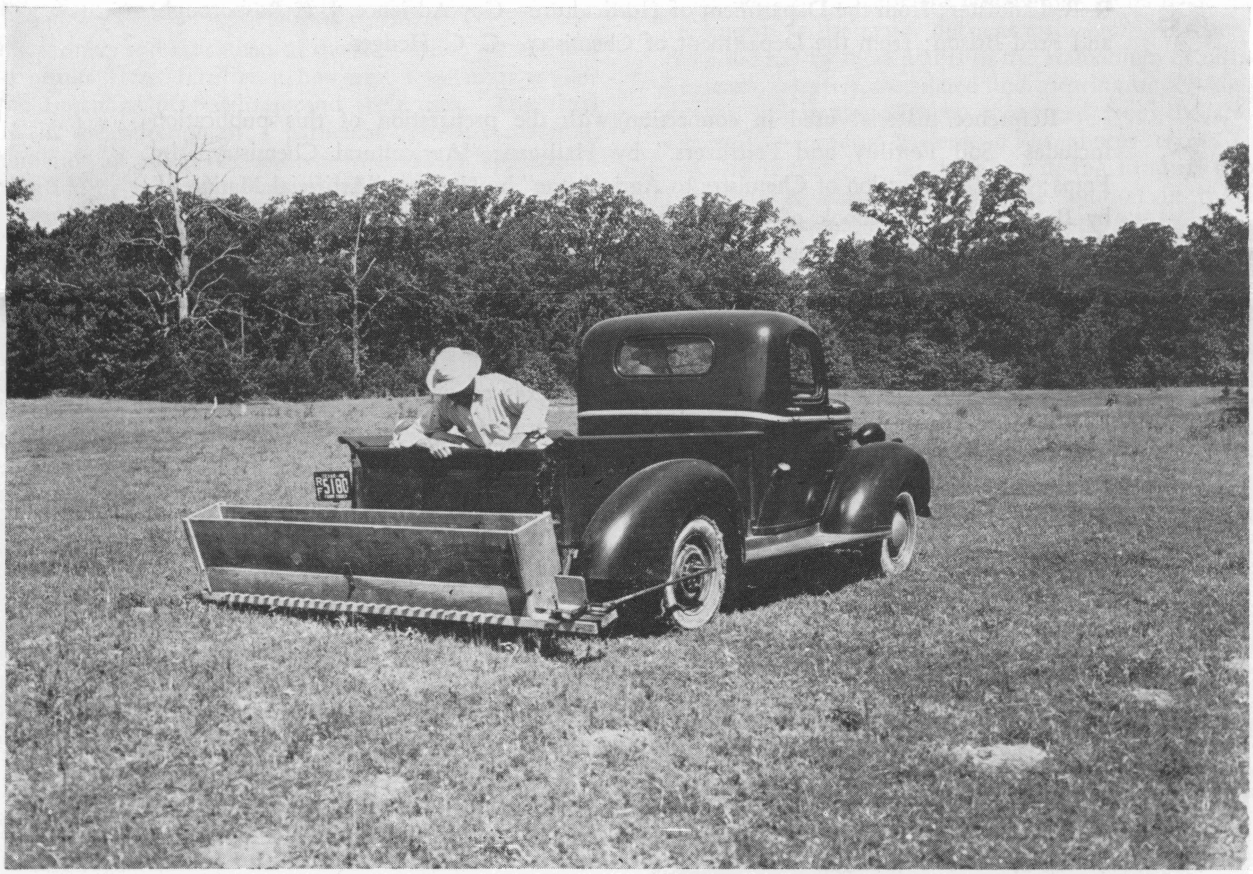
FERTILIZERS

. . . *And Their Use*



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The author also wishes to thank the many Texas county agricultural agents who have, over a period of 35 years, used the basic information presented herein in setting up fertilizer demonstrations in cooperation with the farmers of the state.

ON THE COVER: Homemade fertilizer distributor for broadcast application.

FERTILIZERS

. . . *And Their Use*

M. K. THORNTON
Extension Agricultural Chemist
Texas A. & M. College System

The use of commercial fertilizer has increased rapidly throughout a large part of Texas since 1934 and no doubt will increase much more rapidly in the next few years. Farmers have found that fertilizers pay off in increased yields and in improved quality even on supposedly fertile soils.

If the farmers and ranchmen of the state are to get the best possible results from fertilizers, however, they must understand the functions of fertilizers and their uses. The final decisions in the selection of a particular fertilizer material, or combination of materials, and the method of application must be made by the individual grower on the basis of his experience with the soils of his particular area. But there are general principles for the selection and use of fertilizers which can help him in making his decisions.

PLANT NUTRIENTS

A large number of nutrient, or food, elements are required for the normal development of plants. If any one or more of these elements are low or lacking altogether, the plant either will not grow or will grow very poorly. These necessary elements are shown in the table.

As shown in the table, three of these elements are obtained from air and water. The carbon comes mainly from the air, the hydrogen from the water, and the oxygen from both air and water. So plenty of water is necessary if the plant is to grow rapidly. Since roots breathe the oxygen in the soil atmosphere, however, too much water will drive out the oxygen, suffocate the plant, and possibly kill it.

MAJOR NUTRIENTS

The major elements of the soil required for plant development in relatively large quantities are nitrogen, phosphorus, and potassium. Since the nutrient food element, or elements, most likely to be deficient will be one or more of these, they are known as the major nutrient elements. Nitrogen is taken from the soil by most plants in the ammonium or nitrate form. Legumes, properly inoculated and growing under suitable conditions, obtain the nitrogen they need from the air through the nodule-forming bacteria. Phosphorus comes from the soil and is taken up by the plant in the form of phosphates. Potassium is taken from the soil solution in the form of soluble potassium compounds.

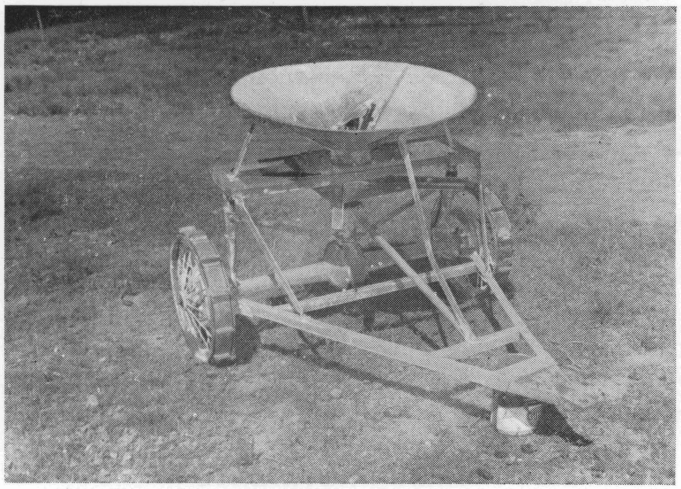
SECONDARY ELEMENTS AND SOIL AMENDMENTS

Calcium, magnesium and sulfur are essential plant nutrients but usually are present in the soil in sufficient quantities to meet the nutritional needs of the plants and to stimulate necessary growth of micro-organisms. Their greatest use, however, is as soil amendments, conditioning the soil so as to improve growing conditions. Lime is usually applied in the form of ground limestone to neutralize, or "sweeten," acid soils. Calcium in lime is needed as a nutrient element also. In such cases, lime is a fertilizer as well as an amendment.

A soil low in magnesium produces definite growth symptoms in plants. Dolomite, which contains both calcium and magnesium, is one of the best sources of magnesium for the soil. Magnesite may also be used. In some areas application of Epsom salts has proved helpful.

ESSENTIAL PLANT NUTRIENTS

Elements from Air and Water	Elements from the Soil			
	Major Elements	Secondary Elements and Amendments	Trace Elements	
Carbon	Nitrogen	Calcium	Iron	Boron
Hydrogen	Phosphorus	Magnesium	Manganese	Zinc
Oxygen	Potassium	Sulfur	Copper	Sodium
			Chlorine	
Constitute approximately 95% of plant weight	Constitute approximately 5% of plant weight			



Fertilizer or lime may be spread broadcast by this type of distributer and later worked into the soil.

Generally speaking, lime and dolomite are not needed in the western part of the state where soils usually are high in calcium and magnesium.

Sulfur is applied as a soil amendment to soils which are too alkaline. It oxidizes (combines with oxygen) in the soil to form sulfuric acid. The acid reduces the alkalinity or increases the acidity, thus improving growing conditions. Sulfur is needed as a nutrient element also.

TRACE ELEMENTS

Since some elements are needed by plants in very small quantities, they are called trace, or minor, elements, but they are just as necessary to plant development as are the major elements. When in the soil solution, they are available to plants. When applied to the soil in the pure form or with fertilizers, they are used by plants for better growth. Soluble iron perhaps is needed more than any of the other trace elements. It is the specific treatment for chlorosis, the yellowing of leaves of plants growing in soils that are too alkaline or have large quantities of limestone. The alkalinity of the soil reduces the availability of the iron to the plants. Iron can be applied to plants in the form of an iron solution spray on the leaves of the growing plants for immediate, temporary relief (1 pound to 50 gallons of water or 1 ounce to 3 gallons of water). For longtime effect, it should be applied in the soil at frequent intervals.

The other trace elements—zinc, copper, manganese and boron—may be applied to the soil or sprayed on the plants when they are needed to correct nutritional disturbances.

Effect of Nutrients on Plant Growth

The presence or absence of a certain plant nutrient has a definite effect on plant growth. Application of one element usually will not substitute for the shortage of another. It is well, therefore, to understand some of the effects of these various nutrients in order to appreciate the role each plays in plant development.

Effects of Nitrogen

1. Encourages vegetative growth
2. Causes a deep-green leaf color by increasing chlorophyll.
3. Increases plumpness and protein of grain.
4. Produces succulence in crops such as grass, lettuce, radishes, etc.
5. In excessive quantity:
   a. Produces a delayed maturity.
   b. Increases tendency to lodge.
   c. Increases susceptibility to diseases.
   d. Decreases resistance to drouth.
   e. Causes plant to fail to set fruit.
   f. Causes sappy growth and promotes winter killing.
   g. Causes fruit to be watery and of poor quality.
6. A deficiency of available nitrogen results in stunted plants with restricted root systems. The leaves turn yellow or yellowish-green and drop off some plants. Yields and quality are reduced.

Effects of Phosphorous

1. Encourages root growth, especially the lateral and fibrous rootlets.
2. Hastens maturity of the crop; flowering and fruiting depend on it.
3. Increases the ratio of grain to straw as well as total yield of grain.
4. Improves quality of crops.
5. Increases disease resistance.
6. Is essential to seed production.
7. Aids in formation of carbohydrates.
8. Aids in assimilation of fats.

Effects of Potassium

1. Improves plant vigor.
2. Increases resistance to disease.
3. Encourages root development.
4. Delays maturity, thus balancing the effect of phosphorous.
5. Gives plump, heavy kernels in grain.
6. Encourages tuber development.
7. Is needed in the development of chlorophyll.
8. Offsets bad effects of excessive nitrogen and phosphorous.
9. Increases drouth resistance.
10. Increases sugars and starches.

Effects of Calcium

1. Encourages root growth.
2. Promotes leaf growth.
3. Is necessary for nodulation of legumes.

Effects of Magnesium

1. Is necessary for chlorophyll formation.
2. Encourages vegetable oil formation in plant and seed.

Effects of Sulfur

1. Increases root system.
2. Promotes formation of chlorophyll.
3. Increases nodulation of legumes.

Effects of The Minor Elements

1. Iron—promotes formation of chlorophyll.
2. Manganese—promotes formation of chlorophyll, sugar, and proteins.
3. Boron is necessary for nodulation of legumes, helps growth of growing tips of branches and roots.
4. Zinc is necessary for chlorophyll formation.
5. Copper is necessary for chlorophyll formation.

Since several of the elements have the same job in developing a plant, it is often hard to decide which is lacking when something goes wrong. For example, magnesium, sulfur, zinc, copper, iron and manganese all help make chlorophyll. When plants develop a pale yellow, or chlorotic, appearance, it is difficult to decide which nutrient element is lacking by merely noting this one symptom. It is necessary to check the plant as a whole, studying all of the symptoms and all of the developments, before deciding for sure what is wrong.

From this, it is seen that all of the elements must be present and available in the soil if the plant is to develop satisfactorily. Furthermore, not only must they be present but they should be in balance so that the plant will be able to absorb them in the proper proportion. Great care should be exercised in their use since large quantities of some trace elements may have serious effects on plants.

The plant nutrients are necessary not only for the best development of the growing plants but also for the best development of micro-organisms in the soil. A shortage of some elements may slow the development of the micro-organisms. Here again, the right amounts of the nutrients are necessary—neither too much nor too little—for best results in both plant and micro-organism growth.

Tremendous quantities of the major nutrients are required to produce the crops now being grown in Texas. As virgin soils lose their natural supplies of the nutrients, reinforcement of the soil by fertilizers becomes increasingly necessary.

NUTRIENTS REMOVED BY CROPS IN POUNDS
(approximate)

Crop	*Nitrogen (N)*	*Phosphoric Acid (P_2O_5)*	*Potash K_2O*	*Lime CaO*
Alfalfa—4 tons	186	46	193	160
Barley—25 bu.	23	10	9	1.5
Corn shelled—20 bu.	17	7	5	1
Corn (ear)—20 bu.	19	8	6	1
Cotton lint—200 lbs.	Trace	Trace	Trace	Trace
Cottonseed based on 200 lbs. lint—360 lbs.	13.2	4.5	4.1	.9
Cowpea Hay—1 ton	60	11.5	48	40
Johnson grass hay—1 ton	21	12	29	24
Maize—20 bu.	18	8	9	5
Oats—30 bu.	18	7	5	1
Potatoes, Irish—80 bu.	16	8	29	10
Potatoes, Sweet—80 bu.	11	8	29	2
Prairie Hay—1 ton	18	5	24	14
Rye—30 bu.	32	15	11	1
Wheat—20 bu.	25	12	6	.5

Fertilizer distributed from a homemade spreader. The barrel has holes in it, through which the fertilizer shakes through. Later, it is worked into the soil.

Commercial fertilizers are applied to soils primarily to add to the supply of plant nutrients already in the soil and not as the only source of the nutrients. The amount used varies, depending on the needs of the soil bacteria and of the soil itself, with increased crop yields and better quality as the goal.

Determining the Need for Plant Nutrients

Productivity of the soil involves many factors besides the quantity and availability of the plant nutrients. Some causes of poor plant production are: lack of drainage, resulting in a water-logged condition; unfavorable temperature; poor physical condition of the soil; drouthy soils; too much alkali; too much acid; too much lime; and hard pans or clay pans near the surface. Such defects, coupled with a depletion of the plant nutrients, all add up to lower production.

The first step in analyzing the problem of poor plant production is a careful examination of the soil itself. Is the structure and texture suited to the crop to be grown?

Next, check the sub-soil. Is there a hard pan near the surface? Then, look over the area. Are there alkali spots or water-logged spots?

Insofar as possible, check the history of the particular soil. What has it grown in the past? How successfully? What deficiencies were indicated in previous crops?

With the information gathered from a firsthand check and from known history of the soil, a good picture of the production possibilities can be obtained.

Deficiency Symptoms of Plants

Information obtained from a study of the soil alone, however, may not be enough. A careful study of the plants themselves will aid in deciding which nutrient elements are lacking. In the following outline, taken from Ohio State Agricultural Experiment Station Bull. 611, signs indicating certain deficiencies are described. A study of the plants, based on these signs, plus a study of the soil itself will give the right answer in many cases. With that answer, the deficiency can be corrected.

Fertilizer may be scattered broadcast by hand. Later, it will be worked into the soil. This is a slow method.

A GENERALIZED KEY TO NUTRIENT DEFICIENCY SYMPTOMS IN PLANTS

A. Effects general on whole plant or localized on older, lower leaves.

1. Effects usually general on whole plant, although often manifested by yellowing and drying of older leaves.

a. Foliage light green. Growth stunted, stalks slender, and few new branches. Leaves small, lower ones lighter yellow than upper. Yellowing followed by a drying to a light brown color, usually little dropping of leaves. *NITROGEN DEFICIENT.*

b. Foliage dark green. Retarded growth. Lower leaves sometimes yellow between veins but more often purplish, particularly on petiole. Leaves dropping early. *PHOSPHORUS DEFICIENT.*

2. Effects usually local on older, lower leaves.

a. Lower leaves mottled or freckled, usually with dead areas near tip and margins. Yellowing beginning at margin and continuing toward center. Margins later becoming brown and curving under and older leaves dropping off. *POTASSIUM DEFICIENT.*

b. Lower leaves chlorotic and usually dead in late stages. Chlorosis between the veins, veins normal green. Leaf margins curling upward or downward or developing a puckering effect. Dead areas developing between the veins very suddenly, usually within 24 hours. *MAGNESIUM DEFICIENT.*

B. Effects localized on new leaves.

1. Terminal bud remaining alive.

a. Leaves chlorotic between the veins, veins remaining green.

i. Dead spots usually absent. In extreme cases death of margins and tip of leaf, sometimes extending inward, developing large areas. Larger veins only remaining green. *IRON DEFICIENT.*
Note: Certain cultural factors, such as high pH, overwatering, low temperature, and nematodes on roots, may cause identical symptoms. However, the symptoms are still probably of iron deficiency in the plant due to unavailability of iron caused by these factors.

ii. Dead spots usually present and scattered over the leaf surface. Checkered or finely netted effect produced by even the smallest veins remaining green. *MANGANESE DEFICIENT.*

b. Leaves light green, veins lighter than areas between veins. Some dead spots. Little or no drying of older leaves. *SULFUR DEFICIENT.*

2. Terminal bud usually dead.

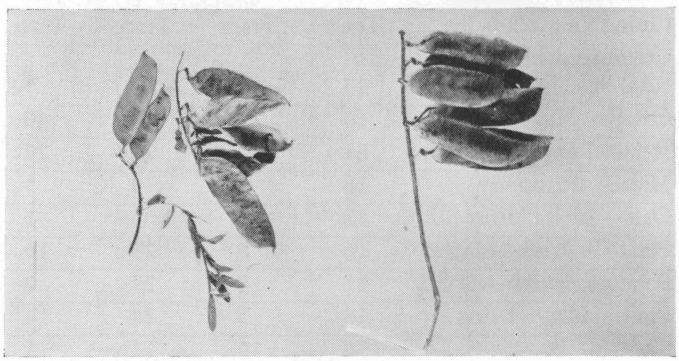
a. Death at growing tip and margin of young leaves. Young leaves often definitely hooked at tip. Death of roots actually preceding all the above symptoms. *CALCIUM DEFICIENT.*

b. Breakdown at base of young leaves. Stems and petioles brittle. Death of roots, particularly the root tips. *BORON DEFICIENT.*

Plant Tissue Tests

Testing the plant tissue itself in a laboratory or in the field actually can supply, in many ways, more accurate information than soil testing. But since the plant tissue test can be made only after the plant has grown, the answers may be too late for immediate help. They may, however, give the information needed for future crops.

For testing plant tissue, parts of the leaves, petioles and stems of the plants are chopped into small pieces and extracted with different solutions. Those solutions then are tested for nitrates, ammonia, potassium, phosphorous and, sometimes, other nutrients.



Lime makes the difference in vetch seed production. Seed on the right received lime at one ton per acre. Seed on the left received no lime.

The information is accurate—but, as mentioned, it may be too late to help this year's crop.

Soil-Testing in Laboratories

An advance look at possible deficiencies can be had by laboratory soil tests. These tests are made for phosphorous, potassium, calcium, magnesium, nitrogen, and other nutrients, and organic matter.

Taken alone, the information obtained in soil tests usually isn't enough for a final answer. But when it is considered along with the information obtained in the on-the-ground check (history, ease of handling, lay of the land and other physical characteristics), the answer should help in planning crop production and general soil improvement.

For a soil analysis to be of value, the sample must be representative of the entire area it is supposed to cover. In one field or on one farm, there may be several types of soil. In such cases, a sample from each type should be tested. Samples should be gathered from several different spots in any field.

If only small plots of land are involved, the samples may be taken from a relatively small area. On the other hand, if one area with a particular problem is to be tested, adjoining areas of the same soil type but not involved in the problem also should be tested.

Field Tests

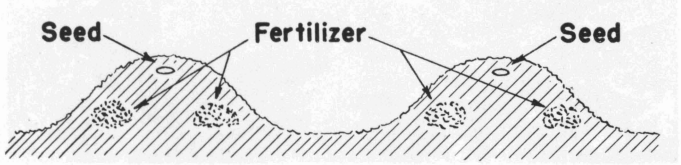
The final test in deciding which plant nutrient is lacking is a field test. These tests are the most valuable means of learning which nutrient element is lacking. A field test will indicate the best adapted fertilizer.

Methods of Applying Commercial Fertilizer

Fertilizers may be applied in any one of four ways:

1. Spread over the entire surface by broadcasting and plowed under.
2. Applied in a small area close to the seed or plant by row or hill placement (best results have been obtained by applying the fertilizer about two to three inches to the side and two to six inches below the level of the seed with a fertilizer attachment on the planter).
3. Applied at the time of land preparation by an attachment placing the fertilizer on the plow sole (plow sole fertilizing will place the material about 8 or 10 inches deep).
4. Dissolved in irrigation water for application to the crops while irrigating.

Generally speaking, the type of crop being grown will determine which method is used. Since hill or row placement concentrates the fertilizer in a band, it usually makes better use of fertilizer than the other methods. In addition, the greater concentration enables the crops to make fuller use of the nutrients.



Fertilizer is placed below and to one or both sides of seed at planting time. This gives excellent results.

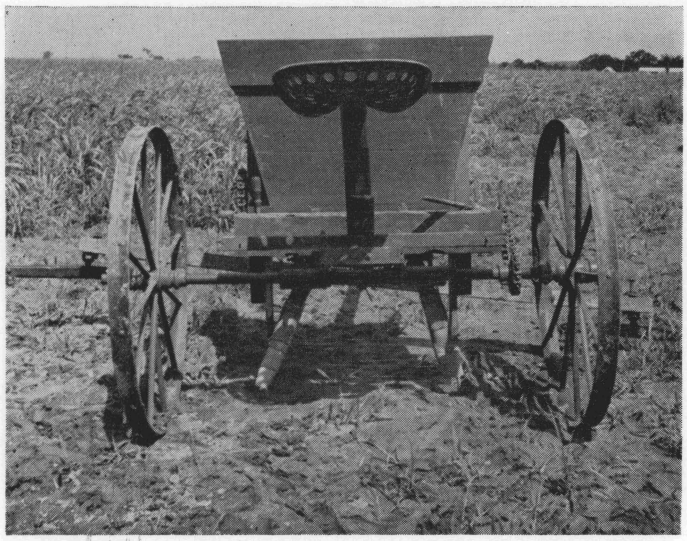
Phosphate fertilizer increases yield of Hubam sweetclover. Fertilized plot is two feet high; unfertilized, one foot high.

Behavior of Nutrients in the Soil

Different nutrients in a fertilizer behave differently in the soil. Nitrogen in the fertilizer can move freely with the soil moisture. Potassium moves a little less but does move with the soil moisture to the plant roots. In times of heavy rains or under heavy irrigation, these two may be lost by leaching. Since phosphorus fertilizers do not move very rapidly or very far, they should all be drilled into the soil deep enough to come into contact with the roots as they grow and develop. For that reason, phosphates are not usually as effective as a side or top dressing as the nitrogen and potassium fertilizers. It is best, therefore, always to apply the phosphates at, or just before, seeding time at the depth of the seed or below. The nitrogen and potassium can be added as a side dressing later if needed.

One of the best methods of fertilizing is to use part of the fertilizer (particularly that containing large quantities of phosphate) at seeding, or just before, with enough nitrogen and potash to start the crop. Later, nitrogen and potassium can be added as a side or top dressing. Top dressing for small grains should be applied in the spring before the crop starts to joint. For corn, grain sorghums and similar crops, the side dressing should be applied when the crop is about knee high. For cotton, tomatoes and other crops, the side dressing should be applied about the time fruit begins to set, or shortly thereafter.

A combination of the broadcast and row placement systems has been used successfully, especially when large quantities of fertilizer are used. Combinations of all methods also have proved successful under certain circumstances.



Homemade distributor that shakes fertilizer on the ground. Later, it is worked into the soil.

FERTILIZER MATERIALS

For those who are unfamiliar with fertilizers, certain facts should be kept in mind. Fertilizer materials may be derived from various sources. Each material from a particular source may have certain advantages and certain disadvantges. For example, nitrogen may be obtained from mineral salts such as sodium nitrate, ammonium sulfate, etc. or from sources such as barnyard manure or cottonseed meal. In the first case, nitrogen is immediately available, while in the latter, the manure or cottonseed meal has to rot and change before the nitrogen becomes available to the plants. Likewise, some of the fertilizer materials have a tendency to make the soils more alkaline while others will make them more acid.

MATERIALS FURNISHING NITROGEN

Ammonia Solutions or Liquid Ammonia

Ammonia solutions are made by dissolving ammonia in water. They are used by the fertilizer trade for making ammoniated phosphate. Ammonia solutions have been used in irrigation water for fertilizing crops, with satisfactory results. They may be used directly on the land as fertilizer. Use of ammonia in solutions as fertilizer requires special equipment, but this presents no major problem.

Anhydrous Ammonia

Under ordinary conditions, ammonia is a gas containing about 82 percent nitrogen. When compressed, it becomes a liquid and may be stored or shipped in high-pressure tanks. It is used primarily in the fertilizer manufacturing industry. Recently, however, machines and equipment have been developed for the direct application to the soil of anhydrous ammonia at the time of land preparation, planting or cultivating. This has proved satisfactory as a source of nitrogen. In addition, it is dissolved in irrigation water for fertilizing crops in arid areas.

Ammonium Sulfate

This fertilizer is made by passing ammonia gas through sulfuric acid and then crystallizing it. Most of the ammonium sulfate is a by-product of the coke ovens and gas plants. It may be made, however, by passing ammonia from the newer synthetic nitrogen plants into sulfuric acid, forming a white or gray crystalline salt which is highly soluble in water. It contains about 20 percent nitrogen and 24 percent sulfur.

When this fertilizer is applied to the soil, the ammonia is rapidly converted into nitrate. In the nitrate form, it is readily taken up by the older plants. In the ammonium form, young plants and rice will take it up quickly. It is an intermediate acting nitrogen fertilizer and is the base for much of the nitrogen in mixed fertilizers. It tends to increase the acidity of soils when used for a long number of years. It is hightly recommended for the alkaline soils and can be used in any area in the state, particularly in the rice area.

Ammonium Nitrate

Ammonium nitrate is a synthetic product manufactured at some of the plants built during the war. In the pure form, the salt is white and absorbs moisture rapidly. It usually is brought on the market as a brown or orange granulated material which has been treated to reduce the rate of moisture absorption from the air and to make it easier to apply. It usually carries about 32½ percent nitrogen, one half as ammonium nitrogen and the other half in the form of nitrate. It is highly soluble in water. It is a rapid acting fertilizer, available to plants immediately upon application. A mixture of ground limestone and ammonium nitrate is marketed as Cal-Nitro. It contains about 20 percent nitrogen.

Ammonium Phosphate

There are two members of the ammonium phosphate family: mono ammonium phosphate and diammonium phosphate. Both contain nitrogen and phosphate and are light colored granular salts. They are produced synthetically. The monoammonium phosphate in pure form contains about 12 percent nitrogen and 62 percent phosphoric acid. The diammonium phosphate, contains about 21 percent nitrogen and 53 percent available phosphoric acid. They are soluble in water and readily available to plants. The two ammonium phosphates that usually come on the market are 11-48-0 and 16-20-0. The 16-20-0 is a mixture of diammonium phosphate and other materials. Both are concentrated fertilizers and may be used where nitrogen and phosphorus are required.

Fertilizer makes the difference—200 pounds of 5-10-5 per acre increased corn yields.

Sodium Nitrate

Nitrate of soda, or sodium nitrate, comes from natural deposits in Chile, and also is manufactured. It is a white to gray salt, highly soluble in water and a quick-acting fertilizer. It carries about 16 percent nitrogen. Since it leaves an alkaline residue, it is probably best adapted to the acid soils in the eastern part of the state. Where the soils are already alkaline, continued use of sodium nitrate over a long period of years may be objectionable.

Calcium Nitrate

Calcium nitrate is a manufactured product, varying in color from white to brown. Since it takes water from the air rather rapidly, caking when exposed for any length of time, this material is treated to reduce moisture absorption. It carries approximately 17 percent nitrogen, largely in the form of nitrates. Since it is highly soluble in water and the nitrogen is in the nitrate form, it is a quick-acting fertilizer. It will have a neutral to slightly alkaline reaction in the soil. Since it is so likely to cake, very little is used in mixed fertilizers.

Calcium Cyanamid

Calcium Cyanamid is a manufactured, black or dark gray, granular material and comes on the market containing about 21 percent nitrogen and 75 percent calcium. Since it contains lime, it slightly increases the alkalinity of the soil. Since it has a good physical condition and will run through ordinary fertilizer distributors freely, it is used in making mixed fertilizers. A slow acting fertilizer, it should be applied at least two weeks before planting and should not come in contact with the seed or growing plants. When finely ground, it is used as a defoliant for removing cotton leaves before picking.

Urea

Urea is a synthetic fertilizer. The nitrogen is in an organic form. It is a white or gray crystalline product containing about 46 percent nitrogen. It is easily soluble in water, the nitrogen converting into ammonia and finally into nitrate. Urea is a high analysis fertilizer and could be used to a good advantage on plants requiring large amounts of ammonia nitrogen. The effect of urea on the alkalinity or acidity of soil is very slight.

Uramon

Uramon is urea which has been so coated that it will feed through the fertilizer distributors more readily. It contains about 42 percent nitrogen.

Guano

Guano is the name given to natural deposits of the excreta and dead bodies of birds and bats. It is usually found on the sea coasts and islands frequented by sea birds and in the caves occupied by bats. There are several caves in Texas containing considerable amounts of this material. Its composition varies according to its purity, running from almost no nitrogen to 12 or 13 percent nitrogen. This nitrogen is in the form of ammonium salts and in organic combination. The phosphoric acid in guano varies from 6 to as much as 25 percent. Since it is so variable in composition, the value of a deposit cannot be judged from its appearance but only by chemical analysis. A good grade of guano is an excellent fertilizer.

Fertilizing small garden plots by hand. A trench is opened to one side of the plants. After putting the fertilizer in the trench, it is worked into the soil and covered.

Dried Blood

Dried blood is a by-product of the packing house industry. It comes on the market as a black or gray material, often rather moist, with a characteristic odor. It may be mixed with ground bone, tankage or other materials. It contains from 8 to 14 percent nitrogen, 0.5 to 1.5 percent phosphoric acid and 1 percent potash. It is a slow-acting fertilizer and has considerable value in greenhouses and around flower beds and gardens because of this delayed action. The organic residues help improve the soil structure.

Tankage

Tankage is a by-product of the packing house industry and contains a wide variety of waste materials. It has from 5 to 10 percent nitrogen, 3 to 13 percent phosphoric acid, and traces of potash. This material is slow acting. It is used mostly in greenhouses and flower beds.

Sewage Sludge

Sewage sludge is a product of sewage disposal plants. The nitrogen is in the organic form and is rather slow acting. Sewage sludge contains from 3 to 6 percent nitrogen and 2 to 4 percent phosphoric acid. It has a good physical condition and usually is easy to handle. It has a disagreeable odor when wet but has considerable merit for use in greenhouses and gardens and flower beds. It likewise finds its way into many special type fertilizers.

Manures

Sheep, hog, chicken, and other manures are all valuable nitrogen fertilizers. They are marketed in a small way and are used in greenhouses and on lawns and gardens. They contain nitrogen in the ammonium form and in organic combinations. In many cases, phosphate and potash are added to increase their values.

Oil Meals

The oil meals consist of cottonseed meal, soybean meal, linseed meal, and other products of similar nature. These vary from 6 to 8 percent nitrogen in organic forms and are slowly available. All are excellent fertilizers but are rather costly. Where meals unfit for animal feeding are available, however, they are a very valuable source of nitrogen fertilizer.

Fish Scrap

Fish scrap and fish meal are a minor source of nitrogen fertilizer. The nitrogen is in the organic form and slowly available to plants. When available in sufficient quantities, fish scrap and fish meal are a satisfactory source of nitrogen for gardens, truck crops, etc.

Miscellaneous Nitrogen Fertilizers

Leather scrap, hoof and horn meal, wool waste, feathers, silk waste, and many other waste materials supply nitrogen in the organic form and are very slowly available. Generally speaking, they are not considered of great value because of the slowness with which they become available. They find some application as fillers or in greenhouses or for other special purposes.

MATERIALS FURNISHING PHOSPHATE

Rock Phosphate

Rock phosphate is found in many parts of the world. In this country the principal deposits are in Florida, Tennessee, South Carolina and the mountainous states of Idaho, Montana, Utah and Wyoming. The largest deposits of rock phosphate in this country lie in the western states, but the largest production now comes from Florida and Tennessee. Its purity varies. It is mined as hard rock phosphate, pebble phosphate, river pebble phosphate, fossil phosphate, boulder phosphate, sedimentary phosphate and apatite.

Rock phosphate in the pebble form is ground and may be put on the market untreated. Soft phosphate with colloidal clay is a product from the washings of the rock phosphate at the mines. It is dug up, dried, screened, and brought on the market. Ground rock phosphate is of a light color and varies in composition from about 28 percent to 33 or 34 percent total phosphoric acid. This soft phosphate with colloidal clay contains about 20-22 percent total phosphoric acid. Apparently it has its greatest value in the more acid soils which are rich in organic matter. In order to derive comparable results from these slowly available phosphates, large quantities must be applied.

Manure spreader in operation. Fertilizer may be mixed with manure before spreading. After spreading, it should be worked into the soil.

Superphosphate

Superphosphate is made from raw rock phosphate by treating it with acid. When sulfuric acid is used, the resulting product ranges from 16 to 22 percent total available phosphoric acid and contains considerable gypsum. Where phosphates are treated with phosphoric acid, the material is known as double superphosphate or triple superphosphate and will range from 40 percent to 48 percent available phosphoric acid. Both regular superphosphate and the double or triple superphosphate are excellent carriers of phosphoric acid for fertilizers. Both are recommended for use on the soils of Texas.

Fused Rock Phosphate

Fused rock phosphate is a new material not yet in general use. It is made by fusing rock phosphate with sand and is a dense gray material not soluble in water. It is free flowing. Still in the experimental stage, it offers much promise for the future.

Calcium Metaphosphate

Calcium metaphosphate is a product of comparatively recent development. It is made by treating rock phosphate with hot vapors from burning phosphorus, forming a molten product known as calcium metaphosphate which is glassy in appearance after cooling. This glass-like material is ground and marketed. It is a high analysis fertilizer carrying from 60 to 63 percent available phosphoric acid. Its effectiveness is about the same as superphosphate, and it may be used wherever phosphatic fertilizers are needed.

Phosphoric Acid

Phosphoric acid is a syrup, usually light colored, and is marketed in drums. It ranges from 50 percent to 75 percent available phosphoric acid. It is being used as a fertilizer on irrigated farms where it is added to the irrigation water. Its use is still in the experimental stage, but it promises well for the future.

Basic Slag

Basic slag is a by-product of steel manufacturing. It is sold as a finely-ground, dark grey or brown powder with a phosphorus content ranging from 6 percent to 15 percent. The phosphorus in basic slag is more readily available than in rock phosphate. It is highly alkaline, containing large quantities of lime and magnesium, an added advantage on acid soils. This material has not been used to any great extent in Texas, largely because of supply limitations. It should be used only on the more acid soils of the State.

Bone Meal

Bone meal is a by-product of the packing houses. It is sold either as raw bone meal or, more often, as steamed bone meal. It contains some nitrogen in the organic form and ranges from 15 percent to 30 percent total phosphoric acid (usually about 20 percent to 22 percent). Because the phosphorus is slow to become available, its greatest use is in the greenhouses, around rose beds, and with garden crops where slow, continued availability of phosphorus is required.

MATERIALS FURNISHING POTASH

Potassium Chloride (Muriate of Potash)—This is a high grade fertilizer varying from 48 percent to 62 percent water soluble potash (K_2O). The white crystalline material is easily applied and lends itself nicely to making mixtures. It is readily available to plants and is recommended for use wherever needed.

Potassium Sulfate (Sulfate of Potash)—This is a high grade fertilizer material varying from 48 percent to 50 percent potash. It is a neutral white crystalline salt readily available for use. It contains about 18 percent sulfur.

Kainit and Manure Salt—These are crude potash salts obtained from natural deposits or as by-products in the manufacture of potassium chloride and potassium sulfate. As they come on the market they contain from 10 percent to 30 percent water soluble potash. They likewise contain varying quantities of magnesium.

SOURCES AND FORMS OF THE COMMON SOIL AMENDMENTS AND SECONDARY PLANT NUTRIENTS

Agricultural Lime

Ground limestone, ground oyster shell, ground marl, builders lime, and burnt lime are all sold as agricultural lime. The value of agricultural lime lies in its purity (lack of clay, sand, and excess water). The commercial products vary considerably as to the fineness and ease of distribution.

In Texas, there are large supplies of limestone that could be ground for use as agricultural lime. Likewise, large quantities of oyster shell could be used for liming the soil.

Blackland soils and most of the soils in the western part of the State are somewhat alkaline and do not require lime. In the eastern part of the state and in the Gulf Coast, however, there are large areas needing lime.

Magnesium

Dolomite is a hard, dense stone composed of approximately 45 percent magnesium carbonate and 53 percent calcium carbonate. Small deposits of this material are found in several parts of the State. It is ground and distributed in the same manner as limestone and is the cheapest source of magnesium for agricultural purposes. Magnesite is a natural carrier of magnesium that may be ground and distributed. In some areas, Epsom salts will be beneficial where the soils are low in magnesium.

Gypsum (Land Plaster)

There are large quantities of gypsum in the western part of the State. It is a good source of calcium and sulfur and may be used to furnish these two materials. It is neutral but will serve to reclaim alkali soils and improve the internal drainage of salty soils.

Sulfur

Sulfur is mined in Louisiana and Texas. For agricultural purposes, it is ground and marketed as agricultural sulfur, which is 98 percent or more pure sulfur.

TRACE ELEMENTS

Iron

The common source of iron is iron sulfate (copperas). Most soils contain an abundance of total iron but it is not always available to the plant. In some of our alkali soils (soils of high pH) plants often suffer from lack of iron. In such cases, iron sulfate, may be applied to the soil or sprayed on the plant. On the other hand, the use of sulfur in the soil may make the iron more available and for this reason sulfur is beneficial in such cases. In addition, barnyard manure or green manure crops turned under will help to reduce iron deficiency.

Manganese, Zinc, Copper

The salts of these elements are applied to the soil or as a spray to the plants when needed. Copper sulfate (bluestone) is commonly used to supply copper. Bordeaux mixtures have copper in them and, when used as a spray, will usually supply the plant's need for copper. Zinc sulfate and manganese sulfate may be applied to the soil or as a spray to the plant.

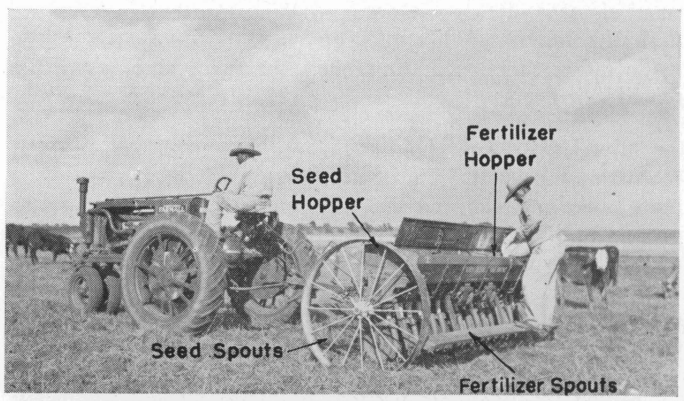
Boron

Borax is the material commonly used to overcome a boron deficiency. Plants are very sensitive to boron and care must be used to avoid an excess (not over 25 pounds of borax per acre).

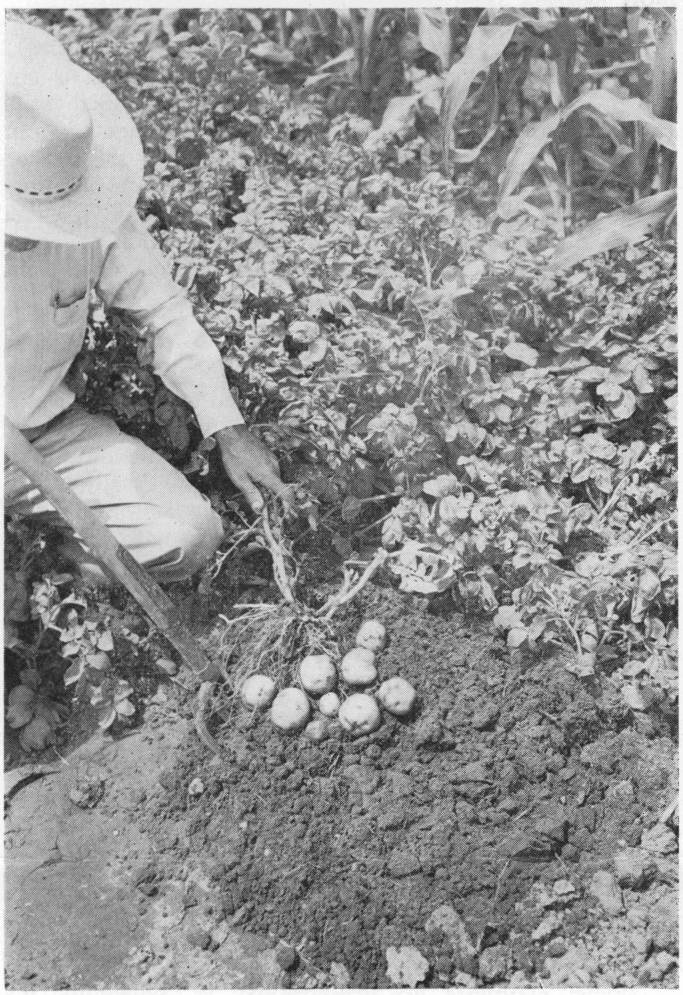
MIXED FERTILIZERS

Mixed fertilizers are commercial products containing at least two, usually all three, of the major nutrients. Those containing all three major nutrients are called complete fertilizers, those containing only two, incomplete fertilizers.

Mixed fertilizers are manufactured by combining the proper amounts of the different carriers of nutrients so as to give the desired composition. For example, ammonium sulfate, superphosphate, and muriate of potash may be mixed to prepare a product containing all three of the major plant nutrients. Sometimes several carriers of plant food nutrients will be used in making a mixed fertilizer.



Modern combination seeder and fertilizer distributor. This type may be used for seeding and fertilizing pastures, small grains or similar crops. (Photo courtesy Texas Agricultural Experiment Station)



Reaping the harvest from a well-fertilized garden.

Occasionally, the trace elements are placed in the commercial fertilizers. Where this is done, it is made the basis for special advertising. The amount of trace elements added per ton of fertilizer is usually small and may or may not meet the minimum demands of a soil in which an actual trace element deficiency occurs. Where trace elements are deficient, direct applications of these nutrients should be made rather than depending upon the small amounts in the mixed fertilizers.

Mixed fertilizers should contain 20 percent or more of the major nutrients. The lower the analysis of fertilizer, the more inert material the sack contains. It costs as much to process and transport inert materials as it does the fertilizer material in mixture. For example, one sack of 10-20-10 contains the same amount of nutrient elements as 2 sacks of 5-10-5 but one sack of 10-20-10 saves freight and handling charges on one sack of fertilizer.

Mixed fertilizers are used to build up the nutrient levels in soils when two or three of the plant foods in the soil are low. The many mixtures and grades on the market permit the farmer to choose the one that fills his particular need. The advantages of using mixed fertilizers over the use of the different pure materials separately are: (1) a mixed fertilizer probably is easier to apply to the land with the present fertilizer distributing devices; (2) less care is required for even distribution and proper balance of the fertilizer than if the materials are applied separately; and (3) cost of application usually is less.

One big disadvantage in the use of mixed fertilizers is the tendency to go by brand names rather than to select the particular mixture best adapted to the area. Factory-mixed fertilizers are somewhat more expensive than home-mixed fertilizers, but they are mixed more uniformly than the farmer normally can mix them. Uniformity may save money in the long run.

Fillers

Every sack of mixed fertilizer contains some material that has no value as a fertilizer. Some of these added materials help the fertilizer flow more easily through the drill and generally help the condition of the fertilizer. The higher the fertilizer grade, however, the lower the amount of filler material in the bag. For example, a 5-10-5 fertilizer and a 10-20-10 fertilizer have the ratio of 1-2-1. Although 10-20-10 is more costly per sack, it contains less filler material and, depending on price, is a cheaper fertilizer in the long run.

In this connection, the fact that a fertilizer is not 100 percent plant nutrients does not mean that there is filler in the sack. For instance, pure sodium nitrate contains about 16 percent nitrogen. The remainder consists of those elements necessary to stabilize the nitrogen and is not to be considered as filler. The same holds true for many other materials.

A sack of fertilizer may be said to have filler in it when worthless materials like sand are added for the purpose of making lower grade fertilizers.

Any specific claims made by the manufacturer with reference to the fertilizer will be on the tag. Everyone using fertilizer should read what the manufacturer says about his product. This often times is very revealing.

Liquid Fertilizers

Recently quite a number of mixed fertilizers in the liquid form have been brought on the market. These are solutions made up from various water soluble carriers of the nutrients. The solutions may have the same nutrient ratios as the solid fertilizer. For example, the ratio may be a 10-20-10 (1-2-1) or it may be a 10-10-5 (2-2-1) or any other mixture.

The nutrients in a liquid fertilizer are more quickly available than those in the solid fertilizer, but the amount of nutrients in 100 pounds of liquid fertilizer of a given analysis will be the same as that in a 100 pound sack of fertilizer having the same analysis.

Liquid fertilizers are more expensive than dry fertilizers.

CROP REQUIREMENTS

Cotton

Cotton requires a soil of good moisture-holding capacity with good drainage and aeration. Soils for cotton need plenty of organic matter and well balanced in nutrients. Fertilizers can be applied in bands at the side of the seed at planting time, followed by nitrogen in the middle of the rows as a side dressing when the cotton begins to fruit. If moisture is not available, side dressing will not be profitable.

Corn

Corn needs plenty of readily available plant nutrients. It likewise requires large quantities of moisture and a deep, friable, permeable soil. During the latter part of growth, corn demands large quantities of readily-available nitrogen. For that reason, side dressing corn when about knee-high is usually a good practice. Although corn requires plenty of water, too much will "drown" the corn, depleting the supply of oxygen and reducing the formation of nitrates from the organic matter.

Phosphorus deficiency in the soil usually will show up as a weak, slow-growing seedling. Soil deficient in potash will show in a rather weak stem, while soil lacking in nitrogen will show slow growth and a pale coloration in the leaves.

It is usually well to fertilize corn rather heavily with a complete fertilizer at or just before seeding and side dress with some nitrogen fertilizer when the crop is about knee-high.

Grain Sorghums

Grain sorghums are tolerant of drier conditions than corn. Otherwise, the statements for corn hold for grain sorghums.

Small Grains (Barley, Oats, Rye, Speltz, Wheat)

Since small grains are best suited to a cool climate, they are planted usually in the fall in Texas. Generally speaking, small grains will grow in less fertile soil than corn, but on some of the more badly worn out soils, nitrogen and phosphorus are needed to insure a crop. Although small grains require an abundance of nitrogen, too much will cause lodging. For most of the soils in the state, top dressings of nitrogen fertilizers should be applied in the spring before the small grains begin to joint. In some areas, a treatment with a fertilizer containing nitrogen and phosphate is advisable in the fall at or just before seeding. This fall application is especially beneficial if the crop is to be grazed.

Rice

Rice is grown in heavier soils with a tight sub-soil which will hold water in the irrigated sections of the Gulf Coast. Although rice will produce moderate yields in less fertile soil than some of the other crops, application of nitrogen has been profitable throughout the entire area. In some cases both phosphorus and potash have shown profitable results, but where phosphorus has been used under poor crop management there has been an increase of grass and weeds in the rice with corresponding loss in yields.

Alfalfa and Sweetclover

Alfalfa and sweetclover are heavy users of phosphates, potash, and lime. They grow best on deep, friable soils, well supplied with those three nutrients and high in organic matter. They require a small amount of nitrogen in the fertilizer to start the seedling. After the seedling is well established no further nitrogen is required. In addition, they require large quantities of water.

Other Legumes

All legumes are heavy users of phosphorus and potassium. If the soils have enough potassium a heavy application of phosphate is all that is required. If the soils have been worn out by continued cropping, a mixture of phosphorus and potassium in the fertilizer is justified for legumes of all types. Use of superphosphate alone at the rate of 400 to 600 pounds per acre has increased tonnage of some of the pasture legumes as much as 50 percent. In other areas, 400 to 500 pounds of superphosphate and 100 pounds of muriate of potash or its equivalent are needed for the same results.

Pastures

In most areas, grazing has been limited to the abandoned areas on the farm. There is much more forage produced per acre on fertile pasture land than there is on worn-out crop land. For this reason, it is particularly important that the pastures have an adequate supply of all nutrients. Phosphorus is particularly important in pastures because of the demands of the better grasses and clovers for this nutrient. To meet this demand, it is suggested that phosphate fertilizer be applied as a base fertilizer before attempting to make a pasture. Potassium also aids in the development of these grasses. Nitrogen stimulates leaf growth and increases considerably the amount of grazing from a pasture.

When a pasture is being newly made, it is suggested that a complete fertilizer be applied, broadcast and plowed into the soil or drilled into the soil about 2 inches deep. After a pasture is established, annual applications of fertilizers rich in phosphorus should be made.

A fertile garden brings joy to the entire family.

Showing the effect of 200 pounds of 20 percent superphosphate on pasture grasses. Fertilized strips contain bermudagrass and lespedeza, while the unfertilized strips are needlegrass.

Peanuts

Peanuts are heavy users of potash and phosphorus. If inoculated, they will gather nitrogen from the air, but the helpful effect of a small amount of nitrogen in the fertilizer at the time of planting will speed the growth of the peanut plant so it will mature earlier and produce heavier. Perhaps the best fertilizer for peanuts is 4-12-4 at seeding time. On soils particularly low in potash, additional potash in the fertilizer is justified. For example, use 4-12-8.

Orchards

Bearing orchards need large quantities of nitrogen, phosphorus and potash. From the standpoint of orchard management, the most valuable single fertilizer element is nitrogen. Available nitrogen in the form of nitrates or ammonium salts at the time of blossoming adds greatly to the set of fruit. Nitrogen also stimulates growth for the development of fruit buds. It is also needed when a non legume cover crop is plowed under to aid decomposition during the critical blossom time. The use of a fertilizer of 400 to 500 pounds of 5-10-5 followed by a top application of 100 to 200 pounds of some nitrogen fertilizer is recommended.

Truck Crops

Truck crops all require fertile soils with large quantities of organic matter and plant nutrients. It is usually profitable to make heavy applications of a complete fertilizer, such as 5-10-5 or a 4-8-8 at planting and side dress with nitrogen fertilizers about the time the crops begin to bloom.

Leafy and succulent vegetables require large quantities of nitrogen. Fertilizers for these should have a high nitrogen content or the plants should receive additional nitrogen as a side dressing.

Root crops such as carrots, beets, and onions are heavy users of phosphorus and potash. Fertilizers for these crops should furnish these required nutrients with sufficient nitrogen to insure good healthy plants. Seed and fruit producing vegetables such as peas, tomatoes and eggplant require large quantities of phosphorus and potash with enough nitrogen to give good vegetative growth and a healthy plant.

Flowers

Flowers require an open, well-drained, fertile soil, well-supplied with all the nutrients in proper balance. If such soil is not available, large amounts of well-rotted compost should be added. For volume production of blooms on current growth, large quantities of nitrogen may be added as a top dressing after the buds begin to set. For plants that bloom on old wood, the soil requires large amounts of phosphorus and potash. Also, slightly to moderately acid soil is best for most flowers.

A good general fertilizer for flowers is 5-10-5.

Home Gardens

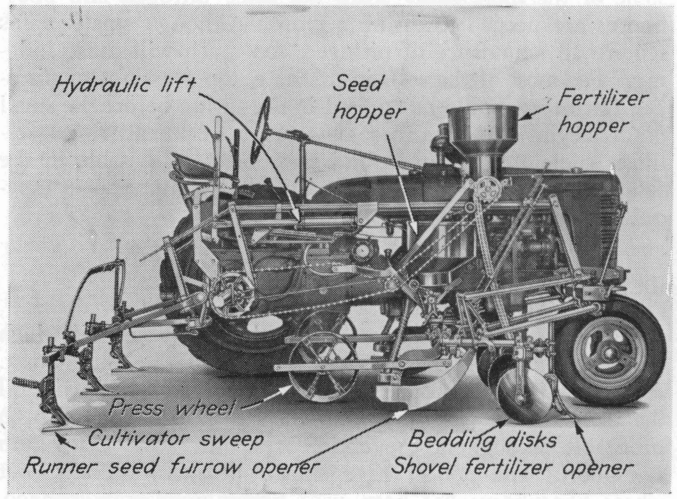
Vegetables grow best on deep, open soils, well supplied with humus and plant food. The soil for a good garden should be slightly acid.

If vegetables grow spindly and don't fruit well, the fertilizer used should be rich in phosphoric acid and potash.

If the soil does not have enough humus, large quantities of well rotted compost should be added.

Where large quantities of barnyard manure are used, 200-300 pounds per acre of 20 percent superphosphate or 300-400 pounds of 0-14-7 or 0-12-12 should be applied to get best results.

If manure or compost is not used, a good general fertilizer for home gardens is 400-600 pounds per acre of 5-10-5. One pound of fertilizer on 100 square feet of surface is 430 pounds per acre.



Modern planter and fertilizer distributor. The fertilizer attachment may be used at planting time or for side dressing crops while cultivating. (Photo courtesy Texas Agricultural Experiment Station)

America's first use of fertilizer.

(Squanto, the first demonstrator)

—Courtesy of National Fertilizer Association

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