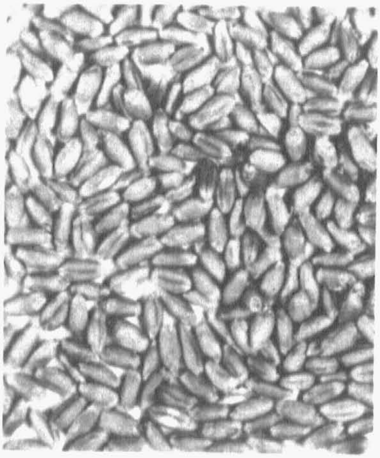
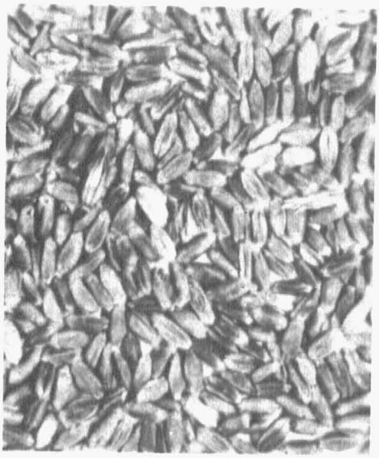
MORE EFFICIENT USE OF FERTILIZER



Soil Treatment:
150 lbs. of 0-45-0 plus 100 lbs. of ammonium nitrate.



Untreated

Fertilizers improve the quality of crops—besides increasing yields.

UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
J. H. LONGWELL, *Director*

BULLETIN 531 **DECEMBER, 1949**

At left: Plant food applied at seeding. At right: No plant food applied.

Fig. 1.—An adequate supply of available plant food in the soil helps small grain resist winter killing.

Fig. 2.—Potash was the limiting plant food in the growth of corn on these adjacent plots. A soil test can be used to determine the plant food needs.

More Efficient Use of Fertilizers Through Soil Testing

A. W. KLEMME AND W. A. ALBRECHT
Department of Soils

"What kind of fertilizer and how much of it can we use efficiently on our soil?" This is a common question about fertilizers. It arises from the realization that soil fertility can be maintained only by applying much of the needed plant food in the form of commercial fertilizers. Naturally one should apply only the nutrients most needed to meet the deficiencies of the soil, and the demands made on it by the crops grown between soil treatments. To detect deficiencies in the soil and measure its levels of the essential elements, chemical testing of the soils has been designed. Soil tests are now widely used in Missouri to make fertilizer applications efficient in both kind and amount.

Results in the Field Are the Final Test

It was not so long ago that field experiments and demonstrations were the only guides for determining the kinds and amounts of fertilizers to use. Though slow in giving information, these still are the final test of fertilizer practices. But there are over 200 different soil types in Missouri, and the fertility variation of the surface soil within a single type may be greater than that between fertility averages of different types. And that means the service of field tests as a guide to efficient fertilizer use is neither rapid nor extensive enough for the State of Missouri as a whole.

As a consequence, the chemical soil testing has been expanded through many separate county laboratories. Sixty modern soil testing laboratories are in operation in Missouri to help farmers take chemical inventories of their various fields and thus select the fertilizers that will correct the deficiencies in their soils. These laboratories are under the supervision of the county Extension agents and the department of soils of the Missouri Agricultural Experiment Station. Their soil testing service is bringing forth much detailed information regarding the fertility of Missouri soils. It is being supplemented by field experiments, demonstrations and tissue tests of plants growing on soils both treated and untreated with fertilizers. And all of these activities help to bring about rapid and efficient use of these purchased plant food materials.

Soil Tests Give Their Reports

Planning more reliable chemical tests of soils and their use on the many soil types of Missouri has been an activity of the soils department of the Experiment Station for many years. Large numbers of tests have

Fig. 3. Production of high acre yields of soybean seed requires an ample supply of plant food minerals. Note the difference in growth of pods by use of mineral fertilizer on plot at right above.

been made by the department laboratory at Columbia but their use out in the counties in recent years has rapidly pushed the total number of soil tests up many thousand annually. As a consequence, the soil types have been more nearly classified as to their levels of fertility. More general recommendations for soil treatments may often be made with greater reliability for the soil type and area.

Soil Nitrogen Is Going Dangerously Low

The low supply of organic matter in almost every soil makes the shortage of nitrogen the major soil deficiency of the state. Tests of the soils for organic matter give emphasis to the need for more leguminous green manures to be plowed under. Unless the declining soil supplies of this organic matter and its accompanying nitrogen are maintained at a level sufficiently high to provide for economical yields of crops which contain enough protein to meet the nutritional requirements of domestic animals, much larger purchases of costly proteins as feed supplements for livestock will be necessary.

Tests of the soil and tissue tests of the crop growing on it are now indicating whether or not the crop is getting enough nitrogen during the growing season. Thus we can learn whether the soil is providing or denying the plant its requirements of this essential element. Because of the soil tests, commercial nitrogen, to supplement the soil nitrogen from leguminous crops is being used more extensively and very efficiently. And efficient use is important, for nitrogen is a costly fertilizer element. The use of more commercial nitrogen with good results in Missouri may be credited, in no small way, to the reports which the soil tests give for the need of this element on the soils.

Limestone As a Calcium Fertilizer Helps Protein Production

The fertilizer used longest in largest amounts on Missouri soil is limestone. It is used to provide calcium, the essential nutrient needed most extensively. Liming the soil adds also the carbonate of the limestone compound to reduce the acidity of the soil. We now know that legumes that can use nitrogen from the air, and other crops that build this element extensively into protein must get significant amounts of calcium from the soil in order to make these food-creative processes possible. Soil tests for the soil's calcium supply and for the degree of soil acidity have suggested that, as a result of extensive applications of limestone, many soils are now well supplied with calcium for some time, and are no longer dangerously acid. Some soils, though once limed, are still in serious need of calcium due to losses through leaching. And thus the liming program for supplying the soil with calcium will be an efficient practice only when guided by soil tests. Calcium in the soil must be at a relatively high level if the more costly fertilizers carrying nitrogen, phosphorus and potassium are to be a wise investment. Calcium is a mobilizer of these into the various crops.

Limestone May Be Needed As Magnesium Fertilizer

Large amounts of calcium (nearly 3 million tons of limestone) a year are now being used in Missouri. This has been going on for several years. At the same time, reduced erosion may not be exposing enough magnesium-bearing subsoil for contact with plant roots. As a result of these conditions, soil tests are finding more and more soil samples deficient in magnesium. Where such is the case soil treatments with dolomitic limestone, a calcium-magnesium stone, must be used if the services by other fertilizers are to be efficient.

Different Soil Origins Make Different Fertilizer Needs

With reference to nitrogen, phosphorus and potassium, the elements more commonly purchased in commercial fertilizers, the soils of glacial origin north of the Missouri River, and those deposited in the river bottoms, may in general need different fertilizer treatment than the soils of limestone origin south of the river. With such wide differences in the parent material from which the soils were developed, and such wide differences in their original fertility, as shown in the forest crops on the latter and the more nutritious prairie grasses on the former, one may well expect that fertilizer use will be likewise different. Those differences can well be detected by use of the soil testing service.

Phosphorus Deficiencies Are Widely Recognized.—In general the soils south of the Missouri River are more seriously deficient in the element phosphorus than those to the north. Liberal applications are needed in both areas for high acre yields of quality crops and for maintenance of the soils in respect to this element. A few local areas of upland soils in the northwestern part of the state and the river bottom soils of the Missouri and the Mississippi may be exceptions to the general statements above, according to the results from soil tests and crop responses to soil treatments with phosphate fertilizers.

Potassium Needs Are Increasing.—Deficiencies of potassium occur in soils south of the Missouri River, on the light colored soils of Northeast Missouri, and in the lowland area of the Southeast. Potassium deficiencies show up most frequently on soils which have been heavily farmed and where the crop residues such as straw and stalks have been removed. Some of the virgin prairie meadows are extremely deficient in potash. Selling prairie hay from such meadows over the years has lowered the exchangeable potassium in these soils. Likewise in this area, when alfalfa is grown continuously for several years, the soil is likely to become deficient in potassium. This is not surprising since each ton of alfalfa removes about 30 pounds of potassium. On many of these light colored soils, after lime and phosphate have been applied, potassium becomes the limiting factor for crop growth.

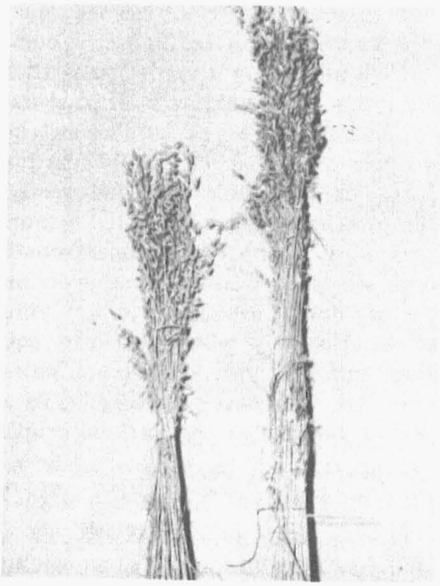


Fig. 4.—Enough fertilizer can be applied at one application to benefit several crops in succession, as seen in oats at right. Left: No fertilizer. Right: 500 pounds 8-8-8 plowed under ahead of corn the preceding year.

Where land has been in permanent pasture for a considerable period, it usually contains an adequate supply of exchangeable or available potash. However, even under pasture use, potash deficiencies may occur where the land has been cropped for a considerable time before being seeded to pasture. Potash deficiencies are on the increase. As soils receive limestone and as crop rotations including legumes are established, the need for potash mounts.

As soils are sampled and tested more extensively in county and state laboratories, and as demonstrations and fertilizer trials are more numerous on the different soils, the use of fertilizers is becoming more efficient. This is bringing the practice of fertilizing out of the category of mere trial and error to one of applying fertilizers as controlled plant nutrition for both yield and quality and for long-time soil building as well.

Soil Tests Are Confirmed by Field Results

Fertilizer use becomes more efficient as the applied materials bolster the supplies of those elements near or even below the minimum for plant nutrition. Soils contain fertility supplies (1) in adsorbed forms on the clay,

(2) in the organic residues, less readily available but slowly delivered during their decay, and (3) in the mineral reserves weathering slowly to pass their nutrients on to the plant by way of the clay and the organic matter mobilized by microbial action. The processes in the soil control the delivery of these nutrients to the plant root. The field performances are, after all, the final performance in crop production. Fertilizer use can be most efficient only when it demonstrates itself through the field results. Soil tests have now shown themselves as good helps in deciding how much fertilizer to apply, and such corrected applications have given ample returns on extensive areas. Field results are confirming what the soil tests report and recommend.

Corn Yields Show Efficiency of Test-Guided Applications.—Some studies in the field with corn have demonstrated clearly that as the soil tests report the soil low, medium, or high in phosphate, a given application of this fertilizer has increased corn yields in reverse order as shown in Table 1.

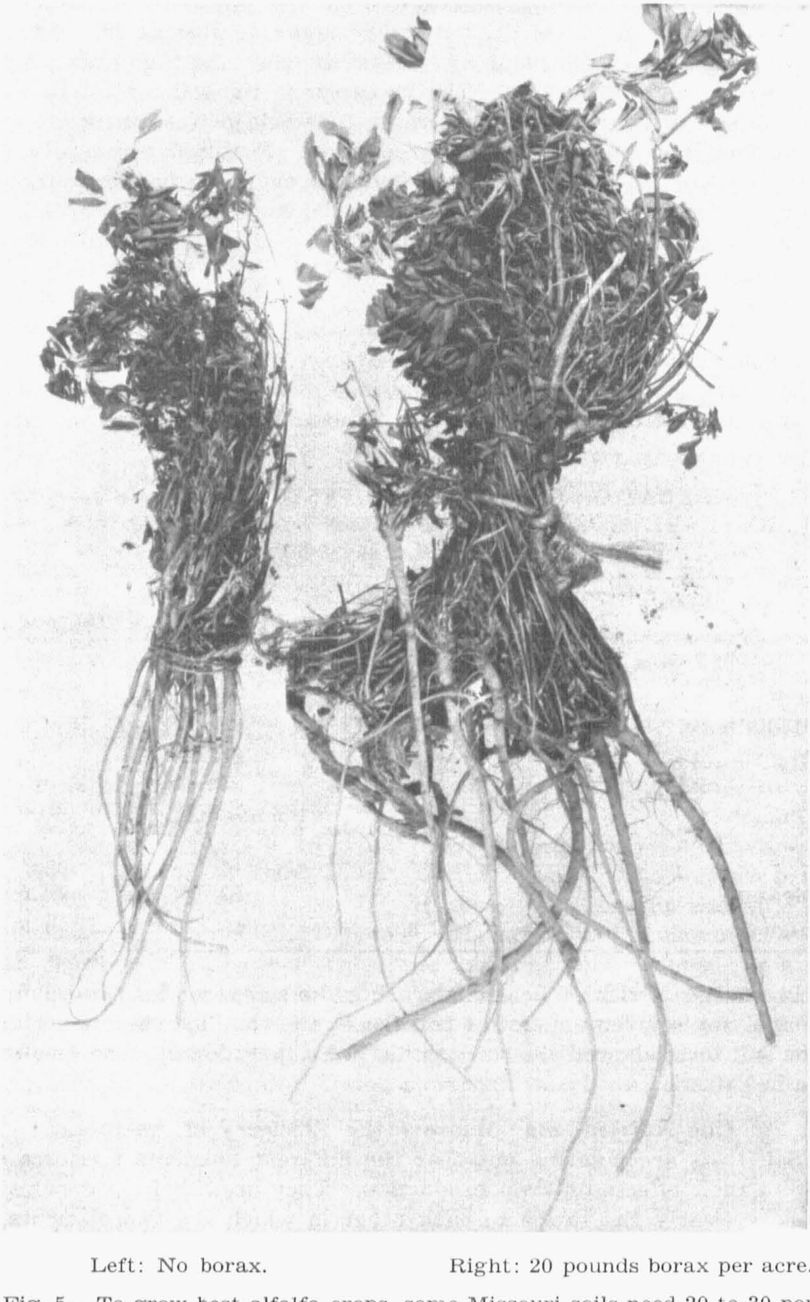
TABLE 1. RELATION BETWEEN SOIL TESTS AND APPLICATIONS OF PHOSPHATE AND POTASH AS SHOWN BY INCREASED YIELDS OF CORN, 1944-1948

Soil Test	Number of Trials	Different Soil Types	Fertilizer Applied per acre	Increase Bu. per acre
For Phosphorus			Pounds P_2O_5	
Low	16	14	59	10.9
Medium	10	6	50	4.4
High	16	8	49	1.4
For Potash			Pounds K_2O	
Low	16	11	44	11.1
Medium	16	12	47	4.9
High	19	8	45	1.3

In another series of field trials using the soil tests for potassium and then applying a given amount of potassium, the yield increases were higher as the soil tests showed the soil's potassium supply lower. The results are given in Table 1.

One Nutrient May Improve the Efficiency of Another

Soil tests are pointing out that the different nutrients reinforce each other in their effects on crop production. They are a help in demonstrating more clearly the ratios to each other in which the two elements, for example phosphorus and potassium, may be most efficient for a crop like wheat. During the period 1944-1947 the combination of phosphate and potash was used on light colored soils reported by the soil tests to be low in each of these two plant nutrients. When the fertilizer used carried these two in the fertilizer unit ratio of one to one, there resulted the highest



Left: No borax. Right: 20 pounds borax per acre.

Fig. 5.—To grow best alfalfa crops, some Missouri soils need 20 to 30 pounds of borax per acre. Fertilizers containing borax are on the market.

yield of wheat grain. Also thicker, and more vigorously growing stands of clover were obtained where the potash in the fertilizer was used in this narrower ratio to the phosphate applied. Even though the chemical analyses of the grain of wheat would not lead one to believe this crop a heavy consumer of potassium, nevertheless, the physiological processes delivering the grain respond to potash fertilization when the tests of the soil indicate a low content of this element and when the season may not be what one would consider the ideal.

Field results from fertilizer use confirm what the laboratory tests of the soils suggest. Phosphate deficiencies are rather general and one might feel confident of results from phosphate use without first testing the soil for this nutrient element, but more efficient results occur when soil tests are used as a guide. Even phosphorus cannot be considered as independent of the other essentials that may be deficient in the soil. Potash needs also vary widely. Tests for this element make its use as a fertilizer more efficient, and its effects on the crop in turn work for more effective use of the phosphates.

The effects from phosphorus, in a like manner, are related to the supplies of calcium in the soil. Then too, the results from application of calcium depend on the supply of magnesium available in the soil for the legume crops and other forages serving as nutritious feeds. This is true because they deliver proteins generously along with many other similarly complex elaborations of high nutrient value. Such effects by one nutrient on those of another offer the basis for fertilizer applications that will build up the most efficient ratios of fertility elements in soil. Not only such commercial fertilizer elements as phosphorus and potassium reinforce each other but the same is true of the calcium and magnesium in limestone. And in both instances there are certain ratios at which they serve most efficiently. All these interrelations and possibly many others cannot be left to chance. They must be studied and worked out by soil tests if our use of fertilizers is to be most efficient. It is quite likely that quantity and quality of crop production are more dependent on the ratio of the plant nutrients in the soil than by the actual amount of any one of them. And our standard of efficiency must be yields high in bulk and in nutritional values for our animals and ourselves.

Fertilizers Are Crop Starters and Soil Builders

Though fertilizers are commonly considered to be promptly effective because of their ready solubility in water, nevertheless, they are not all taken out of the soil by plants or by water percolating through the soil. Because they are soluble they are used much as "crop starters" applied in the surface soil with the seeding and in amounts intended for only one crop. Even such small applications of plant nutrient elements have given some residual effects on the crops which follow, according to results on the University South Farms at Columbia. During 1936-1947 in a rotation of corn, oats, wheat, and sweet clover where only 200 pounds of 0-20-0 was applied at wheat seeding and 150 pounds of the same fertilizer was used in the row with corn, the wheat yields were increased on the average by 5.4 bushels and the corn yields by 5.2 bushels per acre from the direct or starter application. The oat crop which followed and received no direct fertilizer treatment produced on the average 8.2 bushels more than adjacent plots in the rotation which received no fertilizer on the preceding crop.

The amounts of phosphate and potash shown by the soil tests to be necessary to correct deficiencies in the soil's content of these elements are given in Tables 2 and 2-A. These large amounts needed to correct the deficiencies show clearly that "starter" applications of fertilizer are not making up these deficiencies. They are not rebuilding the soil fertility.

One Large Application May Serve for a Succession of Crops.—Since the fertilizers in a small application (too small to replace fertility removed by the crop) give effects over periods far beyond those of "starting" the crop, there is the suggestion that "soluble" fertilizers stay in the soil and that they may well be used as one application in amounts equivalent to the needs for several crops in a rotation. Then too, since their application as a starter locates them in the surface horizon where the soil is dry during much of the latter growing season and therefore where no active roots can get it, fertilizers may well be plowed under or put on the plow sole in heavy applications at greater soil depths. This puts the nutrients down where

TABLE 2. AMOUNTS OF PHOSPHATE (POUNDS OF CARRIER PER ACRE) NEEDED AS INITIAL APPLICATIONS FOR DIFFERENT LEVELS OF PHOSPHORUS IN THE SOIL ACCORDING TO SOIL TESTS

Phosphate levels (shown by soil test)	Superphosphate 20% P_2O_5	Triple Superphosphate 40% P_2O_5	Rock Phosphate 30% P_2O_5
Very low to low	600 to 900	300 to 450	1000 to 1500
Medium	300 to 450	150 to 225	500 to 600
High	150 to 200	75 to 150	- -

TABLE 2-A. AMOUNTS OF POTASH (K_2O POUNDS PER ACRE) NEEDED AS INITIAL APPLICATIONS FOR DIFFERENT LEVELS OF POTASH IN THE SOIL ACCORDING TO SOIL TESTS

Potash level (shown by soil test)	Pounds per acre of K_2O required	Pounds of various fertilizers required per acre to provide the K_2O needed
Very low to low	100 to 150 lbs.	200 to 300 lbs. 50% muriate of potash or 500 to 750 lbs. of mixed fertilizer containing 20% (K_2O)
Medium	40 to 90 lbs.	80 to 180 lbs. of 50% muriate of potash or 200 to 400 lbs. of mixed fertilizer containing 20% (K_2O)
High	Potash removed by crops can be supplied with starter fertilizers.	

the soil remains moist and where roots are more widely active. It makes the plowing an operation to put fertility back into the soil and the fertilizer use a matter of building the soil rather than merely starting the crop. It suggests a better service; that is, nourishing the crop at the time when its vigorous growth demands much fertility from the soil rather than feeding it when its growth is supported by the fertility reserves in the planted seed.

As more soil samples are tested there is increasing evidence that many Missouri soils require more fertilizer than we usually think. This is true regardless of the crop. While there has been the tendency to believe that only seed-producing crops need fertilizers as help in making seed, it is now well demonstrated that even a forage crop, if it is to be good feed, must contain within itself plant elaborations that are about equivalent to a big seed crop. Many soils show that they need to be built back in fertility rather than fertilized only with a crop starter. Phosphates when applied, are absorbed in part on the clay fraction of the soil, part is taken by the microbes as a competitor, and a part may be unusable because the soil has been dried to some depth below the surface. All of these facts, coupled with the favorable crop results from plowing under more fertilizers for soil building have expanded this use of fertilizers when formerly they served mainly as "crop starters."

Larger Amounts May Be Put on As So-Called "Split" Applications.— Because of the high initial expense of heavy applications of fertilizers, many farmers use what they call "split" applications. This procedure consists of building up the soil in terms of the deficient elements in several applications instead of in one. Then after repeated treatment has restored the fertility reserves, the plant food level can be maintained by liberal use of mixed fertilizers only at seeding times. Small grain which often serves as a companion crop for clover usually provides an excellent place in the rotation to make the heavier applications of mineral plant foods in the "split" application approach. This puts the fertility down where deeper rooted crops find it in soil seldom dry during the growing season. Small grains make their growth in the cool part of the season and hence suffer less from dried surface soils. They are relatively shallow rooted as compared to some of the summer growing crops such as alfalfa or corn, but nevertheless have many deep roots so that the soil can be deeply fertilized for small grains at seeding. An adequate application can be made to provide plant food, not only for the small grain crop of which deeper rooting will be stimulated, but also for the standover clover or combination of clover and grasses started with the small grain.

To Rebuild the Soil, Fertilizers Should Be Put Well Down

Many areas turned over to grass and now forming the major part of Missouri land listed as "pasture," are shown by the soil tests to require heavy fertilizer applications. Their soil fertility must be rebuilt if they are to provide nutritious forage. Any pasture system of farming such soils efficiently must include heavy initial applications of mineral or soluble fertilizers put down deep in the soil. There is no place here for the split applications since the shift to grass farming is a sudden step and not a gradual transition. It calls for the dosage of the soil at greater depths for several crops for several years. Fertilizers in deeper applications react more readily with the soil; there is little danger of salt injury; and they are in the zone of the deeper roots when the demand for plant nutrients is heaviest. These advantages are especially pronounced on many soils kept in pasture, where neither the plow layer nor the subsoil layer has much to offer as plant nutrition for better forage. Numerous soil tests on pastures confirm the results in many fields reworked in the earlier demonstrations of "pasture days".

Even when applications as small as 300 pounds of material are applied ahead of summer-growing crops such as corn, soybeans and alfalfa, the greater part of the plant food should be plowed under where it will be in the zone of the plants' feeder roots. Under such conditions a safe rule to follow is to plow under about three-fourths of the application and apply one-fourth in the row at planting. Where the subsoil is well supplied with basic plant food, then only surface applications need be applied to replace that removed by crops.

Advantages that can be expected from plowing under fertilizers as compared to surface applications in normal seasons are well illustrated in field tests with corn. During the period 1942 to 1944, inclusive, on six different soil types where the plant nutrients were plowed under and placed in the plow furrow with a plow attachment, an average yield of 43.3 bushels of corn per acre was obtained. On the other hand, where the same fertilizer at the same rate per acre was placed in the row at planting time, the average yield per acre was but 38.1 bushels. Where no fertilizer was applied the average acre yield was 33.3 bushels. The average increase in yield for plowing the fertilizer under was 10 bushels per acre as compared to an increase in yield of but 4.8 bushels for the same applications in the row.

During this same period a similar comparison was made with only 200 pounds of 0-20-10 plowed down ahead of soybeans. These tests with soybeans were conducted on Gerald Silt Loam in Southwest Missouri. The fertilizer broadcast on the surface and plowed under increased the average yields 6.1 bushels per acre. On adjacent plots where the same fertilizers were placed in the row at planting time, the average yields were increased by only 2.1 bushels per acre.

While fertilizers were originally considered necessary only as helps or supplements to the soil's supply of fertility, the more serious depletion of many soils now makes heavier applications of fertilizers imperative. Laboratory tests of Missouri's soils, located as they are in this country's humid area, where the subsoils are more leached, show the subsoils so much more deficient in fertility. As a consequence when erosion of the surface soil pushes the crop roots down into the subsoil for moisture in dry seasons, crop production can be maintained only as we put fertilizers down deeper to provide food for the crop roots in the same soil area into which they are compelled to go for water. Soil tests are helping to build soils deeper by putting larger applications at greater depths into them.

Time and Method of Application

Even when heavy initial applications of fertilizer or the small "split" applications of fertilizer are made, it is usually helpful to use additional fertilizer at planting time for the purpose of starting the crop. For corn planted early on soils that warm up slowly in the spring, an application of 200 to 300 pounds of a complete fertilizer in the row at planting time hastens its early growth, makes its cultivation easier and often results in better stands. It helps also to maintain the mineral plant nutrient level in the soil. The "starter" fertilizer can be applied with a fertilizer attachment on the corn planter. It puts the fertilizer in bands several inches on each side of the seed and slightly below it. Where a fertilizer attachment for the planter is not available the "starter" fertilizer may be applied on the surface with a drill or fertilizer distributor. On small grains, new grass and alfalfa seedings, starter or maintenance fertilizer application can be applied with a fertilizer grain drill or distributor.

Mineral Fertilizers May Be Applied Any Time Machinery Can Be Driven Over the Fields.—Fortunately for Missouri, the clay fraction of the soil has a high adsorbing capacity for fertilizers. Very little of any fertilizer substance will leach down through the soil if there is some growing crop which will intercept the plant nutrients applied in more soluble form. The application of fertilizer need not be timed with crop planting, then, as it were, in order to let the plant catch the fleeting commercial fertility.

In fact, it may be said that mineral fertilizers can be applied to pastures and crop land at about any time the machinery can be driven over the fields. Field experience has long reported this true for limestone. There is no special season for such soil treatments. Heavy applications can be made on the surface well in advance of the time when it should be plowed under or cut into the soil. This operation need not be done immediately but can be carried out at some time during the year whenever the labor is available. Soil tests indicate good results from putting mineral plant nutrients on the soil during the regular operations of preparing the seedbed for the next crop. As a consequence, fertilizing the soil is not confined to any special season. Instead the mechanics of soil building may be part and parcel of the labor program dealing with regular tillage of the soil at no serious extra cost.

Test-Guided Soil Building Improves Food Outlook

Although it is acknowledged that the fertility of our soils is declining rapidly, its rebuilding by means of fertilizers is getting under way on a wide front. If larger amounts of fertilizer are to be applied per acre, they should be chosen to cover the nutrient shortages in the soil. Chemical soil tests are a good help in pointing out those shortages when such tests are used to start the restoration of the soil fertility and when fertilizer use is followed through by observations of crop quality as well as quantity.

Soil tests can do much to make more efficient the use of fertilizers in bolstering up the soil for building our future supplies of feed and food. It is through those that we shall have greater agricultural stability and more rural security. Soil tests and the restoration of soil fertility are given first consideration in a balanced farming program.

FERTILIZER USAGE IN MISSOURI; 1948

R. C. PREWITT
Supervisor, Fertilizer Inspection

Fertilizer manufacturers doing business in Missouri have reported a total of 355,283 tons of fertilizer shipped for use in this state during 1948. These shipments total 61,579 tons more than the amounts reported in 1947. This represents an increase of approximately 21% over the previous year.

The fertilizers shipped in 1948 contained the following plant foods:

Nitrogen	11,371 Tons
Phosphoric Acid (P_2O_5)	53,827 Tons
Potash	17,142 Tons

In addition to the above, substantial amounts of calcium, magnesium, sulfur and other mineral elements were carried in these fertilizers.

TABLE 3. FERTILIZER TONNAGES SHIPPED IN 1948 CLASSIFIED BY GRADE

	Spring	Fall	Totals
Low Grade Mixes	8,496.5	75.3	8,571.8
Medium Grade Mixes	127,735.1	111,246.6	238,981.7
High Grade Mixes	3,912.5	10,897.8	14,810.3
Nitrogeneous Materials	5,175.1	5,441.6	10,616.7
Superphosphate	28,032.2	19,726.2	47,758.4
Potash Materials	762.5	1,033.2	1,795.7
Rock Phosphate	11,330.9	17,975.2	29,306.1
Miscellaneous	1,600.9	1,841.4	3,442.3
Totals	187,045.7	168,237.3	355,283.0

Definition of Terms Used in Tables 3 and 4.

Low Grade Mixes.—All mixed fertilizers carrying less than 20 units of plant food.

Medium Grade Mixes.—All mixed fertilizers carrying from 20 through 29 units of plant food.

High Grade Mixes.—All mixed fertilizers carrying 30 or more units of plant food.

Nitrogenous Materials.—Include ammonium nitrate, ammonium sulphate, sodium sulphate, sodium nitrate, and cyanamid.

Potash Materials.—Includes muriate of potash, kainit, manure salts, and potassium sulphate.

Miscellaneous.—Includes sewerage residue, bone meal, and animal manures.

TABLE 4. FERTILIZER AND PLANT FOOD TONNAGES BY GRADES; 1948

Kind of Fertilizer	Fertilizer Tonnage		Approximate Tonnages of Plant Food: Nitrogen		Available Phosphoric Acid		Insoluble Phosphoric Acid		Phosphoric Acid From Bone·		Potash	
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Low Grade Mixed	8,496.5	75.3	260.3	0.1	1,014.1	5.5					338.8	2.3
Medium Grade Mixed	127,735.1	111,246.6	4,090.0	3,124.8	15,209.6	13,485.4					7,500.6	6,352.5
High Grade Mixed	3,912.5	10,897.8	112.4	414.3	451.3	1,528.6					632.7	1,533.4
Nitrogenous Materials	5,175.1	5,441.6	1,621.9	1,734.1								
Superphosphate	28,032.2	19,726.2			7,176.5	5,865.8						
Potash Materials	762.5	1,033.2									231.3	541.3
Rock Phosphate	11,330.9	17,975.2			339.9	539.3	3,172.7	5,033.1				
Bone Meal	61.2	48.0	1.2	1.0					16.5	13.0		
Animal Manures	388.0	148.3	7.8	3.0	3.9	1.5					6.8	2.6
Miscellaneous	1,151.7	1,645.1										
Season Totals	187,045.7	168,237.3	6,093.6	5,277.3	24,195.3	21,426.1	3,172.7	5,033.1	16.5	13.0	8,710.2	8,432.1
Grand Totals	355,283.0		11,370.9		45,621.4		8,205.8		29.5		17,142.3	

TABLE 5. SUMMARY REPORT OF FERTILIZER TONNAGES SHIPPED FOR USE IN MISSOURI, CALENDAR YEAR 1948

Grade or Material	Spring Tonnage	Fall Tonnage	Total Tonnage
0-10-20	-----	70.0	70.0
0-12-12	1,828.8	1,064.1	2,892.9
0-14-7	3,548.4	6,417.3	9,965.7
0-20-10	714.4	574.4	1,288.8
0-20-20	-----	214.1	214.1
2-12-6	44,012.4	46,905.5	90,917.9
3-9-18	2,797.8	5,840.5	8,638.3
3-12-6	2,312.8	2,981.4	5,294.2
3-12-8	585.4	2,671.5	3,256.9
3-12-12	12,474.8	5,442.3	17,917.1
3-18-9	-----	1,002.5	1,002.5
4-12-4	51,668.7	40,205.7	91,874.4
4-12-8	2,274.4	1,092.2	3,366.6
4-16-0	1,271.2	817.1	2,088.3
4-24-12	-----	1,428.0	1,428.0
5-10-5	2,609.5	552.8	3,162.3
5-10-10	654.0	7.0	661.0
6-8-12	40.0	115.0	155.0
8-8-8	2,157.6	899.1	3,056.7
10-6-4	1,495.8	21.2	1,517.0
Miscellaneous Grades	10,849.8	5,543.2	16,393.0
Ammonium Nitrate	4,513.0	5,021.6	9,534.6
Ammonium Sulphate	541.9	174.7	716.6
Sodium Nitrate	74.6	80.3	154.9
Calcium Cyanamid	45.6	135.0	180.6
Normal Superphosphate	21,902.7	12,209.9	34,112.6
Treble Superphosphate	6,129.5	7,516.4	13,645.9
Rock Phosphate	11,330.9	17,975.2	29,306.1
Muriate of Potash	167.4	826.1	993.5
Manure Salts	595.1	207.1	802.2
Animal Manures	388.0	148.4	536.4
Bone Meal	61.2	48.0	109.2
Miscellaneous Materials	-----	30.0	30.0
Total	187,045.7	168,237.6	355,283.3

TABLE 6. APPROXIMATE TONNAGE OF FERTILIZER SHIPPED INTO MISSOURI BY COUNTIES, 1948

County	Spring Tonnage	Fall Tonnage	Total
Adair	1652	944	2596
Andrew	403	373	776
Atchison	1246	635	1881
Audrain	2971	4096	7067
Barry	2631	1686	4317
Barton	2923	3621	6544
Bates	2556	3644	6200
Benton	1027	1263	2290
Bollinger	1971	1167	3138
Boone	2647	2346	4993
Buchanan	4553	5619	10172
Butler	596	516	1112
Caldwell	1451	1069	2520
Callaway	1338	1478	2816
Camden	43	67	110
Cape Girardeau	2461	2429	4890
Carroll	1362	1396	2758
Carter	201	66	267
Cass	1995	2969	4964
Cedar	1029	1179	2208
Chariton	974	1694	2668
Christian	2002	1026	3028
Clark	1757	1298	3055
Clay	1591	1719	3310
Clinton	1645	1202	2847
Cole	1534	1880	3414
Cooper	1219	1349	2568
Crawford	577	576	1153
Dade	1570	2102	3672
Dallas	508	790	1298
Daviess	1195	1408	2603
De Kalb	1175	1275	2450
Dent	888	399	1287
Douglas	395	561	956
Dunklin	7825	4287	12112
Franklin	1730	2888	4618
Gasconade	965	1993	2958
Gentry	1668	904	2572
Greene	6180	4081	10261
Grundy	856	630	1486
Harrison	1646	1058	2704
Henry	1128	1895	3023
Hickory	645	731	1376
Holt	245	158	403
Howard	889	720	1609
Howell	1991	1135	3126
Iron	245	242	487
Jackson	6492	3431	9923
Jasper	5703	6334	12037
Jefferson	952	704	1656
Johnson	1392	1937	3329
Knox	1369	1330	2699
Laclede	1373	2140	3513
Lafayette	2837	3661	6498
Lawrence	3166	2886	6052
Lewis	2153	1677	3830
Lincoln	2771	2697	5468
Linn	2090	1358	3448
Livingston	1071	710	1781
McDonald	1392	364	1756
Macon	1712	1377	3089
Madison	1166	574	1740
Maries	331	587	918
Marion	1365	1502	2867
Mercer	836	480	1316
Miller	638	791	1429
Mississippi	1158	544	1702
Moniteau	1298	1456	2754
Monroe	2237	2561	4798
Montgomery	2947	2198	5145
Morgan	995	1142	2137
New Madrid	2681	2567	5248
Newton	2861	2417	5278
Nodaway	1802	1525	3327
Oregon	568	688	1256
Osage	851	1164	2015
Ozark	159	186	345
Pemiscot	1261	867	2128
Perry	1143	1522	2665
Pettis	1525	1965	3490
Phelps	1062	1148	2210
Pike	2726	2102	4828
Platte	1193	1344	2537
Polk	2485	2230	4715
Pulaski	510	464	974
Putnam	894	427	1321
Ralls	305	711	1016
Randolph	1184	1624	2808
Ray	1389	1181	2570
Reynolds	323	94	417
Ripley	758	432	1190
St. Charles	1349	1871	3220
St. Clair	1097	1373	2470
St. Francois	1650	1215	2865
St. Genevieve	819	877	1696
St. Louis	4276	2579	6855
Saline	1669	1791	3460
Schuyler	1351	355	1706
Scotland	1295	713	2008
Scott	2562	753	3315
Shannon	341	84	425
Shelby	2040	2427	4467
Stoddard	1919	1935	3854
Stone	989	202	1191
Sullivan	1177	327	1504
Taney	509	109	618
Texas	1927	1580	3507
Vernon	3362	3102	6464
Warren	656	1303	1959
Washington	490	487	977
Wayne	420	237	657
Webster	2667	1058	3725
Worth	564	558	1122
Wright	2690	1386	4076
TOTAL	187042	167985*	355027*

* In addition to this total, 258 tons were sold in the State but county destination was not indicated on shipment notice.