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Fertilizers boost yields

*of
small grains,
grasses
and legumes*

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Fertilizers Boost Yields Of Small Grains, Grasses and Legumes¹

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Corn is king in Iowa. But corn should not be grown continuously. It should be rotated with small grains, clover or alfalfa. Such a rotation insures a good nitrogen level in the soil, cuts down on erosion, and helps keep the soil in good tilth. These factors in turn result in higher corn yields. Too often we neglect or omit our small grains and seedings because they don't give us the high cash return of corn. One way to make them more profitable is to increase their yields. You can give the yields a real boost with fertilizers.

There are two ways to use fertilizers on small grains and forages—the right and the wrong. Among other things, the right way involves using the correct kind and amount of fertilizer, applying it effectively to the soil and at the best time. You must know how to do these things. They will determine the returns you will get from your fertilizer. To give you the best possible information on these points, the Iowa Agricultural Experiment Station has conducted several hundred experiments on the fields over the state during the past few years. It is the purpose of this bulletin to give you the information gathered from these experiments along with other pointers to help you in your fertilizer program.

WHY YOU MAY NEED FERTILIZER

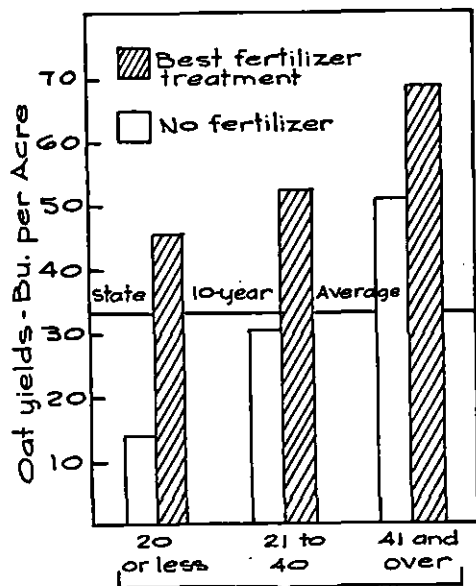
Nature has been unusually generous to us here in Iowa. She gave us some of the most productive soil in the world along with a climate favorable for high crop yields. We were able to coast along for years on the supplies of plant nutrients present in our soils. But high-yielding crops take out large amounts of the essential plant foods. Erosion loss also has taken its toll on our sloping land.

As a result, we are finding ourselves more and more in the position of the farmers in states to the east. We no

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Check yield range - Bu. per Acre

Fig. 1. This graph shows the oat yields that were obtained on plots with no fertilizer and on the best fertilizer plots in 54 experiments throughout the state from 1943 to 1947. The data are divided according to the yields of the check (no fertilizer) plots.

Note that good fertilizer responses were obtained regardless of the productivity of the field. There is, however, a tendency for low-yielding fields to respond more than high-yielding fields.

longer have enough available plant foods in many of our soils for maximum crop yields. For example, experiments with oats conducted over the state since 1944 show that 95 percent of the fields responded to nitrogen fertilizer, 48 percent to phosphate, and 20 percent to potash. Of the experiments with legume hay crops, 67 percent showed response to phosphate and 19 percent to potash. Figure 1 shows the yield responses that were obtained from fertilizers on oats.

FIRST STEP—KNOW YOUR FERTILIZER

You wouldn't buy a Jersey bull to build up a beef herd! But some of us still buy "just fertilizer" to build up the soil. There are a lot of different "breeds" of fertilizer, too. We've got to recognize them before we can use them intelligently.

There are three plant food elements most commonly deficient in our soils. These are nitrogen, phosphorus and potassium. We often call these fertilizer elements, since they are supplied in commercial fertilizers. "Fertilizer" may contain one, two, or all three of these elements.

Kinds of Nitrogen Fertilizer. There are several different kinds of nitrogen fertilizer. They are all good but they con-

tain different amounts of the element nitrogen. This is because their nitrogen is present in different chemical compounds. The kinds of nitrogen fertilizer and the amounts of nitrogen they contain are given below:

Kinds of nitrogen fertilizer	Percent nitrogen content	Equivalent * application rate
Sulfate of ammonia	20.5	100 lbs.
Ammonium nitrate	33.5	61
Cyanamid	20.5	100
Uramon	42	49
Nitrate of soda	16	128

* 100 pounds of sulfate of ammonia contains approximately 20½ pounds of the element nitrogen. But it takes only 61 pounds of ammonium nitrate to supply the same amount of nitrogen.

Now you'll want to know a little about how to handle these fertilizers and how they behave. *Ammonium nitrate* is in granular or pellet form which is treated so that it won't pick up moisture out of the air. Even so, store it only in a dry place. Don't mix it with other fertilizer because you'll destroy its outside coating and it will pick up moisture and cake. It is quick-acting and can safely be top-dressed on growing plants. *Cyanamid* is mostly in granular form. Apply it a few days before you sow your small grains and disk it in. It will injure your germination if you put it in direct contact with the seed. Don't top-dress it after the crop is up because it may kill the young plants. It is slow-acting and gradually releases its nitrogen to the crop.

Sulfate of ammonia can be bought in either powdered or crystalline form. The crystalline form is easier to handle and won't cake. You can mix either form with other fertilizer. It can be top-dressed or drilled. *Uramon* is a trade name for urea. It can be handled just like sulfate of ammonia.

Nitrate of soda isn't sold much in Iowa. It takes up moisture and should be handled like ammonium nitrate.

Kinds of Phosphate Fertilizer. There are two general types of phosphate fertilizer: superphosphate and rock phosphate. They are as different as night and day. But you'll be surprised how often people get them confused.

Superphosphate is made by mixing rock phosphate with

acid. This converts the phosphorus to a form readily available to plants. It comes in a wide range of grades. The table below gives you the most common ones and their equivalent application rates.

Superphosphate grade	Equivalent application rate
0-20-0*	100 lbs.
0-18-0	111
0-45-0	44
0-47-0	42

* The middle figure refers to the percent of available phosphoric acid in the fertilizer. For example, 100 pounds of 0-20-0 contains 20 pounds of available P_2O_5 . It takes 111 pounds of 0-18-0, or only 44 pounds of 0-45-0, to supply the 20 pounds of P_2O_5 .

Rock phosphate is a finely ground phosphate-bearing rock containing from 30 to 33 percent *total* phosphoric acid. But only a small amount is readily available to crops. This amount varies with different soils and crops. Alfalfa and clover can feed better on rock phosphate than can small grains and grasses. Rock phosphate works best on acid soils. It isn't of much value on neutral or alkaline soils.

Colloidal phosphate is a finely divided, low-grade rock phosphate or phosphate clay. It usually contains from 18 to 23 percent *total* phosphoric acid. It acts like rock phosphate. Ton for ton it is less valuable than rock phosphate because it contains only 60 to 70 percent as much total phosphorus.

Kinds of Potash Fertilizer. There are several grades of potash fertilizer. They are all water-soluble and readily available to plants. You can't go far wrong on any of them.

Kinds of potash fertilizers	Equivalent application rate
50% muriate of potash*	100 lbs.
60% muriate of potash	83
48% sulfate of potash	104
25% manure salts	200

* The percentage refers to content of potash (K_2O) in the fertilizer. For example, 100 pounds of 50 percent muriate contains 50 pounds of K_2O , 83 pounds of 60 percent muriate contains 50 pounds of K_2O .

Just keep their equivalent application rates in mind. These are given at the bottom of page 406.

Mixed Fertilizers—What They Are. You can take some nitrogen fertilizer, some superphosphate and some potash, mix them together in different proportions or leave one of them out, and you can come out with almost any grade of mixed fertilizer you want. Most of us don't like to do this sort of thing. So we buy our fertilizer already mixed. We would save a little money mixing it ourselves, but the mixture wouldn't be as easy to handle.

Mixed fertilizers, then, contain two or three of the fertilizer elements. They are sold according to grade—that is, the percentage of nitrogen, available phosphoric acid and potash, always in the order named. For example, the figures 4-16-8 appearing on a fertilizer bag mean that this fertilizer contains 4 percent nitrogen, 16 percent available phosphoric acid, and 8 percent potash. Of actual plant food, 100 pounds of 4-16-8 then contains 4 pounds of nitrogen, 16 pounds of available phosphoric acid (labeled as P_2O_5), and 8 pounds of potash (K_2O). If it is labeled 4-16-0, then it's the same as above except it does not contain potash.

Always buy the grade that fits your need.

HOW TO SELECT THE FERTILIZERS YOU NEED

You want to pick out those fertilizers that best fit the needs of the crops on your soils. Now there are several ways you can get at this. You probably will want to consider them all in making your final selection of fertilizer.

Select by Soil Tests. Reliable soil tests will be your biggest help. There are two very important things to keep in mind about soil tests. First, the soil test is only as good as the sample you take. Second, not all soil tests are reliable on Iowa soils.

Take a little time and get good soil samples. Soils that are distinctly different in appearance, crop growth or past treatment should be sampled separately. Remove a small sample extending from the surface to a depth of 6 inches. Take samples in at least 10 or more places from each area of 10 acres or less in size. Mix them together thoroughly and take out a pint sample.

Don't try to test the soil yourself. Good soil tests require a lot better equipment than you can get in most package kits. Then, too, you have to know how to properly interpret the results for your kind of soil. These have to be based on the results of actual field experiments. The best way is to send your samples to a good soil testing laboratory where the tests can be made and the results interpreted. Iowa State College has set up such a laboratory. If you want to make use of its services, go to your county extension office or local PMA office and they will give you the necessary containers, information sheets and directions.

Select on Basis of Field Trials. Your state experiment station has conducted large numbers of fertilizer experiments. The results from these are the basis for all recommendations either from soil tests or in the pamphlets or bulletins.

These experiments show that the need for the different nutrient elements is related somewhat to the kind of soil or soil type. To simplify the recommendations, we've divided the state into six soil areas. These are shown on the map in fig. 2. Locate your particular soil area and keep it in mind.

Now look at the maps in figs. 3 and 4. From these you'll

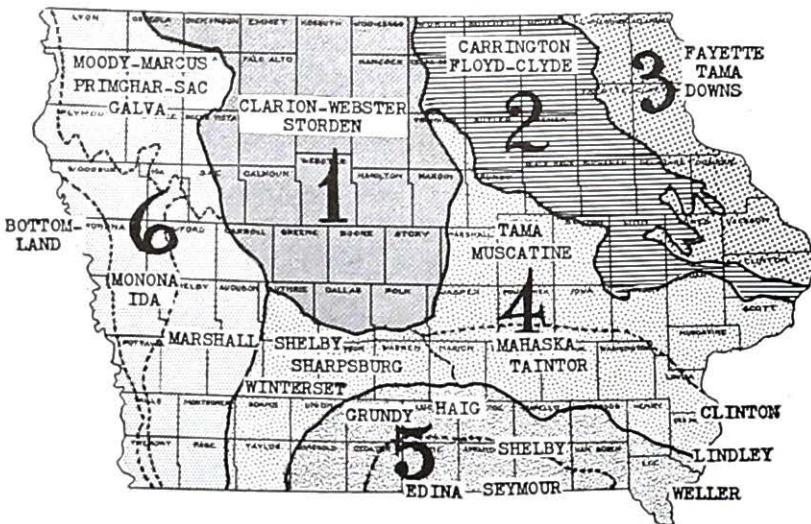


Fig. 2. This map shows the six major soil areas of the state. The names of the more important soils and their approximate locations are shown. Find the approximate location of your farm on the map and keep the area number in mind.

COMPARATIVE RESPONSE OF LEGUME HAYS TO PHOSPHATE FERTILIZER

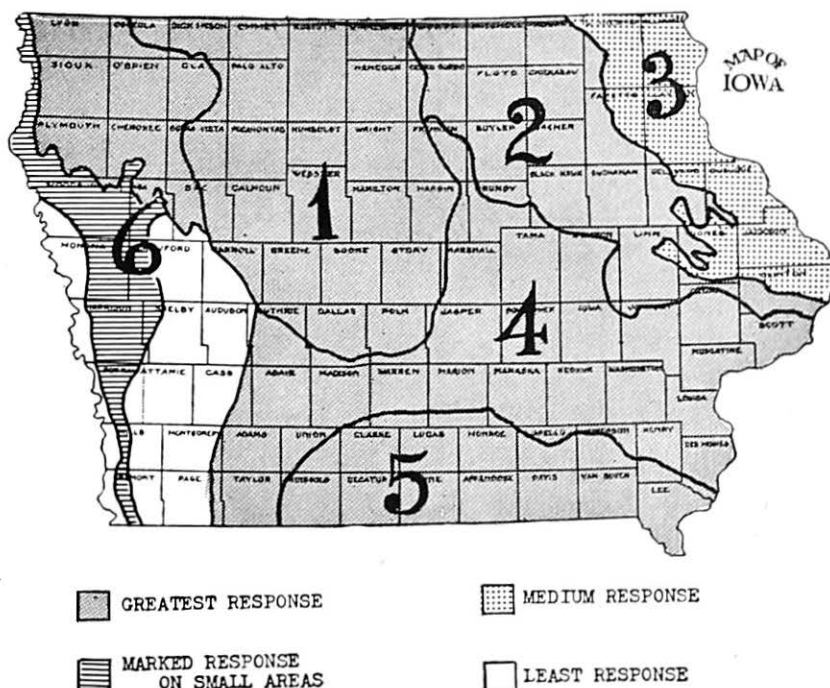


Fig. 3. Crops grown on different soils vary in their response to phosphate fertilizer. This map shows roughly how these responses differ over the state.

get some idea of what to expect in the way of phosphate and potash needs.

Our experiments indicate that the nitrogen fertilizer needs of the different areas can't be separated so distinctly. A lot depends on your past cropping system. But you'll find that soils which developed under forest and soils that are sandy or eroded are most lacking in nitrogen. The light-colored prairie soils need nitrogen more than the deep, black prairie soils. However, nitrogen is needed for small grains pretty much all over the state.

The Extension Service of Iowa State College puts out a fertilizer recommendation pamphlet each year. This will give you valuable information on what fertilizers to apply.

Consider Past Cropping and Past Management. The cropping and soil management history of your field will give you some good leads as to its fertilizer needs.

COMPARATIVE RESPONSE OF LEGUME HAYS TO POTASSIUM FERTILIZER

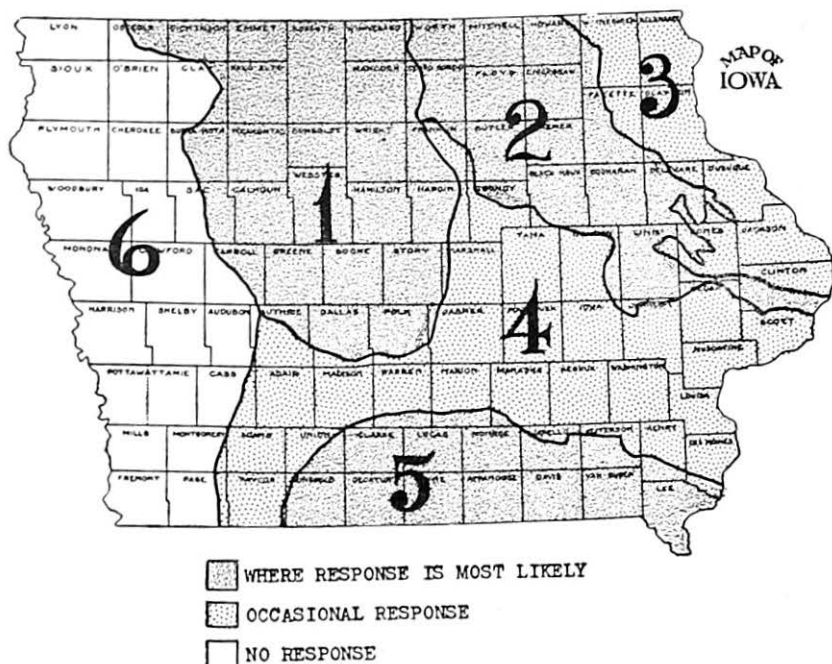


Fig. 4. Small grains and hays grown in Iowa seldom need potash fertilizers. This map shows where legume hays are most likely to respond to potassium.

The crops you grew during the past 3 or 4 years give a pretty good indication of the nitrogen needs of your small grains. This is shown in fig. 5. Nitrogen fertilizer needs are greatest on fields where you have not grown alfalfa or clover for 2 or 3 years. Small grains immediately following soybeans still need some nitrogen fertilizer. Soybeans, even though they are a legume, add very little or no nitrogen to the soil.

Most of us tend to apply the greater portion of our barnyard manure on fields closest to the barn. Here fertilizer often is of little value. On the other hand, the back forty usually has the lowest level of fertility. Farms where large amounts of manure are returned to the fields require less fertilizer than those where little manure is returned.

Yellowing Means Nitrogen Deficiency. When the soil has too little nitrogen this is indicated by the color of the leaves of small grains. They become yellowish-green, and the lower ones

EFFECT OF PREVIOUS CROPPING UPON THE RESPONSE OF OATS TO NITROGEN FERTILIZER

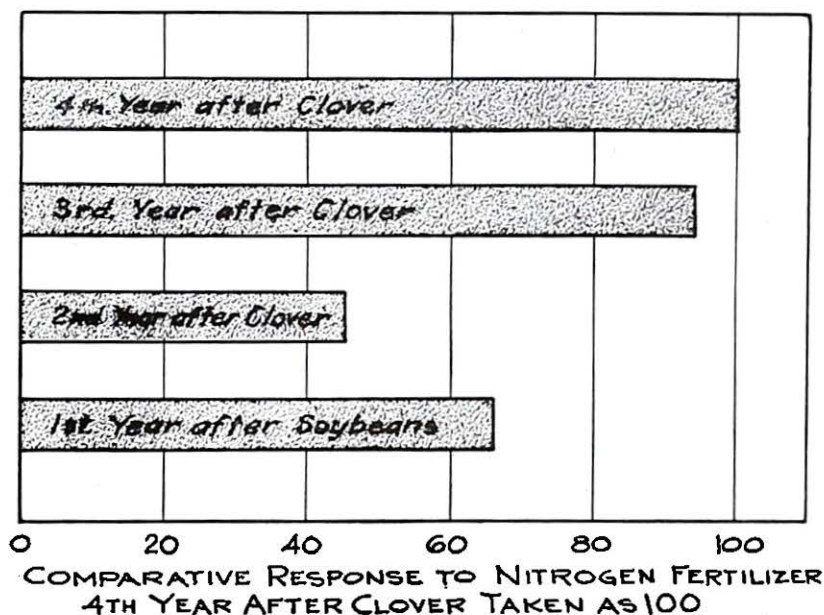


Fig. 5. Past cropping often determines the needs of small grains for nitrogen fertilizer. This graph shows that the largest response of oats to nitrogen fertilizer occurs on fields having the most intensive crop rotations.

turn yellow and die. This can best be seen when the plants are 6 to 12 inches in height. The plants often are stunted in growth. You'll see dark-green patches of vigorously growing plants on spots fertilized by animal droppings. Such fields respond greatly to nitrogen fertilizer.

Leave Some Check Strips. Leave a few unfertilized strips through your field when you are applying fertilizer. Satisfy yourself that your fertilizer is paying. You can even try some different kinds of fertilizer and at some different rates. It doesn't take long to do this and you will learn a lot.

SMALL GRAINS NEED NITROGEN AND PHOSPHATE

Nitrogen fertilizer is of value only to small grains and grasses. As far as we know, it is of no value to legume hays if they are properly inoculated. Phosphate is needed by small grains, grasses and legumes alike. When you apply

phosphate on small grains, remember that you are also applying it for the following hay or pasture crop as well. You need to apply more phosphate than to just meet the needs of the small grain crop. If potash is needed, you can either apply it all on the small grain or split the application and top-dress some of it on the hay crop.

Fertilizing Oats. A combination of nitrogen and superphosphate most often will give you best returns. *Use them together* unless you know definitely that only one is needed. Forget about potash unless soil tests indicate its need. Figure 6 shows how important it often is to apply nitrogen and phosphate together.

Every 2 or 3 pounds of nitrogen up to 20 or 30 pounds per acre will usually increase the oat yield by 1 bushel. Once in a while 1 pound of nitrogen will increase the yield by 1 bushel. But this happens only on soils quite deficient in available nitrogen. Phosphate, especially when you use it with nitrogen, often will increase oat yields. On the average 40 to 60 pounds of P_2O_5 per acre (that's 200 to 300 pounds of 0-20-0) will increase the oat yield from 4 to 6 bushels per acre. On fields that are very deficient in available phosphorus, much larger increases may be obtained. On Iowa soils, potash seldom increases the yield. In fact, potash may decrease the oat yield.

As a general rule, don't apply over 20 pounds of the element nitrogen per acre on oats with seedings. More than this amount may injure your seedings. On oats without seedings you can often go up to 40 pounds per acre.

Apply superphosphate at rates ranging from 20 to 120 pounds of P_2O_5 per acre. The rate you select depends on how deficient your soil is in phosphorus and how long you plan to leave the field in hay or pasture. Oats without seedings seldom justify applications of over 40 pounds of P_2O_5 per acre.

An easy way to apply nitrogen and phosphate combinations is in mixed fertilizers such as 4-16-0, 6-24-0, 10-20-0 or 11-48-0. Another good scheme is to apply phosphate at the time of seeding, then top-dress straight nitrogen on the oats after they are up. This way you can spread nitrogen only on the areas where the oats are yellowish from nitrogen deficiency. This will also cut down your fertilizer cost. Of course, there are some fields where you will need only nitrogen (fig. 7) or only phosphorus.



No fertilizer
Yield—12.8 bu.

Nitrogen alone
Yield—16.1 bu.

Phosphorus alone
Yield—19.1 bu.

Nitrogen and
phosphorus
Yield—49.0 bu.

Fig. 6. The oats in these pictures were grown on a nitrogen- and phosphate-deficient Ida silt loam soil in Monona County. Note (on the far right) that a good

yield was obtained only when nitrogen and phosphate were applied together.



Fig. 7. Oats often respond markedly to nitrogen fertilizer when enough phosphorus is available. The plot on the left received no nitrogen and yielded 43 bushels per acre. The plot on the right received 250 pounds per acre of ammonium nitrate and yielded 71 bushels per acre. This soil was well supplied with available phosphorus.

Fertilizing Winter Wheat. When you fertilize your winter wheat, do this: Disk in or drill phosphate in the fall. Top-dress nitrogen in the spring.

Our experiments show that you will get bigger returns from putting nitrogen on in the spring. Twenty pounds of nitrogen applied in the spring produced as large yields as 40 pounds applied in the fall. But you will want to work your phosphate into the soil, so apply it when you sow your wheat.

Very likely you will get large yield increases from the nitrogen. Here are some results from field experiments conducted in western Iowa: Of 19 locations, 15 of them responded well to nitrogen. The largest responses were obtained on 12 low-yielding fields where legumes had not been grown for 2 or 3 years before. The average yield on the unfertilized areas was 17.9 bushels per acre. Twenty pounds of nitrogen raised the yield by an average of 6.6 bushels per acre. Forty pounds of nitrogen raised it by 10 bushels per acre. Eighty pounds raised it by 12 bushels. Still higher rates produced no further yield increases.

Here is something else we found out. Fields that are capable of producing 30 or more bushels to the acre should ordinarily not receive nitrogen fertilizer. Nitrogen causes

TABLE 1. SPRING TOP-DRESSINGS OF NITROGEN FERTILIZER INCREASE THE PROTEIN CONTENT AND THE YIELD OF WINTER WHEAT. HERE IS WHAT NITROGEN DID ON OLIVER STEVENSON'S FARM IN FREMONT COUNTY.

Pounds ammonium nitrate per acre	Percent protein	Yield bu. acre
NONE	12.0	21.1
100	13.1	32.5
200	14.3	35.0
400	17.7	41.5

the wheat to lodge, and the yield will actually be decreased.

Now in addition to increasing the yields on low-yielding fields, the nitrogen produced better quality wheat—higher in protein. An example of this is given in table 1.

For fertilizing winter wheat we recommend applying 200 to 300 pounds of 0-20-0 (this will contain 40 to 60 pounds of P_2O_5) per acre on fields deficient in phosphorus. Disk it in or drill it when you plant your wheat in the fall. If your field is low in potash, too, then make it 0-20-10. On low-yielding fields and where you haven't had a good legume crop in the past 2 or 3 years, top-dress from 20 to 40 pounds of nitrogen per acre. Do this in the spring when your wheat is 5 to 10 inches high.

Flax Needs Nitrogen. Flax often responds well to nitrogen fertilizer. We have increased the yields as much as 4 to 6 bushels per acre in northwest Iowa from 40 pounds of nitrogen per acre. It's a good practice to top-dress with nitrogen when the flax is 4 to 5 inches high. This will help get around the weed problem. Weeds respond to nitrogen too, and it pays to give the flax some start over the weeds.

Flax doesn't respond very much to phosphate. But on phosphorus-deficient soils you will want to apply phosphate if you have a seeding in flax. Apply this at planting time. Either disk it in or drill it.

Apply from 20 to 40 pounds of nitrogen per acre. Top-dress it if you have a weed problem.

Barley Responds Well. This crop requires a higher level of fertility than oats. It often responds markedly to applications of nitrogen and superphosphate. Our experiments on low-fertility soils in northwest Iowa indicate that barley yields may be increased 50 to 100 percent from applications of nitrogen and superphosphate.

You'll find that different barley varieties do not behave the same when fertilizer is applied. The Moore variety is capable of greater responses and does not lodge. Mars, another lodging-resistant variety, responds the least to fertilizers. Kindred and Wisconsin 38 respond well to fertilizer but often lodge at the higher rates of application. Superphosphate appears to improve the malting qualities of barley, while large applications of nitrogen tend to lower them.

On low-fertility soils in northwestern Iowa, probably a combination of 20 pounds of nitrogen and 60 pounds of P_2O_5 (this is equal to 300 pounds of 0-20-0) per acre will give the best returns.

GO EASY WITH NITROGEN ON SMALL GRAINS

As we have said before, nitrogen fertilizer is badly needed for small grains. But go easy. Some nitrogen is good; too much may cause lodging or hurt your seeding stand.

Danger of Lodging. Too high applications of nitrogen cause lodging in small grains. You'll have the most trouble if you apply nitrogen on fields already high in available nitrogen. These include fields where you keep alfalfa down for 2 or 3 years, where you apply large amounts of manure, and where the topsoil is deep and high in organic matter. Under such conditions, either apply no nitrogen or not more than 10 pounds to the acre.

Even on fields low in nitrogen, high applications such as 80 pounds of nitrogen to the acre may cause lodging.

Danger of Shading-out Seedings. Keep your nitrogen rate low enough so that you don't get rank vegetative growth of the small grain. Rank growing grain tends to kill out the seedings underneath. (Fig. 8.) Not enough sunlight reaches the seedings to permit them to manufacture the sugars they need for growth.

One way to get around the severe shading is to keep the nitrogen rate down to 20 pounds or less per acre. Our experiments show that 20 pounds is a safe rate. Forty pounds often has a depressing effect and 80 pounds will often kill out most of your seeding. Of course a hard and fast rule can't be laid down for all fields. Those of low fertility can often take 40 pounds without any damage to crops.

You can use high rates of nitrogen and not damage your



Fig. 8. Too much nitrogen fertilizer on the nurse crop may ruin the stand of a legume seeding. The plot on the left received no nitrogen. The plot on the right received 250 pounds per acre of ammonium nitrate applied on the oat nurse crop the previous season.

seedings if you drill small grains in wide-spaced rows. We've found that you can drill oats in 14-inch rows (that's done by plugging up every other drill spout), use 40 pounds of nitrogen, and not hurt your seedings. At the same time, your oats may yield as well as or better than where they are broadcast or drilled in 7-inch rows.

NITROGEN INCREASES BROMEGRASS YIELDS

Look at the bromegrass seed yields in table 2. You'll agree that there is no other Iowa crop where fertilizer will give such large returns. But there is a trick involved. If you want good seed yields, you must top-dress the nitrogen very early in the spring—even before the bromegrass starts to turn green. Apply it later and you are likely to increase the vegetative growth only.

On most fields, apply from 30 to 60 pounds of nitrogen per acre. That is equivalent to 90 to 180 pounds of ammonium nitrate. Put it on each spring. It won't carry over much from one year to another.

Some of you have mixed stands of alfalfa and bromegrass and you want to take off a bromegrass seed crop before you

cut your hay. Applying nitrogen will increase bromegrass seed production but at the expense of alfalfa. Your hay crop will be made up of a greater percentage of brome and a smaller percentage of alfalfa than if you left off the nitrogen. "Sodbound" bromegrass is nitrogen-deficient.

TABLE 2. NITROGEN FERTILIZER GREATLY INCREASES THE SEED AND FORAGE YIELDS OF BROMEGRASS. THE YIELDS SHOWN IN THE TABLE CAME FROM A BROMEGRASS TRIAL IN PAGE COUNTY IN 1948. THE FERTILIZER WAS APPLIED IN LATE MARCH.

Ammonium nitrate lbs. per acre	Seed yield lbs. per acre	Forage yield (less seed) lbs. per acre
0	229	1053
60	478	1842
120	621	2700
180	730	3505

ALFALFA AND CLOVER NEED PHOSPHATE

Phosphate Needs Vary. Our experiments show that about two-thirds of the soils of the state need phosphate for maximum production of alfalfa and clover. These needs aren't evenly distributed, as you can see from the map in fig. 3. Your chances of needing phosphate are high in Areas 1, 2, 4 and 5, and on the Monona and Ida soils and the Moody, Marcus and Primghar soils in Area 6. The Marshall soils and many of the Missouri Bottomland soils are usually well supplied with available phosphorus and you won't obtain much response. We haven't had many experiments in Area 3 but we have found only slight responses here. Then, too, if you have used a lot of manure it's likely that you will need less phosphate.

Sometimes you will obtain a phosphorus response on small grains but won't get a response on alfalfa or clover.

Eroded soils often need phosphate.

Stunted Growth Indicates Extreme Phosphorus Deficiency. Perhaps you have seen alfalfa and clover that has made an extremely stunted, short growth. This occurs mostly in the shaded area shown on the map in fig. 9. This short growth usually results from a lack of phosphorus. It can be corrected through use of superphosphate fertilizer (fig. 10). Rock phosphate is of no value.

WHERE EXTREME PHOSPHORUS DEFICIENCIES OFTEN OCCUR

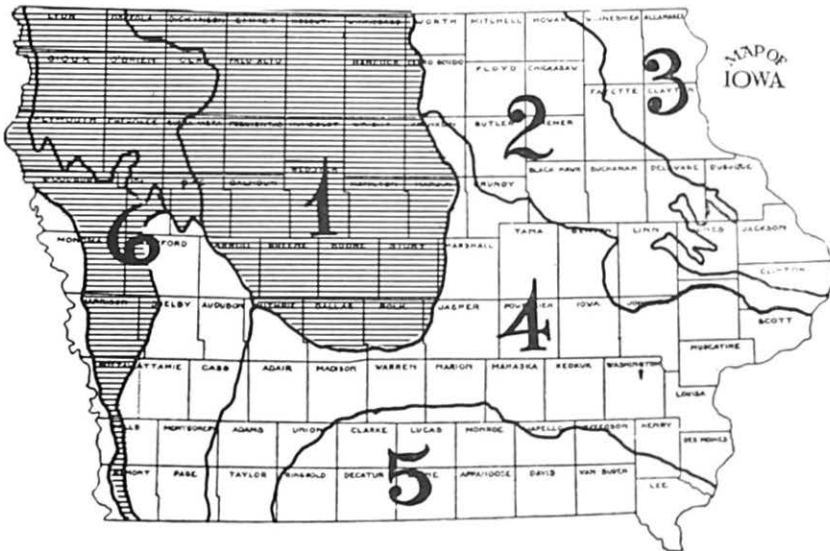


Fig. 9. The shading indicates areas where extremely phosphorus-deficient soils are most likely to occur. Alfalfa and clover often grow short on these soils, and application of superphosphate results in normal growth.



Fig. 10. Lack of phosphorus often severely limits the growth of legume hays. This field of alfalfa on Clarion soil in Greene County responded greatly to superphosphate fertilizer. The alfalfa on the left received 300 pounds per acre of 0-20-0 and yielded 1.4 tons per acre per cutting. That on the right received no phosphate and yielded 0.5 ton.

We have found that these soils are nearly always neutral or alkaline in reaction, or at best only slightly acid. They have no lime requirement. In fact, they often contain free lime (calcium and magnesium carbonates).

It takes more than the usual amount of superphosphate to bring your yields up to normal on these soils. Not less than 60 pounds of P_2O_5 should be applied. Often 100 or 120 pounds will give you most profitable returns. That's a range of from 300 to 600 pounds of 0-20-0 per acre. Of course the higher rates should be used on alfalfa that is to be left down for 2 or 3 years. Yields are increased by threefold or more.

Not only do you increase the yields very markedly but you also increase the phosphorus content of the hay. We have found that on these soils the phosphorus content of unfertilized hay often averages only 2.5 pounds per ton. Hay from phosphated areas averages about 3.4 pounds per ton. Other experiment stations have found that hay containing less than 3.0 pounds of phosphorus per ton may cause injury to livestock unless supplemental phosphate is provided.

What to Expect on Moderately Phosphorus-Deficient Soil. Not many of our soils need phosphate as badly as those we just discussed. Usually 40 to 60 pounds of P_2O_5 per acre (200 to 300 pounds of 0-20-0) applied on the small grains will do the job. On the average you can expect about 800 pounds of dry hay increase on the first cutting. This may decrease somewhat on the following cuttings. Increasing the rate by another 40 pounds of P_2O_5 usually gives an additional 200 to 400 pounds of hay.

When to Apply Superphosphate for Hays. Our experiments show that the best time to apply superphosphate for legume hays is when you prepare your land for the small grain crop. There are several advantages in doing it at this time. You can get it disked or drilled into the soil where it will do you the most good. You take care of the phosphorus needs of the grain crop. It's there in time to get your seeding off to a good start. All of these mean greater returns to you.

Occasionally it will pay you to top-dress established stands of alfalfa or clover with superphosphate. However, top-dressing will not give as good increases in yields as disking or drilling the fertilizer into the soil at seeding time. But

on phosphorus-deficient soils, phosphate top-dressed is usually better than no phosphate at all.

Top-dressing can best be done with a low-down broadcast type spreader. Apply the phosphate at a rate equal to 200 or 300 pounds of 0-20-0 to the acre. Put it on either in the late fall or in the early spring. You can also drill it with a combination grain-fertilizer drill. But, don't top-dress unless the stand is good.

Where and How to Use Rock Phosphate. The kind of soil you have, along with the kind of rotation you are following, determines pretty much whether or not you can use rock phosphate. Rock phosphate usually will give the best account of itself on the more acid soils in Areas 2, 3, 4 and 5. Don't apply it in Area 6. It is of questionable value in Area 1. Rock phosphate is of no value on high-lime or alkaline soils and of little value on neutral or near-neutral soils. Have your soil tested for acidity before you apply rock phosphate. Alfalfa and the clovers can feed on rock phosphate best. Don't expect much returns from it on grains or grasses, even on acid soils.

You'll need to apply from 750 to 1,000 pounds of rock phosphate per acre. Repeat this application every 6 or 8 years. Apply it broadcast about 1 year ahead of the time you make your legume seeding. This gives a little time for it to get worked into the soil and for the soil to react with it.

We believe that it is a good idea to use some superphosphate in addition to rock phosphate. This way, the superphosphate will help take care of the phosphorus needs of your small grains and grasses. You won't need as much superphosphate. Cut the rate down to around 100 or 200 pounds of 0-20-0 to the acre. Apply the superphosphate just as we have suggested elsewhere.

Potash Fertilizers Are Seldom Needed. Our soils are still pretty well supplied with potassium. You will seldom obtain responses to potash fertilizers on alfalfa or clover in Iowa. Then too, if you do get a response it is usually small. The crop that potash is most likely to help is corn. Potash applied at a rate equal to 100 pounds of 60 percent muriate of potash to the acre seldom produces over 400 pounds of additional dry hay to the acre. Usually it is much less. Response is most likely in Areas 1, 2 and 5. (See fig. 4.)

Sometimes slight response is obtained in Areas 3 and 4. So far, we have never obtained a response anywhere in Area 6. But watch those Ida soils. If you use plenty of phosphate and get several years of good yields, potassium may become limiting.

Now there are some fields in the state that are extremely deficient in potassium. They are few and far between, but we know that they exist. Soil tests will pick them up. Mostly they are sandy soils. Use of potash fertilizer on these may increase your hay yields several fold.

The easiest way to put potash on is at the time of seeding your small grain crop. Instead of using fertilizers without potash, apply 4-16-8, 0-20-10, 0-20-20, or even 0-10-20. You can top-dress potash on established stands of alfalfa and get good results. But be sure first that you have a real potassium deficiency.

WAYS TO APPLY FERTILIZER

There are several ways to apply fertilizer on small grains and hays. Some of these are more effective than others. It's important for you to use the best methods. More efficient fertilizer use means more dollars in your pocket.

First Choice, Drilling at Time of Seeding. The most effective method for applying mixed fertilizers or super-



Fig. 11. The combination grain-fertilizer drill is the most effective method for applying fertilizer. This drill is being used on disked cornstalk land.

phosphate is with the combination grain-fertilizer drill. (See fig. 11.) The fertilizer goes down the same spout as your seed. You get it down in the moist soil where the plants can feed on it. It is in contact with less soil. This is important because your superphosphate will remain longer in a soluble form. Plants can feed on it easier. Then too, drilled oats yield on the average about 4 bushels to the acre more than broadcast oats. Your seedlings also have a better chance to survive.

Broadcasting Before Seeding. At present this is by far the most common practice followed in the state. The main thing is to spread your fertilizer evenly. Then disk it in.

The old endgate broadcasters aren't very satisfactory. They spread the fertilizer unevenly. More fertilizer falls right behind the spreader with smaller amounts going out to the sides. That's why so many fields have that wavy, rolling appearance. On windy days, dusty fertilizers take off for your neighbor's field.

If you want to broadcast your fertilizer, then get the low-down, broadcast type of spreader. These release the fertilizer close to the ground. You get even distribution, and blowing isn't much of a problem. The new models are capable of delivering a wide range of amounts, and they operate efficiently at tractor speeds.

Top-dressing Nitrogen on Grain. As we indicated earlier, there are times when it is a good idea to top-dress nitrogen after the grain is up. If you do this, use the sower type spreader. Apply it when the grain is anywhere from 3 to 10 inches high. On oats, you can pick out the areas in the field that show yellowing. Hit these and skip the areas where the grain has a dark green color. Don't top-dress when the plants are wet. Burning might result. Never use cyanamid, since it may injure the plants.

Applying Rock Phosphate. Here again it pays to use a low-down sower spreader. There is no advantage to drilling rock phosphate. You want it spread evenly so that you can get it well disked into the soil. Unlike superphosphate, rock phosphate does better when it is well mixed with the soil. Put it on sometime before you plant corn or soybeans.

PROFITS DETERMINE FERTILIZER USE

You've got to have a profit from fertilizers or you won't use them. It's nice to talk about soil building, and returning all of the plant foods that you remove through cropping. But this won't put new tires on your tractor. Use fertilizers when and if they give you a profit.

Now the important thing to determine is how much fertilizer to apply when a particular set of price levels prevail. The price of fertilizer doesn't vary much from year to year, so the main thing is the price you can expect from your crops and the amount of response you get from using the fertilizer. If prices are high you can well afford to apply higher fertilizer rates. If they are low, then you'll want to apply the lower rates. Or maybe you won't want to use fertilizer at all.

OTHER GOOD PRACTICES INCREASE FERTILIZER EFFICIENCY

You'll find that fertilizers pay best when you use them with other good practices of soil and crop management.

Many practices, besides the use of fertilizers, are involved in getting high crop yields and in maintaining them over a long period of years. These include:

1. Moisture control, such as proper drainage on level land, and moisture conservation on hill land.
2. Liming of acid soils.
3. Use of good crop rotations.
4. Control of weeds, insect pests and plant diseases.
5. Use of proper tillage methods.
6. Erosion control.
7. Application of manure and maintenance of organic matter.
8. Use of disease-resistant and adapted crop varieties.

All of these, where needed, are necessary for maximum crop production. Omit any one for any length of time and you will have lowered crop production. Fertilizers can supplement the above practices but cannot replace them.

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