MINNESOTA FEED SERVICE

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Nitrogen, Our Big Need

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The need for nitrogen in the soils of the Middle West is so great that calculating a figure for nonlegume crops is impossible. That figure would be astronomical and wholly unrealistic!

The amount of nitrogen that should or will be used is related to the degree of efficiency in producing our crops under good management. Some of the factors good managers have to consider are:

1. Supply of the other nutrient mineral elements, including trace elements.
2. Use of herbicides, soil fumigants, and chemical insect or pest controls.
3. The genetic potential of the crop, the stand, and the supply of moisture.
4. Placement and balances and frequency of fertilizer application.

There are many other factors, too, that determine nitrogen need.

We have a tremendous quantity of experimental data bringing out the need for nitrogen and the inter-relationship with these other factors. Many farmers have ventured beyond Experiment Station recommendations in the use of nitrogen and other fertilizer elements.

However, many farmers' reports are spectacular, emphasizing the great potential nitrogen has in connection with good management practices. We must treat nitrogen not as a separate factor but in relationship to all of these various factors.

What then is the true need for nitrogen? It depends partly on how much efficiency we want in crop production. Minnesota, which was using only an average of 3.5 pounds of nitrogen per acre of crop land in the 1954-55 season, reflects how inadequate we are in efficient crop production. The same is true of other states.

The same year a few farmers used as much as 100 pounds per acre of nitrogen for corn in these same states and even more in subsequent years.

Obviously if all crops were grown efficiently the crop surplus would be increased. However, up to a point, the cost per unit of crops would go down.

It is wishful thinking to assume that all crop lands will be operated with optimum efficiency. We need only to look at the low average yields of our major crops to see that we don't use the most efficient practices.

Farmers using the major optimum practices have been making money and are presenting severe competition for farmers who are still farming by methods that were adequate before farming became a highly competitive business. This competition boils down to a struggle between the two groups for whatever market there is.

There is much evidence to show that using adequate nitrogen in balance with other top practices to lower the cost of production is profitable. Lowering the cost of production is one way to broaden its acceptance in the market.

The nitrogen deficiency symptoms indicated by tissue tests in most nonlegume crops shows that nitrogen is one of the first limiting factors in crop growth.

Anyone interested in nitrogen would find it a valuable experience to make plant tissue tests of several kinds of crops, excluding the legumes. Start such tests as soon as growth begins in the spring and continue making them every three or four weeks throughout the growing period until harvest. (Include tests for the other major elements, too). Such an experience would probably shock you about the great nitrogen deficiencies of most plants at various stages of growth. I believe that whenever a plant is showing no free nitrate nitrogen (except legumes) it is not doing its optimum growing.

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This issue is devoted to reports made at the Nitrogen Conference held February 20-22 in St. Paul. The Conference was sponsored by the University of Minnesota and the Middle West Soil Improvement Committee.

All people interested in selling farmers commercial nitrogen should emphasize the need and use of lime just as much as if they were selling clover or alfalfa seed. It is to the future interest of both the nitrogen industry and the farmer that the lime requirements of the soil are not neglected. We have natural tendency to overlook the fact that most synthetic nitrogen commonly used tends to increase soil acidity. (Notable exceptions are nitrate of soda, calcium cyanamid, and various calcium-nitrogen compounds).

In the Middle West we have built a highly productive agriculture based on mining our soil for nitrogen. Legumes have tended to delay this day of nitrogen starvation. The toll in depleting our soils in phosphorus and potassium, and perhaps other mineral elements is great. Therefore, as our agriculture grows older, we no longer depend on inherited nitrogen from organic matter. In many places, too, it will not be economical to depend on nitrogen from legume sources.

Early Starts

Nitrogen has "magic" in getting crops started early in the spring while the soil is still too cold for organic matter to decay and release nutrients.

In summary, we have two alternatives. Shall we use too much land badly without adequate nitrogen and management practices and seek elsewhere for farm income and soil conservation? Or should we produce what we need on as little land as possible with adequate nitrogen and management practices and thus lower the cost per unit and try to avoid soil damage?

Consider P, K, and Lime

A. C. CALDWELL*

After years of cropping without treatment, grain yields seem to stabilize at 12 to 15 bushels per acre, long-time experiments and observations indicate. This yield is conditioned by the amount of nitrogen available and not by other major nutrient elements such as phosphate or potash.

Crops grown on soils without an element such as phosphorous will have available for growth only that phosphorous in the seed, and there would be no yield. This is not true of nitrogen. No matter how nitrogen-depleted a soil may be, there will always be some added from the atmosphere by electrical and nonsymbiotic fixation. This amount probably is enough for about 12 bushels of grain per acre.

Another situation prevails, however, when extra nitrogen is added to the soil by turning under leguminous residues or applying fertilizer nitrogen. Yields will be increased to some level controlled perhaps by the amount of potassium or some other essential element. So it is possible to reach successive yield plateaus. The levels of these plateaus are influenced by growth controlling factors including amounts of available nutrients. Many experiments pinpoint the first limiting element.

Table 1(A) shows the effects of nitrogen, phosphate, and potash applied as the starter fertilizer to corn grown on land very deficient in potassium. Nitrogen was adequate for good yields, but yields were very definitely controlled by potassium addition.

Table 1. Corn yields as affected by fertilizing nutrients, alone and in combination, on land deficient in certain elements*

Fertilizer pounds per acre			A. Potassium Deficient		B. Phosphorous Deficient		C. Nitrogen Deficient	
			Yield		Yield		Yield	
N	P_2O_5	K_2O	Bu/acre	Difference	Bu/acre	Difference	Bu/acre	Difference
0	0	0	67.5	.....	63.9	.....	76.7	.....
32	0	0	62.1	—5.4	70.3	6.4	89.9	13.2
0	64	0	69.2	1.7	78.7	14.8	79.4	2.7
0	0	64	83.4	15.9	58.7	—5.2	76.8	0.1
32	64	0	65.3	—2.2	80.4	16.5	91.4	14.7
32	0	64	82.0	14.5	56.7	—7.2	89.7	13.0
0	64	64	92.3	24.8	73.0	9.1	85.4	8.7
32	64	64	94.9	27.4	87.3	23.4	95.8	19.1

* Minnesota data.

In other experiments phosphorous (table 1[B]) or nitrogen (table 1[C]) was the major limiting element. In all three a balanced fertilizer containing nitrogen, phosphate, and potash gave best corn yields.

The full response in corn to heavy nitrogen rates can sometimes only be fully realized when extra phosphate and potash are applied (table 2).

The necessity for considering more than one nutrient is shown by fertilizer experiments with barley in South Dakota (table 3) and with wheat in the Red River valley area of Minnesota (table 4). The best yield of oat grain and straw resulted in combining nitrogen, phosphate, and potash in south central Minnesota.

Soil Reaction

Proper soil reaction is necessary, too, for best yields and maximum use of fertilizer. If soils are too acid, some nutrients like phosphorous are fixed in an unavailable form, and even added phosphates become unavailable very quickly. Furthermore, the beneficial action of soil organisms is inhibited and organic matter breakdown is slowed.

Farm operators, judging by the number of soils found to be acid by soil testing laboratories throughout the country, don't recognize this. Maintaining a proper reaction in the soil will increase grain yields, but legumes are particularly affected by too low a soil pH. Low pH reduces alfalfa growth and restricts fertilizer use (table 5).

Phosphate, potash, and lime should be considered along with nitrogen in a good fertility program. As yields increase and other soil nutrients are depleted, it will be necessary to apply essential elements such as boron, copper, zinc, molybdenum, magnesium, and others.

Tables 2-4 Show Fertilizer Effect on Yields

Table 2. Corn yields as affected by sidedressed nitrogen, phosphate, and potash*

Fertilizer† lbs. of N. per acre	Sidedressed lbs. of 0-20-20 per acre	Yield bushels per acre	Diff. due to 0-20-20
0	0	75.4	.....
0	200	76.0	0.6
60	0	94.4	.....
60	200	98.2	3.8
120	0	94.1	.....
120	200	104.4	10.3
180	0	96.9	.....
180	200	105.4	8.5
300	0	95.9	.....
300	200	109.6	13.7

* Minnesota data.
† Starter fertilizer 150 lbs. per acre of 6-24-12.

Table 3. Barley yields as affected by nitrogen and phosphorous, South Dakota*

Fertilizer† lbs/acre			Yield	
N	P_2O_5	K_2O	Bu/acre	Difference
0	0	0	41.4	.....
40	0	0	47.2	5.8
0	40	0	45.1	3.7
40	40	0	56.2	14.8

* Data by B. L. Brage, South Dakota State College.
† Fertilizer broadcast.

Table 4. Wheat yields as affected by nitrogen and phosphorous*

Fertilizer† lbs/acre			Yield	
N	P_2O_5	K_2O	Bu/acre	Difference
0	0	0	19.8	.....
0	40	0	23.1	3.3
20	0	0	21.3	1.5
20	40	0	29.3	9.5
40	0	0	27.4	7.6
40	40	0	34.7	14.9
80	0	0	33.2	13.4
80	40	0	40.8	21.0

* Minnesota data.
† Phosphate applied with the grain; nitrogen broadcast.

Table 5. Alfalfa yields as affected by fertilizer and soil pH*

Fertilizer† lbs/acre			pH of surface soil	Yield tons/acre
N	P_2O_5	K_2O		
0	0	0	5.5	0.56
0	0	0	6.7	1.08
80	40	40	5.3	0.83
80	40	40	6.8	1.34

* Minnesota data.
† Fertilizer applied to companion crop (flax) the preceding year.

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Production Potentials and Their Economic Implications

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There has been a long felt need to establish goals or production potentials for Minnesota crops. The reasons for such goals include:

1. Give farmers a better idea of what their soil can produce under good management.

2. Give all agricultural workers a concrete objective in planning a farm business.

3. Give industry an opportunity to base their sales and advertising on scientifically supported data.

Just what yields should farmers shoot for? Actually they might consider four levels:

1. **Maximum yield per acre**—Rarely if ever should a farmer shoot for this. Many times the added cost of getting these top yields is more than the dollar return from the extra yield.

2. **Highest net return per acre**—If a person has unlimited capital or can borrow heavily for capital, he should try for this. Here the last dollar invested in fertilizer would still give him a return equal to his investment.

3. **Highest return for last dollar invested**—If a farmer is partially limited in capital, he should invest his dollars wherever they give him the greatest returns. In other words, he should invest money in fertilizer only to the point where the return for the last dollar invested in fertilizer gives him as high a return as the investment elsewhere.

4. **Highest return per dollar invested**—If a farmer has very little capital, he should invest money in fertilizers in such a way that he obtains the highest possible return per dollar invested.

In discussing production potentials, we are assuming that fertilizer will be used where capital is moderately limited and where good management is practiced. In other words, we have set yields at a level where the last dollar invested in fertilizer will give more than $1.00 (a range of $0.50 to $2.00) in return.

Our discussion takes as an example an area including parts of 27 counties in south central Minnesota. The major crops are corn, oats, soybeans, and hay (table 1).

On the basis of this data the estimated net return from crops in this area is $58,615,200 for corn, a loss of $5,088,125 for oats, a net of $13,432,650 for soybeans, and a loss of $928,074 for hay. This would be an $8.00 net return per acre on the average.

In this area 152,000 tons or $12,160,000 worth of fertilizer is used. This is nearly half of all the fertilizer used in Minnesota. The average application per acre of crop land is only 37 pounds of fertilizer or approximately 15 pounds of plant food per acre.

Now that we have looked at present yields and returns, what is the potential of this area? Table 2 gives these potentials.

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* Extension soils and farm management specialists, respectively.

Table 1. Percentage of land in various crops, average yields, and estimated labor returns in south central Minnesota area

Crop	Land use	Average yield 1944-53	Returns*	
			Per acre	Per hour
	percent	bu.		
Corn	40	48	$18.00	$3.00
Oats	25	42	—2.50	—0.50
Soybeans	15	18	11.00	2.44
Hay	15	1.8	—0.76	—0.12
Other crops	5	.....	.....	.....

* Present prices, 1958.

Table 2. Production potentials of different soils in the south central Minnesota area*

	Well drained	Sands	Medium over sand	Poorly drained		Mucks	
				Some	None	Drained	Not drained
Percent of land	76	9	3	5	2	2	3
Corn, bushels per acre	90	50	75	55	0	80	0
Oats, bushels per acre	68	45	60	35	0	40	0
Soybeans, bushels per acre	30	18	25	20	0	27	0
Hay, tons per acre	3.5	2.0	3.0	3.0	.....	3.5	.....

* In order to obtain these yields, improved management practices and increased amounts of fertilizer are necessary.

Industry's Program

LAURIE PETERSON*

Every segment of the fertilizer industry—which include suppliers of basic raw materials, mixed fertilizer manufacturers, wholesale distributors, dealers, custom applicators—everyone connected with the total job of fertilizer distribution has a responsibility to maintain and build a high degree of prestige and respect for the fertilizer industry.

We need also to set up as our common objective: To help farmers maximize the return on their farm investments through the most intelligent and efficient use of commercial fertilizers as part of a sound soil management program.

Revolutionary changes have taken place in American agriculture. Forty years ago a farmer used $6.00 worth of goods and services and 26 hours of labor to produce one acre of corn. Today it takes 6 hours of labor and $26.00 worth of goods and services. With each succeeding year farms become more dependent on many different industries to carry on this increasingly more complex farming enterprise.

No generation in history has witnessed as great a scientific development in all branches of industry. Whether we like it or not, we are caught in this age of specialization and with it a greater interdependence on one another for our livelihood. This is true in our private lives, it is true in our civic life, and it is also true in the business community. This discussion of our role, recognizing this, will center on the mixed fertilizer manufacturer and dealer.

The fertilizer manufacturer is really the captain of our distribution team. The leadership responsibilities are really in his hands. Let's take a look at some of these responsibilities:

1. Improve quality so his product will be increasingly acceptable to the ultimate farmer patron.

2. Improve manufacturing techniques so he can manufacture commercial fertilizers at the lowest possible cost.

3. Improve delivery service, not only physically but also in timing.

4. Set up a dealer organization.

The fertilizer dealer is the most important link in our whole distribution team because he makes the all-important contact with the farmer. To be effective, he should:

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Nitrogen's Role in Production Potentials

PASTURES—

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Cool-season grasses such as bluegrass, timothy, and bromegrass grow rapidly in the spring and fall but are semi-dormant in midsummer. When grass becomes dormant in a pasture, weeds or legumes become dominant. Grazing pure stands of legumes is often hazardous due to bloat or other digestive disturbances.

Drouth, untimely grazing and clipping, and a lack of available nitrogen are important factors causing dormancy. Proper management precautions, however, will give greater grass yields in midsummer.

Management of cool-season grasses should start in late summer. A nitrogen topdressing of from 50 to 75 pounds per acre will stimulate growth during the moist cool weather. Such growth restores food reserves in the grass roots and results in many overwintering buds.

Stages of Development

The following spring these buds go through three stages: tillering, jointing, and heading. Since nitrogen intensifies the effect of mismanagement, the three stages must be identified for proper pasture management.

Tillering or stooling (early spring)—This growth arises from overwintering buds. Early nitrogen fertilization promotes early and vigorous growth from these buds. Food reserves are used to support this early spring growth. Consequently nitrogen, which stimulates growth, temporarily causes a serious depletion of the food reserves. This intensifies the need for precautions in management.

A single clipping or a short period of grazing during tillering will have little if any harmful effect. Continuous heavy grazing or frequent clipping, however, will eventually weaken the grass.

Jointing—This phase starts when the central stem of the shoot starts to develop. The young seed head and the active growing region lying just beneath it are raised to a vulnerable height above the soil. At this stage, a single low clipping will destroy this vital region. Death may result if this portion of the stem is destroyed because there is no adequate mechanism for regrowth. The food reserves are low. Consequently at the early-jointing stage, it is essential to control the height of grazing or clipping.

Grass becomes more tolerant to defoliation at the late-jointing stage because there is less demand for the daily supply of sugars manufactured by the leaves. In fact, there is excess sugars. These sugars are transported to the root system, and are used to support regrowth from new tillers following the harvest.

Heading—At head emergence the grass is ready for harvest. It can be clipped or severely grazed, and new tillers will give vigorous regrowth. There are two important advantages to complete utilization of the forage now. First, the grass has reached the point of highest yield of maximum quality. Further delay in grazing or mowing will only result in loss of protein and a decreased digestibility. Second, by destroying the seed heads we remove a source of naturally occurring hormones which retard or temporarily inhibit the development of the second crop of tillers.

To get best midsummer production, it is essential to destroy the seed heads at approximately head emergence. Then the second crop of tillers can grow and develop an entirely new root system before dry periods. Since the first crop of forage has removed most of the available nitrogen and potash, it is very important to liberally topdress with these elements.

Aftermath Management

The secret of obtaining good midsummer performances lies with the management of the second crop of shoots (often called aftermath). This growth is quite tolerant to a single clipping or a short period of intensive grazing after about 3 to 4 weeks of recovery. However, after 5 weeks of recovery. However, due to jointing after 5 weeks of recovery, extreme precautions must be taken to control the grazing or clipping height.

An account of recommendations in connection with turf will be included in a later issue.

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SMALL GRAINS—

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Small grains occupy an important spot in the economy of the upper midwest. From 23 to 30 million acres are usually devoted to wheat, barley, and oats in Minnesota, North Dakota, and South Dakota. In 1957, these states produced about 9 million acres of wheat, 5 million acres of barley, and 9 million acres of oats. This is 38 percent of the total harvested acreage of all crops in the three states.

Yields of these crops in Minnesota, North Dakota, and South Dakota for the 10-year period, 1944 to 1953, and for 1957 are presented in table 1.

These yields, even for 1957 which was a "good" year, are fairly low in comparison to the wheat yields of 40 or more bushels per acre, barley yields of 60 or more, and oat yields of 100 or more bushels per acre which are reported from some farms and in experimental work in the area most years.

In North Dakota, during the period, 1952 to 1957, the average yield of wheat from the best treatments in 64 fertilizer trials over the entire state on nonfallow land was 25.9 bushels per acre. Many of these were on farmers' land. The highest statewide average yield of wheat (much of which is grown on fallow) for any year during the period was 18.8 bushels per acre in 1957. During this year, the average yield of wheat from the best treatments in 19 fertilizer trials on nonfallow land was 34.0 bushels per acre. All this indicates that small grain yields in this area are falling far short of those which are possible.

Soils Nitrogen Deficient

The results of fertilizer trials over the past several years indicate that many soils do not supply amounts of available nitrogen adequate for maximum production of small grains. In North Dakota, 92 nitrogen fertilizer trials with wheat on nonfallow land

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Table 1. Yields of wheat, barley, and oats in Minnesota, North Dakota, and South Dakota, average 1944-53 and 1957

State	Wheat		Barley		Oats	
	1944-53	1957	1944-53	1957	1944-53	1957
	bu. per acre					
Minnesota	17.2	22.6	26.2	25.0	37.9	42.0
North Dakota	13.2	18.8	21.1	21.5	28.0	32.0
South Dakota	12.0	20.2	19.1	23.0	30.1	35.0

were conducted during the period, 1948 to 1957. Some 34 of these trials involved two or more rates. In these, 10 failed to show profitable response, 12 gave maximum return from rates of 20 or 30 pounds of N, and 12 gave greatest profit from rates of 40, 50, or 60 pounds of N. The results of these trials indicate that a 25 to 30 pound application of N is a good average recommendation on non-fallow land in western North Dakota and that 30 pounds or more should be used in eastern North Dakota.

In sharp contrast to the recommended rates is the pitifully small amount of fertilizer nitrogen currently being used on small grains in North Dakota. The average rate of application of N on the fertilized portion was 3 pounds per acre of wheat and barley and 2 pounds per acre of oats.

Our estimates are that 10 pounds of N give an increased yield of 1.4 bushels of wheat, 4.0 bushels of barley, and 3.0 bushels of oats under present conditions. These figures are based on 92 wheat trials and 15 barley trials. The one for oats is pure speculation, but it probably is very conservative.

Additional potential production of small grains can be realized by use of nitrogen fertilizer and modern weed control techniques to eliminate much of the summer fallow now used in North Dakota.

What has been said about North Dakota probably applies, with certain modifications, to Minnesota and South Dakota. In 1954, in Minnesota 31 percent of the wheat received an average of 7 pounds of N per acre, 11 percent of the oats received an 11-pound application, and 27 percent of the barley got a 5-pound treatment.

FORAGES—

PAUL M. BURSON*

Nitrogen fertilizer has been the forgotten nutrient in the production of quality forages. It has sensitive reaction to different forage species, and its responses are governed by soil and moisture conditions. Consequently its use and management may become a specific problem as compared to other kinds of fertilizers.

Forages, the same as other crops, require a definite nutritional balance of lime, nitrogen, phosphate, and potash. However, in fertilizing and managing forages, most of which may be mixtures, specific consideration must be given to the use of each fertilizing nutrient as to rate and time of application. When mixtures of legumes and grasses are used, the fertilization becomes somewhat more complicated than that of one individual crop.

Proper or improper fertilization can change the actual forage composition regardless of the kind of legume-grass mixtures used. At the University of Minnesota, Agricultural Experiment station, Rosemount, an addition of at least 60 pounds of N per acre can change a 70-30 percent legume-grass mixture to a 70-30 percent grass-legume. This is important in producing more and better hay, especially in the control of bloat when used for pasture.

In 1957, consistent bloating occurred in steers grazing on unfertilized pastures compared to very little on fertilized pastures. This difference could be the results of the change in the legume-grass mixture to a higher composition of grasses or the possible change in the chemical composition of the forages consumed. More information on this phase is needed. Today no one seems to know how to control or prevent bloat.

The use of nitrogen on bluegrass pasture increases both yield and protein content. General observations on the average old permanent bluegrass pastures of Minnesota seemed to indicate that at least 100 pounds of N per acre is essential. We must not lose sight of the essential need of lime, where needed, phosphate, and potash. If these nutrients are forgotten or are improperly used, nitrogen's value will be lost.

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CORN—

JOHN M. MacGREGOR*

From 1866 to 1875, Minnesota corn yields averaged 31 bushels per acre. Nearly three quarters of a century later, 1930-39, the average was about the same. In the thirties fertilizer use was small. Then for 1940-49, average corn yields increased 12 bushels to 42 bushels per acre. More ample rainfall, general acceptance of hybrid corn, and fertilizer played an important part in this increase.

From 1949 to today corn yields have averaged 48.6 bushels per acre. This has been accomplished not by the introduction of higher-yielding corn hybrids but rather by better soil management, involving the average annual use of 296,000 tons of fertilizer.

During the past 10 years, the use of nitrogen in Minnesota has climbed 712 percent from 4,537 to 36,850 tons annually. During the last three years, however, sales have not increased as phenomenally as in the early fifties. What then is the future of commercial nitrogen in the area?

Field corn and pasture offer the greatest return from nitrogen. Assuming that half our present acreage (6,000,000 acres) of the two crops could profitably use 60 pounds of nitrogen per acre annually, the annual average consumption of nitrogen would be 180,000 tons, about five times our present usage.

Fall Fertilization

During the past 8 years, 51 of our field experiments have dealt with fall-applied fertilizer for corn, oat, and hay crops. Thirty-five tested solid fertilizer materials as mixed goods; 16 dealt with the four forms of the straight nitrogen fertilizers now widely available. Generally fall application was as effective as spring application on the medium- to fine-textured soils of Minnesota.

Fall fertilization, however, has not become popular in Minnesota for several reasons:

1. It means an investment a full year before the crop is harvested.
2. Late spring sidedressing allows the farmer to determine if his corn stand warrants the application of additional nitrogen.
3. By late June, the farmer often knows what prices will be paid for his corn.
4. Too often fall fertilizer price automatically becomes the spring price.
5. It does not allow accurate placement of fertilizer and unless a farmer is well supplied with capital and is a relatively far-sighted manager, he will tend to defer the purchase of fertilizer as late as possible, even though it may be more troublesome to apply it later.

Spring Application

We conducted several experiments to compare applying nitrogen in late April, late May, and late June to see if early application favors yields or stimulates undesirable additional corn suckers. We tested 60-pound applications of anhydrous ammonia on 10 fields in 1954, of ammonium nitrate on 5 fields in 1955, and of urea on 5 fields in 1956. Except for one field in 1954, we also applied starter fertilizer. Ten days after planting we fertilized with 200 pounds per acre of 0-20-20. Table 1 shows the results.

In all three years, nitrogen and additional phosphate and potash increased yields significantly and in two of three years, nitrogen increased yields significantly. Consequently in most years, medium- to fine-textured soils can be fertilized with nitrogen when conveni-

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Putting Soil Fertility Facts to Work

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Team work is the secret of success. Agricultural science is progressing entirely too fast for any one individual or group of individuals to keep abreast with all developments. Efficiency is the keynote of progress. Progress is measured, this day and age, in return per acre, return per hour of labor, and return per dollar invested. In other words, farming has now become a business. Those who prosper must farm with brains instead of with brawn.

The team in American agriculture I am talking about in connection with nitrogen use is composed of the research agencies, both public and private, the educational agencies, again both public and private, the manufacturer of fertilizer, the sales force, and the farmer.

Farmer Is Boss

The key individual in this team is the farmer. He is the boss. If he prospers all other members of the team should prosper. If he fails financially, the other members of the team are doomed.

All members of our team must keep the profit angle in clear focus if we are to put soil fertility facts to work on the farm. The number one requirement of any practice is that it prove profitable first to the big boss, the farmer, and second to all other team members.

The farmer is not interested in yields per se, but he is interested in profits per unit of production. This means that research and educational agencies must go beyond just collecting and talking about yield data. They must translate the yield data into economic data. This has at least two advantages. First, it puts the results in terms that the growers understand, and second, it indicates that it is false economy to recommend that fertilizer applications be held below the optimum rate to play it safe.

Colleges Have Influence

Many commercial concerns fail to recognize the tremendous influence that college staffs have on farm practices. The National Plant Food Institute recently hired a first class public opinion survey outfit, National Analysts, to conduct a survey to find out what factors influence farmers to or not to use fertilizers. One portion of the questionnaire asked, "What source of fertilizer information is most practical?" Raoul Allstetter showed preliminary data for Oregon, Washington, and Montana, at the Northwest Plant Food Association meeting last October. Here are the approximate ratings:

County agent	100%
Agricultural college publications	70%
Neighbors	40%
Local farm magazines	30%
National farm magazines	15%
Newspapers	5%
Radio and T.V.	1%
Other	1%

To double check, another question was also asked. It was, "What source gives the most impractical fertilizer information?" The results tallied out about as follows:

Manufacturers' salesmen	100%
Nonclassified sources	80%
Newspapers	45%
Radio	40%
T.V.	40%
National farm magazines	40%
Local fertilizer dealers	30%
Neighbors	30%
Agricultural publications	15%
Local farm papers	10%
County agent	10%

If these data are any way near correct, they show why team work between the research-educational agencies and the fertilizer industry is necessary for putting soil fertilizer facts to work on the farm.

Not Nitrogen Alone

As nitrogen producers we must never forget that nitrogen alone, on a field deficient in phosphate and/or phosphate and potash, is not a paying proposition to farmers. To sell a farmer on such a plan of straight nitrogen is a sure way to keep farmers feeling that salesmen give unreliable information and also a sure way to have an unsatisfied customer—even lose a customer. On the other hand, to sell a mixed fertilizer high in phosphate and potash on land abundantly stocked with phosphate and potash is not the correct approach for gaining and holding customers.

Many manufacturers often times become disturbed by the more or less general recommendations given by our universities to the effect that a pound of nitrogen is a pound of nitrogen, and the farmer should buy the one he can get the cheapest. This may not always be true. Growth conditions under actual farming operations vary widely, however. The wide awake manufacturer can capitalize on the merits of his particular product and demonstrate to farmers that a pound of nitrogen is not necessarily a pound of nitrogen. Every nitrogen product has certain advantages and when used to take advantage of these properties is superior to other sources.

Let me explain. In sulfur deficient areas, ammonium sulphate is far superior to ammonium nitrate per pound of nitrogen because of its sulfur content. On the other hand, ammonium nitrate applied to a quick growing crop, when the soil is cold, will chalk up a better record than will ammonium sulphate if there's no sulphur deficiency.

A man who fully understands the properties of his product can program the use of his fertilizer to make the big boss, the farmer, the maximum profit. The best sales tool is knowledge of product and product performance. In other words, how much to use and when and how to apply.

Selling Service

Service selling, for greatest profit, is of real value to the farmer. Sure, such service cost money, but it makes profits for the farmer.

It's time we sell results (or profits) not pounds of nitrogen. The old and still used approach of cost per ton or pound must give way to return on investment for the fertilizer industry to raise itself to the position we deserve.

If we can plant in the minds of all our team members that a reasonable profit is paramount in all operations we can put soil fertility facts to work on farms. The reason is that this will mean that each material sold will be properly programmed to take advantage of its individual merits. Yield per acre and cost per ton of fertilizer will become secondary to return on investment. When this is done our fertilizer industry will come of age and take its proper place as a chemical industry.

There will also be realization on the part of the farmer, actually spearheaded by our university friends, that service is worth money if this service can put soil fertility facts to work on the farm.

SCARSETH ADVICE TO INDUSTRY . . . Sell farmers on top management practices for efficient and low cost production, and the use of nitrogen will become the easiest of all the production practices to sell.

* Chief Agronomist, California Spray Chemical Corporation, Richmond, California.

Production Potentials

(Continued from page 3)

Table 3 gives the fertility level of soils in the area and table 4 the plant food needs to reach the potential given in table 2.

Table 3. Present fertility level of soils in south central Minnesota area

	Low	Medium	High	Very high
	percent			
pH	35	.....	.....	.....
Phosphorus	20	40	20	20
Potassium	3	56	15	26
Organic matter	27	48	10	15

On this basis (table 4) the area would need 258 million pounds of nitrogen, 250 million pounds of phosphate, and 128 million pounds of potash. This is about five times the total now being applied, or a total of an average of $8.00 per acre.

Thirty-five percent of the land in this area is also lime deficient and needs approximately 2 tons of lime per acre, adding another big need. This would cost $2,000,000 a year.

Table 4. Average plant food needs per acre to obtain production potential in the south central Minnesota area

	Nitrogen	Phosphate	Potash
	pounds		
Corn*	75	50	45
Soybeans	.....	.....	.....
Oats	20	33	24
Hay	.....	33	24
Corn†	50	30	25

* On soils of high potential.
† On soils of limited potential.

Net crop returns can be increased in these 27 counties from $66 million at present to $163.1 million through proper use of fertilizer and efficient crop management. The additional fertilizer would cost $54,000,000 and lime $1,700,000. This would increase farm returns $100,000,000. This indicates that for every dollar spent on fertilizer we can expect $2.00 of extra profit.

What's more, these estimates are being made on the basis of cash crops. Many of these crops can be used as livestock feed and in that way give additional income.

Table 5. Potential yield and labor returns from average fertilizer applications shown in table 4 on high-yielding and limited-yielding soils

Crop	Type of soil					
	High	Limited	High	Limited	High	Limited
	(yield per acre) bushels		(return per acre)		(return per hour)	
Corn	90	60	$35	$20	$6.00	$4.00
Oats	68	45	6	.....	1.20	.....
Soybeans*	30	22	30	19	7.00	4.50
Hay	3.5 tons	2.5 tons	20	10	3.33	1.70

* Soybeans benefit from fertilizers on other crops. No charge made for that with this table.

Nitrogen's Role---Corn

(Continued from page 5)

ent either in the late fall or during spring.

In the same studies we found that the application of 60 pounds of nitrogen at the various times did not increase sucker production in either July or late September.

Heavy Fertilization

We studied the effect of heavy nitrogen fertilization on corn yield, maturity, and suckers development in 1955 and 1956. We applied nitrogen late in May to six corn fields (five, ammonium nitrate and one, anhydrous ammonia) at 60, 120, 180, and 300 pounds per acre, both with and without additional phosphate-potash (0-40-40) in 1955, and again to five additional fields (urea) in 1956. See table 2. With the exception of one field of Anoka loamy fine sand in both years, all soils were of medium texture and all were starter fertilized.

Although yield increases varied between fields, late May application of nitrogen increased yields substantially. The lowest rate of N application (60 pounds) is probably the most profitable.

Table 2. Effect of rate of nitrogen application on the average yield of ear corn, May 1955 and 1956

Pounds of nutrients per acre above starter	Ammonium nitrate or anhydrous ammonia 1955	Urea 1956
	bu.	bu.
None	88.3	81.2
	Increase	
0-40-40	—1.5	1.3
60-0-0	12.3†	22.5†
60-40-40	14.0†	23.0†
120-0-0	6.4*	30.3†
120-40-40	13.4†	29.4†
180-0-0	13.2†	30.4†
180-40-40	15.8	32.3†
300-0-0	12.1†	30.9†
300-40-40	13.7†	36.2†
* Significant (5 percent)	5.7	13.6
† Significant (highly)	7.6	18.2

Corn maturity is usually based on moisture content of the ear corn at the close of the growing season. However, we had to harvest in late September, earlier than usual. This still gives a valid comparison (table 3).

Table 3. Effect of rate of nitrogen application in late May on moisture content of ear corn in late September

Pounds of nutrients per acre above starter	Percentage moisture	
	1955	1956
None	36	40
0-40-40	37	40
60-0-0	36	38
60-40-40	37	37
120-0-0	36	38
120-40-40	35	39
180-0-0	35	39
180-40-40	35	39
300-0-0	36	39
300-40-40	35	39

Even the heaviest of nitrogen application (300 pounds per acre) did not increase moisture content.

There was little effect of heavy nitrogen fertilization on sucker numbers on these experimental fields.

Conclusions

1. Much more nitrogen must be used to approach yield potentials of our soils.

(Continued on page 8)

Table 1. The effect of applying 60 pounds of N per acre as anhydrous ammonia (1954), ammonium nitrate (1955), and urea (1956) in April, May, and June on yield of field corn in Minnesota

Pounds of nutrients per acre above starter	Anhydrous ammonia (1954)				Ammonium nitrate (1955)				Urea (1956)			
	Average yield	Average increase 0-40-40	N alone	N + 0-40-40	Average yield	Average increase 0-40-40	N alone	N + 0-40-40	Average yield	Average increase 0-40-40	N alone	N + 0-40-40
	bu. per acre				bu. per acre				bu. per acre			
None	85.6	.....	.....	.....	88.5	.....	.....	.....	81.2	.....	.....	.....
0-40-40	87.2	1.6	.....	.....	88.9	1.4	.....	.....	83.5	2.3	.....	.....
60 N in April	90.1	.....	4.5	.....	101.2†	.....	12.7	.....	89.2†	.....	18.0	.....
60 N in April + 0-40-40	95.5*	.....	.....	9.9*	101.0†	.....	.....	12.5	98.4†	.....	.....	17.2
60 N in May	91.5	.....	5.9	.....	99.5*	.....	11.0	.....	103.7†	.....	22.5	.....
60 N in May + 0-40-40	97.7*	.....	.....	12.1*	103.1†	.....	.....	14.6	104.2†	.....	.....	23.0
60 N in June	94.6	.....	9.0	.....	99.6*	.....	11.1	.....	102.6†	.....	21.4	.....
60 N in June + 0-40-40	99.4*	.....	.....	13.8*	100.0†	.....	.....	11.5	102.8†	.....	.....	21.6

* These increases are statistically significant. For 1954, L.S.D. (5 percent level) was 9.5 bushels; 1955, 8.3; and 1856, 9.7.
† These increases are highly statistically significant. For 1955 L.S.D. (1 percent level) was 11.2 bushels and for 1956, 13.0.

Nitrogen and the Life of the Soil

E. L. SCHMIDT*

Nitrogen, of all the nutrients plants obtain from the soil, is most intimately linked to the life of the soil. Microscopic life in the soil is critically dependent on a supply of nitrogen.

A few forms obtain their nitrogen from the atmosphere and are very important in adding to the supply of nitrogen available to all life. The other forms use nitrogen compounds in the soil in the course of activities that make nitrogen and other nutrients available to crops, build organic matter, and interact in many ways with soil fertility.

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As nitrogen reaches the soil with plant and animal residues, it is locked up in complex combinations that cannot be used by plants. As microbes grow in the soil and feed on the residues, the complex combinations are broken down. Some of the nitrogen goes to feed the microbe; the rest becomes available to the crop. Recognition of these activities of microorganism can help manage nitrogen (a) to make it available to crops, (b) to protect it from run-off or leaching loss, and (c) to avoid competition between the microbes and the crop for soil nitrogen.

The addition of fertilizer nitrogen to the soil must be practiced with an awareness that microbes use and change nitrogen. Crop residues low in nitrogen tie up soil nitrogen as the microbes feed. To convert a ton of cornstalks into active soil organic matter, 30 to 40 pounds of nitrogen are needed, and the residue itself contains only about 10 pounds. The deficit must come from the soil or must be added as fertilizer. Soils well supplied with nitrogen reserves may easily meet these demands of the soil life. But soils that are low or moderately low in nitrogen will need fertilizer nitrogen to insure rapid breakdown of the cornstalk residue and to insure against nitrogen shortage for the growing crop.

The few organisms that can fix atmospheric nitrogen are of immense importance to the whole biological economy of nitrogen. New forms of nitrogen-fixing microorganisms have been described in recent years, but little is known of the practical effect that these forms have. Certain forms of soil life are known to contribute to the loss of soil nitrogen due to life activities that release inert nitrogen gas back to the atmosphere.

Nitrogen's Role---Corn

(Continued from page 7)

2. Nitrogen can be applied profitably to corn on many more Minnesota farms. However, not all fields will respond, and care should be observed in making recommendations. By using soil test, knowing previous management, and considering the crop, nitrogen will give profitable returns on most fields.

3. There has as yet been no field evidence of overwinter losses of late-fall-applied nitrogen.

4. Nitrogen applied at rates of 60 pounds per acre either in April, May, or June produce about the same increase in corn yields provided the soil is not seriously deficient in available nitrogen.

5. Ample supplies of available phosphate and potash must be present in the soil to utilize the added nitrogen.

6. The 60-pound per acre rate of nitrogen is probably more profitable at present than 120-, 180-, or 300-pound rate.

7. Nitrogen applied at rates as high as 300 pounds per acre did not substantially increase moisture content.

8. Applications of nitrogen at rates of 60, 120, 180, and 300 pounds per acre had no effect on the number of suckers.

9. A good corn population is essential for efficient use of applied nitrogen.

10. Residual nitrogen effect is often observed on the yields of following crops such as corn, oats, and flax. In most fields, soybeans do not respond to nitrogen applied to the soil the preceding year.

Industry's Program

(Continued from page 3)

1. **Offer a complete fertilizer service** including a bagged fertilizer program (warehousing, farm delivery, records), bulk fertilizer spreading service, and a sidedressing or preplant program with either ammonium nitrate, nitrogen solutions, or anhydrous ammonia.

2. **Sell a sound fertility program**—This would include soil test, adapted seed varieties, stepped-up plant population, liming (where necessary), fertilization according to soil test, insect and weed control, and preplant or sidedress application of a straight nitrogen material.

3. **Set up a training program** including the dealer, employee, and salesmen to grasp a good understanding of the product itself and how to help farmers get the maximum return from their fertilizer dollar. It would also include conducting farmer meetings.

4. **Advertise**—Supplement mass media advertising by major fertilizer companies with local dealer advertising.

5. **Merchandise better in the store**—This includes fertilizer displays, bulletin board, card file records for each patron, and taking advance orders.

6. **Set up demonstration plots**—Successful fertilizer dealers will testify demonstration plots sell fertilizer. All it takes is sound planning, a little cooperation, and a small expenditure.

We have a responsibility to maintain and build a high degree of prestige and respect for the fertilizer industry. We have as our objective to help farmers maximize the return on their farm investments through the most intelligent and efficient use of commercial fertilizers as part of a sound soil management program. This is our "Success Formula." Actions speak louder than words. Let's as an industry activate this program.

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