MINNESOTA FEED SERVICE

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Chemicals for Weed Control in Corn and Soybeans

H. J. OTTO and R. BEHRENS*

A successful weed control chemical should (1) control weeds without damage to the crop or succeeding crops in the rotation, (2) be safe to apply, (3) not accumulate in the crop plant in qualities that might harm humans or animals, and (4) be economical. Thousands of chemicals must be tested to find one that approaches these specifications.

Promising herbicides are evaluated in research and demonstration plots in Minnesota. These trials show the performance of the herbicides under many different soil and climatic conditions in the state.

Pre-emergence Herbicides

Practically all of the recently introduced herbicides are applied to the soil after the crop has been planted but before it emerges. Applications made at this time are called pre-emergence applications.

The effectiveness of chemicals taken into the plant from the soil is more dependent upon soil type and rainfall than where the chemical enters the plant through the foliage. Hence, results are often more erratic with pre-emergence chemicals than with those applied to the foliage. At least ½ inch of rainfall is needed within 2 weeks after application if the chemicals are to be effective.

Pre-emergence applications of herbicides offer many advantages:

(1) The chemical can be applied as part of the planting operation, thus saving a trip over the field. This saves time and money. In addition, rainfall often delays post-emergence spraying and cultivating beyond the proper time for these operations.

(2) Early season competition between corn and weeds is reduced. Corn can then get off to a fast, vigorous start.

(3) The first cultivation can often be delayed. More time is then available for other farm operations such as putting up high quality hay. Research has shown conclusively that hay crops cut in the early-bloom stage are much higher in feed value than when cut at later stages of growth.

(4) The number of cultivations may be reduced. Savings in time, money, and soil compaction result from fewer cultivations.

(5) Weeds in the row can be controlled much more effectively than where cultivation is the only means of weed control. Pre-emergence chemicals allow the control of annual grasses. This was previously impossible without wire checking the corn and cross cultivation.

Most of the pre-emergence herbicides are available for application with either a granular applicator or sprayer. Granules are more convenient to apply, but cost somewhat more than liquid or wettable powder forms.

The effectiveness of the two forms is comparable on the average if both are applied uniformly.

Widely Tested Chemicals

Some of the chemicals tested widely in Minnesota are discussed below. The rates given are for broadcast applications. Proportionately lower rates should be used for band applications. Instructions on the container should be followed closely.

CDAA (Randox) controls annual grasses for 4 to 6 weeks after application. It can be used in corn and soybeans. It should be applied at the rate of 4 pounds active ingredient per acre. Randox is very irritating to the skin and eyes and should be handled with caution.

CDAA-T (Randox-T) has shown promise for controlling both annual grasses and broad-leaved weeds in corn for 4 to 6 weeks after application. The rate of application is 4½ quarts of liquid product or 30 pounds of granules per acre. This chemical is relatively new and has been widely tested in Minnesota only 1 year. Like Randox, it should be handled with caution.

Simazine and Atrazine control both annual grasses and broad-leaved weeds in corn. They should be applied at 2 to 4 pounds active ingredient per acre. The lower rate may be used on light textured soils while the heavier rate will be needed on heavier textured soils or soils with high organic matter content.

Both Simazine and Atrazine are sold as wettable powders for spray application. Granular Atrazine has been effective, but granular Simazine has not.

Under some conditions, residues of these chemicals have caused damage to other crops following corn in the rotation. This is most likely to occur when rainfall is low than where ample moisture is received.

2, 4-D (ester) has been used for pre-emergence weed control in corn, but is not recommended. It has caused serious damage to corn and weed control is less dependable than with other chemicals. The use of 2, 4-D as a post-emergence application in corn for controlling broad-leaved weeds is highly recommended.

Amiben has shown a great deal of promise for controlling both annual grasses and broad-leaved weeds in soybeans. It can be used only in seed production fields since it does not have label clearance for use on commercial soybeans.

Alanap has given very erratic results on soybeans. Weed control has not been consistent and soybeans are sometimes damaged by the chemical.

Complete Weed Control Program

An effective weed control program should include cultural practices such as the preparation of a good seedbed and timely and effective cultivation. The chemicals discussed here serve as additional tools but can not, at present, replace the cultural practices. A complete weed control program should include both.

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* Extension agronomist and associate professor, Department of Agronomy.

The Latest on Nitrates

Nitrates and nitrate poisoning are causing increased discussion in agriculture today. Here we review several aspects of the subject.

Environment Influences Nitrate Content in Plants

LAWRENCE H. SMITH*

Nitrate is the form of nitrogen that is taken up from the soil in greatest quantity by plants and ordinarily is quickly converted to protein. A small amount of nitrate (up to one half of 1 percent of the dry matter) exists in many crops at some time during their growth. High levels of nitrate (greater than 1 percent of the dry matter) which may be harmful or toxic to livestock when the plant is eaten are found only under unusual circumstances.

We do not completely understand the conditions which change a normal plant absorbing nitrate to synthesize protein, into one which is potentially dangerous because it has too much nitrate.

Drought is one of the major environmental conditions that leads to high nitrate concentrations in plants. Most plants are highest in nitrates when they are actively growing. Thus it is at this stage that a drought will lead to a plant high in nitrate. In addition, the severity and length of the drought are important.

Nitrate content of the soil also influences nitrate accumulation. Work at Cornell University and at South Dakota has shown that even in those species that tend to accumulate high levels of nitrate (oats is an example) very high concentrations of nitrate must be in the soil to cause more than a small quantity of nitrate to accumulate in the plant. Except under droughty conditions, oats used for pasture, hay, or silage ordinarily can be fertilized with up to 75 pounds of nitrogen per acre without danger of excess nitrate. This factor is considered in more detail in the article by J. M. MacGregor in this issue.

Light has a very dramatic effect on nitrate accumulation. The plant needs energy from sunlight to convert nitrates to amino acids and protein. A lack of sunlight, therefore, results in an accumulation of the nitrate taken up by the plant. On the farm, plants growing in continuous shade from trees could accumulate large amounts of nitrate. However, these plants probably represent only a small part of the total dry matter from fields of harvested forage. Therefore, shade is usually only a minor factor in the practical problem of nitrate accumulation.

Other factors, such as hail and wind damage, or other conditions which tend to disrupt the normal growth of the plant and cause abnormal plant development can produce high nitrate concentrations under the proper circumstances.

All plants will not accumulate nitrate to harmful or toxic levels under abnormal environmental conditions. Plants that contain harmful levels of nitrates under the conditions we have mentioned include: Corn, sorghum, sudan grass, cereals (oats, wheat, barley, rye), soybeans, and many weeds (especially redroot pigweed). The common forage legumes and grasses (clovers, alfalfa, bromegrass, timothy, etc.) are seldom accumulators of high nitrate concentrations even under the same conditions which lead to high nitrate concentrations in the accumulator plants.

It is not enough to know which plants are likely to contain high concentrations of nitrate. We need to know in what part of the plant the nitrate is likely to be concentrated. Nitrates are taken up through the plant roots and move up the stem to the leaves where they are converted to protein. In the mature plant, the nitrate content of the stems is usually higher than that of the leaves. On the other hand, the grain itself is very low in nitrate but high in amino acids and protein.

Grains, therefore, probably would not cause nitrate injury to animals. The grassy crops (corn, sorghum, sudan grass, and cereals) have their highest concentration of nitrates in the lower portions of the stem. In corn it is frequently concentrated in those areas of the stem below the ear. Soybeans, however, have their greatest concentration of nitrates in the upper parts of the plant.

In the final analysis of the conditions and the relative influence of these conditions upon nitrate accumulation in plants, the following factors should be considered:

1) The stage of growth of the plant when subjected to those conditions. Plants which are growing actively have the greatest potential for high nitrate concentrations.

2) The duration of the abnormal condition. A drought of a week is far less dangerous to nitrate accumulation by plants than one of longer duration.

3) High nitrate content of the soil. A high content of nitrate in the soil can result from heavy nitrogen fertilization as well as from very heavy applications of manure or in soils unusually high in organic matter.

By considering these three factors one can predict, with some accuracy, the status of the plant with respect to nitrates under adverse conditions.

* Assistant professor, Department of Agronomy.

Soil and Fertilizer Influence Nitrate Content in Plants

J. M. MACGREGOR*

Nitrogen is essential to all life, whether plant or animal. In plants it enters the structure of chlorophyll, the amino acids, amides, alkaloids, protein, and protoplasm. Fortunately it occurs mainly in organic combination which is not toxic to animals. Usually there are only traces of the inorganic ammonium, nitrate, or nitrite forms present. Plants take up nitrogen from the soil in one or more of these inorganic forms which, under normal growing conditions, is rapidly converted into organic nitrogen compounds. Severe droughts interrupt this conversion and may allow a build-up of the inorganic nitrate to levels toxic to animals. This interruption is more serious when the plant is growing rapidly.

Most nitrogen in the soil is also present as organic compounds. The inorganic forms such as nitrates and ammonium are the forms available to plants and seldom exceed 100 parts per million in the soil (less than 1 in 10,000 parts).

It is frequently desirable for a farmer to increase this supply of available native soil nitrogen by applying farm manure or by growing legumes, or by fertilizing with a commercial nitrogen fertilizer. A reasonably good addition would be 100 pounds of nitrogen per acre and this increase would be adding approximately 50 parts per million of nitrogen to the surface soil. This would mean a 50-percent to 100-percent increase in the level of inorganic nitrogen in many farm soils. If the nitrogen was supplied in farm manure or by legume growth, only a part of this would be mineralized to nitrate form at any one time. Eventually, however, all of this must pass through the mineral form before it becomes available.

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* Professor, Department of Soils.

Here we are mainly concerned with nitrate content of fodder crops most likely to be fed in the green condition, such as corn or oats, even though many pasture grasses and weeds may contain relatively high nitrate levels under normal growing conditions. Since corn is the crop most likely to be treated with the heaviest nitrogen treatments, this crop is presently our chief concern in Minnesota.

Unless there is a reasonable supply of available nitrogen (either as the nitrate or as ammonium) present in the soil, the growth of nonlegume crops will be seriously reduced and yields will be substantially less than economically desirable. There will be a normal conversion of inorganic to organic nitrogen compounds taking place within the plants under normal growing conditions.

The presence of ample (and even very large) concentrations of available nitrogen in the soil will increase the nitrogen content of most nonlegume plants some. However, this increase will be essentially all in organic forms and these higher proteinaceous plants can be fed to livestock at any time with little or no danger. During droughts, care should be taken in the feeding of all forages grown on soils high in available nitrogen, especially during late June, July, and August.

The farm operator is faced with two choices. One, he can supply ample nitrogen to his soils for optimum crop production and use care in feeding if drought conditions arise. Or two, he can let his available soil nitrogen run low and be willing to accept much lower yields of low-protein nonlegume crops. Under present economic conditions, few can afford to take the latter choice, especially when reasonable precautions can essentially remove the feeding hazard. An analogy may be made to our universal use of gasoline, even though it is extremely explosive in nature. In the same way, the maintenance of a good supply of available nitrogen in the soil is an essential to economic crop production, and the hazards of dry weather and nitrate accumulation in forage can be avoided.

Effect of Sodium Bisulfate on Nitrate Content of Silage

JOSEPH SCALETTI*

Nitrates have caused such problems as blue babies, silo gas poisoning in humans, and poisoning of animals. In this article we trace how nitrates form in some plants and how this affects human and animal health.

Fortunately most of this trouble can be avoided by careful feeding of forages and by adding sodium bisulfite in the silage-making process.

What's Involved

The common forages, barley, wheat, rye, corn, and hay, sometimes contain enough inorganic nitrate to be toxic to animals. The degree of nitrate accumulation in plants varies widely and is affected by several environmental factors such as drought, soil deficiency, soil nitrate content, degree of shading, and use of herbicides.

Sometimes, for example, these forage crops accumulate high levels of nitrate during early growth. As the crop approaches maturity it assimilates nitrates and changes them to other nitrogenous forms such as proteins and amino acids. If environmental conditions are adverse when the nitrate level in plants is high, the entire growth process may be disrupted and all the nitrates may not be assimilated to proteins and amino acids. Then they remain as nitrate up to the time the material is used as feed or ensilage.

It is difficult to give reliable information as to the level of nitrate in plants that could be lethal to animals since this varies with the nutritional state of the animal, size and type of animals, and the consumption of feeds other than nitrate-containing material. It would seem advisable, however, that forages with a nitrate nitrogen content of approximately 0.22 percent (1.5 percent as potassium nitrate) on a dry weight basis should be fed with caution.

Certain bacteria, occurring both in the rumen and in silages can reduce nitrates to nitrites. If this reducing activity comes when the animal is getting high levels of nitrate from feed, as salts, or from well water, the nitrite ion accumulates rapidly and extensively. The nitrites are readily absorbed into the blood causing the blood hemoglobin to be changed to methemoglobin. Methemoglobin can't supply the animal tissue with sufficient oxygen, and death results from asphyxiation.

Human Health Involved

The problem of nitrate poisoning in animals is somewhat related to the problem involving public health.

Well water containing more than 10 parts per million of nitrate nitrogen is considered potentially toxic for infants. Several cases of "blue babies" have been associated directly with consumption of well water high in nitrate conent.

Another problem involves human poisoning through inhaling silage gases from freshly filled silos. This has caused several deaths and serious bronchial or pulmonary disorders recently.

Nitrogen doixide gas is responsible for this condition. It is produced in the early stages of silage fermentation and is readily recognized by its pungent odor and yellow-brown color. Nitrogen dioxide gas is produced, in part, by silage microorganisms converting the plant nitrates to nitrites which, in the presence of lactic acid or other fermentation acids, exist as nitrous acid. The nitrous acid, which is unstable, decomposes rapidly to the noxious gases, nitric oxide, and nitrogen dioxide. Thus, the higher the concentration of plant nitrates in fermenting silage, the greater the concentration of noxious gases.

Many plants contain nitrates, particularly during drought or other adverse environmental conditions, and silage fermentations normally result in production of fermentation acids; consequently it would appear the production of nitrogen dioxide gas through nitrous acid decomposition is an inevitable consequence of silage making. The University of Minnesota, Institute of Agriculture, during the past 4 years, has studied the relationship of nitrate in forage material with subsequent production of nitric oxide and/or nitrogen dioxide gases. The University hopes to establish suitable means to prevent these gases from forming without hurting the feeding value of the silage.

Studies conducted during the summers of 1958, 1959, and 1960 with corn, oats, and alfalfa silages indicated that adding sodium bisulfite to the forage at the time of silo loading controls and prevents the formation of toxic gases, nitric oxide, and nitrogen dioxide from silage. Moreover, this step prevents these toxic gases irrespective of the initial concentration of nitrate present in the forage, the maturity of the crop, the application of nitrogen fertilizer, or the level of moisture in the material at ensiling time. Furthermore, sodium bisulfite treatment does not interfere with the reduction or disappearance of nitrate from the plant material through the ensiling process.

Work from the Iowa and Missouri experiment stations, as well as our own data, indicates that the ensilage process reduces nitrate content of forages.

In Iowa and Missouri work, this reduction was about 10 to 45 percent of the nitrate initially present in the forage and could, depending on the amount present, reduce the nitrate from a lethal to a sub-lethal level.

In our studies, we used laboratory silo units and controlled conditions of pressure, temperature, and anaerobiosis.

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* Assistant professor, Department of Animal Husbandry.

Here nitrate reduction ranged from a low of 50 percent to a high of 90 percent of the amount initially present. Under these conditions most of this reduction occurred in the first few days of ensiling.

The addition of sodium bisulfite to silage to prevent noxious gas production did delay reduction of nitrate for approximately 2 days. But by the fourth or fifth day the extent of reduction was equivalent to that of untreated forages. Consequently, we anticipate no additional problem in the feeding of bisulfite treated silage to animals with regard to the possibility of such material contributing to nitrate poisoning. These studies, however, are not complete and we intend to assess more completely bisulfite treated silages with respect to both toxicological and nutritional considerations.

Nitrate Poisoning in Livestock

O. E. KOLARI and R. M. JORDAN*

Nitrate poisoning or oat-hay poisoning in livestock has been recognized for years. For example, Kansas reported (1895) that cattle fed cornstalks grown on hog lot land were toxic. Corn had grown well early in the season, but drought stunted it in July. South Dakota reports in 1942 showed greatest losses from oat-hay poisoning occur from consuming oat-hay after a spring rain or thaw.

Forages from most farm grain crops, such as oats, wheat, barley, corn, and sorghums; pasture grasses; and numerous weeds can concentrate nitrate under certain conditions.

Symptoms of Poisoning

Accelerated respiration and pulse rate, diarrhea, frequent urination, depressed appetite, general weakness, trembling, staggering gait, frothing from the mouth, and a blue color of the mucous membranes, muzzle, tongue, and udder are symptoms of nitrate poisoning. Animals usually die within 4½ to 8 hours after eating lethal levels of nitrate.

Methemoglobinemia

Brown-colored blood is characteristic of cattle suffering from nitrate poisoning and actually may be the single best diagnostic tool. The brownish color of the blood is due to the formation of methemoglobin.

When an animal eats nitrate, it may be converted to nitrite in the rumen and absorbed into the blood stream. The nitrite oxidizes oxyhemoglobin to methemoglobin which cannot transport oxygen. The methemoglobin turns the blood brown. When about three-fourths of the oxyhemoglobin has been converted to methemoglobin, the animal dies. Actually death from nitrate is like asphyxiation or strangulation.

Nitrate Metabolism in the Rumen

South Dakota scientists (1942) demonstrated that nitrate in plants caused the losses from feeding oat-hay with a high nitrate content. Their data suggest that conditions in the rumen are best to reduce nitrate when all roughage rations are fed.

In another study English scientists (1951) showed that microorganisms change nitrates to nitrites to ammonia (NH_3) in the rumen. When they increased the dose of sodium nitrate from 12 to 25 grams, nitrate nitrogen and ammonia nitrogen levels in the rumen and methemoglobin values both increased sharply. They felt that when a certain concentration of nitrate in the feed was reached the rate of reduction of nitrite to ammonia was limited, thus causing nitrite to accumulate in the blood. In a Missouri study (1957) with sheep, an injection of nitrite produced symptoms of nitrate poisoning and nitrate did not. They concluded that nitrate in ingested feed must be reduced to nitrite by rumen flora and then absorbed into the blood stream as nitrite before methemoglobinemia occurs.

South African studies (1949) with sheep showed that nitrate in ruminal ingesta disappeared more quickly with a ration of alfalfa hay than of a poorer quality hay. Feeding glucose (a sugar) sped up conversion of nitrate to nitrite and then to ammonia. When alfalfa hay and about two-thirds of a pound of corn were fed to sheep, 50 grams of potassium nitrate (KNO_3) were required to produce the same effect as 20 grams fed with poor quality hay.

The Missouri Station (1958) noted that high-energy rations offset milk production losses when dietary nitrate content was not over 0.85 percent. Molasses and corn have been used successfully as energy sources, but they must be fed with that portion of the ration containing the nitrate. If nitrate is not reduced in the rumen or if completely reduced to ammonia, then there is little danger from nitrate poisoning.

Nitrate poisoning is not as severe when forages containing high amounts of nitrate are consumed slowly. Thus, you would expect that nitrates given as a drench or capsule would have a lower toxic level (be more toxic more quickly). Cornell workers (1960) suggest that sudden death is possible when a high concentration of nitrate—2 to 5 percent of the dry matter intake, or greater—forms the principal portion of the ration.

Toxic Levels of Nitrate

No single level of nitrate is toxic under all conditions. Cattle appear to be more susceptible than sheep, horses, or hogs, but there appears to be a marked difference in tolerance between animals of the same specie. Level of nitrate in the feed, kind of ration, and speed of nitrate intake all have a definite bearing on toxicity.

Early Wyoming studies (1940) estimated the minimal lethal dose of KNO_3 at 25 grams per 100 pounds liveweight. Thus a 500-pound animal eating 5.5 pounds of oat-hay having 5 percent KNO_3 would in effect be eating 25 grams KNO_3 per 100 pounds liveweight. Wyoming researchers reported a range of 2.2 to 7.3 percent KNO_3 in oat-hay or straw that had caused losses in cattle. Furthermore, they showed that cattle do not develop a tolerance to nitrate, enabling them to safely consume larger amounts of nitrate later.

Dairy Cattle

Missouri workers (1958) suggested maximum levels of KNO_3 on a dry matter basis and the expected animal response as follows:

Levels of KNO_3	Animal response
Percentage	
0-0.5	Normal, if on adequate rations.
0.6-1.0	Milk production decreases, slowly at first, increases after sixth to eighth week. Typical vitamin A deficiency symptoms in 6 to 8 weeks.
1.0-1.5	Milk production drops in 4 to 5 days. Reproductive difficulty over the period fed to several weeks after removal of feed.

Cornell workers (1960) sprayed sodium nitrate on hay at a rate to supply 45 grams per 100 pounds liveweight. Fifty percent of the total hemoglobin of the cattle was converted to methemoglobin. An antidote of methylene blue was necessary to prevent death in several animals.

Other experiments had shown that dairy cattle were near death when methemoglobin values were 50 percent or greater. They felt that 45 grams of nitrate per 100 pounds of animal would probably result in death of about one-half of the animals. They demonstrated

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* Assistant professor and associate professor, respectively, Department of Animal Husbandry.

that a mediocre ration offered some degree of protection. When a ration adequate in energy and protein was fed, the least injury to cattle was reported. Twenty-five grams nitrate per 100 pounds of animal (2.5 percent nitrate on a dry matter basis) did not reduce milk production or result in abortion. This level of dietary nitrate was much higher than would be likely with recommended rates of nitrogen fertilization.

Wyoming scientists (1940) set the lower limit for potentially toxic hay at 1.5 percent KNO_3, but in 1946 they cited reports of abortions in cattle occurring when feeds containing a range of 0-1.5 percent KNO_3 (average 0.45 percent) were fed.

In another experiment (Missouri, 1958) dairy cattle were fed 75 grams KNO_3 (0.075 percent) and 125 grams (1.25 percent) KNO_3. Milk production dropped. When 5 precent molasses was added to the ration, production returned to normal. Feeding 0.75 percent KNO_3 led to abortion in another trial and feeding 1.25 percent KNO_3 caused death within 3 weeks.

In Wisconsin studies (1959) 100 grams KNO_3 fed to dairy cattle led to abortion and lesions of the fetal membranes. Another heifer fed 70 grams KNO_3 for 47 days resulted in considerable methemoglobin formation, but did not cause abortion.

Sheep

Illinois workers (1960) fed sheep a complete ration containing 12.8 percent KNO_3 without visible symptoms of nitrate toxicity. In other trials they reported that lambs fed poor quality hay and 0.5 grams KNO_3 per kilogram bodyweight daily resulted in 75 percent methemoglobin on the third day of the trial. Lambs on pasture treated in a similar manner also showed severe symptoms of nitrate toxicity.

Hogs

Illinois studies (1960) indicated that levels over 1.84 percent dietary nitrate depressed gains of pigs fed corn-soybean oil meal rations. Pregnant gilts fed nitrate had a reduced rate of growth, but no differences in *corpora lutea* numbers, percent implantation, ovary weight, or thyroid weights were observed.

Beef Cattle

Beef cattle fed mountain meadow hay fertilized with 90 pounds of nitrogen per acre made slower weight gains than cattle fed unfertilized hay in a Colorado study (1960). They extracted hay that had been produced under heavy nitrogen fertilization and found that this extract inhibited gas production when incubated with rumen microorganisms. The factor in the hay causing the decreased activity of rumen organisms was nitrate.

Ensiling Destroys Nitrate

South Dakota (1952) reported corn silage fermentation in which a pungent yellow-brown gas was produced from silos. The corn apparently contained considerable nitrate when ensiled, and during normal fermentation processes, the nitrate was reduced to gases containing nitrogen. Upon completion of fermentation the yellowed silage was removed from top of the silo and the remaining silage safely fed. **Fermentation processes in the silage which result in the production of these gases (i.e. nitric oxide, nitrogen dioxide, and nitrogen tetroxide) in effect reduce the amount of nitrate remaining in the silage. Juices draining from silos containing high nitrate ensilage may be toxic.**

Wyoming workers (1946) report livestock losses from both eating forages containing lethal levels of nitrate and from drinking water having large amounts of nitrate (6,200 ppm).

Grazing Livestock

Wisconsin (1959) studied pregnant heifers pastured on weedy lowland pasture with a history of noninfectious abortion. Weeds, under certain conditions, may have as much or more nitrate as cultivated crops. They felt that a definite relationship existed between the nitrate content of weeds in lowland pasture and abortion in cattle grazing them. Application of fertilizer reduced abortions by stimulating growth and development of bluegrass and other grasses. They were not able to correlate the time of abortion or predict impending abortion from methemoglobin measurements. Methemoglobin values varied among cattle on different days.

Missouri researchers (1960) measured serum nitrate in relationship to nitrate toxicity and concluded that it was not a reliable diagnostic tool. Cattle grazing heavily fertilized and manured sudan grass pastures containing 1.8 percent KNO_3 on a dry matter basis resulted in abortions (Missouri, 1958).

Vitamin A and Nitrate

Numerous field reports have suggested a vitamin A deficiency in cattle when fed forage high in nitrate. Adequate experimental evidence explaining the precise role of nitrate in its relationship to carotene and/or vitamin A has not been presented.

The Missouri Station (1958) reported that dietary levels of 0.6 to 1 percent KNO_3 on a dry matter basis fed to dairy cattle produced typical symptoms of vitamin A deficiency in 6 to 8 weeks. They recommend feeding supplemental vitamin A when a nitrate problem was suspected. They also observed that cattle grazing sudan grass pasture containing high nitrate had high blood nitrate, low vitamin A, and an oversupply of carotene in the blood.

A recent study (Missouri, 1960) with rats suggests that nitrate interferes with vitamin A storage in the liver. In this study potassium nitrate (KNO_2) interferred with the utilization of carotene and in addition precipitated a vitamin E deficiency.

However, Illinois workers (1960) fed lambs rations containing 4 percent nitrate for 83 days. Their results indicated dietary nitrate had no effect on blood carotene or vitamin A values.

Treatment of Nitrate Poisoning

Drawing a sample of blood will give a rapid diagnosis for nitrate poisoning. Normal blood is red and becomes brighter on standing. Methemoglobin blood is brownish and does not brighten as rapidly. South Dakota researchers (1952) stated that freshly drawn blood stored at room temperature had 30 to 50 percent of the methemoglobin changed back to oxyhemoglobin within 2 hours. The remainder changed at a gradually decreasing rate.

Animals that are acutely poisoned with nitrate should receive speedy veterinary treatment. Treatment consists of injection of a chemical that acts as an oxidation-reduction system to reverse the reaction of oxyhemoglobin to methemoglobin. A 4-percent solution of methylene blue injected into the blood stream to provide 2 grams of methylene blue per 500 pounds of animal has effected rapid recovery in cattle (South Dakota, 1952). Other concentrations of methylene blue and chemical reagents have been effective.

Feeding High Nitrate Feeds

When conditions are such that nitrate accumulates in forages (seeds have little or no nitrate), analyze samples of suspected feed. When the nitrate content of the feedstuff is known, cut down on the high nitrate feed. This can be done by

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SOIL TEST CORRELATION PROGRAM —A CHECK OF SOIL TEST RESULTS

LOWELL HANSON*

The job of providing sound fertilizer recommendations to Minnesota farmers is one of the important responsibilities of county agricultural agents. This is accomplished through the Soil Testing Service, a team effort of agents, University Extension soils specialists, and the University Soils Department.

In 1960, Minnesota farmers used 51,200 tons of nitrogen, 105,200 tons of phosphate, and 66,300 tons of potash. This cost them about $40 million. Its actual value in terms of more efficient yields may be double that amount if used in the right situations.

The "if" is a big one because a lot of fertilizers are not used where they should be. This is the reason for increased interest in getting reliable information as a basis for selecting rates and grades of fertilizer for a specific field. Soil testing is the method relied on by the Soils Department, the Agricultural Extension Service, and most of the fertilizer industry in getting this information to farmers.

However, the laboratory soil test is not capable of solving all the soil fertility problems in the state. It is a very useful tool but is only reliable if there is an understanding of the fertility response to different nutrients on all of the widely varying soils of the state. This understanding depends on greenhouse and field fertility studies of soils with a known soil test. Then the relationship between the field experimental results and the soil test can be determined and the soil test can be interpreted. Finding this field response-soil test relationship is called soil test correlation.

Having only laboratory analysis results is not of much help in deciding how much fertilizer to apply. Knowing only a laboratory number is something like looking at a gauge that says the tank is one-half full. If you don't know the size of the tank, you still don't have very much information. Field soil test correlation plots are in effect calibrating the actual size of the soil fertility tank.

Soil test correlation work of various kinds has been a part of some of the soil fertility research work for a number of years. However, it has not been possible to have a large enough number of field fertilizer plots devoted to calibrating soil tests to cover all the important agricultural soils.

For this reason the University Institute of Agriculture organized a program in the spring of 1959 to establish a large number of field plots on corn with the cooperation of its county extension agents. The Extension soils specialists and soil testing laboratory personnel assembled the necessary materials and shipped them to county agents. Detailed instructions on site selection and plot technique were provided along with the materials. A total of 68 plots were harvested from 39 counties in 1959. The program was repeated with some modifications in 1960 when 83 plots were harvested.

The objective of these plots has been to gain some additional general information about N, P, and K response in different soil areas and different soil tests as well as provide demonstration and teaching material for county agents. The information gained is intended to be supplementary to that of the research program of the department.

The fertilizer treatments which have been used consist of a check plot with no fertilizer and 4 combinations of N, P, and K. These are phosphate and potash, nitrogen and potash, nitrogen and phosphate, and the complete treatment —nitrogen, phosphate, and potash. These have been applied at the rate of 100 pounds of each nutrient per acre. This high rate is usually not recommended but was used on these plots to eliminate the need for the particular nutrient studied. With this arrangement of fertilizer treatments the yield increase from any element can be measured. A comparison of, for example, a 100-bushel yield on the NPK treatment to 85 bushels on the NP treatment would mean that potash accounted for a 15-bushel increase. A similar calculation can be made for nitrogen and phosphate.

In 1959 all the fertilizer was broadcast and worked in the soil. In 1960, 30 pounds of the phosphate and 8 pounds of the nitrogen were applied in the row with the rest broadcast.

One of the important results of the program has been the information gained on the effect of a number of factors other than fertility which determine corn yields. This has been possible because records are kept on each field of rainfall, past soil management and yields, subsoil moisture, time of planting, weed competition, insect infestation, soil type, and stand.

Table 1 shows that although average yields were lower under low rainfall conditions, fertility treatments increased yields 11.4 bushels per acre.

A summary of the average increase in yield from phosphate and potash under farmer field conditions is one of the valuable results of the experiments. This is done by grouping the fields into the various soil test categories and averaging all yield increases where the NPK plot yielded more than the NP or NK plots.

Table 2 shows the results for phosphate response for 1959 and 1960.

These results show that it is very important that the higher rates of phosphate fertilizer should be applied on the low testing fields. Much of the

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Table 1. Effect of rainfall and fertility treatments on corn yields, 1959

Rainfall from June 15 to August 1	Number of fields	Fertilizer treatments				
		Check	PK	NK	NP	NPK
		bushels per acre				
Less than 6 inches (Average 4.0 in.)	21	53.4	57.8	61.7	63.0	64.8
Greater than 6 inches (Average 8.2 in.)	17	79.4	75.8	90.4	88.6	95.7

Table 2. Average increase in corn yield from 100 pounds P_2O_5 and P soil test (Bray's No. 1)

Phosphorus test	1959		1960		Two-year average	
	Number of fields	Yield increase	Number of fields	Yield increase	Number of fields	Yield increase
0-10 Low	21	12.4	28	14.6	49	13.6
11-20 Medium	22	3.5	28	5.3	50	4.5
20+ High and very high	24	2.3	25	5.1	49	3.5

* Extension soils specialist.

Results of the 1960 Minnesota Extra Profit Corn Contest

KENNETH H. THOMAS and CURTIS J. OVERDAHL*

Since 1953 the Extra Profit corn contest has helped farmers demonstrate how to use the various factors of production for greater profits from their corn crop. The contest is co-sponsored by THE FARMER magazine of St. Paul and the University of Minnesota Agricultural Extension Service.

Any corn grower in the state may enter. He must enter an area of not less than 3 acres at one location on the farm. These 3 acres must have had the same management and cropping history. One of the 3 acres must be left as a check plot. He manages the other 2 acres in any way he feels will give him the greatest profit, yield, or both.

The contestant fills out a detailed field record booklet to provide information on recent soil tests and all production costs. An official designated by the county contest committee is present at harvest.

A state contest committee consisting of state Extension specialists and the editors of THE FARMER magazine selects zone and state winners on the basis of the yield. Awards are given for (1) the highest yield and (2) greatest extra profit.

The 1960 Results

The 1960 corn contest emphasized extra profits (additional net income obtained from improved practices over a check plot having no fertilizers, herbicides, or insecticides).

Nearly 50 percent of the contestants had no increase in profits. Some had considerable decreases. There are three primary reasons:

1. Many contestants aimed at the highest yield possible on the 2-acre Extra-Profit plot, without regard to economics.

2. Some faced weather or other conditions which adversely affected yields.

3. Others misjudged the productive capacity of their soil.

Table 1 shows a summary of profits according to check plot yields in 1960 for Zones I, II, and III (Roughly south of a line running west from Minneapolis through Willmar). Here, as check yields go up the extra profits decline but net profit per acre continues to increase until check yields are above 120 bushels per acre.

This suggests that farmers with relatively low soil fertility levels, indicated by the low check plot yields, can be reasonably sure of a marked increase in profits when they use fertilizer and other improved practices. For example, a farmer with check yields below 60 bushels could afford to spend about $20 per acre on improved practices and realize a return on this added investment from $1.70 to $2.18 per dollar invested.

However, the farmer who now has his land in a high state of fertility (i.e., check yields above 100 bushels per acre) must use considerable judgment when attempting to increase his net return per acre. For example, the added cost column in table 1 suggests that farmers in this area tended to spend a similar amount for improved practices (primarily fertilizer), regardless of their initial soil fertility levels. But results indicated that with check yields above 100 bushels the farmer had little opportunity "to get his money back" when he used these practices at such high levels. The extreme, of course, is the case of the 10 farmers with check yields in excess of 120 bushels. On an average, these farmers actually had slightly lower yields than from those obtained in the check (note the negative (-$1.94) on added return).

The farmer, short on capital, should heed these results carefully. A basic principle he must follow is to spend his limited funds so he will get the greatest return per dollar spent. Fields now in a low state of fertility will likely give the greatest return per dollar spent. Thus, if the farmer has some fields in a low state of fertility or has acquired a run-down farm, he will find fertilizer can be very profitable on a year-to-year basis. Also any excess fertilization beyond the 1-year need will carry over and be reflected in a higher net return per acre in following years.

Farmers with more adequate capital and/or high check yield face another situation. Their key management decision is—How much more fertilizer can

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Table 1. Relationship between check yield and added return on investment, extra profit, and net return per acre on the extra-profit plot

Range of yields of check plot	Extra-profit plot, Zones I, II, III					
	Number of fields	Added cost of improved practices	Added returns	Added return per dollar invested	Extra profit per acre	Net return per acre
Less than 40	17	$19.96	$43.53	$2.18	$23.57	$17.30
40-60	22	19.36	32.90	1.70	13.54	24.74
61-80	70	16.49	26.01	1.58	9.52	33.12
81-100	70	18.28	19.13	1.05	0.85	37.51
101-120	46	17.30	13.99	0.81	—3.31	51.01
More than 120	10	15.30	—1.94	......	—17.24	35.25

Table 2. Effect of following recommended practices on added rations per dollar invested and extra profit per acre

Zone*	Number of fields	Added return per dollars invested	Extra profit per acre
I. Southeast			
A	79	......	$ 4.17
B	34	$1.63	12.83
C	45	.90	—2.37
II. South Central			
A	101	......	$ 6.47
B	46	$1.64	13.62
C	55	1.02	.49
III. Southwest			
A	53	......	—$2.52
B	17	$1.16	5.33
C	36	......	—1.19
State Average			
A	260	......	$ 2.49
B	101	$1.60	11.13
C	159	.87	—3.00

* A—all contestants, B—those who closely followed recommendations, C—those who deviated considerably from recommendations.

* Extension economist and Extension soils specialist, respectively.

[1] For a more complete report see Soil Series No. 62, *Minnesota Extra-Profit Corn Contest Yield Results 1960.*

Soil Test --

(Continued from page 6)

gamble of an economic fertilizer response can be eliminated if soil tests are used to determine the starting fertility level.

The results on potash response are similar to that of phosphate in that the largest increase is on the low testing fields. However, there are benefits such as less lodging and higher quality corn grain in addition to yield which is important.

In using these figures it is important to remember that they represent a number of fields where yield and, therefore, fertilizer response were restricted because of adverse weather conditions. When weather conditions are favorable, the fertilizer response will probably be considerably above the figures given in tables 2 and 3.

Further summaries of the information will be made to measure the effect of such things as soil type and rainfall on the fertilizer response.

The soil test correlation program has proved to be a very successful way of obtaining additional information about the reliability of soil test information and also of providing local information for county agents and farmers. Cooperation between the National Plant Food Institute, Minnesota Fertilizer Manufacturers Association in providing funds, and the Extension Service and Department of Soils of the University made the program possible.

Table 3. Average increase in corn yield from 100 pounds of K_2O and K soil test (exchangeable K)

Potassium test		1959 Number of fields	1959 Yield increase	1960 Number of fields	1960 Yield increase	2-year average Number of fields	2-year average Yield increase
0-90	Low	9	11.2	11	18.4	20	15.1
91-150	Low-medium	34	4.7	20	4.5	54	4.6
151-220	High-medium	7	2.1	29	4.2	36	3.8
220+	High and very high	14	3.3	20	3.0	34	3.1

Corn Contest --

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I use before profits begin to decline? Table 1 (net return per acre column) suggests that the **maximum profit yield** in many areas of southern Minnesota is in excess of 100 bushels. In 1960 with these farmers the most profitable point (for other than starter fertilizer at least) was near the 120-bushel level. This will vary by areas and farms.

Importance of Following Soil Test Results

Until the individual farmer has determined his most profitable yield level on other than small trial areas, the use of soil test recommendations from the University is a sound practice. The results in table 2 support this statement.

These results indicate that of the 79 farms in the contest from Zone I, 34 applied fertilizer and other practices reasonably close to that which would be recommended. These farmers received increased profits of $12.83 per acre and earned returns of $1.63 per added dollar invested.

However, the remaining 45 farmers who deviated from the recommendations experienced a decrease in profits (-$2.37). Zones II and III show similar results favoring the use of recommended levels.

Of course, many farmers in the contest have high yields as an objective and are willing to risk uneconomical rates of fertilizer on a small acreage for this purpose. However, they do contribute valuable information as to what corn yield potentials really are.

Finally, a summary of all fields indicates that close attention must be given to the money spent for fertilizer and other marginal production costs in order to maximize net profits per acre and/or to provide reasonable returns per dollar spent. With limited capital, moderate rates of fertilization will be more in keeping with wise use of funds. When capital is more readily available, maximum return yields can then be our goal.

UNIVERSITY OF MINNESOTA, INSTITUTE OF AGRICULTURE, ST. PAUL 1, MINN.

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Nitrates --

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feeding feeds low in nitrate in combination with high nitrate feeds or ensiling the high nitrate feeds.

Various reports have suggested that high energy feeds, such as corn or molasses, and also protein supplements increase the tolerance of livestock to nitrate poisoning.

Summary

Results of the studies presented here indicate that:

* Animals vary as to the point where a nitrate dose becomes lethal.
* Cattle appear to be the most susceptible to nitrate poisoning.
* The amount of the dose to be lethal is lower when poor quality hay is fed.
* Feeding high-energy feeds increases the tolerance of animals to nitrate.
* Supplement protein may also assist in raising the tolerance to nitrate.
* The slower animals eat high-nitrate feeds, the better their ability to "detoxify" nitrate.
* Losses are usually related to drought conditions or lowland pastures.
* Rumen microorganisms can convert nitrate to ammonia. The ammonia may then be incorporated into microbial protein in the rumen.
* Excess nitrate intake causes methemoglobinemia, which may cause death.
* Treatment of acute cases of nitrate poisoning should not be delayed.
* Vitamin A deficiency has been related to high dietary nitrate intake.
* Well or other water, high in nitrate, may be toxic.
* Silage juices from ensiled high nitrate forage may be dangerous.
* Silage fermentation reduces the initial nitrate content of ensiled forage.
* Feeds suspected of high nitrate content should be chemically analyzed and the feeding program adjusted according to nitrate content of the feeds.

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