Soils, Fertilizer & Agricultural Pesticides Short Course

Dec. 12, 13, 14, 1977
Mpls. Auditorium

TABLE OF CONTENTS

Table of Contents-Con't

Agricultural Extension Service
UNIVERSITY OF MINNESOTA
Office of Special Programs
Institute of Agriculture

COMBINED SOILS, FERTILIZER AND AGRICULTURAL PESTICIDES SHORT COURSE

PROCEEDINGS

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Minneapolis Auditorium

Presented by the
University of Minnesota
Institute of Agriculture, Forestry
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Agricultural Experiment Station
Agricultural Extension Service
College of Agriculture

in cooperation with
Minnesota Plant Food and Chemical Association
Minnesota Aerial Application Association
Minnesota Certified Applicators Association
Minnesota Limestone Producers Association
Minnesota Department of Agriculture

Presentation on 2,4-D Situation
Soils, Fertilizer & Agricultural Pesticides Short Course
December 12, 1977

By O.A. Wolcott
CENEX

I was going to take the Minneapolis Tribune and the Channel 5 TV program, "The Weed Killers", for the source of some of my presentation on the 2,4-D situation, however, I decided that both were biased and neither had taken the time nor had the conscience to utilize the scientific facts in making their presentations. I went to the scientific record for the facts.

2,4-D was heralded as the greatest scientific development for agriculture and forestry in the 1940's. It gave us the first effective opportunity to manage the flora in crops, forests, roadsides, lawns, parks and etc. We could now grow desirable crop plants. We could suppress the undesirable plants, those that robbed the fertilizer, moisture and sunlight; those that poisoned the livestock, cluttered the rights-of-way and caused hay fever, poison ivy and the like in both urban and rural people. The key to success, and the most important point environmentally, is that we were now able to maintain a good grass stand while controlling the weeds with 2,4-D. This gave us our first major opportunity to control soil erosion. From then on we had federal and state funds that paid for the 2,4-D use in projects to control weeds and prevent soil erosion. We also have noxious weed control laws, and here again, these are designed to conserve our soils and at the same time provide for maximum crop production.

We have four million acres of land in Minnesota that can be improved and developed into prime timber production, chiefly through the labeled uses of 2,4-D and 2,4,5-T. You add this to our already good timber lands and you have the largest segment of the main Minnesota resource - forestry and agriculture.

In presenting to you a close-up on the status of 2,4-D, I'll be quite concise.

- It is a major chemical in managing the flora on farms, in the forests and on the rights-of-way. More acres are treated every year with 2,4-D than any other herbicide.

- Every year for over 25 years, it has been the first choice of farmers and foresters.

- 2,4-D is the lowest cost herbicide for farm use.

- 2,4-D is used by more home owners on their lawns than any other pesticide. It is estimated that 70% of the Twin City home owners use it.

- 2,4-D is used for weed control on 99% of the golf courses, parks and recreation areas.

In summary of the uses of 2,4-D in Minnesota, most people (millions) with a concern for controlling weeds use it. This has been customary for over 25 years, and there is no recorded sickness, chronic or acute, due to their use of 2,4-D. This is a far better record than this same group has using aspirin. 2,4-D is safer to use than aspirin. It is better labeled and people follow the directions for use.

There are no state restrictions against the uses of 2,4-D that are cleared by the Environmental Protection Agency. All of these uses are accepted in all states, to the best of my knowledge. In small areas of some states, where cotton and grapes are near the wheat and grass fields, the use of 2,4-D is limited to the amine form and at certain times of the year. We have no such restrictions in Minnesota or surrounding states.

The statements made by former Secretary of Agriculture, Earl L. Butz, exemplify the need to continue to defend the scientifically proper uses of 2,4-D. Antagonists and activists continually seek to destroy the modern progress of agriculture and Secretary Butz's answer to these is to continually display the slogan, "So Reason Might Rule".

> "The Body Politic in this country opted for a stringent system of public regulation which has placed very great demands upon our increasingly limited resources by seeking to end environmental pollution and to eliminate personal risk -- while at the same time attempting to maintain an ever-improving level of living. During the last few years, however, we have been forced to give this policy stance second thoughts."

> "No longer can it be taken for granted that there will always be ample supplies of everything we want."

> "Clearly, Man cannot have all he wants to consume -- and at the same time maintain a super-pure environment and a completely risk-free society."

> "If we are to continue to reap the benefits of technology in a time when the limits of our resources become more clear each day, we must first come to grips with just how we shall proceed to deal with our environmental idealism and our attitude toward risk."

> "Today American agriculture is being seriously threatened by restrictions on the use of agricultural technology which -- through perhaps well intended -- have not been promulgated on any rule of reason."

> "Throwing away our present chemical technology in agriculture would turn back the clock at least 75 years. Someone would indeed have to decide which 50 million Americans would go without food -- because we simply would not be able to feed our present population, even at subsistence levels, without the substantial use of fertilizers, pesticides, and antibiotics."

> "I have been extremely critical of public decisions made without benefit of a Rule of Reason. So have other scientists, farmers and agricultural professionals."

> "We need adequate criteria for a meaningful evaluation of technology in agriculture that separates objective fact from subjective conjecture. That is a vital prerequisite for reaching conclusions based on a proper assessment of the risk versus the benefits from use of such technology."

We expect 2,4-D to continue to be the major herbicide for crops and uses for which it is cleared by EPA. We look forward to many many more years of use in both agriculture and forestry where it is highly productive of excellent crops.

O.A. Wolcott

OAW:elb

THE SUNFLOWER SITUATION

Ralph Taylor

Ladies and gentlemen, it is a pleasure for me to be invited to speak to you today concerning what I consider to be a very exciting future for our sunflower industry. I guess that if you had asked me to speak to you any year during the past 16 years, I probably would have started my talk the same way, therefore, you can take this for what its worth. However, I believe when we look at the statistics over the past years there has been a reason for excitement in this emerging industry. Although it is a new industry to us in the United States; in the world, sunflower is the #2 vegetable oil second only to soybean. I might add that it has advanced from the #4 in the early 1960's to the #2 position at this time and still gaining market share in the world market.

In 1962 there were approximately 30,000 acres of sunflowers planted in Minnesota, North Dakota. These were mainly large striped type grown for bird food and confectionery market. These sunflowers return an average of $4.15 per hundred weight to the grower and the average yield at that time was about 980 lbs. per acre. For a $40 return per acre, there was a small acreage of sunflower grown in the Delta area around Modesto, California, which was also the large grey striped sunflower grown for salted inshell trade.

From 1962 until 1967 there was a steady growth of the bird food and confectionery type sunflower, harvested acreage went from the 30,000 acreage in 1962 to 216,000 acres in 1967 with an average yield of about 1,000 lbs. per acre.

1967 was also the year that the first acreage of oil type sunflower was planted in the Red River Valley. The total acreage that year was about 92,000 acres. They yielded about 1,000 lbs. per acre with an average price of $4.90 per hundred weight. These acres were mainly planted to the Russian varieties of sunflower, which had been introduced into Canada and then introduced into the United States.

I would be remiss if I did not mention that probably some of the early growth of the sunflower acreage was attributable to the government farm program that was in effect at that time, which provided for sunflower planting on some of the diverted acreage without entire loss of the diversion payment. This was, in effect, a subsidy for growing sunflower and many of the farmers who had been rather reluctant to grow the crop did try growing sunflowers.

Some of the early problems that we experienced were discouraging to farmers; there was a good deal of turnover of growers in the industry. In general, the sunflower acreage in those days was planted on some of the poorer land the farmer had. I always said that the sunflower was treated somewhat like we used to treat the sheep back on the farm in central Minnesota, we just turned them into the grove and let them shuffle for themselves. We had problems with weeds, stands, equipment for planting and harvesting, insect pests, early frost, and with many experts in the industry predicting diaster for the crop with every new insect or disease pest that became apparent.

In the face of all of these problems and without the farm support program since those early oilseed years, the crop has shown a steady increase in acreage which was brought about by improvements in varieties, cultural practices chemicals for control of weeds and insects, and a dependable market for the product. Once the farmer was able to see the potential of this crop, they moved sincerely into the sunflower production business, attacking and licking most of the problems that we have had in cultural practices.

We have also seen the acreage spread out considerably from the original planted acreage which existed along a very narrow band on each side of the Red River of the North, until now, we see sunflowers grown in most of the states in the mid-continent of the United States; some rather sizable acreage in many of these areas. As you are well aware, there were well over 2 million acres of sunflowers grown in the U.S. this past year with large concentrations of acreages in the three states of Minnesota, North Dakota and South Dakota; with sizable acreages in Texas, Oklahoma, Nebraska, Missouri and lesser acreages in many of the other corn belt and great plain states.

Up until this time 2/3 rds to 3/4ths of all of the sunflowers grown in the United States have been exported. I guess that this makes me wonder if the Europeans know something about sunflowers that we don't, for they are willing to pay more for sunflowers for export than we are able to generate in our domestic market.

I guess that we can look at this as a liability or opportunity, depending on which side of the coin you would like to look. Frankly, I see it as an opportunity because the U.S. is still the best vegetable oil market in the world with 52# per capita consumption compared to 22# per capita in the rest of the world and the fact that we are able to grow and market this much sunflower without touching the biggest market in the world, provides a very exciting marketing picture. I think that we are already seeing some development of this opportunity. As many of you are aware, Proctor & Gamble has product in test market in St. Louis and Dallas, Fort Worth area called "Puritan", which is a sunflower base vegetable oil, now Lever Brothers has a product on the shelf in the metropolitan Minneapolis area called Promise, which is a sunflower base margarine. Also, Hunt-Wesson is test marketing a product called "Sunlite" which is 100% sunflower vegetable oil in the Seattle market at this time. Although it is difficult to get a commitment from the companies, I think in general, when a product is put into the test market a good deal of capital has been expended toward the success of that test market including the eventual marketing of the product. I feel certain that some or all of these products will be marketed nationally within the next 12 months. There is a good deal of difference in the fatty acid makeup of sunflowers grown in the northern half of the country from those grown in the southern half. The sunflowers grown in the southern half of the country have a higher percentage of oleic acid which makes it better as a frying oil. I understand there is a good deal of interest in the oils produced in this area for frying potatoes and other products cooked with vegetable oil.

As you know, sunflower oil has a very high smoke point containing approximately 70% unsaturated fats along with a rather neutral flavor which I feel, puts it in a premium oil classification. This, along with the increased yields that we are seeing from the new hybrid varieties that are now on the scene makes sunflower a very exciting crop from the standpoint of oil production per acre. This past year we have seen sunflower acreage in the country approximately double. I guess that I am not so optimistic to think this would occur again next year; however, I do feel in my personal opinion, that we will see a 20% or better increase in the sunflower acreage again this coming year. I know that many of you are asking where are we going to market all these seeds, but, if we consider the soybean acreage of approximately 50 million acres in the U.S. and the sunflower acreage of approximately 2.3 million, maybe possibly going to 3 million next year, we are looking at a rather small acreage in comparison to the total oil supply situation in the United States. We also know that there is an increased need for oils to satisfy the population growth each year. It would take about 1 million acres of sunflower just to keep up with the population increase in the United States. Converting this to a world situation, the population would require about 6 million acres increase in sunflower to supply the added needs of this market. Add to this the fact that world consumption of fats and oil have been increasing at 2# per capita every 5 years. It seems to me that this is one area in the agricultural scene that can stand some rather marked increases. I am sure that the prices paid now, through these winter months, are going to have an impact on the number of acres that are planted. However, if we look at the price situation we have seen this fall and early winter, it certainly would indic that the sunflower market has stood up much better than many of the other feed grain markets we are competing with.

This fall we have seen prices at Duluth as low as $8 and recently as high as $10.60 per hundred weight. With prices in this area certainly we are at a good competitive position with other crops grown in the area.

What about the problems in growing this crop of sunflower now that we have talked about the market? -- Many of you are aware of the chemicals that have label clearance for sunflower. Some chemicals that have been used widely for weed control such as Eptam and Treflan have changed the sunflower image in many farmers minds. It give's them a row crop that can help them break the continuous grain cycle and does clean up their land and make for a better farming operation. I believe that weed control has been one of the major reasons for the acceptance of sunflower by the farmer and for the improvement in seed yield. We are a little less fortunate in regard to chemicals cleared for use on insect pests. We seem to have a host of these pests such as cutworm, wire worms, sunflower beetles, sunflower midge and 2 species of sunflower head moth plus numerous other insects which have caused some economic impact on the crop over the years. A major problem with a new crop such as sunflower, is trying to determine the economic threshold of the particular pest so that a farmer or commercial applicator can intelligently plan a program of control for the pest. As we all know, the chemical industry is under scrutiny and subject to more regulation every year. We must use great care to protect the few chemicals we have to handle insect pests on this crop. We have been at a great disadvantage with the few acres we have had in past years in that chemical companies with the large capital expenditure required to get a label clearance on a crop have not been particularly interested in getting label clearance for sunflower.

And now with the RPAR procedure that we are facing, we stand a chance of loosing many of the chemicals that we have been relying on. I don't mean to paint a gloomy picture of our industry, but, I know that you as chemical and fertilizer dealers, are faced with farmers problems each year. The growing need to become informed on these facts will help you do a better service to the customers in your area.

A good publication for your reference is the bulletin, "Sunflower Production" put out by North Dakota State University at Fargo which has good pictures and explanations of major insect and disease pests. This can help you in identifying problems in your particular area.

I guess that I, for one, feel that this crop has shown tremendous growth in the face of all of these problems and certainly as years go along we will learn to control these pests; this will make us even more competitive in the agricultural arena.

We have a lot to learn about feeding the sunflower crop as we do about many of the other things that I have spoken about, however, we know that sunflowers respond to high fertility. But, applications of fertilizer as a starter have not shown the response on sunflower that we see in many other crops. We know that sunflower has an extensive root system and is able to forage for nutrients and water very effectively and efficiently. This is why early growers were able to get better returns from their poorer land. However, many times when they came back around on the rotation, the sunflower yields were disappointing.

I believe that the sunflower is able to feed from lower soil profiles than most other crops, this is probably why early growers felt sunflowers were hard on the land. Anytime that we grow dry matter that we do with a 2,000 lb. sunflower crop, we are going to be utilizing a lot of nutrients.

probably about like an 80 bushel corn crop. Therefore, in order to maintain the level of fertility in that particular field, we will need to either pre-fertilize or post-fertilize that field in order to replace those nutrients used by the sunflower crop. Many sunflower growers have gone to a program of heavy fertilizer application on the crop preceding sunflowers with a broadcast application previous to seeding the sunflower crop, then an application of nitrogen on the stalks before they are plowed or disked down. There has been very little work done on nutrient requirements or methods of fertilization on this crop, as I said earlier, we still have a lot to learn. We do believe we can say with certainty that sunflowers are not hard on the ground, in fact, I believe the reverse is true. They improve tilt of the soil, the extensive root system opens up the soil and the stalks deteriorate quite rapidly, crop residue causes only minimal problems in the succeeding years.

You are all aware of the volunteer problem in the following crop, therefore, care must be taken to grow a crop in which the volunteers can be controlled, such as corn or small grain. Certainly we would not want to put soybeans on sunflower ground or not a broad leaf crop which could not be sprayed with a broad leaf herbicide to control the sunflower volunteer. Again, I am sure we have all heard the comment that "those damn sunflowers are nothing but a weed," I guess that from my stand point I say that anything grown in the wrong place is a weed. I don't like to see corn growing in my sunflowers as the corn grower does not like to see sunflowers growing in his corn. We do know that if the profit is there the farmer will find a way to solve the minor problems involved in growing this crop. We do know that this crop is a researcher's dream still in its infancy. Certainly the potential for improvements in yields in standing ability, disease and insect resistance are monumental. It is really a plant breeders dream to work on a crop like this.

15 years ago there was approximately 1 man year being spent on sunflower research in the United States at this time, there are at least 5 commercial companies with 2 or more professionals working on sunflower breeding and several USDA and state experiment station people that are spending part or all of their time on the developing sunflower crop. In the years to come we will find out much about the water needs of sunflowers in relationship to growing them on irrigated land, we will find out much about the fertilizatic of the sunflower crop and succeeding crop, we will find out the best place in the rotation for the sunflower crop, we will certainly be more intelligent as to the techniques and methods of pollination that are involved in the sunflower crop, we will improve yields by better cultural methods and by better varietal development. I believe that I can say that with confidence.

Again, I know of no other crop that has the potential for improvement that this crop does. I am sure we will also see a much wider maturity range in hybrid varieties marketed in the coming years. Varieties that will adopt themselves to second crop situations such as sunflower after winter wheat, sunflower after peas, sunflowers after any early season crop, or a double cropping situation.

Secondly, we will see longer maturing varieties that will yield better in the southern area of the country where the frost free days are longer. In short, I think that we will have a crop that will lend itself to better utilizations of growers time, equipment and resources, which I believe, will make for a more efficient farm operation.

These are some of the reasons that I am excited about the sunflower industry. I know that I have brushed very lightly over several topics without answering any questions that you came here with today. However, I think that, if nothing else, we may have alerted you all to the possibilities for this crop. I believe that it will be important for you in the coming years to become as well informed as you are able to on this crop, looking at it as a lasting part of our future agricultural economy.

I thank you very much for your invitation and wish you all the best in the coming years in this exciting business of agriculture.

NPK SUPPLY/DEMAND
MINNESOTA SOILS & FERTILIZER SHORT COURSE

JOE LEE, VICE PRESIDENT
AGRICO CHEMICAL COMPANY
DECEMBER 12, 1977

Another fertilizer demand peak is only four months away. A lot has to happen in our business every year between December 15 and April 15. Our numbers indicate that the one we now face is headed for the record books. Looking at who has the fertilizer today and who will need it four months from today - a record tonnage must change hands in the next 120 days. This situation creates the big challenge for all of us from suppliers to retailers to crop growers. It is more significant to most this season than the fertilizer supply/demand situation per se.

The starting point when addressing fertilizer supply is generally a review of production capacities. If all nitrogen, phosphorus and potash operations in the U.S. and Canada were run at capacity and sold only in the U.S. and Canada, we would have an over supply. This, of course, doesn't happen. Plants are not run at 100% of their rated capacity and the U.S. and Canada are prominent exporters of N, P & K. It is what is actually produced that matters - not the total of name-plate plant production capacities.

Compared to last year, there is some new nitrogen production in the U.S. and Canada - there is no new phosphate or potash production. The new nitrogen production has been primarily ammonia with few significant additions to upgrading facilities. Due to the slow fertilizer movement the last six months there has been significant production curtailment. It is known, for example, that all Florida P_2O_5 production units were under production curtailment programs last month. There also has been a step-up in exports of nitrogen and phosphorus. Imported nitrogen is running ahead of year-ago tonnage. This has been primarily due to new Canadian ammonia and urea production. July through September nitrogen tonnage was up 60,000 tons actual N over 1976. All totalled, our estimate is that the probable NPK supply for the approaching season is about the same as last year.

The demand side of the approaching spring season is a moving target that is difficult to predict. Our demand forecasts have become more optimistic over the last 60 days. Much of our new bullishness comes from the improved grain prices during this period. This improvement in crop prices now makes any government acreage control program on spring planted crops unlikely. The spring planted acreage of corn and other feed grains now looks like about the same as last season. We also know that winter wheat acreage is down - particularly soft red winter wheat. Some of this acreage will go to soybeans and other spring planted crops. Although the numbers are not available most checks indicate that less fall-applied NPK for spring planted crops went on this fall than last. This was due to wet weather and harvest delay plus some farmers delaying any expenditures possible and, as stated earlier, exports sales have been above expectations. Put all of these factors together and one can create a case for a record spring fertilizer demand.

If we are headed into a period of excellent fertilizer demand this spring, our No. 1 problem will be supply. It will be the logistics of getting the right product in the right place at the right time. This is no new problem to our industry. It has surfaced off and on over the past 20 years and in most years no serious shortages developed. With full knowledge of what has happened before, this one coming up looks like a different "set of blocks".

It does seem logical that the sooner all of us start to solve the problem the better. Promote early application where feasible. With today's application equipment, winter spreading is a growing practice in more and more areas. The spring usage peak is not more than 120 days away. Remember too that every unfilled tank or bin from now on out makes the spring supply problem tougher. The old meaningful phrase "nothing happens until someone sells something" can guide us to avoiding any spring supply problem. Retailers must sell the farmer and suppliers sell the retailer on keeping his wagon full.

Remember too that most crop growers still underfertilize rather than over-fertilize. Also, that fertilizer is the best input one can call upon to lower production cost per bushel or per pound. In most areas the average yield per acre needs to be pushed higher; there are still too many acres that receive no plant food; there is too wide a gap between what the best growers are doing compared to the rest. Progress is attacking these needs will add to demand.

Will there be adequate NPK to meet the demand this coming spring? The answer is "yes" IF we all start to work now.

The Economics of Fertilizer Use-- Emphasis on the Dealer*

by Thomas H. Foster
Test and Demonstration Branch
Tennessee Valley Authority
Muscle Shoals, Alabama

ABSTRACT

The talk is to focus on how to examine the economics of fertilizer. Emphasis will be placed on the derived demand for agricultural inputs and farmer fertilizer use decisions. The talk will discuss how to calculate the economic optimum rate of fertilization, the breakeven prices of fertilizers, and how to determine the economic value to the residual effects of fertilizer given adequate response data. The sensitivity of the optimum N fertilizer rate to commodity and fertilizer price changes will also be examined. In a very general manner, variables in the decision-making process will be reviewed to illustrate how dealers may contribute to more efficient fertilizer use.

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*Abstract of a talk to be given at the Minnesota Plant Food and Chemicals Association 27th Annual Short Course and Equipment Exposition, Minneapolis, Minnesota, December 12-14, 1977.

Soil Science Research and Agricultural Production

W. P. Martin - Soil Science Department
University of Minnesota

A year ago we were concerned about reduced crop yields because of drought and having been more than bailed out by Mother Nature's bounty of ample precipitation, our concern now is about reduced farm income because of surplus crop production. Nevertheless, the nation has become aware of agriculture as never before in our history, of the necessity to accommodate world food needs, and the fact that much of our prosperity rests on our agricultural base including our agricultural exports which are expected to pick up this year because of poor grain harvests in Russia and other parts of the world. In any event, production efficiencies are mandated if profit margins are to be increased, conservation of dwindling energy supplies must be accommodated, the resource base of soil and water must be surveyed and classified as to appropriate use such as the preservation of "prime" farm lands, and soil and crop management systems improved so as to reduce non-point pollution of our essential water supplies as mandated by law. Research and education are increasingly important. However, as noted last year, current staffing in our agricultural production departments is inadequate, laboratory and classroom facilities must be expanded, technical equipment and supply budgets increased, and support for expensive field researches greatly extended. Recognizing both the opportunity and the need for accommodation of current programs as well as imminent growth prospects, the Regents of the University are requesting of the Legislature this year funds for building additions for the Departments of Agronomy, Soil Science and Plant Pathology. These three departments have primary responsibility for improving crop production in Minnesota and improving our agricultural prosperity. We need your active support for these badly needed facilities. It will help the dedicated teachers, Agricultural Extensionists and scientist in these departments better serve the citizenry of Minnesota and the nation.

Research priorities: As noted in earlier discussions a number of distinguished panels of scientists and laymen have established priorities for research funding to assure advances in food production. Among these were a World Food and Nutrition Study of the National Academy of Sciences, an Agricultural Research Policy Advisory Committee on Research to Meet U.S. and World Food Needs, an International Conference on Research Imperatives for Crop Productivity, and an Office of Technology Assessment of Alternatives for Supporting High Priority Research to Enhance Food Production.

Four areas where research information is inadequate and which consequently will receive initial emphasis are in the areas represented by the research disciplines of the participants in this Short Course, namely, agronomic crop sciences, soil science and plant protection. These are: (1) photosynthetic efficiency, (2) biological nitrogen fixation, (3) genetic engineering of plants, and (4) plant protection studies as related to such pests as insects, weeds, nematodes, viruses, bacteria and fungi. Research information is also needed in other areas if advances in crop and food production are made. These include (5) how hot and cold temperatures and drought effect crop plants, and (6) physical and chemical characteristics of soils, their erosion characteristics, and their capabilities as disposal sites for wastes.

To briefly expand on the significance of a much better understanding of the physical and chemical characteristics of soils, item (6), this must be done on identified soil types and the mapping of Minnesota soils must be accelerated. The Legislature has, in fact, provided funding for the first biennium of a program to complete the soil survey within the next dozen years or so. It is a cooperative venture between the Soil Conservation Service, the U. S. Forest Service, County Boards, and of course the Department of Soil Science in the Minnesota Agricultural Experiment Station.

As noted in a recent regional committee report on relating soil and landscape characteristics to land use, the lack of basic soils information has reached critical levels. Among the important problems on Minnesota soils requiring better information to assist in decision making are: (1) Hardpans associated with reduced tillage systems; reduced water infiltration, reduced water availability, poorer plant nutrition, reduced crop yields. (2) Rapid increase in irrigation systems. Data on infiltration rates and water holding capacities as well as soil salinity problems must be researched here. (3) Soil erosion processes. Section 208 (non-point pollution) of the Federal Water Pollution Control Act of 1972 requires that "best management practices" be adopted by the farmer to reduce soil losses. We must make recommendations based on many more researches on the wide range of soils found in Minnesota and management systems. (4) Physical and chemical soil changes induced by cultural operations. We have disappearing soils, changing profiles and accelerating soil forming processes induced by changing microclimates related to irrigation, cropping, tillage, chemical weed control, manure and organic waste as well as fertilizer application practices and related. These are difficult and expensive research areas. (5) Criteria for identifying "prime" or essential farmlands. Although the ability of technology such as improved fertilizer practices to improve a soils capability for crop production is known, it has not been adequately researched for Minnesota's many different soil types and it is not considered in legislation which provides for the protection of prime agricultural soils. The public needs to be awakened to the implications of various land uses. Protection of prime and unique farmland is surely essential to the nation's best interest. If the best lands are lost to production, farmers must use steeper and more erosive soils which require higher energy production inputs. (6) Waste disposal through septic systems and landfills and the utilization of soils for energy production. These are related mostly to non-agricultural problems and require information on the total soil profile often well below three feet where soils research data are mostly unavailable. If the whole crop is removed to meet our demands for energy (it is called biomass) soils are depleted more rapidly both of nutrients and of aggregate stability. Peat soils may be used directly for energy and the implications of this practice for Minnesota both as regards the areas to be harvested and reclamation efforts after harvesting should be carefully studied.

Departmental staff changes: As has been customary in my past introductory comments the following staff changes or additions in Soil Science have occurred during the past year or are in prospect:

Dr. Robert Gast, Professor of Soil Chemistry, resigned to head the Department of Agronomy at the University of Nebraska, Lincoln. He will be replaced December 1, by Dr. Paul Bloom, a former Minnesotan, who is completing his advanced degree work at the Cornell University, Ithaca, New York.

Dr. Joe Vavra, Professor in Soil Conservation, has been appointed to work on our project in Morocco at the Hassan II Agricultural Institute. He is from Illinois but was working for the World Bank in Spain before joining our US-AID supported project.

Dr. Jean Molina, Associate Professor of Soil Microbiology, has returned from Morocco and will work in the areas of nitrogen transformations (forms, losses, crop availability) in Minnesota soils including that released during the decomposition of organic materials.

Dr. Pierre Antoine, Assistant Professor of Pedology, has also returned from Morocco and in the department teaching courses in soil geography and part-time in administration as director of the Moroccan project.

The State Legislature provided funds during the last session for two new positions in the Department. One is for an Extension Specialist in Agricultural Climatology and the other for an Assistant Professor and Extension Specialist in Soil Physical Management with emphasis on tillage. Recruitment is underway for both of these positions.

Dr. William (Bill) Fenster, Professor and Extension Specialist in Soil Fertility has been temporarily reassigned to a project in Colombia via a grant from MUCIA. The University holds membership in a midwest consortium of universities which contracts work in developing countries. His position is being temporarily filled by Mr. Robert Schoper, M.S. degree from Minnesota, as Assistant Extension Specialist in Soil Fertility.

RELATIONSHIP OF WEATHER AND SOIL MOISTURE

Earl Kuehnast
State Climatologist
Minnesota Department of Natural Resources

Soil moisture is entirely dependent on the weather throughout the year unless one is able to irrigate. The direct relationship of weather and soil moisture can be explained in four phases during the year in which moisture is added, drawn out, or frozen within the soil.

Figure 1 shows the 1960-1976 mean total plant available water in a 5 foot column of soil under continuous corn at the Southwest Agricultural Experiment Station, Lamberton, Minnesota, throughout the year. The curves were drawn by Dr. Donald G. Baker, Soil Science Department, U. of Minn. An explanation of the phases of the curve is as follows:

The First Phase, the summer draw-down or grand consumption phase, starts in early June, the time the corn roots are using more water from the soil than is being supplied by normal rainfall. This continues until early September when the corn is maturing.

The Second Phase shows the primary recharge of water from precipitation, at this point precipitation exceeds water consumption of the plant. It begins in early September and continues until freeze-up, which normally occurs in the Minnesota corn belt area in early December.

The Third Phase is a period in which soil is frozen or the soil water is solidified in the soil. Precipitation that occurs during the period is stored on the soil surface and in the spring the majority is lost as runoff.

The Fourth Phase shows another period of recharge of water into the soil. It begins in early April with the spring thaw and continues into early June at which time the corn plant is now using more water from the soil than is being supplied by normal precipitation.

The question has been asked What is the relationship of spring soil moisture and summer precipitation to yield? During the summer of 1976, May through August, all of the rain that fell was absorbed into the soil with virtually no runoff, a most unusual circumstance. As a result this afforded a wonderful opportunity to discover the value of water to the corn crop. The early spring "plant available soil water" was added to the rain of May through August in 1976 for each county. Figure 2 shows these values plotted against the county yields. The R^2 value equals 0.88 for the data. The graph shows that corn plants need 20.5 inches of water to produce 100 bushels per acre corn in Minnesota, assuming current management condtions common (across) to the southern half of the state. The curve does not take into account run-off, thus in those years when run-off occurs more water than 20.5 inches is required to produce 100 bushels corn. The 1976 season resulted in an unusual situation that gave a means of determining the value of water, as shown in Figure 2.

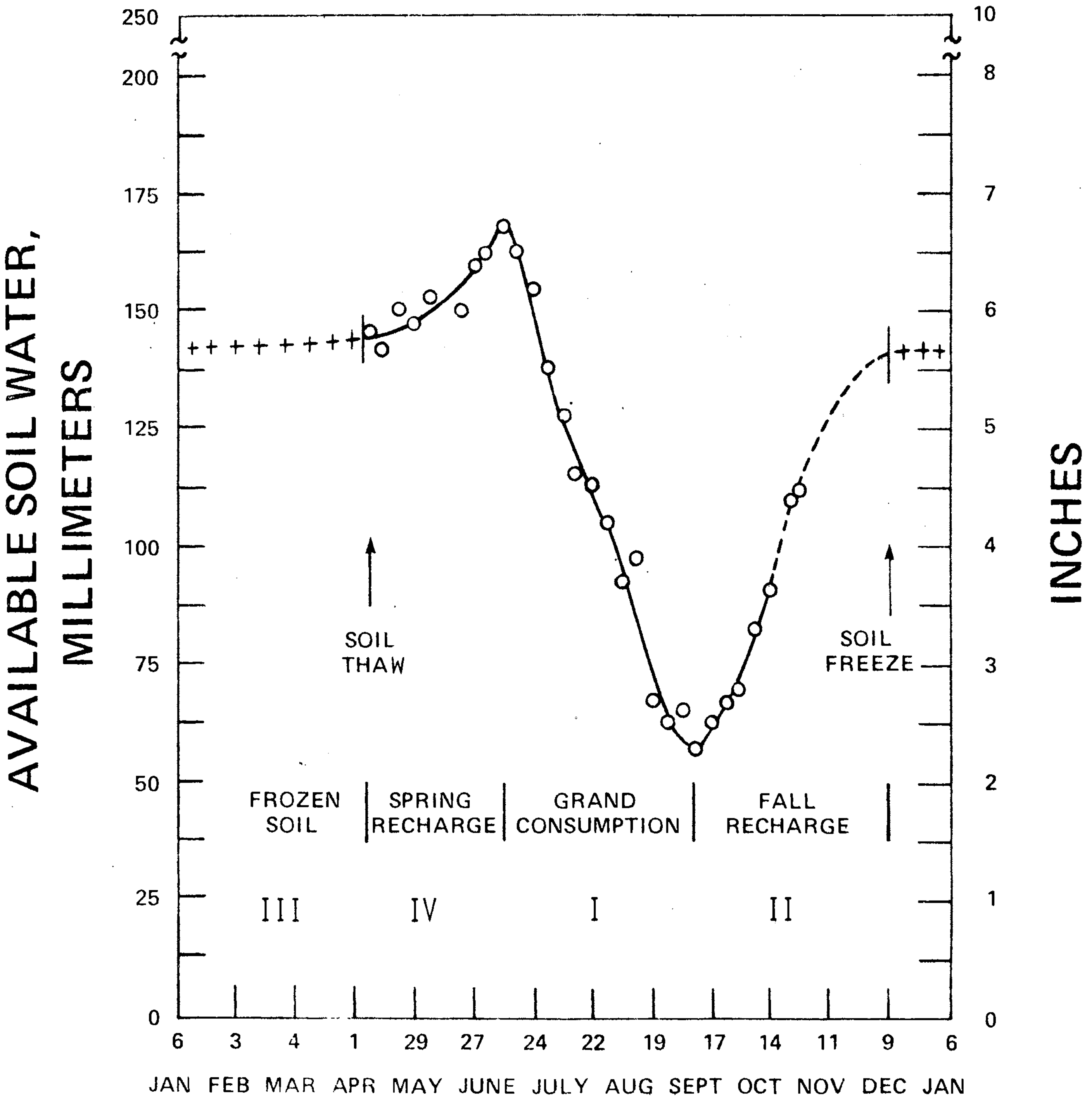
The 1977 growing season compared to the 1976 season was very similar, in that all of the rainfall that fell from May through August was absorbed by the soils except in localized areas in late August.

Figure 3 shows the amount of plant available soil water on May 1, 1977 across Minnesota. The area of 6-8 inches of plant available soil water is about average for that time of the year. It extends generally from the west central part of the state along the Minnesota River southeast across the State. The rest of the State had below average plant available soil water on May 1st.

Figure 4 shows the May through August, 1977 total rainfall (for 1977). The rainfall amounts throughout the corn area on the whole were near normal for this period. As was computed before, the sum of the spring "plant available soil water" and summer precipitation were again totaled for 1977 for the 42 counties which produce about 90% of the corn. Estimates of corn yield by county were made as shown on Figure 5, using the 1976 yield curve. The higher county corn yields in bushels per acre show an orientation along the Minnesota River southeast through the State, which is similar to the orientation of the spring soil moisture shown in Figure 3.

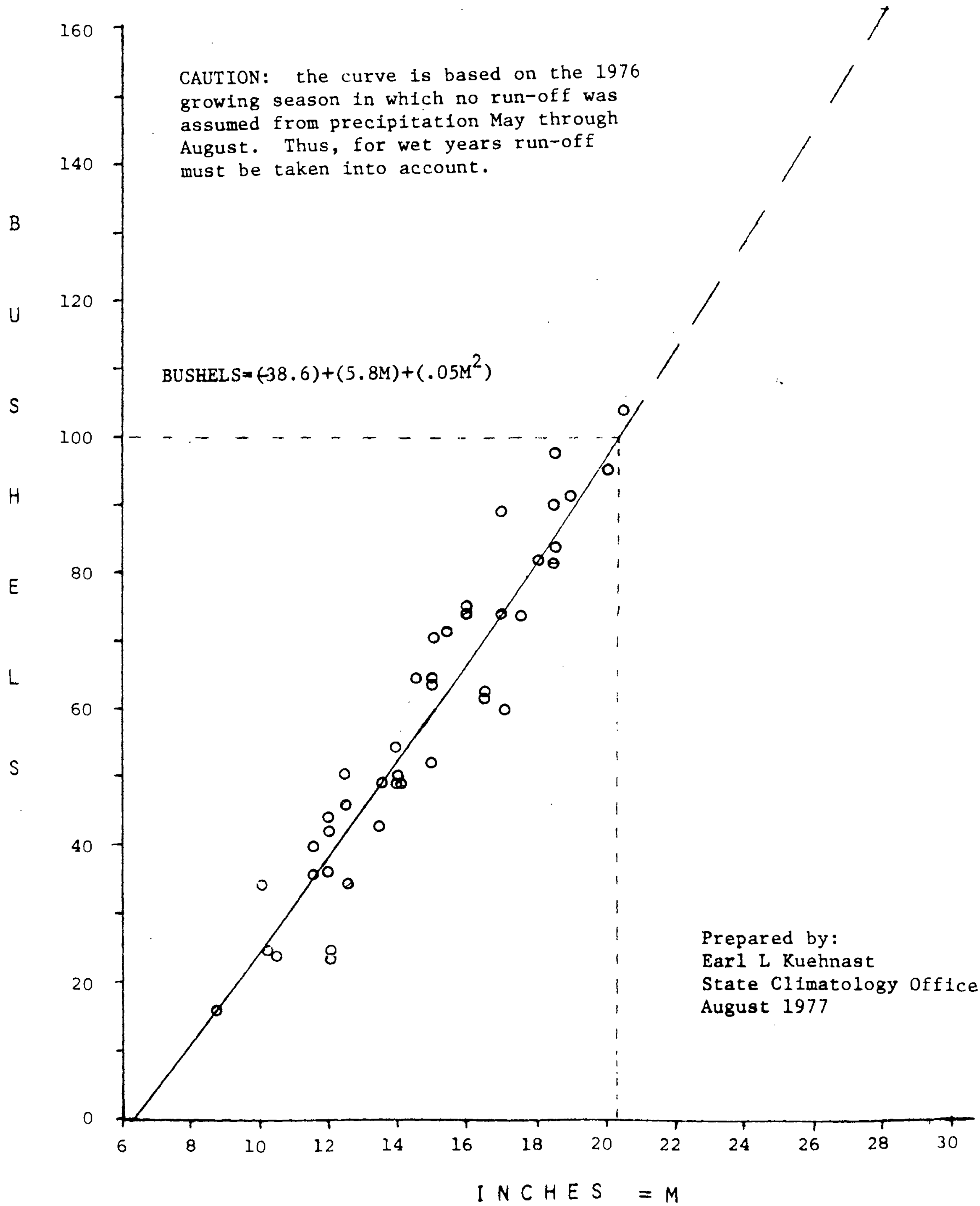
Figure 6 shows the August, 1977, precipitation amount for the State. In the counties where the precipitation amounts were 5 inches or more the corn yield estimates are expected to be too high since run-off was not taken into account but no more than about 10-15 bushels per acre too high.

In order to make yield estimates for wet years and for other crops we will need a statewide soil moisture network, first to aid in determining the amount of run-off in those wet years, and second to determine the amount of moisture needed to raise optimum yields of other crops.



Prepared by:
Donald G Baker
Dept of Soil Science
University of Minnesota

Figure 1



Average county corn yields compared to the calculated plant available water during the 1976 growing season. "Inches" equal the amount of available water in the top 5 feet of soil on May 1 plus the amount of precipitation from May through August.

Figure 2

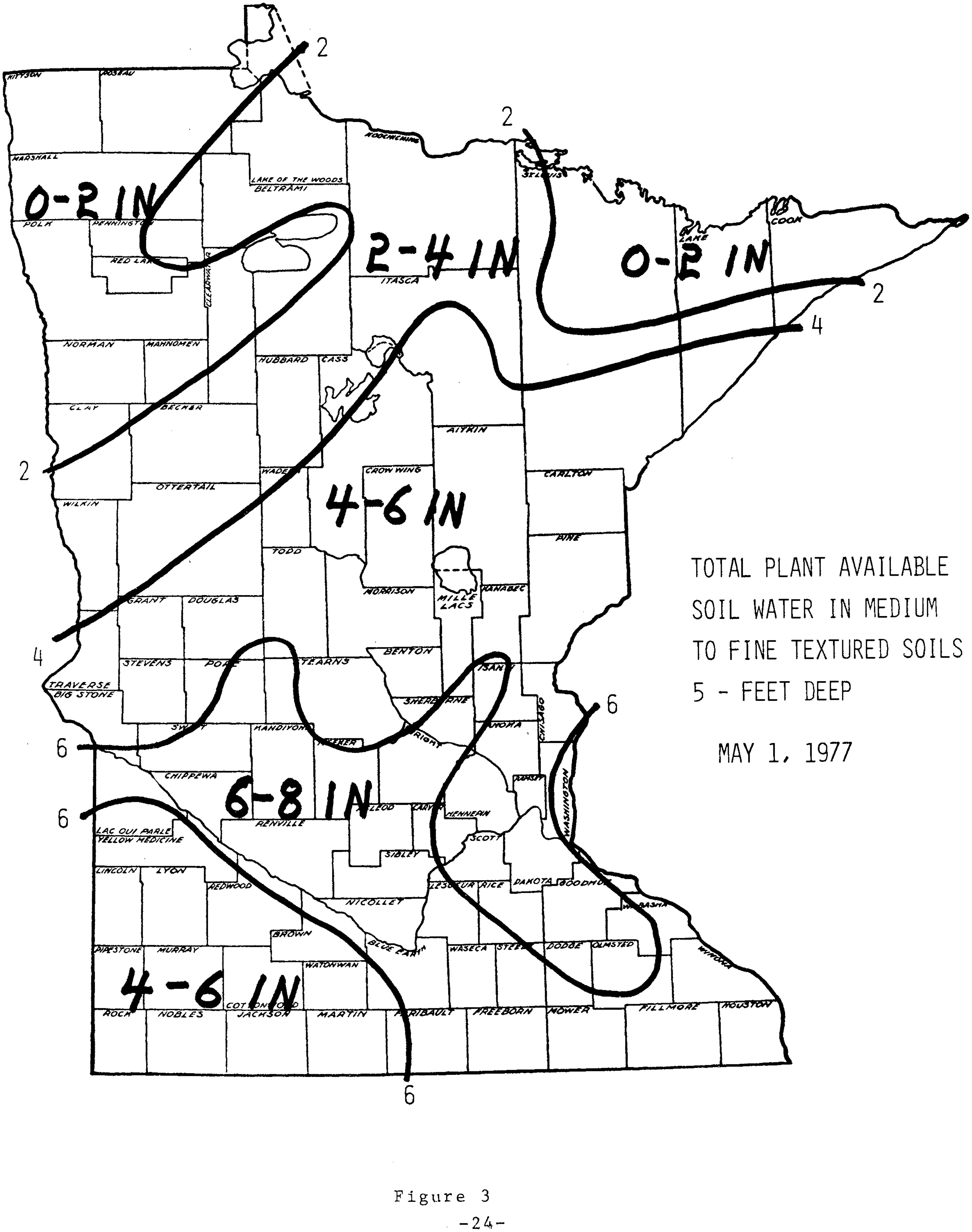
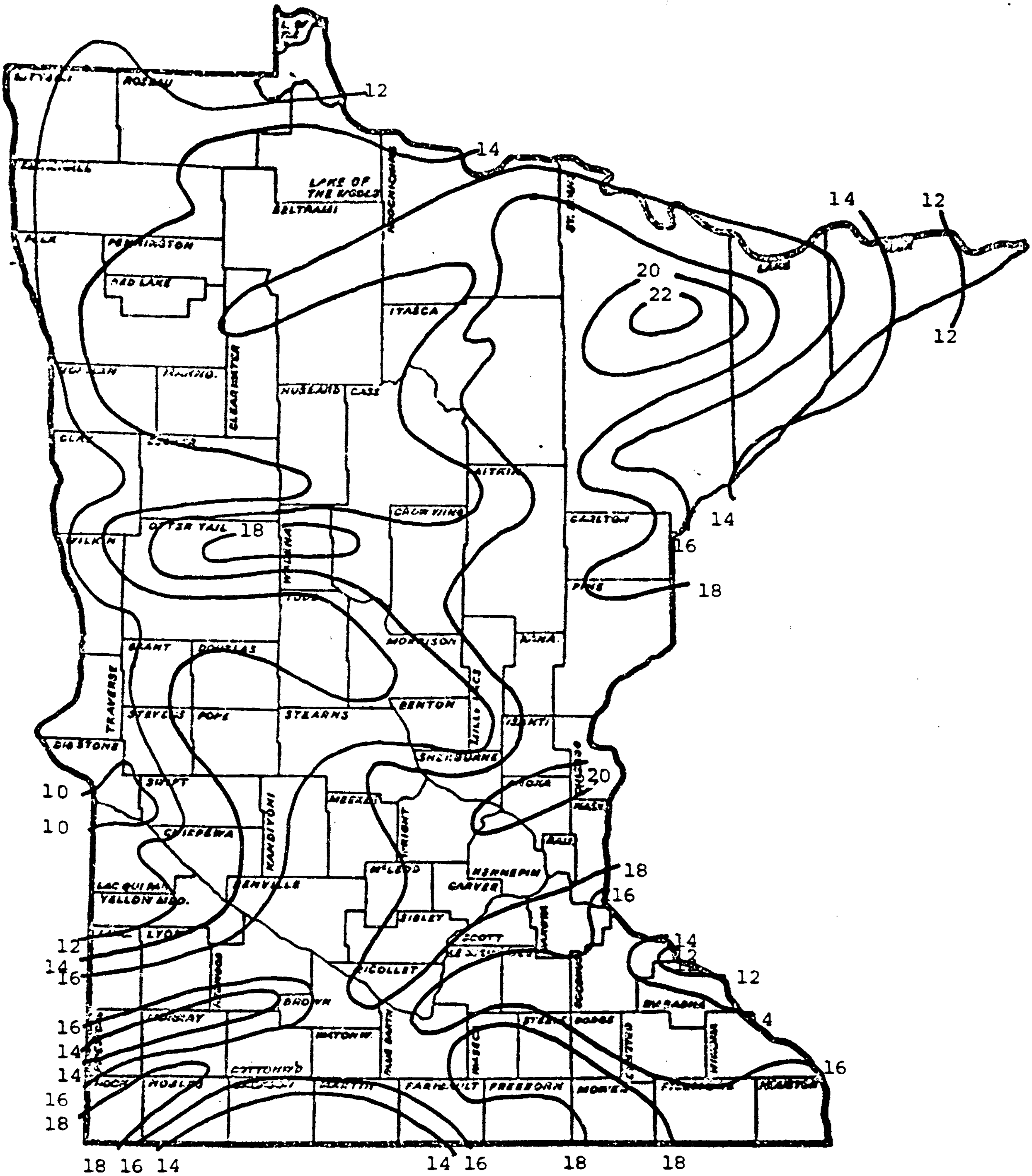
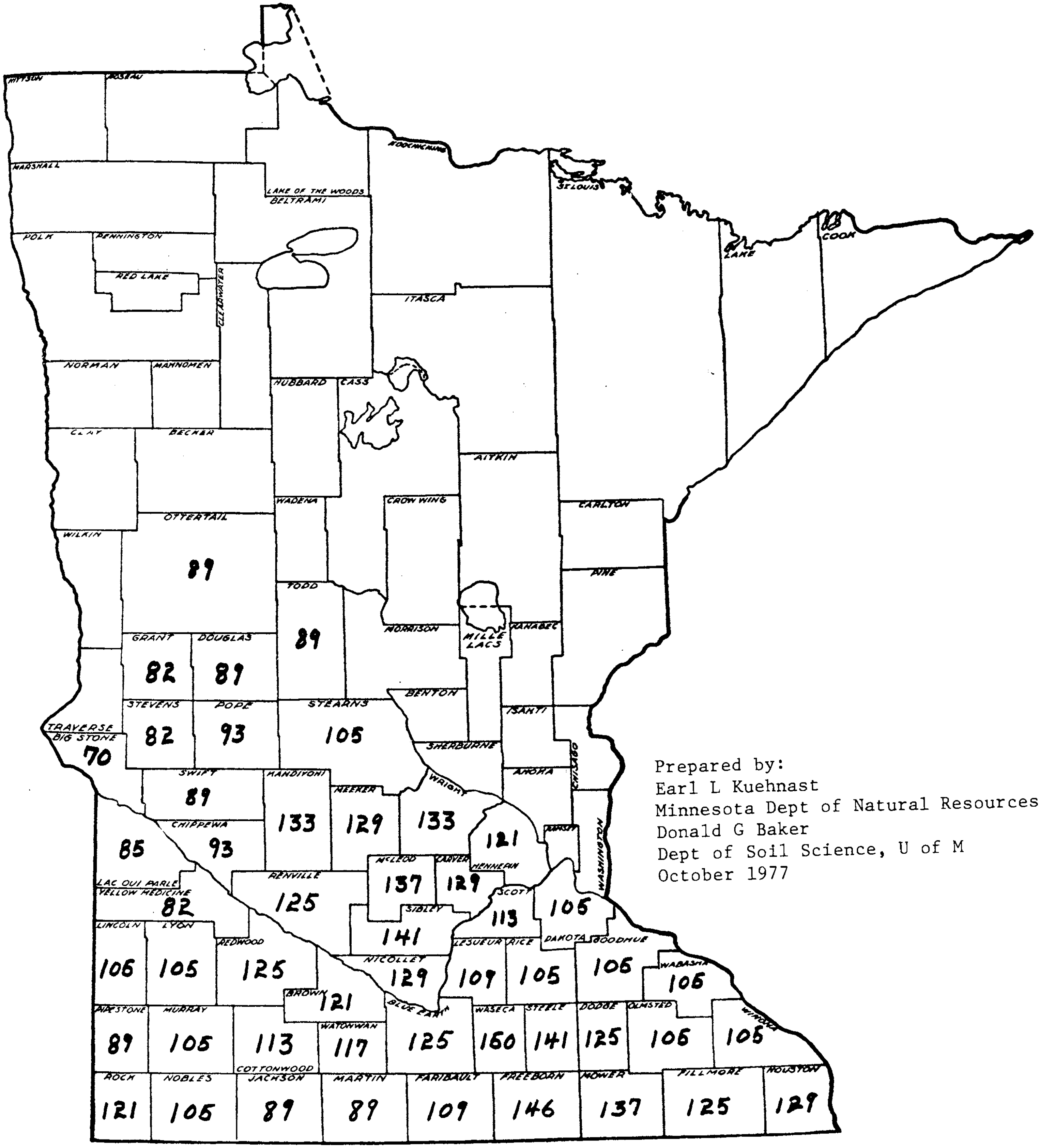

TOTAL PLANT AVAILABLE
SOIL WATER IN MEDIUM
TO FINE TEXTURED SOILS
5 - FEET DEEP
MAY 1, 1977
0-2 IN
2-4 IN
0-2 IN
4-6 IN
6-8 IN
4-6 IN
2
2
2
2
4
4
6
6
6
6
6
KITTSON
ROSEAU
MARSHALL
LAKE OF THE WOODS
BELTRAMI
KOOCHICHING
POLK
PENNINGTON
RED LAKE
CLEARWATER
ITASCA
COOK
LAKE
NORMAN
MAHNOMEN
HUBBARD
CASS
CLAY
BECKER
AITKIN
CARLTON
WADENA
CROW WING
WILKIN
OTTERTAIL
PINE
TODD
MORRISON
MILLE LACS
KANABEC
GRANT
DOUGLAS
BENTON
STEVENS
STEARNS
TRAVERSE
BIG STONE
SHERBURNE
CHISAGO
KANDIYOHI
MEEKER
WRIGHT
ANOKA
CHIPPEWA
RAMSEY
WASHINGTON
RENVILLE
HENNEPIN
LAC QUI PARLE
YELLOW MEDICINE
SCOTT
SIBLEY
LINCOLN
LYON
REDWOOD
RICE
DAKOTA
NICOLLET
BROWN
WASECA
DODGE
OLMSTED
WINONA
PIPESTONE
MURRAY
WATONWAN
ROCK
NOBLES
JACKSON
MARTIN
FREEBORN
MOWER
FILLMORE
HOUSTON

Figure 3



Precipitation May through August 1977 in inches.

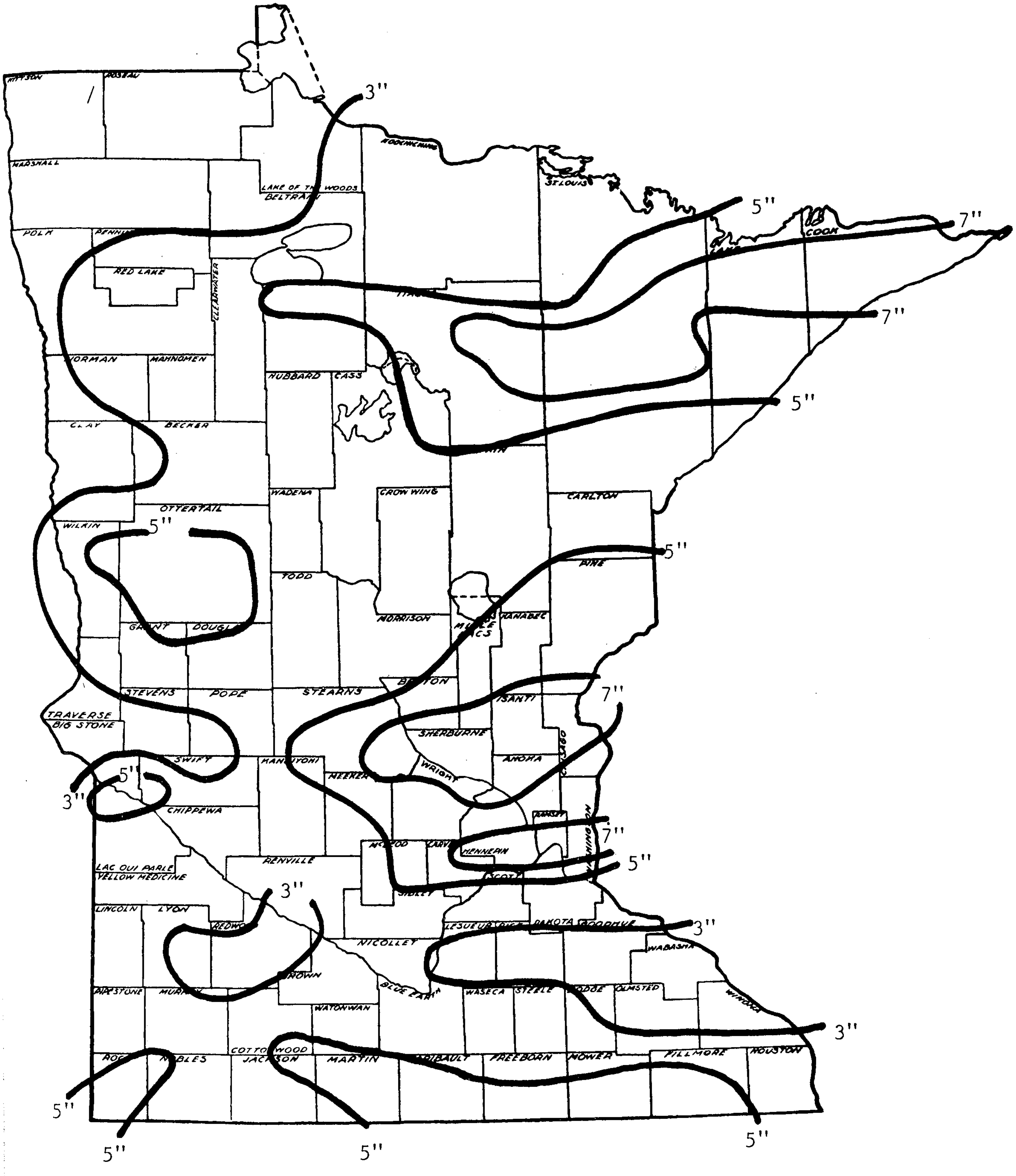
Figure 4



Prepared by:
Earl L Kuehnast
Minnesota Dept of Natural Resources
Donald G Baker
Dept of Soil Science, U of M
October 1977

Estimated county corn yields for 1977. Yields are based on plant available moisture in the top 5 feet of soil on May 1, 1977 and the amount of precipitation from May thru August 1977. The counties represent 94% of the corn for grain.

Figure 5



Precipitation - August 1977

Figure 6

FERTILIZER PROBLEMS IN 1977

Wallace W. Nelson, Superintendent
Southwest Experiment Station
Lamberton, Minnesota

The outstanding fertilizer problems in 1977 was the relative non-existance of them compared to almost any crop year in memory. A combination of circumstances over the last several seasons and the - "normal" - that is very abnormal 1977 season - combined to make this possible.

Drier than normal growing seasons for the last several years with above normal growing degree weather set the stage for higher than normal mineralization of organic matter, lower than normal leaching or denitrification of nitrates and thus accumulation of readily available nutrients compared to most seasons. This with a history of fairly good fertilization over the years by the good commercial farmers set the stage for 1977.

A very early spring with near ideal planting moisture and temperature allowed the early growth to utilize the nutrients that were readily available and to develop an excellent root system. Moisture came as needed but never in surplus throughout the growing season.

A series of slides show the growth and development of the corn and soybean crops throughout the season.

ADDING NITROGEN TO THE GROWING CROP

Gyles W. Randall, Soil Scientist
Southern Experiment Station
University of Minnesota

INTRODUCTION

Urea-ammonium nitrate (UAN) solutions are rapidly gaining acceptability in Minnesota as a source of nitrogen fertilizer. One of the common uses of UAN is to combine herbicides with the N solution and to apply both in one application, commonly called "weed and feed". This combination can be applied postemergence as late as the 4-leaf stage of corn. Another possible usage for UAN is a late postemergence treatment in areas where N has been lost by denitrification or leaching. Sometimes this late treatment is placed over the top of corn or banded as a substitute for side-dressing anhydrous ammonia. The purpose of this study was to increase the efficiency of N fertilizer applied as UAN to corn by determining the:

1) maximum rate of UAN applied postemergence to corn without significant plant damage and/or yield loss.

2) optimum stage of corn growth or method of application for greatest N efficiency.

3) possible synergistic effect of UAN and atrazine on corn production.

EXPERIMENTAL PROCEDURES

An experiment with 20 treatments (Table 1) and five replications was established on a Webster clay loam at the Southern Experiment Station in 1976 and 1977. Broadcast P and K (0+50+100 $N+P_2O_5+K_2O/A$) was applied to corn stalks and plowed down each year. Supplemental N as ammonium nitrate was added to each plot to bring the total N amount to 150 lb N/A (except trt 3 which received 200 lb N/A). The ammonium nitrate was broadcast and disked in before planting.

Corn was planted in 30-inch rows at 26,100 ppa in 1976 and 24,200 ppa in 1977. Starter fertilizer (140 lb/A of 0-23-30) and insecticide (1 lb Furadan/A in 1976 and 1 lb Counter/A in 1977) were used. Weeds were chemically controlled with Lasso plus Bladex (3 + 2½ lb/A).

UAN (28% N) was applied over the top of the corn with a calibrated bicycle sprayer at the 4-leaf (5-leaf in 1977) and 8-leaf stages. Skies were clear and with moderate to warm temperatures on both days. Atrazine was mixed with the UAN and applied at the rate of 2 lb/A at the 4-leaf (5-leaf) stage (trts 18, 19 & 20). At the 12-leaf stage premeasured amounts of UAN were sidedress-applied by hand. No cultivation followed the sidedress application.

Plant growth as affected by the UAN application at the 4-and 8-leaf stages was determined from the border rows of each plot. All other data was obtained from the center two rows of each four-row plot.

RESULTS

Topdress applications to emerged corn did effect the vigor and growth of the plants. In 1976, twenty-four hours after application of UAN at the 4-leaf stage, leaves showed increased chemical burn with increasing UAN rates. The 30-lb N rate showed very slight burning of the tips. Slight to moderate burning was observed on the 2nd and 3rd leaves with the 60 and 90-lb N rates. Heavy burning with wide-spread necrosis on the 2nd, 3rd and 4th leaves was shown with the 120 and 150-lb N rates. Some leaves were sloughed from the plants at the high rate. When atrazine was added the 60-lb N treatment resulted in leaf burn similar to the 150-lb N rate without atrazine. The 90-and 120-lb N rates with atrazine resulted in severe necrosis and partial loss of leaves. New leaf growth, however, was emerging from the whorl of plants from all treatments. Seven days after application, necrosis was only evident on the 120-and 150-lb N treatments and those that received atrazine. Some delayed plant growth was also observed 7 days after application but differences 14 days after were negligible.

In 1977 similar burning patterns were observed. The UAN plus atrazine treatments did result in reduced plant growth when compared to UAN alone (Table 1). In addition, at both 13 and 35 days after application plant growth was significantly reduced by UAN applications at rates of 60 lb N/A or greater.

Table 1. Effect of post-emergence application of UAN on growth and height of corn at Waseca in 1976 and 1977.

	Treatments			Plant Growth			Plant Height	
	N rate 1/		Growth 2/					
No.	UAN	AN	stage	7/6/76 3/	6/20/77 4/	7/12/77 5/	8/31/76	8/19/77
	--lb N/A--		leaf	---------g/plant---------			----inches-----	
1	0	0	pre	42.7		111.	77	92
2	0	150	"	41.7	16.8	129.	78	92
3	0	200	"			121.	78	91
4	30	120	4		15.2	123.	79	91
5	30	120	8	39.2		112.	78	91
6	60	90	4		12.9	119.	76	90
7	60	90	8	40.5		104.	75	90
8	60	90	12			119.	76	91
9	90	60	4		11.3	116.	75	92
10	90	60	8	36.7		109.	77	90
11	90	60	12			119.	78	91
12	120	30	4		9.8	103.	78	89
13	120	30	8	32.9		96.	77	86
14	120	30	12			116.	80	93
15	150	0	4		8.4	104.	76	89
16	150	0	8	26.6		87.	77	84
17	150	0	12			113.	81	93
18	60+2 Atra.	90	4		10.7	113.	78	90
19	90+2 Atra.	60	4		9.7	103.	74	88
20	120+2 Atra.	30	4		6.6	93.	77	89
	BLSD(.05)			4.9	1.6	10.	5	3

1/ Supplemental N as AN (ammonium nitrate) was added to each plot to total 150 lb N/A except trt. 3 which received 200 lb N.

2/ Because of wet conditions in 1977 UAN was applied at the 5-leaf stage rather than at the 4-leaf stage.

3/ 16 days after application at the 8-leaf stage.

4/ 13 days " " at the 5-leaf stage.

5/ 35 days and 22 days after application at the 5-and 8-leaf stages, respectively.

In both years at the 8-leaf stage, UAN resulted in more severe burning and lasting necrosis than at the 4-leaf stage. Plant growth, measured 16 days after application in 1976, was not significantly reduced when rates of 30 or 60 lb N/A were used (Table 1). Reductions of 12, 21 and 36% were found with the 90, 120 and 150 lb N rates, respectively.

In 1977, plant growth measured 22 days after application was reduced by all UAN rates applied at the 8-leaf stage. Reductions of 10, 17, 13, 23 and 30% were found with the 30, 60, 90, 120 and 150 lb N rates, respectively.

Plant heights in late August were influenced by the post-emergence UAN treatments in both years (Table 1). Because of the very dry conditions in 1976, plant height was variable; although the tallest plants were associated with the sidedress application at the 12-leaf stage. In 1977, height was reduced significantly by the 120 and 150-lb UAN treatments applied at the 8-leaf stage. Other treatments did not appear to effect plant height.

Grain yields were low and quite variable in 1976 -- a very dry year (Table 2). Although plant growth was reduced substantially by the higher UAN rates applied at the 8-leaf stage, no effect on yield was noted. Somewhat lower yields were obtained when combining atrazine with larger amounts of UAN.

In 1977, yields were higher and were quite uniform within treatments throughout the experiment. Yields from the check treatment (0 lb N/A), the 90-, 120-, and 150-lb N rates applied at the 8-leaf stage, and the 120-lb N rate plus atrazine applied at the 5-leaf stage were reduced significantly from the 150-lb soil-applied treatment (no. 2). The 150-lb rate applied at the 8-leaf stage actually depressed the yield 16 bushels below the corn which received no N (trt. no. 1). Although growth differences were observed 13 and 35 days after the application at the 5-leaf stage, no yield reductions were found.

SUMMARY

UAN applied to the growing corn plant does result in phytotoxic effects. When applied at the 4-leaf stage, the effects are magnified by increasing N rate, but are not permanent and do not appear to reduce corn yields. When applied at the 8-leaf stage, the severity of the leaf burn is again increased with increasing N rate. However, these effects are longer lasting and do result in decreased yields at rates greater than 60 lb N/A. Combining atrazine with UAN at N rates greater than 90 lb/A and applying at the 5-leaf stage did result in a significant yield reduction.

Table 2. Effect of post-emergence application of UAN on corn yield at Waseca in 1976 and 1977.

	Treatments			Yield	
	N rate[1]		Growth[2]		
No.	UAN	AN	stage	1976	1977
	-----lb N/A-----		leaf	----bu/A----	
1	0	0	pre	62.8	134.7
2	0	150	"	77.5	150.1
3	0	200	"	76.5	144.7
4	30	120	4	68.9	147.7
5	30	120	8	85.6	147.6
6	60	90	4	68.6	152.7
7	60	90	8	77.1	142.4
8	60	90	12	63.5	150.8
9	90	60	4	69.1	150.8
10	90	60	8	77.9	135.0
11	90	60	12	73.1	148.5
12	120	30	4	80.1	147.8
13	120	30	8	76.1	126.8
14	120	30	12	84.3	149.0
15	150	0	4	66.2	149.3
16	150	0	8	73.1	118.6
17	150	0	12	70.1	148.9
18	60+2 Atra.	90	4	72.9	153.8
19	90+2 Atra.	60	4	61.7	145.1
20	120+2 Atra.	30	4	66.4	137.5
	BLSD(.05)			15.0	11.1

1/ Supplemental N as AN (ammonium nitrate) was added to each plot to total 150 lb N/A except trt. 3 which received 200 lb N.

2/ Because of wet conditions in 1977 UAN was applied at the 5-leaf stage rather than at the 4-leaf stage.

3/ 16 days after application at the 8-leaf stage.

4/ 13 days " " at the 5-leaf stage.

5/ 35 days and 22 days after application at the 5- and 8-leaf stages, respectively.

NITRIFICATION INHIBITORS
1977 MINNESOTA RESEARCH

Gary Malzer - Assistant Professor, Department of Soil Science

Nitrification inhibitors have currently been available for commercial use in Minnesota for the last three years. Although there are a large number of chemicals known which can inhibit the process of nitrification, at the present time there is only one product which is currently available. This product, N-serve (often called nitraprin) is marketed by the Dow Chemical Company and is advertised as a nitrogen stabilizer.

What is the purpose of a nitrification inhibitor?

Nitrification inhibitors are chemicals which are toxic to the microorganisms in the soil which are responsible for the conversion of ammonium nitrogen to nitrate nitrogen. Although plant roots may utilize either the ammonium form or the nitrate form, the nitrate form will usually be more available since it moves to the plant root quite readily with the soil water. The ammonium form will be retained by the soil organic matter and clay and will not move readily with soil water until it has been converted to the nitrate form. The potential advantages associated with the use of nitrification inhibitors are related to the potential losses of nitrate nitrogen which may occur either through leaching and/or denitrification. If climatic conditions are such that losses of nitrate nitrogen are severe, potential benefits of nitrification inhibitor application will be associated with improved nitrogen utilization efficiency and potentially higher yields. An additional advantage of increased flexibility with fall nitrogen applications may also be obtained where nitrogen losses occur. Current recommendations suggest delaying fall nitrogen application until soil temperatures reach 50-55 degrees. This recommendation is made in order to minimize the conversion of ammonium nitrogen to nitrate nitrogen and thereby limit the amount of nitrate nitrogen which may be suspectible to leaching and denitrification losses the following spring. If chemicals are effective in controlling this reaction as well as temperature added flexibility may be obtained in the nitrogen fertilizer application programs.

Minnesota Nitrification Inhibitor Research

Research is currently in progress in two situations where nitrification inhibitors should have their greatest potential. These two situations are: 1) on fine textured soils where losses of nitrate through denitrification may be a problem and, on 2) coarse textured soils where losses of nitrate nitrogen by leaching may occur. It is normally recommended that in both of the above situations if nitrification inhibitors are utilized they should be applied with ammonium forming fertilizers such as anhydrous ammonia or urea simultaneously with fertilizer application.

Nitrification Inhibitor Research on Fine (heavy) Textured Soils

Projects are currently in progress at the experiment stations at Waseca, Lamberton, Morris and Crookston. These projects are similar and were designed to evaluate the significance of nitrification inhibitors and the importance of soil temperature with relation to fall nitrogen application programs. The experimental parameters used in 1977 are presented in Table 1.

Table 1. N-Serve experiments with fall nitrogen applications

	Experimental Locations			
	Waseca	Lamberton	Morris	Crookston
N Rate #/A	0 75 150	0 50 100	0 40 80	0 40 80
Date of N Application	9/10 10/5 11/1 4/25	9/15 10/1 11/1 4/29	8/25 9/24 10/26 4/26	8/17 9/15 10/19 5/3
N Serve Rate #A.I./A	0 1/2	0 1/2	0 1/2	0 1/2
Test Crop	Corn	Corn	Corn	Wheat

The 17 treatments at each location included three fall applications and one spring application with the times and rates of nitrogen adjusted according to the geographical area and test crop. All nitrogen was applied as anhydrous ammonia in 30 inch knife spacings for corn and 15 inch knife spacings for wheat. At each time and rate of nitrogen application the nitrification inhibitor, N-Serve, was either not applied or applied at one-half pound active ingredient per acre.

Soil samples were obtained from a 0-1' depth directly over the anhydrous ammonia band at approximately one week intervals to follow the conversion of ammonium nitrogen to nitrate nitrogen. Some of

Table 2. Soil ammonium concentrations at a 0-1' depth following fall and spring applications of anhydrous ammonia with and without N-Serve (1976-77)--WASECA EXPERIMENT STATION.

N. Appl.[1]	N-Serve	Soil Ammonium Conc. PPM NH_4^+-N (0-1')											
	Sample Date	9/15	9/29	10/13	10/27	11/10	4/8	4/22	4/28	5/10	5/19	6/8	7/6
	Control		5				11	13	7	7	9	6	7
9/10	-	301	182	180	188	172	96	89	57	36	28	12	11
	+	287	200	216	232	209	122	127	122	75	88	56	17
10/5	-				259	288	210	168	99	76	45	16	13
	+				206	251	180	211	135	84	95	60	15
11/1	-					243	197	177	100	61	53	20	17
	+					244	254	178	153	115	77	46	19
4/25	-								216	174	127	55	12
	+								191	128	72	49	15

[1]Samples were taken from treatments receiving 150 # N/A

the information obtained at the Waseca Experiment Station is presented in Table 2. This data would suggest that N-Serve did have an effect in keeping more nitrogen in the ammonium form especially with fall applications. Fall samples appeared inconclusive although samples taken in the spring from the fall nitrogen applied areas indicated that N-Serve held 10-20% more of original nitrogen applied in the ammonium form than was present with no treatment. If this is indeed the case this should result in fewer nitrates being present in the soil which may be suspectible to leaching or denitrification. Since soil nitrate moves readily with soil water, samples were taken to a depth of five feet at monthly intervals to follow movement and accumulation of nitrate nitrogen in the soil profile. Results of samples taken in the spring from areas which received fall nitrogen are presented in Table 3.

Table 3. Soil profile nitrate concentration as effected by N-Serve and time of all nitrogen application (1976-77 Waseca Experiment Station). Samples taken 4-8-77.

		Date of N Application [1]		
Depth	N-Serve	9/10	10/5	11/1
ft			ppm NO_3^- - N	
0-1	(-)	20	24	16
1-2		39	25	9
2-3		16	6	4
3-4		3	2	2
4-5		2	2	2
0-1	(+)	16	16	14
1-2		29	22	13
2-3		12	9	5
3-4		3	2	2
4-5		2	1	1

[1] 150 # N/A as A.A.
control 21-6-6-4-3

Temperature was an effective method of minimizing nitrate nitrogen accumulation in the profile. More total nitrate nitrogen and also a greater movement downward in the soil profile was found in the spring where early fall nitrogen was applied. N-Serve also had an influence in reducing nitrate nitrogen accumulation. When nitrogen was applied at temperature above 50-55 degrees N-Serve appeared to provide an additional three weeks for application without increasing the nitrate accumulation in the profile the following spring.

Corn grain yields from the three corn experiments at Waseca, Lamberton and Morris are presented in Table 4.

Table 4. Corn Grain Yields as Influenced by Time of N Application, Rate of N and Nitrification Inhibitor Application

	Waseca	Lamberton	Morris
	Corn grain Bu/A 15.5% Moist.		
N Application Date			
Early Fall	148 (9/10)	131 (9/15)	113 (8/25)
Mid Fall	155 (10/5)	134 (10/1)	113 (9/24)
Late Fall	150 (11/1)	133 (11/1)	111 (10/26)
Spring	154 (4/25)	135 (4/29)	114 (4/26)
N Rate			
Control	140 (0)	128 (0)	118 (0)
Medium	150 (75)	133 (50)	113 (40)
High	153 (150)	133 (100)	112 (80)
N-Serve			
-	150	133	113
+	153	133	112

Nitrification Inhibitor Research on Coarse (light) Textured Soils

Recommendations for nitrogen application to coarse textured soils especially those under irrigation are considerably different than fine textured soils. Because of the lower water holding capacity and the potential losses of nitrate nitrogen through leaching fall nitrogen applications are not recommended. The most efficient practice has been to add nitrogen to the irrigation water in proportion to the plants needs during the season. This is normally a very good practice, but in the event that adequate moisture is received during the growing season so that only limited irrigation takes place, less than optimum nitrogen will be applied.

Experiments were established in 1977 at the irrigated sand plains research farm at Becker, Minnesota to evaluate the importance of nitrification inhibitors in single vs. split nitrogen application programs. Two chemicals, N-Serve (Dow Chemical) and Terrazole (experimental chemical of Olin Corp.) were compared to no inhibitor treatment. Nitrogen was applied as urea at rate of 0, 60, 120, 180, and 240 # N/A in either a single application (preplant and incorporated) or in split nitrogen applications (1/6 preplant, 1/6 12-18" plant height, 3/6 at sidedressing and 1/6 at tasseling). The nitrification inhibitors were applied as a coating on the urea prior to soil application and corn grown on the area. The yields obtained in 1977 are presented in Table 5.

Table 5. 1977 Corn Grain Yields at Becker, MN as Influenced by Nitrogen Rate, Time of Application and Nitrification Inhibitor Treatment.

	Nitrogen Rate #/A				
	0	60	120	180	240
	Corn Grain Yield bu/A 15.5% moist				
Single N Application					
Control	37	93	144	160	142
N-Serve[1]		93	143	145	158
Terrazole[1]		110	161	174	166
Split N Applications					
Control		121	162	175	169
N-Serve		129	152	164	160
Terrazole		111	153	170	169

[1]Applied at 0.5 # A.I./A

Grain yields were substantially increased with the application of nitrogen. Splitting of nitrogen application at a given rate of N increased yields 15-20 bushels indicating that losses of nitrogen must have occurred with the early spring application. Single applications of nitrogen with a nitrification inhibitor should approximate the yield obtained with split applications if it was effective in minimizing the nitrogen losses. Terrazole at the rate applied appeared to be effective in minimizing the nitrogen losses since 1 application with Terrazole was similar to split N applications without inhibitor. N-Serve application was not as effective suggesting that the rate of chemical applied was not high enough for the climatic conditions encountered in 1977. The use of nitrification inhibitors both N-Serve and Terrazole were not beneficial in split nitrogen application programs.

General Summary

We are finding that the chemicals under investigation are effective in slowing down that rate at which nitrification takes place. A beneficial yield response to the application of nitrification inhibitors will be achieved only when we encounter climatic conditions which create losses of nitrate nitrogen either through leaching and/or denitrification. If crop response to nitrogen is minimal the beneficial effects of nitrification inhibitors will also be minimal. Under irrigation it would appear that increased information on rates of nitrification inhibitor to apply with nitrogen fertilizers may be necessary.

PEST MANAGEMENT IN MIDWEST CROPS

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I. WHAT IS PEST MANAGEMENT?

A. The management of pest populations using crop varieties, cultural and mechanical techniques, parasites, predators, pest diseases and pesticides to keep the pest level below economic thresholds.

II. WHAT IS AN ECONOMIC THRESHOLD?

A. The level of a pest population at which, if left uncontrolled, losses caused by the pest would exceed the costs involved in its control.

III. WHAT ARE THE COSTS OF CONTROL?

A. They vary with the pest, but from the growers standpoint they are chemical costs, application costs and environmental effects.

IV. HOW IS PEST MANAGEMENT PRACTICED?

A. Consulting firm contracts with grower to provide

1. Expertise to make objective recommendations
2. Regular, routine field visits, monitoring crop progress, pests, predators, parasites, diseases, etc.
3. Light trap records to monitor insect flights and predict possible pest outbreaks.
4. Make pesticide recommendations only when they are needed, recommendations to include the best material, best application technique and best timing for that specific situation.

V. Is PEST MANAGEMENT ECONOMICALLY FEASIBLE?

A. It is from 4 years of experience on corn, milo and alfalfa.

1. Savings on corn rootworm insecticides will more than pay costs of the pest management service on corn. 50% of the acreage being routinely treated now, does not need soil insecticide.
2. Difficult to put dollar figures on
   a. Timely applications of pesticide applied in the best way.
   b. Knowing you don't need a pesticide when others around you are treating.
   c. Using the best pesticide for the job that will also have the least effect on the environment.

PUT KNOWLEDGE OF PEST BIOLOGY TO WORK IN SPECIFIC CROPS WHERE THAT FIELD"S ENVIRONMENT WILL INFLUENCE THE OUTCOME.

SPRAY NOZZLE SELECTION FOR GROUND SPRAY APPLICATION OF HERBICIDES

Alan Dexter
Sugarbeet Weed Control Specialist
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Spray nozzles used in agriculture produce four types of spray patterns: tapered edge-flat spray, even spray-flat spray, hollow cone, and solid cone.

The flat spray nozzles produce a thin sheet of liquid which breaks into droplet shortly after leaving the nozzle. Tapered edge-flat spray nozzles deliver more spray to the center of the pattern than to the edges while even spray-flat spray nozzles deliver a uniform amount of spray across the spray pattern. Tapered edge-flat spray nozzles are used for broadcast applications and the patterns from the nozzles must be overlapped for uniform application. Even spray-flat spray nozzles are used for band applications and any overlap with even spray nozzles will give a double application. Examples of tapered edge-flat spray nozzles are Delavan Type LF nozzles (such as LF-2 80°) and Spraying Systems Teejet nozzles (such as 8002). Examples of even spray-flat spray nozzles are Delavan type LE (such as LE-2 80°) and Spraying Systems Teejet E type (such as 8002E).

The hollow cone and solid cone sprays emerge from the nozzle in a circular pattern. The spray droplets are uniformly distributed throughout the circle in a solid cone pattern while the spray droplets are concentrated around the circumference of the circle with the hollow cone pattern. The solid cone pattern is used very little in agriculture and will not be discussed. A nozzle with a hollow cone pattern produces a fairly uniform droplet distribution from one edge of the pattern to the other when the nozzle is pointing straight down. Thus hollow cone nozzles oriented straight down can be used for band applications. When hollow cone nozzles are oriented 45 degrees or more from the vertical then the nozzles deliver more spray to the center of the pattern than to the edges. Thus hollow cone nozzles at an angle can be overlapped and used for broadcast applications. Examples of nozzles which produce hollow cone patterns are whirl chamber nozzles, disc and core type nozzles, and one piece hollow cone nozzles like Delavan type HC nozzles and Spraying Systems Conejet nozzles.

The numbers and letters on nozzles generally have a specific meaning which can be helpful in nozzle selection. For example with 8002 or LF-2 80 nozzles, the "80" indicates that the nozzles have an 80 degree spray angle at 40 psi and the "2" indicates that the nozzle will deliver 0.2 gpm at 40 psi. The lack of an "E" following the 8002 and the "F" on the "LF-2" both indicate that these are tapered edge-flat fan nozzles. Even spray nozzles of the same size would be designated 8002E and LE-2 80. Nozzles come in a wide range of spray angles and delivery rates and the numbers on the nozzle indicate the angle and delivery rate. Spray angle determines proper nozzle height and delivery rate determines the gallons per acre applied at a given speed. Other types of nozzles have numbering and lettering systems which are different from the flat spray nozzles but the meaning of the numbers and letters can usually be determined from manufacturer's catalogues and technical data sheets.

The flood nozzle is a different type of nozzle in which the spray emerges from a round hole, strikes a deflector plate, and this deflector plate produces the spray pattern. The distribution of the spray from a flood nozzle in a horizontal position is approximately uniform from one edge of the spray pattern to the other. A flood nozzle in the vertical position delivers more spray to the center of the pattern than at the edges. Regardless of orientation, flood nozzles produce a pattern that is very non-uniform across the pattern. For any herbicide application with flood nozzles, the spray pattern should be overlapped at least 100 percent to reduce the non-uniformity of application. An overlap of 100 percent means that the edge of the spray pattern from one nozzle should fall directly under the next nozzle.

The three nozzles most commonly used for broadcast herbicide applications are the tapered edge-flat fan spray nozzle, the flood nozzle, and the whirl chamber nozzle.

The advantages of the tapered edge-flat fan nozzle are: a) a wide range of spray angles and spray volumes are available, b) applications with good uniformity are possible, and c) nozzles are relatively inexpensive and fit in standard nozzle assemblies. The disadvantage of the tapered edge-flat fan nozzle is greater susceptibility to plugging than the flood or whirl chamber nozzles.

The advantages of the flood nozzle are: a) quite resistant to plugging and b) the nozzle has a 120 degree spray angle which allows placement of the nozzles close to the ground and at a wider spacing than tapered edge-flat fan nozzles. However, the tapered edge-flat fan nozzle is available in a spray angle as wide as 110 degrees which allows a low placement. The disadvantages of the flood nozzle are: a) poor uniformity of application, b) high variability between nozzles, and c) spray pattern is greatly affected by changes in spray pressure. The flood nozzle should not be used with a sprayer that adjusts application rates by changing spray pressure. Maintaining at least 100 percent overlap is essential to achieve acceptable uniformity of application and any reduction in spray pressure will cause a decrease in overlap.

The advantages of the whirl chamber nozzle are: a) quite resistant to plugging, b) resistant to wear, c) available in a 120 degree spray angle, d) spray angle is relatively insensitive to spray pressure, and e) a version of the whirl chamber nozzle called "Raindrop type RA" is available. This nozzle produces a larger, more uniform sized droplet than other nozzles and would be a good nozzle to use for application of herbicides which cause problems with drift. The Raindrop nozzle would also be good for application of incorporated herbicides especially on a hot windy day. More herbicide would reach the soil with less volatility and drift with the large droplets from the Raindrop nozzle as compared to other nozzles. The disadvantage of the whirl chamber nozzle is they do not fit in standard nozzle assemblies.

Nozzles are available in several materials. Brass, stainless steel, and plastic or nylon are the most common. Brass is the least resistant to wear and stainless steel is the most resistant. However, some of the new plastic materials are nearly as resistant to wear as stainless steel and are cheaper. Plastic may be a good alternative to stainless steel for some uses.

Regardless of nozzles selected, all nozzles on a spray rig should: a) be constructed of the same material so any change in delivery rate with age will be similar with all nozzles, b) have the same spray angle and delivery rate, c) have the same mesh screen because mesh size can affect delivery rate, and d) be free from excessive wear or flaws in construction. A percentage of new nozzles will have flaws which prevent a uniform application. Often flaws can be determined by observing the spray pattern with a dark background. Any nozzles with visible streaks in the spray pattern should be replaced.

Since nozzles wear with use, a sprayer should be recalibrated on a regular basis. The first step in calibration is to check all nozzles for delivery rate. Any nozzles that deliver more or less spray than the other nozzles should be replaced.

- R P A R -

Phillip K. Harein

"Rebuttable Presumption Against Registration"

The Federal Insecticide, Fungicide and Rodenticide Act requires that the Environmental Protection Agency reviews all registered pesticides in the United States. About 1500 active pesticides are currently formulated into 50,000 brand name products. EPA must reregister each formulation as either general use, restricted use or send them through the RPAR process.

The RPAR process begins with the pesticides themselves. If existing evidence indicates that a pesticide may represent a potential risk, then that pesticide becomes a candidate for RPAR. Specifically, EPA is examining those pesticides which are highly toxic and pose threats of poisoning people or wildlife, those which may cause long term health problems such as tumors, mutations or birth defects in people or "nontarget" animals, or those which lack emergency first-aid treatment. If a pesticide meets one or more of these risk criteria, an RPAR notice is issued in the Federal Register. The notice provides the risk information to manufacturers, users, and the general public. It also indicates the beginning of public examination of the evidence, which takes place in a definite cycle of events.

The EPA needs two distinct kinds of information: rebuttal and/or benefits data. If the risks can be rebutted by other data, the RPAR process will be quite short. However, if EPA's risk data prove valid, then benefits data will be absolutely necessary to allow the Agency to make a final decision.

The rebuttal period lasts for 45 days form the date of the notice. This period allows all affected parties to offer data to the Agency. Specifically, the data should rebut the risks, that is, indicate that the risks do not actually exist or that the studies indicating risks were in error. If you do not have rebuttal data, then you should submit whatever benefits data you may have demonstrating the benefits received from the use of the pesticide. Data on economics, improved yields or quality, or other significant use information would be most helpful. In addition, the Agency will accept additional risk studies offered at this time. The rebuttal period can be extended another 60 days if necessary.

At the end of the rebuttal period, EPA scientists will decide if the risks have been rebutted. If they have, the pesticide will be reregistered. If the risks stand, then a risk/benefit analysis is necessary to determine whether the pesticide meets needs important enough to justify continued registration.

To ensure that the EPA has adequate benefits data on hand, the USDA has instituted the "Pesticide Impact Assessment Program" (PIAP). This program will attempt to gather nationwide benefits data.

The EPA will use all of the collected benefits information to make a decision within 240 days of the original RPAR notice. If the benefits outweigh the risks, the pesticide will be reregistered. The EPA may also decide that the product should be restricted and used only by certified applicators, or that some label changes are necessary to reduce the risks to an acceptable level. If, however, the risks continue to outweigh the benefits, one more step is necessary.

For the final review, the Agency will begin formal consultation with USDA on the economic effects of cancellation. At the same time, the independent Scientific Advisory Panel, composed of nationally distinguished scientists, will review the health and environmental effects data. This step lasts about 60 days, and will result in a final EPA decision. There will either be a "notice of intent to cancel," or a decision to reregister the pesticide. This ends the RPAR process.

Minnesota has a Pesticide Impact Assessment Team composed of the following members:

University of Minnesota Staff:

Phil Harein (Extension Entomologist), Liaison Coordinator

Howard Deer, (Assistant Extension Specialist)

Leonard Hertz (Extension Horticulturist)

Don Wyse (Agronomist)

Jim Percich (Plant Pathologist)

Ed Sucoff (Forestry)

Minnesota Department of Agriculture:

Mike Fresvik

Minnesota Department of Natural Resources:

Howard Kroush

Their primary objective is to establish a network in Minnesota, to provide on short notice, benefit-use data on RPAR pesticides.

The process involves a lot of work, but it offers all concerned parties a chance to contribute to the decision making on pesticides. Your own involvement is vital because good decisions are based on good information, and if you have any information that would apply to any RPAR chemical, then it is most important that EPA receives the data. The RPAR program relies on public effort and participation.

There are funds to conduct short-term research on RPAR candidate pesticides. These funds are available through the North Central Regional Pesticide Impact Assessment Program. Additional details are available from Phil Harein (612) 373-1705.

PLANT PARASITIC NEMATODES IN MINNESOTA CORN FIELDS

BY

D.H. MacDonald, A.R. Pierce, and P.A. Mansager, Plant Nematology Laboratory, Department of Plant Pathology, University of Minnesota.

ABSTRACT

Although their distribution is not uniform and potentially damaging populations are not present everywhere, plant parasitic nematodes are present in every corn field in Minnesota. The lesion nematode, *Pratylenchus* spp., which causes a fairly characteristic type of root rot, is presently considered to be the most damaging type of plant parasitic nematode that is present in Minnesota corn fields and throughout the corn belt. The detrimental effects of lesion and other parasitic nematodes which cause root rots are likely to be of significance only in years of environmental stress. Control of these parasites by planting-time application of granular formulations of certain soil insecticides-nematicides is possible.

PLANT PARASITIC NEMATODES IN MINNESOTA CORN FIELDS

BY

D.H. MacDonald, A.R. Pierce, and P.A. Mansager, Plant Nematology Laboratory, Department of Plant Pathology, University of Minnesota, St. Paul

INTRODUCTION

The results of our early work at Rosemount Experiment Station supported the idea that damaging populations of plant parasitic nematodes could not develop very often on field corn. Although a lesion nematode (*Pratylenchus* sp.) was fairly numerous (180-2850/ 100 cm^3) in one area where field corn had been grown each season for at least the previous 10 years, it was only rarely encountered right across a field road from the continuous corn plots where an experimental rotation utilizing corn, soybeans, wheat, oats, and flax was followed. When that rotation was terminated and each of those crops was grown on the same land for the next 4 growing seasons, there was no appreciable buildup of lesion nematodes. Thus, although the cultural practices employed at Rosemount (fall plowing) were not the most favorable for nematode buildup, it appeared that the large population of lesion nematodes in that one isolated area (the continuous corn plots), represented a typical situation that, for reasons as yet unknown, would be hard to duplicate.

SURVEY RESULTS

With time, however, our ideas about the potential significance of plant parasitic nematodes on field crops under Minnesota conditions began to change. Soil samples submitted to us through the Plant Disease Clinic, which often were from areas of unusually severe or unexpected stalk rot, frequently yielded large populations of lesion nematodes. In 1975 15 locations selected by the LeSueur, Murray, Renville, and Wabasha County Agents were sampled for nematodes in August and in October. Since, for a number of reasons, there is a much greater chance of large populations of parasitic nematodes developing under continuous corn than under a rotation. At our request, the fields chosen for the survey had to have been in corn for a number of years. The results of that survey are presented below.

LESION NEMATODE POPULATIONS PRESENT IN SELECTED MINNESOTA CORN FIELDS IN 1975

		Number of Soil Samples Containing Low (0-50), Moderate (51-500) or large (more than 500/100 cm^3 of soil) Numbers of Lesion Nematodes.	
County	Location	August Sampling	October Sampling
LeSueur	1	5-1-0	3-3-0
Murray	1	0-3-2	0-5-0
	2	0-5-0	0-5-0
	3	3-2-0	1-4-0
	4	2-3-0	3-2-0
	5	3-1-1	1-3-1
Renville	1	1-4-0	0-5-0
	2	5-0-0	2-2-0
	3	3-2-0	1-4-0
	4	4-1-0	3-2-0
	5	4-1-0	1-2-2
Wabasha	1	0-3-2	0-2-3
	2	5-0-0	5-0-0
	3	5-0-0	5-0-0
	4	4-1-0	4-1-0

These results substantiate, we believe, our firm contention that, since potentially damaging populations of plant parasitic nematodes are obviously not present in all fields or even at all locations within a field, an enlightened approach in dealing with these pathogens requires that the nematode populations of a given field be characterized with regard to numbers, types and distribution. In addition, since the effects attributable to the actions of plant parasitic nematodes are not specific, their presence can only be positively confirmed by means of soil and/or root analysis.

KINDS OF PLANT PARASITIC NEMATODES

There are a dozen or more different genera of plant parasitic nematodes extracted frequently enough from soil samples collected from around the roots of plants growing in Minnesota to cause us to be concerned about, and interested in, determining their significance. However, we believe that there is only one nematode, the lesion nematode, that has the confirmed capacity to seriously affect the growth of field corn. Although a statewide distribution pattern is not presently apparent, there are at least three, and possibly more, species of this one organism that are fairly widely distributed in the central and southern parts of Minnesota. At least two species are present together at some locations. Of the other kinds of plant parasitic nematodes that we commonly find in Minnesota corn fields, only the spiral nematode, usually *Helicotylenchus pseudorobustus*, appears to be both numerous enough, and capable of possibly causing measurable losses in some locations under Minnesota conditions.

There are several reasons why we consider the lesion nematode to constitute the most serious potential threat posed by plant parasitic nematodes to corn production in Minnesota. We now know of a number of locations where large populations of this nematode have developed under continous corn. The largest populations found so far exist near the southern edge of the Southern Experiment Station at Waseca where, in late September 1976, the populations ranged from 1338 to 8358/100 cm^3 of soil and averaged about 3740. Although the number of lesion nematodes at that location as well as elsewhere, declined as the result of the severe winter of 1976-77, an average of 1522 lesion nematodes was present in soil samples collected from untreated plots on 1 September, 1977. The lesion nematode, although microscopic like most plant parasitic nematodes, is more damaging than many of the other types of plant nematodes found in Minnesota. This is because they are migratory endoparasites or, in other words, they move through and between the cortical cells of plant roots, and feed on these cells. The net result of their various activities is a distinctive and characteristic root rot that, during periods of moisture or nutrient stress, will limit the infected plant's ability to cope with the unfavorable environment. The vast majority of the other parasitic nematodes present in Minnesota soils do not enter plant roots. As a result, they cause a much more superficial type of damage to the roots than do the lesion nematodes. Thus, in terms of numbers, and the amount and type of damage that they cause, no other plant parasitic nematode found in Minnesota corn fields comes even close to the lesion nematode. Other nematologists who are working in the corn belt states basically share this assessment of the significance of the lesion nematode on corn.

CONTROL OF PLANT PARASITIC NEMATODES

Since 1974 we have had experimental plots at several locations in Minnesota. We are trying to determine how nematicides, (granular formations of materials like Furadan, Mocap, etc.), should be applied for most effective nematode control, and when the nematodes are controlled, if the growth and yield of corn will be improved as a result. Although the yield data from these experiments have been quite variable and inconclusive, tremendous differences in the size of the lesion nematode populations have been obtained as the result of the chemical treatment. Recent results (September, 1977) from our work at Waseca and Lamberton are presented below.

SOIL POPULATIONS OF LESION NEMATODES PRESENT IN SEPTEMBER, 1977 FOLLOWING SPRING APPLICATION OF VARIOUS CHEMICALS

Chemical	Rate pounds a.i./acre	Lamberton	Waseca
CG 12223	3	108	---
Nem-A-Tak	1	145	281
Counter	1	160	339
CG 12223	2	167	860
CG 12223	1.5	---	1103
Mocap	2	181	949
Mocap	1	217	1155
Furadan	3	230	1941
Furadan	2	246	1922
Furadan	1	---	1540
Bux	1	343	1650
Check	-	359	1522

These results should only be taken as an indication of what can be done with available or potentially available chemicals in the manipulation of soil populations of plant parasitic nematodes. The Waseca location, with a long history of Furadan usage, is atypical both because of the very large nematode populations that are present, and the ineffectiveness of Furadan as a rootworm insecticide in that limited area. However, at both locations, differences in root system size and quality agree with differences in the size of nematode populations. This suggests that under stress conditions, yield increases due to protection and enhancement of root quality and quantity may be achieved as the result of nematode control.

YES VIRGINIA - SUNFLOWERS HAVE DISEASES!

H.L. Bissonnette, Extension Plant Pathologist

A few years ago the sunflower crop was confined to a small area of the Red River Valley; and now we can find flowers growing in almost every part of the state. The sunflower is a new crop in many areas, with a new crop new plant diseases soon follow. The sunflower crop might be spared of disease loss if growers plan ahead.

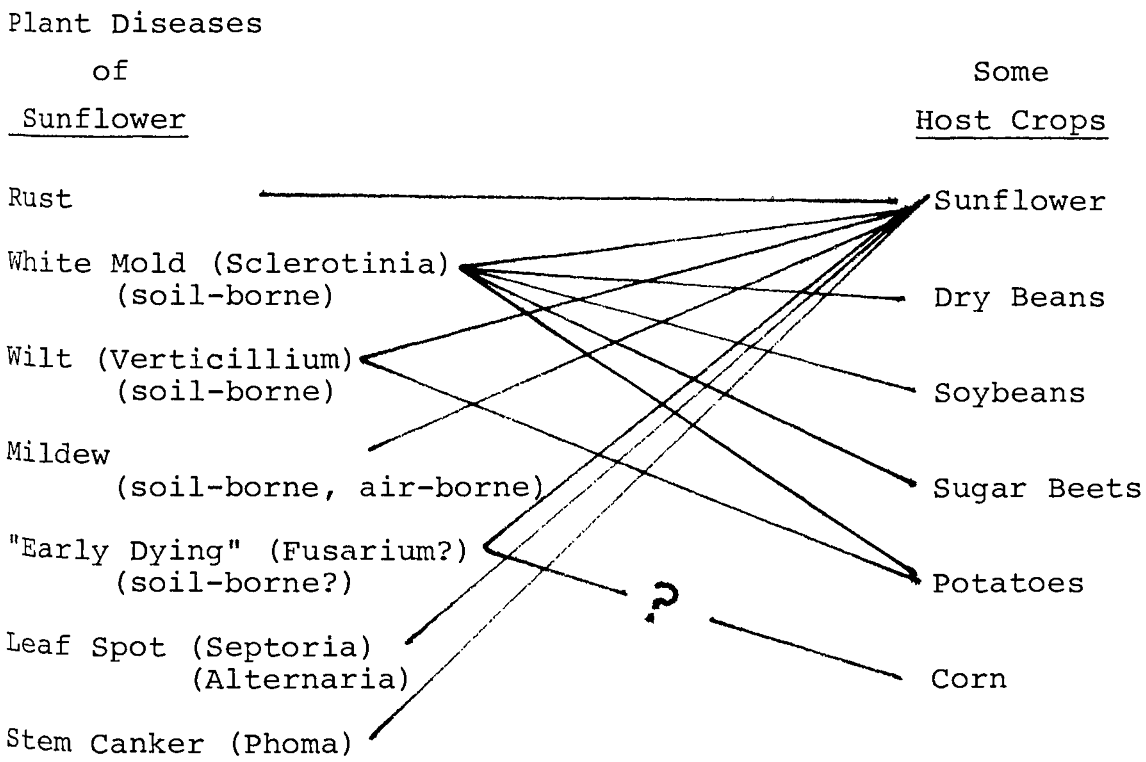
In regard to plant diseases, a grower has some choice in how he may wish to solve the problem. First it should be understood that plant diseases do exist, that plant diseases may reduce yield and that plant diseases are not about to go away. A grower can choose to grow a disease resistant variety. A resistant variety will produce a crop under disease pressure, while a susceptible variety under the same disease pressure may only produce a very small crop. Such a gamble may be won in years when the environment is unfavorable for a disease to develop. In new areas a grower may win on such a gamble for several years. The success of such a gamble depends upon the type of plant diseases which the crop is susceptible too. Soil borne diseases may require several years of cropping with a susceptible variety before the population of the micro-organism is sufficient to cause crop loss. Once this level is attained, the disease may be expected to persist until some corrective measures are taken. In the case of an air-borne disease, where a microorganism is carried in the wind, the disease may occur, because of an "ill-wind".

When resistant varieties do not exist, a grower can choose to avoid a disease problem by not growing a crop in such a system that would favor disease development. A crop rotation system where susceptible crops are not repeated on the same field year after year will slow-up the development of soil-borne disease problems. In the case of air-borne diseases, destroying or turning under crop debris may slow-up the next seasons spread of the disease. Often the air-borne micro-organisms survive from season to season on infected plant debris. The concentration of the same crop in a localized area may influence the spread of air-borne plant diseases.

Resistant varieties are not immune to plant diseases. Resistance means that under a certain amount of disease pressure a percentage of the crop will survive and produce some portion of the potential crop. A susceptible crop under the same disease pressure may fail.

There are several plant diseases of sunflowers. Some have been around for awhile and some are relatively new. Some of these diseases appear to be specific for sunflowers, and others have a wide host range which include other field crops.

RELATION-OF SUNFLOWER DISEASE TO OTHER FIELD CROPS



Many of the sunflowers were resistant to Rust, however, now a new race of Rust has developed and we may again find Rust on formally resistant varieties.

White Mold and Wilt are probably the most hazzardous disease on flowers at this time.

This past season we have experienced a very severe problem with a relatively new disease "Early Dying", a stalk rot problem. The problem seemed to be centered in Wilkin, Grant and Stevens Counties. This disease was seen in 1973, and a similar problem has been reported from Indiana and New York. We have isolated three species of Fusarium from affected plants. This winter we will be trying to identify the relationship of these fungi to the disease problem found in the field. We will also be trying to develop a technique to test varieties for resistance.

DEVELOPMENTS IN SOIL TESTING

John Grava, Professor
Department of Soil Science
University of Minnesota

An important responsibility of the Soil Science Department, shared with the Agricultural Extension Service, is to provide farmers and homeowners with reliable information on the use of fertilizer and soil amendments. Research by soil scientists provides information which is implemented into soil test analyses and recommendation programs. Soil testing has progressed during the last 25 years from the use of simple color indicators to sophisticated laboratory instruments and computers. Its development reflects changes and needs experienced in fertilizer industry and by the farmer.

The 1949 Minnesota Legislature allotted monies for the establishment of the University of Minnesota Soil Testing Laboratory. Professor Paul Burson directed the soil testing program from 1949-1954. Dr. Janis (John) Grava has supervised the laboratory since 1954. Two extension specialists have been assigned to work specifically in the soil testing area. Dr. Lowell Hanson (1958-1967) developed educational and promotional programs. Dr. William Fenster joined the extension staff in 1967 and developed the computerized recommendation program. The laboratory, for many years, was operated primarily with student part-time technicians. Since 1967, the main work load has been carried by full-time employees with students helping out during peak periods. Over 300 students have benefited financially and gained valuable experience through work in the laboratory.

Prior to 1950, simple field kits were used by soil scientists for trouble shooting purposes. After the establishment of the laboratory on January 1, 1950, recommendations were made at the laboratory. In 1954, improved methods for phosphorus and potassium were introduced. These included Bray P-1 method for P and ammonium acetate extract for K measured with a flame photometer. Intensive training sessions on soil fertility and soil testing were organized in 1955 and county agents started to make recommendations. A chemical organic matter test was introduced in 1956 as a substitute for the nitrogen test desired by farmers and industry. From 1959 to 1962 over 300 soil test correlation - fertilizer demonstrations were established with county agents or Vo-Ag instructors tending and harvesting the plots. In 1968, the laboratory started to provide tests for zinc, sulfur, soluble salts and adopted the SMP buffer lime requirement test. A Computerized Recommendation Program for farm crops was introduced in fall of 1968 and expanded to lawns and gardens in 1972. The laboratory started to provide a test for nitrate in 1971. In 1975, for all calcareous soils testing low in extractable phosphorus, the Bray-1 method was modified by increasing the soil/solution ratio from 1:10 to 1:50. In 1976 the DTPA method was adopted for Zn soil test.

Nearly one million samples have been processed by the laboratory as of July 1, 1977. Currently over forty thousand samples are tested annually.

Soil test results have been summarized periodically since the establishment of the laboratory. A summary provides a general picture of fertility levels of Minnesota soils and changes that occur from time to time. We are in process of summarizing soil test results of all samples included in the computerized recommendation program.

Current summaries include two types of soil samples: (a) 178,834 farm samples, received from 1968-1976; (b) 19,224 lawn and garden samples, received from 1972 to 1976. The state is divided in six areas: southeast, south central, west central and south western, northwest, northeast and north central, and metropolitan. Information about the samples received includes results of various tests and plant nutrient recommendations for major farm crops. County extension offices have a copy of the county summary on file. The area and state summary data will be published in the near future.

INFLUENCE OF FOLIAR APPLICATIONS OF FERTILIZER NUTRIENTS AND FUNGICIDE ON THE YIELD AND PROTEIN CONTENT OF SMALL GRAINS

C. A. Simkins, extension soils specialist; R. P. Schoper, assistant soils extension specialist; G. W. Randall, soils scientist, Southern Experiment Station, Waseca; S. D. Evans, soils scientist, West Central Experiment Station, Morris; H. L. Bissonnette, extension plant pathologist

Recent investigations of spray applications of N, P, K and S on soybeans by Dr. Hanway and others has renewed the interest in foliar feeding of crops.

A review of literature reveals that the foliar feeding of crops has been investigated by several scientists during the early 1950's. Most of the research, however, was limited to foliar applications of nitrogen and phosphorus.

Based on the quantity of plant nutrients required to increase a crop yield a given amount, it would appear that the greatest opportunity lies in foliar feeding of oil seed and other high protein crops. It may, however, be more economical to use foliar feeding on crops where the quantity of plant food nutrients needed to bring about an increase in yield requires significantly less N, P, K and S, i.e., soybeans versus rice or wheat; approximately 8 pounds N per 100 pounds soybeans, 1.5 pounds N per 100 pounds rice, 3 pounds N per 100 pounds wheat. This small quantity of spray would also allow for a larger acreage to be covered by the flight of an aircraft.

It is of particular interest to the researchers that investigations indicate that the application of fungicides on small grains often results in economical increases in yield when leaf rust, Septoria leaf blotch, and Helminthosporium are kept under control.

The timing of the application of fungicides for disease control would appear to nearly coincide with the recommended time for foliar applications of plant food nutrients for small grains. The combined application of plant nutrients and fungicides might prove to be additive in their ability to increase yields and quality of small grains.

STUDIES CONDUCTED

Trials were established at the experimental stations at Morris, Crookston, and Waseca. Treatments were as follows:

1. Control.

2. Foliar application of nutrients at flag leaf stage and 10 and 20 days later.

3. Fungicide applied at flag leaf stage and 10 and 20 days later.

4. Combinations of treatments 2 and 3.

SITE SELECTIONS

The sites for these studies were specifically selected to represent fields of high fertility. The NO_3-N level at all locations contained more than 100 pounds NO_3-N in the top 2 feet. Additionally, the P and K soil test levels were very high.

TREATMENT FORMULATION

Urea, potassium polyphosphate, and potassium sulfate were combined to develop a foliar spray which would contain plant nutrients similar to the small grain crops. The following quantities were used:

	Pounds per ton
Urea	260
Potassium polyphosphate	177
Potassium sulfate	58
Water	1,505

This formulation resulted in a ratio of the nutrient elements of 6-2.3 and 3.7 for N, P_2O_5 and K_2O. Additionally, the formula supplied .5 percent sulfur. The material was applied at the rate of 26.4 gallons per acre or 250 pounds per acre. The quantity of nitrogen, phosphorus, potassium, and sulfur applied per acre was 15, 6, 9, and 1.3, respectively.

A fungicide--Manzate 200--was applied at the rate of 2 pounds per acre alone and in combination with the fertilizer nutrients.

YIELDS OF SMALL GRAIN

Table 1 shows a summary of the yields of small grain. Yields at the Crookston experimental site are not shown because of the extreme variability of plant growth at the site.

Data from these trials show no increase in yield due to spray applications of plant nutrients. At the Waseca location, grain yields of wheat were significantly decreased by the application of 45 pounds of nitrogen per acre in combination with the other fertilizer nutrients.

Table 1. Yields of small grain as influenced by foliar applications--Minnesota--1977

Treatment lbs/A	Waseca Wheat	Morris Wheat	Morris Oats	Morris Barley
	---------	Bu/A	---------	---------
0	41	52	55	60
15	39	52	60	60
30	39	54	59	60
45	36	53	58	61
Sig.	**	ns	ns	ns
No Fungicide	39	51	53	60
Fungicide	38	55	63	59
Sig.	ns	**	**	ns

Table 2. Protein content of wheat as influenced by foliar application--Minnesota--1977

Treatment	% Protein--Wheat Waseca	% Protein--Wheat Morris
0	16.1	15.1
15	16.1	15.1
30	16.5	15.4
45	17.8	15.9
Sig.	**	*

The application of fungicide at the rate of 2 pounds per acre applied at the flag leaf stage and 10 and 20 days later resulted in significant increases in yield of wheat and oats at the Morris location. There was no significant interaction between the foliar nutrient spray and the fungicide.

PROTEIN CONTENT OF SMALL GRAIN

The protein content of wheat was significantly increased by the foliar application of plant nutrients at Waseca as well as Morris. The protein content of the barley and oats crop has not been determined at this date. It is anticipated that the nitrogen content of the wheat straw will also be determined.

NITROGEN RESPONSES AND NITRATE SOIL TESTS

C. J. Overdahl

On nitrogen depleting crops (all grasses, including corn), no nutrient provides a consistant response as regularly as additions of nitrogen.

Phosphate and potash are always important considerations, but in the heart of the corn country, liberal applications over the past decade have brought these soil tests to very high levels. Applications of phosphate and potash should continue, even with these high tests, but rates can be minimal until soil tests indicate a need for more.

Experiments with P and K in southern Minnesota on very high testing soils over several years show that corn yields are not further increased when various levels of broadcast applications are made. These experiments were conducted by maintaining all other nutrients at sufficient levels.

Today nitrogen is the chief concern among top corn farmers. Yield increases in adequate rainfall areas are usually very high where corn follows a nitrogen depleting crop. Data from Waseca shows a 5 year annual average yield increase of 64 bushels per acre.

Reasons for yield differences have sometimes been puzzling. For example, in Martin County, a plot on virgin land that was put into corn in 1971 yielded 41 bushels per acre higher than intensively cultivated land on a plot beginning just 28 feet away. This is no surprise, but the basic reason for the difference isn't always easily explained. The 6 year average yield on the no nitrogen plots in the virgin area averaged 133 bushels per acre, while similar plots in the land under long time cultivation averaged 91. When nitrogen was added, even up to 400 pounds per acre, there was still a 17 bushel advantage for the virgin area.

Differences in organic matter could be one reason, resulting in both a physical as well as a nutrient advantage. The average organic content over the past 4 years was 5.6 percent on the recent virgin area and 4.4 percent where the land was intensively farmed a long time. The fall following the first plowing showed 7.1 percent organic on the virgin area.

Also of interest is the perhaps related nitrate tests of these two areas. The table on the last page of this article shows soil nitrate test to 5 feet, by years, on the virgin land (V) and the continuously cultivated land (C) and compared to an identical experiment in Waseca County. Note that the average nitrate test over 5 years is 150 pounds per acre in the 5 feet on the virgin area compared to 103 on the adjacent cultivated area and only 54 on the same experiment in Waseca County. In Martin County, the higher organic matter could account for the higher nitrate content. In Waseca County, organic matter was also high, but drainage was more limiting and denitrification appeared to be one reason for low nitrate levels, at least on some years. In Martin County, it would be of considerable interest whether organic matter could be added adequately through frequent manure treatments on the long time cultivated area to balance the organic matter advantage the virgin area appears to have.

Research is underway to study nitrate relationships to corn yield in southwest and southeast Minnesota. It is premature to predict how successful this will be in figuring nitrogen treatments, but high nitrate tests in 1977 were always related to a very small nitrogen response. Perhaps the test can at least show where it is safe to reduce nitrogen rates and still get the most profitable yield possible.

To summarize, it is advised that careful attention be given regularly to phosphate and potash levels through soil tests and even plant analysis. Where these tests are very high, however, reductions in broadcast rates of these nutrients are logical and consideration of adding the saving to purchases of more nitrogen may be desirable. High nitrate areas, when rains are adequate, usually results in high corn yields. Soil testing for nitrates to either 2 feet or perhaps 5 feet could become a desirable practice in determining the most practical yield. An attempt to keep active soil organic matter high in order to maintain the best chemical and physical soil conditions may become increasingly important.

Nitrates, Yields and Yield Increases

	N lbs/A	1971	1972	1973	1974	1975	Avg.*
				Nitrate lbs/A to 5'			
Waseca	0	56	44	60	144	56	54
Martin (C)	0	128	104	92	132	88	103
" (V)	0	160	132	156	168	152	150
				Yield Increases			
Waseca		108	26	64	57	64	64
Martin (C)		23	10	24	47	55	32
" (V)		11	ns	ns	ns	ns	3
				Top Yields			
Waseca		151	144	168	113	115	140
Martin (C)		153	68	121	147	132	124
" (V)		195	107	151	155	128	147

* 1974 excessive nitrate tests excluded.

SOYBEAN YIELD IMPROVEMENT WITH FOLIAR FERTILIZER

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University of Minnesota

The recent soybean yield increases of 23 bushels per acre reported from foliar fertilization of soybeans has greatly increased interest in the subject. Dr. John Hanway of Iowa State increased Corsoy soybean seed yields from 53 to 76 bushels per acre in tests in 1975.

Foliar fertilization is not a substitute for a good soil fertility program of soil applied fertilizers. Rather, foliar fertilization is in addition to soil applied fertilizers with other top management factors such as narrow rows and high-yielding varieties. If all other factors are optimum, foliar fertilization can result in increased yields.

The time of application is important and the best time to apply foliar fertilizers to soybean leaves is between the time when the top pods start filling and when about half of the leaves have turned yellow. Generally, 2-4 foliar fertilizer applications at least a week apart give the best results. One large application would probably "burn" the leaves severely and reduce the yield response to foliar fertilization.

The rate of application for an acre of soybeans is up to 25 pounds of nitrogen, 3 pounds of phosphorus (6 pounds of P_2O_5), 7.5 pounds of potassium (9 pounds of K_2O) and 1.5 pounds of sulfur in 25 gallons of solution. Urea supplies the nitrogen; some potassium and the sulfur comes from potassium sulfate; and the phosphate and additional potassium comes from potassium polyphosphate. All four nutrients (nitrogen, phosphorus, potassium and sulfur) must be in the solution. Omitting any one of the nutrients decreases the yield response. Using other sources of nutrients (commercially available liquid fertilizers) in the quantities mentioned above may "burn" the leaves and reduce yields.

In a study at Rosemount in 1976, the seed yield of Evans variety soybeans was increased significantly (from 56 to 65 bushels per acre) by the treatment with the same materials used by Iowa State University (Table 1). Adding phosphorus, potassium and sulfur from the same sources and changing the nitrogen source (calcium nitrate, ammonium sulfate or ammonium chloride) reduced yields very severely due to burning. Adding nitrogen only as a foliar or soil treatment did not increase yields.

In studies during 1977, no fertilizer treatment increased soybean seed yields across all locations and varieties.

One suggestion to farmers in regard to foliar fertilization of soybeans would be to "wait and see". Research is being conducted in many states in the Midwest to determine how the technique works under a wide range of conditions. If one must try foliar fertilization of soybeans, use the proper source and rate of nutrients applied at the right time. Spraying any source of fertilizer or spraying too much may "burn" the leaves and reduce the yield as reported by some Universities and some farmers.

Considerable research needs to be done before the process of foliar fertilization can become practical and economically feasible. Evaluation in commercial soybean production is necessary since the experimental sites represent only a small sampling of environments. The yield responses obtained so far indicates that foliar fertilization has potential for increasing soybean seed yields.

Table 1. Influence of Foliar and Soil Fertilization on Evans Soybean Yields in 1976 at Rosemount, Minnesota.

Treatment	Seed Yield-Bushels/Acre
Control	56
Surfactant only	57
NPKS foliar1/	65
Urea only - soil	58
Urea only - soil	57
Calcium Nitrate Foliar1/	44
Ammonium Sulfate Foliar1/	43
Ammonium Chloride Foliar1/	34

1/ Four applications of 18-2-5-1 pounds NPKS/application in 25 gallons solution containing 0.1% Tween 80 as surfactant.

Table 2. Influence foliar fertilization on 1977 soybean seed yields in Minnesota.

Treatment	Waseca		Becker		Rosemount	
	Corsoy	Hodgson	Evans	Hodgson	Evans	Hodgson
	---Bu/Acre---					
Control	60	54	50	56	57	61
NPKS (3-4)[AB]	59	53	52	57	57	57
NPKS (2-4)[AC]	60	56	48	57	57	64
NPKS (1-4)[AD]	61	57	48	53	54	63
10-34-0+NKS[ADE]	59	55	45	52	55	65
10-34-0+NKS[ADF]	55	47	37	48	47	58
Bayfalon[G]	59	55	50	54	57	65
Folian[G]	65	59	48	53	56	66
Natures[G]	59	55	48	55	58	63
Seaborne[G]	60	55	49	54	55	62

[A] 18-2-5-1 pounds NPKS/application in 25 gallons solution containing 0.1% Tween 80 as surfactant.

[B] Applied twice.

[C] Applied three times.

[D] Applied four times.

[E] 10-34-0 + urea + potassium sulfate

[F] 10-34-0 + 28%N solution + potassium sulfate

[G] Applied according to label.

Maize Dwarf Mosaic (MDM) - In September 1976 two sweet corn fields for fresh market use in Anoka County were found to have plants infected with MDM virus. This was the first verified case of this disease in Minnesota although the disease may have occurred in trace amounts for a few years. In July 1977, it became evident that MDM was present over a wide area of Minnesota and with a prevalence in some sweet corn fields of 100% of plants diseased. Field surveys were made over a large part of Minnesota until mid-September. Several things were evident by that time, but many questions could not be answered. The infection was confined to fields planted from late May through June. This narrowed the fields to mostly sweet corn for late canning and fresh market use. The field corn crop planted by mid-May was intact, at least symptoms of the disease were not evident. Two field corn fields planted in mid-June had about 25% infected plants. Sweet corn fields of the same variety and similar planting date and a few miles apart would have a wide range of disease prevalence. In individual cases the range was 1-100% and 0-100% infected plants. The later the planting the more severe the effect on crop production in infected fields with 100% of prevalence. A field planted May 30 produced over four tons of ears, while fields planted June 25 were abandoned because of low yield.

This disease was first identified in the Ohio River Valley in the early 1960's. The virus is spread from plant to plant by several species of aphids. There is a great deal of speculation as to the prevalence of this disease in Minnesota in 1978 and other future years. At present we have many ideas, but few facts. Five or six strains of the MDM virus have been identified in other places in previous years. Present work here indicates that strains A & B of the virus were present in Minnesota in 1977. The known area of infection in Minnesota was at least the southern one-third and the entire west edge of the state.

Corn Rootworm Insecticides - 1977

Southern Experiment Station University of Minnesota

Waseca, Minnesota

William Lueschen & John Lofgren

I. Planted May 2

Minnhybrid 4201

Granules in 7 inch band except where noted

Basal treatments applied June 7 with Cultivation

4 Reps	AI/A	Root Rating (1-6)	% Lodged	Yield
Dotan 15G	1 lb.	2.15	0.75	147.6
Dotan 15G	1½	2.15	1.25	141.0
Furadan 10G	1	2.25	3.75	154.0
Furadan 4F	1 Basal	2.25	3.00	146.4
Nem-A-Tak 15G	1	2.25	0.75	149.3
Oftanol 15G	1	2.25	1.50	153.0
Thimet 15G	1	2.30	3.50	154.6
Counter 15G	1	2.30	1.75	156.1
CGA 12223 20G	1	2.35	1.25	143.0
Mocap 10G	1	2.35	1.25	149.4
Mon 0768 10G	1½	2.35	2.25	148.9
Nem-A-Tak 15G	3/4	2.40	0.25	149.2
Nem-A-Tak 15G	3/4 Basal	2.40	3.25	148.7
Nem-A-Tak 15G	1 Basal	2.40	0.25	160.6
Dyfonate 20G	1	2.45	0.50	164.8

Mon-0768 10G	2	2.45	3.25	153.8
Mon-0768 10G	3	2.45	1.75	155.8
Lorsban 15G	1	2.45	1.25	160.8
Counter 15G	1 Furrow	2.50	3.00	153.6
Counter 15G	1 Basal	2.60	1.25	157.0
NC 6897 10G	1	2.70	5.75	144.4
Mon 0768 10G	1	2.75	3.00	138.1
Mocap 6E	2 lb. Bdcst PPI	3.30	5.75	144.2
Check		4.45	38.00	147.7

II. Furadan History Area

Planted May 2

Minnhybrid 4201

Granules in 7 inch band at planting

6 Reps.	AI/A	Root Rating	% Lodged	Yield
Nem-A-Tak 15G	1	2.00	1.6	145.2
CGA 12223 20G	2	2.00	1.6	133.6
Counter 15G	1	2.00	2.3	131.7
CGA 12223 20G	1½	2.22	1.4	137.2
Mocap 10G	2	2.28	3.8	125.9
Mocap 10G	1	2.33	5.1	130.3
Furadan 10G	3	2.78	9.8	141.8
Furadan 10G	1	3.33	24.6	137.8
Bux 10G	1	3.50	25.8	129.8

Furadan 10G	2	3.55	14.7	125.3
NC 6897 10G	1	4.11	54.7	113.9
Check		4.28	48.2	113.2

III. Adult Control Area

Planted May 2

Minnhybrid 4201

4 Reps

Sevin 4-oil applied 7/29 and 8/14/76

	Root Rating	Yield
Furadan	2.25	138.7
Counter	2.25	137.9
Check	2.83	131.5

Sevin 4-oil applied 7/29/76

	Root Rating	Yield
Furadan	2.17	141.2
Counter	2.42	140.1
Check	3.08	134.2

No Sevin 4-oil applied in 1976

	Root Rating	Yield
Counter	2.25	130.8
Furadan	2.42	129.6
Check	4.25	123.3

1977 Cutworm Problem

According to estimates by County Extension Directors, the 1977 cutworm infestation cost Minnesota farmers about $5,000,000. Almost 500,000 acres of crops had economic infestations, about 100,000 acres were treated with insecticides and over 50,000 acres were replanted because of cutworm damage. Corn was the major crop infested with sunflowers, soybeans, sugarbeets and other crops suffering less damage. Crop damage was reported from 68 counties. Home gardens were also reported to have been damaged over much of the state.

Control measures applied after cutworm damage was detected were rated as only fair by most extension directors.

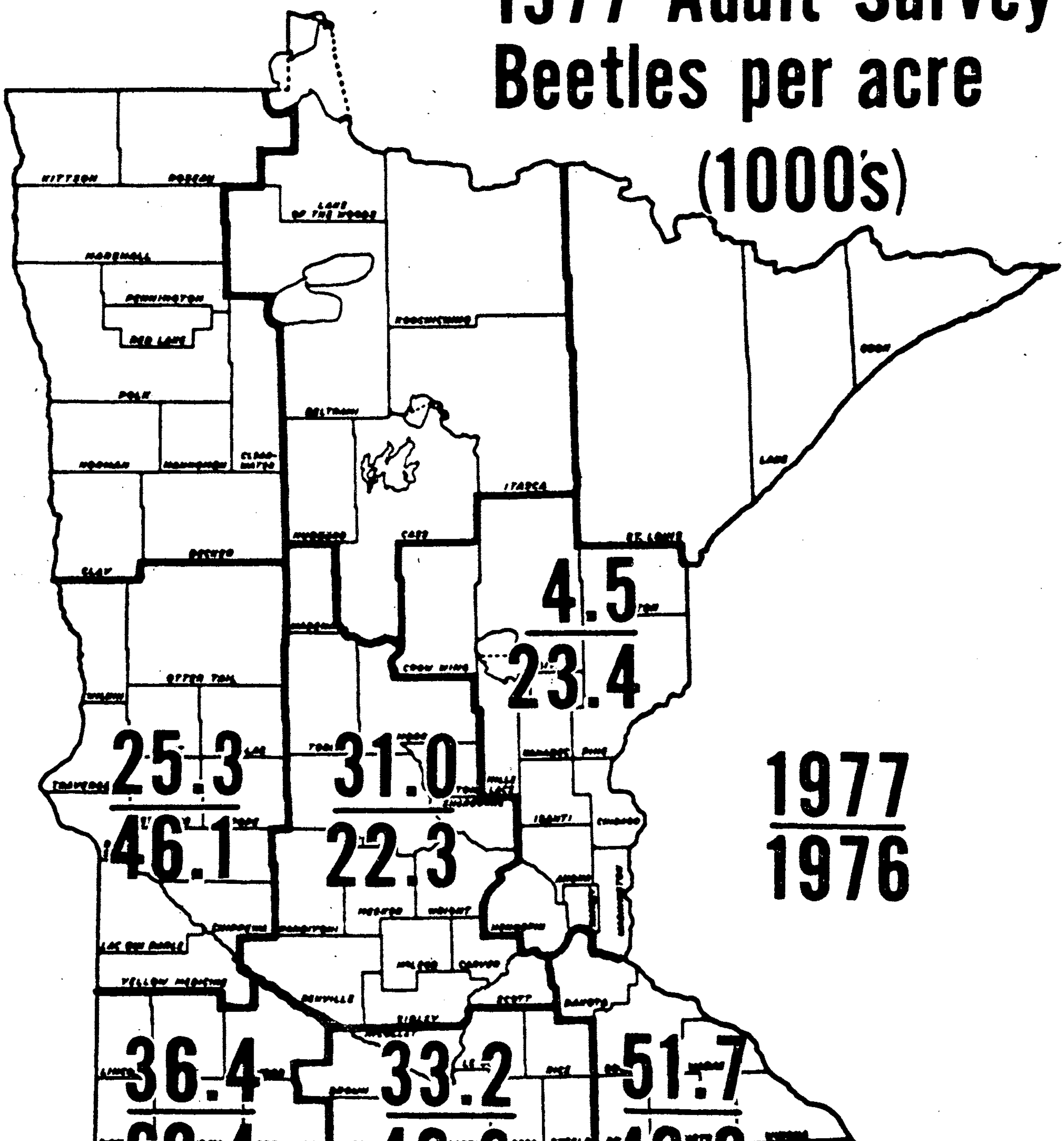
	Acres Infested	Treated	Replant	Estimated $ Loss
Corn	320,110	53,305	24,545	2,687,500
Soybeans	58,000	6,000	5,810	535,800
Sunflowers	56,000	29,000	15,820	1,088,970
Small Grain	33,667	1,000	1,600	82,000
Sugarbeets	16,000	10,150	4,050	408,500
Flax	400	400	150	8,000
Sorghum	300	90	150	7,000
Alfalfa[1/]	700	--	--	7,000
Dry beans	650	150	100	5,500
Gardens[1/]	7,000	2,140	550	98,000
Totals	492,650	102,530	52,740	4,913,000

[1/] Incomplete, not all counties estimated home garden data and heavy infestations of variegated cutworms developed in alfalfa after the survey.

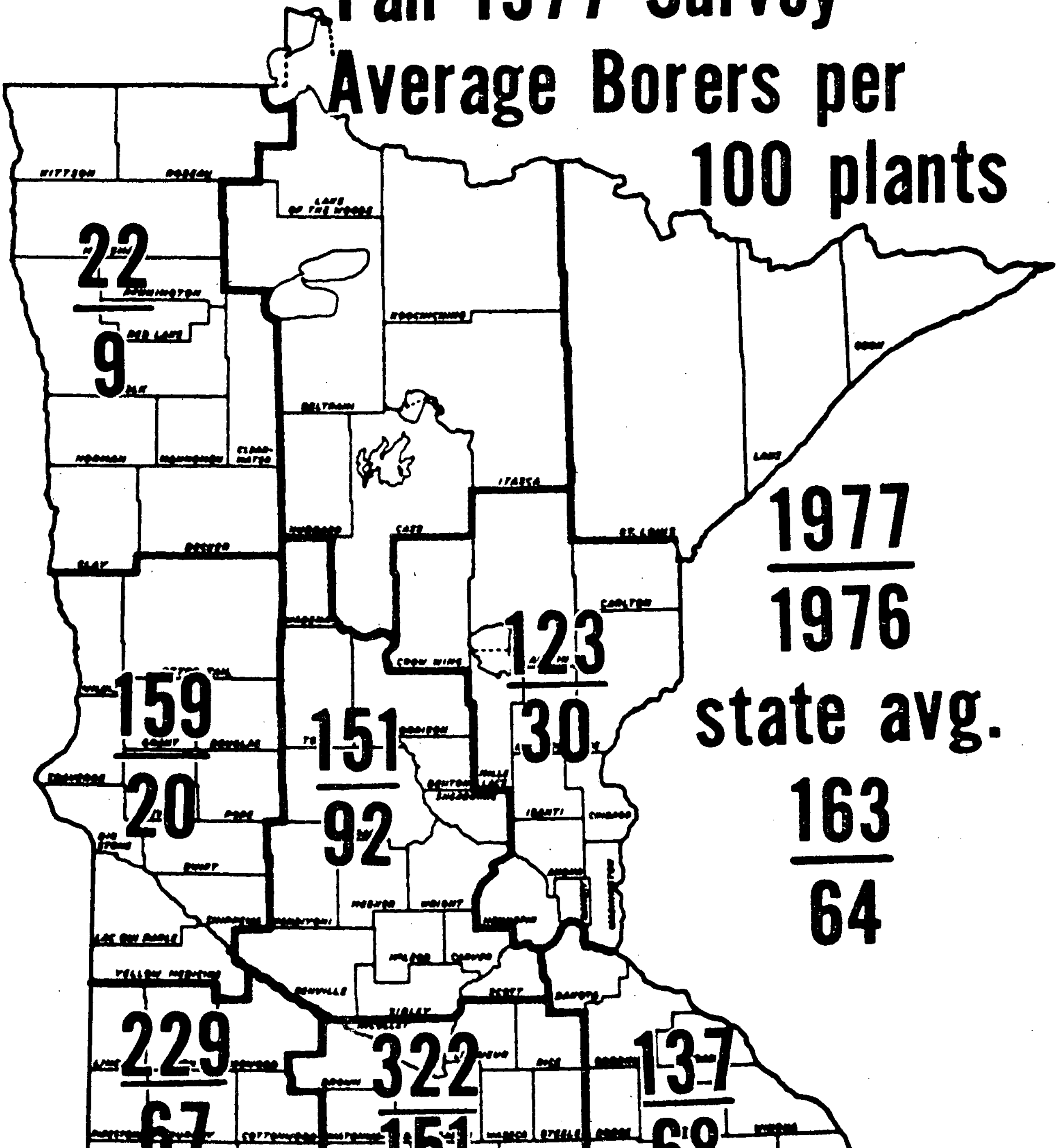
Average Control Results:

Excellent	12½%
Good	25%
Fair	50%
Poor	12½%

Corn Rootworm
1977 Adult Survey
Beetles per acre
(1000's)



European Corn Borer Fall 1977 Survey Average Borers per 100 plants



SUNFLOWER INSECTS 1977

Dennis Warnes, associates professor, West Central Experiment Station, Morris
J. Harlan Ford, agronomist, Southwest Experiment Station, Lamberton
David M. Noetzel, extension entomologist, Agricultural Extension Service and Department of Entomology, Fisheries, and Wildlife

Cutworms

Approximately 50,000 acres of sunflowers were destroyed by cutworms in 1977. At least five species of cutworm were involved with major acreage being damaged by the army cutworm. In addition to the cost of control and replanting, yields in the replanted fields were reduced from 30 to 50% due to late planting.

Control of cutworms in sunflowers with toxaphene was erratic. It appears best control was achieved before plants were severely damaged (i.e. toxaphene acted more as a stomach poison when sprayed on sunflower plant material). Night application of chemicals also seemed to improve efficacy and higher gallonage with highest labeled rates banded over the row added to the effectiveness of control. Any cultivation associated with the application of toxaphene rendered the insecticide almost ineffective.

Stem weevil (*Apion occidentale*, *Cylindrocopturus adspersus*)

Stem weevil numbers were extremely variable. A set of soil insecticide plots (Table 1) were placed in a field (Robert Buhl farm) where there were between three and four weevils (*Cylindrocopturus*) per plant at the 4-8 leaf stage. Stem dissections at immediate post bloom showed so little weevil tunneling in the stems that there must have been an absolute population collapse in that particular field. Thus, these data obtained relative to soil treatment are only of value in showing no phytotoxicity.

At the same time, there were a large number of fields in the Graceville, Clinton, Beardsley area that had weevil tunneling as severe as during the 1976 season. None of these fields where stem size and plant height was normal had any stalk breakage due to weevil activity. In normal seasons then, it does not appear necessary to control either species of stem weevil.

Sunflower Moth

Although this insect received considerable publicity during 1977, the following data indicate that it did not cause as much damage as was suggested. We noticed early in the season (Table II) that one age group of sunflowers, usually an early one (May 21st planting in RBA plots at Olivia, Minnesota) suffered the greatest attack. We also observed that many fields had adult moths present on the flower face at night or in the morning and still suffered almost no larval infestations. Where infestation did occur, some heads were almost totally destroyed while others were virtually uninfested. We are not sure at this time why this occurs; however, the observations suggest that the presence of adult sunflower moths indicates only a potential for infestation and in the early plantings only.

In 1977, once we passed the 4th of July in Minnesota, there was almost an end to sunflower moth oviposition. Fields which came into bloom after the first week of July escaped oviposition almost completely even though some of these fields had over four adult moths per plant. Treatment for control of sunflower moth larvae in these fields was unneeded and certainly not economical to the grower.

Geographically, the highest sunflower moth adult and larval populations were found in the south central and southwestern parts of the state. Plots at the Lamberton Experiment Station (Table III) averaged 23 larvae per plant in untreated plots. One, two and three applications of ½ pound of methidathion AI per acre significantly reduced the larval populations. At the same time, we did not obtain a significant reduction in yield due to the 23 larvae per plant in the checks.

A regression analysis using these larvae counts and yields showed that on the average, one larvae per plant can reduce yields per acre by approximately 15 pounds. We normally use an economic threshold where the grower can obtain $2.00 return on $1.00 invested in control (i.e. cost of chemical and application). If sunflower seed is $8.00 per 100 pounds and if cost of control is $8.00 per acre, then a 200 pound reduction in yield is the economic threshold. It would take 13 larvae per plant on the average to produce such a yield reduction.

A similar experiment at Morris (Table IV) with considerably lower larval populations showed a trend toward better control with more than one application of insecticide. However, variability was such that yield differences probably do not mean very much.

A more interesting experiment (Table V) to determine timing of applications at Morris was carried out. Two applications of ½ pound AI methidathion in 20 gallons of water were applied with a high boy applicator beginning with ray flower at 3-4 day intervals thereafter.

Sunflower moth larval counts per plant were below five in the untreated checks. Although there is an apparent trend toward prevention of yield decreases with earlier application the yield differences are of a magnitude which suggests little probability of their being real. Certainly there were not enough sunflower moth larvae to account for the differences if the differences were real.

A most interesting observation regarding sunflower moth was that a partial second generation occurred in 1977. Newly emerged adult moths were observed at Beardsley, Clarkfield, Lamberton and Springfield in late September. It did not appear that suitable hosts were available at that time.

Seed Weevils

Two species of adult *Smicronyx* were observed to be present in the sunflower in May when plants were in the two to eight leaf stage. *Smicronyx fulvus*, *Smicronyx sordidus*, *Apion occidentale* and *Cylindrocopturus adspersus* (the latter two are stem weevils) were all present and active on the 25th of May in the Morris and Beardsley area. Two applications of methidathion gave between 80 and 90% control of this weevil complex at that time. However, there appears to be no economic justification for such an application under normal conditions.

A field coming into bloom near Clinton, Minnesota (Table VI) with between 15 and 20 Smicronyx fulvus per head was treated by aerial application at 15% bloom (July 28). Five treated five head samples and five untreated five head samples were removed from the field on September 22. A quadrate was selected from each of the five heads and comingled with the rest of the sample for weevil damage analysis. The results show 55% reduction in weevil damage with the single application of insecticide at the 10-15% bloom stage. No yield data were taken.

The seed weevils, (Smicronyx fulvus in particular) were extremely abundant in the Wheaton-Morris-Ortonville triangle and to the western border of the state. We observed as high as 60 per plant and had reports of over 100 per plant. The weevils are particularly abundant in field margins and have an excellent ability to migrate some distance to new plantings of flowers.

RECOMMENDATIONS FOR 1978 SUNFLOWER INSECT CONTROL INCLUDE:

I. Follow all good agronomic practices to insure high yields.

  A. Plant recommended varieties (See Miscellaneous Report 24).

  B. Plant on dates to insure maximum yields (See Minnesota Ag. Ext. Bulletin 299).

  C. Plant at recommended rates (See Minnesota Ag. Experiment Station Miscellaneous Report 141) to maintain head size in the 4" to 6" diameter range.

  D. Maintain as uniform stands as possible.

II. Monitor sunflowers at germination and emergence and apply toxaphene at the highest labeled rate before cutworms destroy seedlings.

III. Again monitor field at heading time late in the evening or at sunrise for sunflower moth. If no adult moths are present there will be no larvae. If there is evidence of severe larval infestation (i.e. more than 10-50 per plant) then early treatment with ½ pound AI per acre methidathion, #1 parathion or #1 endosulfan in 5 gallons of total material is recommended.

We observed excellent control of sunflower moth larvae with a single application of methidathion in 1977. This is the first time this had occurred so fields should be checked by the applicator after the first treatment. If no larvae remain, certainly there is no need for a second application. However, in severe infestations (50 or more per plant) two applications will be required.

Pollination and honey bee kills

Older sunflower varieties like Peredovik, VNIIMK 89:31, Mingren and Arrowhead required cross pollination for over 80% of their yield. Plant geneticists, however, have made a great effort to select hybrid lines which do not require cross pollination. Yet commercial hybrid lines presently available can be near 100% selfing while others may only self 30%. The grower may want to know how well the hybrid they are growing does self because if moderate or low selfing lines (USDA 903 for example) are grown, they do need pollinators for top yields. However, it should be kept in mind that some low selfing lines produce excellent oil content and yields when adequate pollinator resources are present.

Table VIII, Hybrids and their self fertility

USDA	244	93%	USDA	893	68%
USDA	894	88%	USDA	8903	64%
USDA	8941	80%	USDA	891	53%
Sundak		73%	USDA	903	39%
USDA	8944	68%	Peredovik		18%

Hybrids like 8903, 891 and 903 will need pollinators just for maximum yields. Work underway suggests that oil levels in nearly all high oil lines also can be raised with adequate pollinator levels (40 bees per 100 plants). Because of the beneficial value of pollinators to many of the hybrid lines, the grower must be careful using insect control in order that bee kills (i.e. yield and oil reductions) do not occur.

Current hybrid sunflowers secrete good amounts of nectar which is attractive to honey bees. Also, much of the sunflower bloom takes place after the decline of sweet clover. This concentrates foraging bees in sunflowers making the honey bees highly vulnerable to insecticides applied to sunflowers. Over 2000 colonies of bees foraging sunflowers were damaged or killed in Minnesota during 1977.

In view of the reduced oil content and yields which can result from insecticide use (i.e. reduced pollinator numbers) on sunflowers and in view of the lack of evidence for yield reduction from pest insects, growers should be sure pest levels warrant the need for controls. It is very difficult to see how injury to honey bees can be avoided if sunflowers are treated with presently labeled insecticides.

Table I. Soil treatments for sunflower control - Graceville, Minnesota

Granular insecticide*	AI per acre	Sunflower seed yield in Pounds/acre
Mocap	1#	1781
Furadan	2#	1701
Temik	1#	1763
Check	--	1884
		$LSD_{5\%}$ 614

*All applied as side dress with plants in 4-8 leaf stage and cultivated in.

Table II. Sunflower moth adult counts and percent of fields with resulting larval populations

Moth counts per 100 plants	Larval counts per plant in fields blooming in June			Larval counts per plant in fields blooming in July		
	0	1-14	15 -	0	1-14	15 -
401 -	-	3	10	2	3	-
101 - 400	3	12	5	8	9	-
51 - 100	10	20	3	11	12	-
1 - 50	24	9	-	20	8	-
None	-	-	-	25	2	-
	37	44	18	66	34	

N - 59 N - 201

Table III. Sunflower moth control; economic threshold determination - Lamberton. (Ford and Noetzel)*

Hybrid: Interstate 894
Planted: 11 June 1977
Plants: 15% in bloom on 7/19; (Two adult moths per plant)

Dates of Application	Number of larvae per plant	Yield in pounds per acre
Pretreat	27.1	-
Check	22.9	2530
7/19	1.7	2979
7/19, 24	1.8	3012
7/19, 24, 29	.8	3037
$LSD_{5\%}$	2.95	609

*Francisco Nancovilu of Chillan, Chile and Richard Biege of the University of Minnesota Insect Pest Clinic assisted with applications and counts.

Table IV. Sunflower moth control; number of treatments - Morris (Warnes and Noetzel)

Variety: Interstate 894
Treatment: methidathion (Supracide) ½ lb. AI/A per application in 20 gallons water

Date of application		Yield in pounds per acre
Check		2730
7/28		2989
8/1		3148
7/28, 8/1		3078
7/28, 8/1, 8/5		3114
	$LSD_{5\%}$	590

Table V. Sunflower moth control; time of treatment study - Morris (Warnes & Noetzel)

Variety: Interstate 894
Treatment: methidathion (Supracide) ½ lb. AI/A per application in 20 gallons of water

Date of application		Yield in pounds per acre
Check		2822
7/25, 28		3144
7/28, 8/1		3097
8/1, 5		2919
8/5, 8		2840
	$LSD_{5\%}$	517

Table VI. Status of Sunflower bloom - Morris plots

7/25	20% ray flowers
7/28	10% bloom
8/1	50% bloom
8/5	100% bloom
8/8	past 100% bloom

Table VII. Seed weevil damage and reduction with one application of methidathion ½ lb. AI/A; Shannon Field - Clinton, Minnesota

Variety: NK-223
Treated: 28 July 1977
Bloom: 15% at treatment time

Sample No.	% Weevil damage		% Sunflower moth damage	
	untreated	treated	untreated	treated
1	36.0	21.0	2.0	1.0
2	29.0	15.5	1.0	2.0
3	30.5	4.5	2.5	1.0
4	26.5	8.0	3.5	4.5
5	29.0	20.0	2.0	1.0
Mean	30.2	13.8	2.2	1.9

2,4-D

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Thirty years ago the discovery of 2,4-D was proclaimed by millions of farmers and their families. Previously, there was no effective way to control weeds such as wild mustard and thistles in wheat and other crops. With the introduction of this herbicide, farm families could now enjoy a level of human dignity comparable to other members of society with time for personal and social development, rather than being bound to the unending drudgery of hoeing weeds.

Chemicals are being criticized and their use threatened. This could force farm families back into a life of drudgery and reduce our food supply to starvation levels. A few isolated and highly questionable incidents amplified in the media have increased anxiety about continued use of chemicals. These unproven suspicions of harm must be weighed against the real benefits that 2,4-D and other herbicides contribute to our supplies of food and forest products.

The discovery of 2,4-D was a landmark breakthrough in agricultural science. R. S. Dunham, Professor Emeritus, University of Minnesota, tells the events in his book, The Weed Story. (3) In the last half of the 19th century, Julius Sachs wrote about "chemical messengers" that were responsible for flowering of begonias and squash and Darwin observed that something caused the shoots of oat seedlings to bend toward the light. In 1926, Went showed that these plant responses were due to chemicals which he called plant hormones. In the early 1930's, the chemical identity of some plant hormones was established and similar synthetic chemicals with hormone properties were developed. Two of the plant hormones identified were IAA and NAA. These compounds killed some weeds in small grains, but they were expensive and low in activity. Work with related growth regulators led to 2,4-D and MCPA. These compounds were studied intensively during the early 1940's in England and the United States. In 1946, 2,4-D was introduced to the American farmer with a national advertising campaign. Extravagant claims were made that 2,4-D "forces the toughest weeds to absorb it and commit suicide; all trace of bindweed gone within six days; the weeds get tremendously oversexed; kills the weed completely, while leaving the soil sweet and unharmed." Kraus and Mitchell carried out key experiments at the University of Chicago during the 1940's. Kraus, to prove the safety of the compound, ate 0.5 gram of 2,4-D acid daily to demonstrate that it was harmless and observed no ill effects.

In Minnesota, 2,4-D is now used annually on 5 million acres of grain crops and 30,000 acres of forests. (6, 10) It is the most commonly used herbicide for pastures, lawns, golf courses, parks, lakes, and rights-of-way. Two, four-D increases crop yields, reduces labor costs, and reduces tillage requirements. The benefits from its use are an adequate food supply, lowered food prices, and energy savings. Water runoff and erosion are greatly reduced from pastures, lawns, and other turf areas where brush and weeds are controlled with 2,4-D. Two, four-D controls poisonous plants and human irritants such as ragweed which annually dumps 1/4 million tons of pollen into the air causing hay fever in 1 in 20 Americans. Weed control is essential to keep highways, railroads, powerlines, and drainage ditches functioning.

There is no totally safe, effective economical alternative to herbicides to accomplish this massive task of weed control. Cultivation and handweeding are not physically or economically possible in Minnesota's 7 million acres of small grains. Controlling wild mustard with 2,4-D costs $3 per acre, increases yields by 1/3, and returns 130 times the energy consumed in using 2,4-D. Handweeding corn and soybeans in Minnesota would require 6 weeks of hard labor by 3/4 of the state's population. Using 2,4-D in forests to control brush and encourage pines costs less than $20 per acre. Spraying is required only once or twice in the 30-to-80-year forest rotation cycle. Handcutting, required 4 or more times to control regrowth, costs an unreasonable $50-160 per acre each time for a total cost of $200 to $640 per acre (6).

The hazards involved in using any chemical are determined by the toxicity of the chemical, persistence of the chemical in the environment, and the degree of exposure to the chemical. The Food and Drug Administration collects food samples from grocery stores across the country and analyzes them for pesticides. Each market basket sample represents a 2-week diet for a 15 to 20 year-old male. In the last report (5), no 2,4-D residues were found in any of the samples from any region in the country. So there is hardly any chance of exposure to 2,4-D from the food supply.

Over 580,000 gallons of 2,4-D were sold in Minnesota in 1976. (9) The seven counties in northeastern Minnesota - Cook, Lake, St. Louis, Itasca, Koochiching, Aitkin, Carlton - reported sales of only 370 gallons. If 2,4-D were a causal agent of various illnesses and deformities as claimed by a few individuals, we would expect an increased incidence of such problems in areas of more intensive use where exposure is more likely. Such is not the case. Fifteen counties that reported sales of over 10,000 gallons of 2,4-D, each, had no reports of human or animal harm. The only claims of harm in Minnesota were from a few individuals in northeast Minnesota.

Two, four-D has a low order of toxicity. It is impossible for animals or persons to consume enough 2,4-D-treated feed or food to get a toxic dose. The LD_{50} values range from 300 to 1000 mg/kg of body weight which is an average of about twice the toxicity of aspirin. (7) An average toxic dose for an 800 lb animal is about 8 oz of 2,4-D ester, which is equivalent to 1 pint of a commonly used 4 lb/gal formulation. On pastures treated at 1 lb/A, to get a toxic dose, an 800 lb animal would have to eat a ton of vegetation (approximately all the vegetation on 1/2 acre) at one time. This assumes that all the 2,4-D stayed on the vegetation which is not the case. Wildlife has been shown to have a high level of tolerance to 2,4-D. (10) Two mule deer given daily oral doses of 80 mg/kg/day and 240 mg/kg/day for 30 days showed only slight symptoms but no weight loss. In the literature, there are reports of cases of individual allergies that lead to dermatitis and cases of accidental or deliberate poisoning. (14) But 2,4-D and related herbicides do not present a significant hazard to man when correctly handled and used for weed control.

Two, four-D is rapidly detoxified in the soil. At rates used for selective weed control in crops and trees, 2,4-D disappears within two to four weeks. (7)

Two, four-D has a very low solubility in fat so it does not accumulate in fatty tissues or build up in the food chain. Most studies have shown a rapid and essentially complete elimination of 2,4-D in the urine of animals without metabolism in the body. (7) This has been demonstrated in rabbits, rats, sheep, and cattle. Milk from dairy cows grazing on pastures treated with 2,4-D has shown low levels of 2,4-D residues in the milk for up to seven days after treatment using detection methods with a sensitivity of 0.01 ppm. The highest level detected was 0.06 ppm. The precautions on use of 2,4-D require that dairy animals not be grazed for 7 days after treatment with 2,4-D.

Since the toxicity level of 2,4-D is low, there is little exposure to the compound either directly or through the food supply, 2,4-D is nonpersistent, and it does not accumulate or biomagnify in the food chain, there is little risk involved from its use.

The claims of harmful effects from 2,4-D are generally speculative and coincidental. No causal relationship between the alleged human and animal health problems and proper use of herbicides has been documented. Most of the opposition to 2,4-D, from people who are opposed to all chemicals, is unrealistic considering the chemical nature of all things and that chemicals are essential to life. Some oppose any alteration of the "natural" environment in spite of its low productivity. Some concerned people have an honest fear based on erroneous information. Others fuel these fears for various reasons including personal, political, and economic gain. For some, criticism of 2,4-D started with its use in defoliation mixtures in Vietnam. Two, four-D used here does not contain the toxic contaminant TCDD (dioxin) and lower rates are applied more precisely, so comparisons with Vietnam are not valid.

Publicity of a few isolated incidents in which individuals claimed 2,4-D harmed animals and people has created an emotional issue. Scientific investigators found these claims are not supported by fact.

A nationally televised crippled goat was found to be suffering from malnutrition, phosphorus deficiency, and the burden of nursing three kid goats, rather than from herbicide exposure as claimed. A two headed calf was recently publicized to be the result of 2,4-D use. The length of time between the 2,4-D use and the cow's pregnancy was such that the calf's condition could not have possibly resulted from the cow's grazing in the 2,4-D treated area. The incident contradicts experiences of thousands of farmers who have reduced cattle deaths and abortions by killing poisonous weeds with 2,4-D. The death of a Swedish railroad worker was publicized to be caused by 2,4-D and 2,4,5-T. (9) Medical research showed that Swedish railroad workers exposed to 2,4-D and 2,4,5-T had tumor incidence and mortality rates no higher than the general population. (1)

Another widely circulated report claimed major deaths and abortions in reindeer herds in Sweden in 1970 due to 2,4-D and 2,4,5-T spraying. This incident was cited in testimony in the State of Minnesota vs Seaver case in Grand Marais last fall. (9) Testimony in the case stated that 40% of a herd of 600 reindeer died and that 40% of the pregnant females aborted. A scientific report by Professor Kurt Erne on this incident and subsequent experiments disputes this claim. (4) He reported that "available information on the circumstances of the Visstrask incident and on the biological effects which appeared did not permit a reliable judgment to be made on the possible role of the herbicidal treatment in this incident". Subsequently, research was conducted to determine the effects of phenoxy herbicides on pregnant reindeer. For 4 to 6 weeks, female reindeer were fed birch leaves that had been sprayed with 2,4-D and 2,4,5-T. There were no deaths or abortions or any visible injurious effects among the animals receiving the treated leaves. The autopsy of sacrificed animals showed no injurious effects. All of the fetuses were alive and normally developed. On the basis of this study and many others, there is no support for claims that properly used 2,4-D applications are responsible for wildlife mortality.

The cancer issue is not finally resolved on 2,4-D or any other chemical, and it may never be. But the evidence based on long-term exposure of workers in factories and users clearly supports that 2,4-D can be used without risking increased incidence of cancer. (12) Those who claim that 2,4-D causes tumors and birth defects cite experiments in which massive doses are injected into animals or hatching eggs. Similar tests show that lower dosages have no effect. These lower rates are still many times higher than the levels to which people or animals are exposed in actual use. But the biological significance of these tests as a basis for predicting that a compound may cause cancer in people at exposure levels that actually occur from use of compounds such as 2,4-D is highly questionable. Until the cause(s) of cancer is determined, undoubtedly some people will continue to implicate all chemicals. Since 2,4-D does not accumulate in animals or persist in the environment, its potential for long term effects is extremely low.

The one concern about use of 2,4-D that has a real basis is the problem of drift which damages vegetation. This is a correctable problem. Through proper application techniques, use of appropriate equipment and formulations, and spraying within certain weather conditions, drift can be prevented.

When the evidence is objectively evaluated it is apparent that the benefits from using 2,4-D are great and the risks are minimal and often speculative imagination based on fears that resulted from misinformation. Chemicals are essential to our well-being. Some risk is involved with the use of any chemical. Most people are willing to accept a reasonable risk rather than give up substantial benefits such as adequate food, shelter and health.

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Herbicides For Field Crops

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Tables 1 to 7 are summaries of the suggested herbicides for crops as they will be listed in the 1978 edition of Cultural and Chemical Weed Control in Field Crops, Extension Bulletin 400 which will be available January 1. Tables 2 and 4 show the expected crop tolerance and control of common weeds for several herbicides used on corn and soybeans. These tables do not give all the information needed to use these herbicides properly. Be sure to read the new labels and follow the specific use instructions.

The major changes in suggested uses include the following:

Several preplanting treatments are added for corn. These are: atrazine + EPTC (Eradicane), atrazine + metolachlor (Dual), cyanazine (Bladex), cyanazine + EPTC (Eradicane), cyanazine + alachlor (Lasso), and metolachlor (Dual). Bentazon (Basagran) is listed for postemergence control of many annual broadleafs, Canada thistle and nutsedge in corn.

In soybeans, pendimethalin (Prowl) is added to the list of chemicals for preplanting incorporated applications. Metribuzin (Lexone, Sencor) may be tank-mixed for preplanting incorporated treatments with dinitramine (Cobex), pendimethalin (Prowl), profluralin (Tolban), or trifluralin (Treflan).

In sugarbeets, the mixture of pyrazon (Pyramin) + TCA is added for preemergence use only on medium to coarse textured soils with less then 5% organic matter. The postemergence mixture of pyrazon + dalapon (Pyramin Plus) was deleted because newer postemergence herbicides are giving more consistent weed control.

Difenzoquat (Avenge) may be used on durum varieties except Lakota and Wascana as well as an Era spring wheat. Barban (Carbyne) has some rate and time of application changes for several crops. Barban should be applied when wild oats are in the 2-leaf stage and before crops reach the following stages: before the 4-leaf stage for wheat, semidwarf wheat, and barley, before the 12-leaf stage for flax, and within 30 days after emergence of sugarbeets, sunflower, safflower, mustard, and soybeans. The label previously permitted application for only 14 days after emergence. The suggested rate of application for semidwarf wheat varieties, sunflowers, soybeans, and mustard is now 3/8 lb/A (3 pints/acre). Previously, 1/4 to 3/8 lb/A was suggested.

For perennial weeds, metolachlor (Dual) is added as an alternative for nutsedge control in corn. EPTC (Eradicane) is added for germander or field mint control in corn. Glyphosate (Roundup) may now be used as a spot treatment in corn, soybeans, wheat, oats, barley and grain sorghum as well as in the fall or spring before planting these crops. This chemical is effective on many perennial weeds. Spot treatments in growing crops will kill the crop in the treated area. Control of drift is very critical to avoid crop injury.

Table 1. Suggestions for chemical control of weeds in corn[1/].

Chemical	Pounds per acre of active ingredient or acid equivalent broadcast	Remarks[2/]
Preplanting incorporated		
Alachlor (Lasso)	4	For nutsedge and annual grass control
(Lasso II)	3.9	
Atrazine	2 to 3	May injure some crops following year; controls annual grasses, quackgrass, and broadleafs.
Butylate (Sutan+)	3 to 6	Controls annual grasses only.
EPTC + protectant (Eradicane)	3 to 6	For nutsedge, quackgrass and annual grass control.
Atrazine + butylate	1 to 1-1/2 + 3 to 4	
Cyanazine (Bladex) + butylate	1 to 2 + 3 to 4	
Atrazine + EPTC (Eradicane)	1 to 1-1/2 + 3 to 4	Preplanting incorporated mixtures control annual grasses and broadleafs.
Atrazine + metolachlor	1 to 2 + 1-1/4 to 2-1/2	
Cyanazine (Bladex)	2 to 4	
Cyanazine + EPTC (Eradicane)	1-1/2 to 2 + 3 to 4	
Cyanazine + alachlor	1 to 2.2 + 2 to 2-1/2	Controls annual grasses and many annual broadleafs.
Metolachlor (Dual)	1-1/2 to 3	For nutsedge and annual grass control.
Preemergence		
Alachlor (Lasso)	2 to 3-1/2	Controls annual grasses primarily.
(Lasso II)	2.4 to 3.9	
Atrazine	1 to 3	May injure some crops following year.
Cyanazine (Bladex)	2 to 4	Do not use on sandy soils.
Metolachlor (Dual)	1-1/2 to 3	Do not graze or use corn for silage.
Propachlor (Ramrod, Bexton)	4 to 6	Controls annual grasses only.
Atrazine + alachlor	1 to 2 + 1-1/2 to 2-1/2	
Atrazine + metolachlor	1 to 2 + 1-1/4 to 2	Do not graze or use corn for silage.
Atrazine + propachlor	1 to 1-1/2 + 2 to 3-3/4	
Cyanazine + alachlor	1 to 2.2 + 2 to 2-1/2	Do not use on sandy soils.
Dicamba (Banvel) + alachlor	1/2 + 2 to 2-1/2	Do not use on sandy soils.
Linuron (Lorox) + alachlor	1/2 to 1-1/2 + 1 to 3	Do not use on sandy soils.
Linuron + propachlor	1 to 1-1/2 + 2 to 3	Do not use on sandy soils.

Table 1. (continued)

Chemical	Pounds per acre of active ingredient or acid equivalent broadcast	Remarks[2/]
Postemergence		
Atrazine + oil	1.2 to 2	Apply when weeds less than 1-1/2 inches tall.
Bentazon (Basagran)	3/4 to 1	Weeds 2 to 6 inches. Earlier applications are more effective on most weeds.
Cyanazine (Bladex)	2	Apply when weeds less than 1-1/2 inches tall and before corn has more than 4 leaves.
Dicamba (Banvel) Dicamba + 2,4-D amine	1/8 to 1/4 1/8 to 1/4	Controls broadleafs only. Apply before corn is 2 feet tall and not within 15 days of tasseling. Follow drift control precautions on the label.
2,4-D amine 2,4-D ester	1/4 to 1/2 1/6 to 1/3	Corn 4 inches to 3 feet tall. Use drop nozzles after corn is 8 inches tall. 2,4-D controls broadleafs only.
2,4-D amine 2,4-D ester	1/2 to 1 1/3 to 2/3	After corn is 3 feet tall. Use drop nozzles so only base of stalk is sprayed. Do not apply between tasseling and dough stage.

Table 2. Effectiveness of Herbicides on Major Weeds in Corn[1/].

	Preplanting						Preemergence								Postemergence				
	Alachlor (Lasso)	Metolachlor (Dual)	Butylate (Sutan+)	EPTC (Eradicane)	Cyanazine (Bladex)	Atrazine	Alachlor (Lasso)	Atrazine	Dicamba (Banvel)	Pendimethalin (Prowl)	Propachlor (Ramrod, Bexton)	Metolachlor (Dual)	Linuron (Lorox)	Cyanazine (Bladex)	2,4-D	Dicamba (Banvel)	Atrazine and oil	Cyanazine (Bladex)	Bentazon (Basagran)
Corn tolerance	G	G	G	G	F	G	G	G	F	F	G	G	F	F	G	G	G	F	G
Grasses																			
Giant and robust foxtail	G	G	G	G	F	F	G	F	P	F	G	G	F	F	N	N	F	G	N
Green foxtail	G	G	G	G	G	G	G	G	P	F	G	G	F	G	N	N	G	G	N
Yellow foxtail	G	G	G	G	G	G	G	G	P	F	G	G	F	G	N	N	G	G	N
Barnyardgrass	F	G	G	G	F	F	G	F	P	F	F	G	F	F	N	N	F	F	N
Crabgrass	G	G	G	G	F	P	G	P	P	F	G	G	G	F	N	N	P	F	N
Panicum	G	G	G	G	F	P	G	P	P	F	F	G	G	F	N	N	P	F	N
Nutsedge	G	N	G	G	P	P	F	P	N	N	F	F	P	P	N	N	F	P	G
Quackgrass	N	N	N	F	P	G	N	G	N	N	N	N	N	P	N	N	G	P	N
Woolly cupgrass	G	-	F	G	P	P	G	P	P	F	F	-	P	P	N	N	F	F	N
Wild proso millet	G	F	F	G	P	P	F	P	P	-	F	F	P	P	N	N	P	P	N
Broadleafs																			
Cocklebur	N	N	P	P	F	F	N	F	F	P	P	N	P	F	G	G	G	F	G
Lambsquarters	F	P	P	F	G	G	F	G	G	F	P	P	G	G	G	G	G	G	P
Mustard	P	P	P	P	G	G	P	G	G	P	P	P	G	G	G	F	G	G	G
Pigweed	G	G	F	F	F	G	G	G	G	F	F	G	G	F	G	G	G	F	P
Ragweed	P	P	P	F	G	G	P	G	G	P	P	P	G	G	G	G	G	G	G
Smartweed	P	P	P	P	G	G	P	G	G	F	P	P	F	G	P	G	G	G	G
Velvetleaf	P	P	F	F	F	F	P	F	F	F	P	P	F	F	G	G	F	F	G
Wild sunflower	P	P	P	P	F	F	P	F	F	P	P	P	P	F	F	G	G	F	G
Canada thistle	N	N	N	N	P	P	N	P	N	N	N	N	N	P	F	G	F	P	F
Buffalobur	P	P	F	G	P	P	P	P	P	-	P	P	P	P	P	P	G	P	P
Kochia	P	P	P	F	G	G	P	G	F	-	P	P	F	G	F	G	G	G	-
Jerusalem artichoke	N	N	N	N	P	P	N	P	P	N	N	N	P	P	G	G	P	P	P

G - Good; F - Fair; P - Poor; N - None

Table 3. Suggestions for chemical control of weeds in soybeans[1].

Chemical	Pounds per acre of active ingredient or acid equivalent	Remarks[2]
Preplanting incorporated		
Alachlor (Lasso)	4	For nutsedge control.
(Lasso II)	3.9	For nutsedge control.
Dinitramine (Cobex)	1/3 to 2/3	Primarily annual grass control.
Fluchloralin (Basalin)	1/2 to 1-1/2	
Pendamethalin (Prowl)	1/2 to 1-1/2	
Profluralin (Tolban)	1/2 to 1-1/2	
Trifluralin (Treflan)	1/2 to 1	
Vernolate (Vernam)	3	Controls annual grasses and some broadleafs. Incorporate immediately.
Metribuzin (Lexone, Sencor)	1/4 to 1/2	Used in mixtures with dinitramine, pendimethalin, profluralin or trifluralin.
Preemergence		
Alachlor (Lasso)	2 to 3-1/2	Controls annual grasses primarily.
(Lasso II)	2.4 to 3.9	
Chloramben (Amiben)	3	Controls annual grasses and broadleafs. Apply same day soybeans are planted.
Chloramben + alachlor	2 + 2	
Chlorbromuron (Maloran) + alachlor	3/4 to 2-1/4 + 1-1/2 to 2-1/2	For medium textured soils with less than 4% organic matter. Do not use on sandy soils.
Chlorpropham (Furloe Chloro-IPC)	2 to 3	For annual smartweeds only.
Linuron (Lorox) + alachlor	1/2 to 1-1/2 + 1 to 3	For medium textured soils with less than 4% organic matter. Do not use on sandy soils.
Metribuzin (Lexone, Sencor) + alachlor	1/4 to 1/2 + 2 to 2-1/2	Do not use on soils low in organic matter or on sandy soils. Soybean injury may be more severe on alkaline soils or on soils with atrazine residues.
Postemergence		
Bentazon (Basagran)	3/4 to 1-1/2	Apply when soybeans are in first trifoliolate leaf stage. Controls most annual broadleaved weeds, Canada thistle, and nutsedge. Apply second treatment to Canada thistle and nutsedge 10 days after first application.
Chloroxuron (Tenoran)	1 to 1-1/2	Apply when soybeans are in first trifoliolate leaf stage and weeds are less than 2 inches tall. Controls certain broadleaves only.

Table 3. (Continued)

Chemical	Pounds per acre of active ingredient or acid equivalent	Remarks[2/]
2,4-DB amine	1/5	Controls only cocklebur. Apply 10 days before bloom up to midbloom or as directed spray when soybeans are 8 to 12 inches tall.

Table 4. Effectiveness of Herbicides on Major Weeds in Soybeans.[1/]

	Preemergence							Preplanting						Post-emergence		
	Alachlor (Lasso)	Chloramben (Amiben)	Chlorpropham (Furloe)	Chlorbromuron (Maloran)	Linuron (Lorox)	Metribuzin (Sencor, Lexone)	Alachlor (Lasso)	Trifluralin (Treflan)	Dinitramine (Cobex)	Fluchloralin (Basalin)	Pendimethalin (Prowl)	Profluralin (Tolban)	Vernolate (Vernam)	Chloroxuron (Tenoran)	2,4-DB amine	Bentazon (Basagran)
Soybean tolerance	G	G	G	F	F	F	G	F	F	F	F	F	F	F	P	G
Grasses																
Giant foxtail	G	G	P	F	F	F	G	G	G	G	G	G	G	P	N	N
Green foxtail	G	G	P	F	F	F	G	G	G	G	G	G	G	P	N	N
Yellow foxtail	G	G	P	F	F	F	G	G	G	G	G	G	G	P	N	N
Barnyardgrass	G	G	P	F	F	F	G	G	G	G	G	G	G	P	N	N
Nutsedge	F	P	N	P	P	P	G	P	N	N	N	N	F	N	N	F
Broadleafs																
Black nightshade	G	F	P	P	P	P	G	P	F	P	P	P	P	-	-	F
Cocklebur	P	P	P	P	P	F	P	P	N	N	N	N	P	F	F	G
Kochia	P	G	P	F	F	G	P	G	G	G	G	G	-	-	-	-
Lambsquarters	F	G	P	G	G	G	F	G	G	G	G	G	G	F	P	F
Mustard	P	F	F	G	G	G	P	P	N	N	N	N	F	G	P	G
Pigweed	G	G	P	G	G	G	G	G	G	G	G	G	G	F	P	F
Common ragweed	P	G	P	G	G	G	P	N	P	N	N	N	P	P	P	G
Giant ragweed	P	F	P	F	F	F	P	N	P	N	N	N	P	F	F	F
Smartweed	P	G	G	F	F	G	P	P	F	P	F	P	P	P	P	G
Velvetleaf	P	F	P	F	F	F	P	P	P	N	F	N	F	P	P	G
Venice mallow	P	G	P	G	G	G	P	P	P	P	P	P	G	-	P	G
Wild sunflower	P	P	P	P	P	F	P	N	N	N	N	N	P	F	P	G

G - Good; F - Fair; P - Poor; N - None

Table 5. Suggestions for chemical control of weeds in small grains.[1/]

Crop	Chemical	Rate - Pounds per acre of active ingredient or acid equivalent broadcast	Time of application - crop stage
Wheat or barley	2,4-D amine	1/4 - 2/3	Fully tillered to early boot.
	2,4-D ester	1/6 - 1/2	
	MCPA amine	1/4 - 2/3	Two leaf to early boot.
	MCPA ester	1/6 - 1/2	
	Bromoxynil + MCPA ester	1/4 + 1/4	Two leaf to early boot.
	Bromoxynil (Brominal, Buctril)	1/4 - 1/2	Two leaf to early boot.
Wheat or oats	Dicamba + MCPA amine	1/8 + 1/4	Two- to five-leaf stage.
Oats	2,4-D amine	1/4 - 1/2	Sixth leaf to early boot.
	MCPA amine	1/4 - 2/3	Two leaf to early boot.
	MCPA ester	1/6 - 1/2	
	Bromoxynil	1/4 - 3/8	
Winter wheat	2,4-D amine	1/4 - 3/4	Fully tillered to boot stage.
	2,4-D ester	1/4 - 1/2	
	MCPA	1/4 - 3/4	
	Dicamba + MCPA amine	1/8 + 1/4 - 3/8	After dormancy until wheat begins to joint.
	Dicamba + 2,4-D amine	1/8 + 1/4 - 3/8	
	Bromoxynil	1/4 - 1/2	Fully tillered to boot stage.
	Bromoxynil + MCPA ester	1/4 + 1/4	
Flax	MCPA	1/4	2- to 6-inch flax.
	Dalapon (Dowpon, Radapon)	3/4	2- to 6-inch flax.
	EPTC (Eptam)	3	Preplanting incorporated
	Bromoxynil	1/4 - 1/2	2- to 8-inch flax.

Table 6. Suggestions for chemical control of weeds in dry beans, sugarbeets, and sunflowers.1/

Crop	Chemical	Rate - pounds per acre of active ingredient or acid equivalent broadcast	Remarks
Dry beans	<u>Preplanting incorporated</u>		
	Alachlor (Lasso)	2-1/2 - 3	Controls annual grasses, nutsedge, pigweed, black nightshade.
	EPTC (Eptam)	3	Controls annual grasses, some broadleafs.
	Dinitramine (Cobex)	1/3 - 2/3	Controls annual grasses, pigweed, common lambsquarters.
	Profluralin (Tolban)	1/2 - 1	
	Trifluralin (Treflan)	1/2 - 1	
	<u>Preemergence</u>		
	Chloramben (Amiben)	3	Controls annual grasses and most annual broadleafs.
Sugarbeets	<u>Preplanting incorporated</u>		
	Diallate (Avadex)	1-1/2 - 2	Controls wild oat.
	EPTC (Eptam)	2 - 3	Controls annual grasses and some broadleafs.
	<u>Preemergence</u>		
	TCA	5 - 7	Controls annual grasses except wild oat.
	Pyrazon (Pyramin) + TCA	3.8 + 5 to 7	Use only on medium to coarse textured soils with less than 5% organic matter.
	<u>Early postemergence</u>		
	Dalapon (Dowpon)	2 - 3	Apply when sugarbeets are up to 6-leaf stage for controlling annual grasses except wild oat.
	Dalapon	2-1/2 - 3-1/2	Apply as directed spray when sugarbeets are 7-leaf stage to 14 inches.

Table 6. (continued)

Crop	Chemical	Rate - pounds per acre of active ingredient or acid equivalent broadcast	Remarks
Sugarbeets (continued)	Barban (Carbyne)	5/8 - 3/4	For wild oat control when wild oat has two leaves.
	Phenmedipham (Betanal)	1 - 1-1/2	Controls some annual grasses and most annual broadleafs except pigweed. Apply after sugarbeets have four leaves.
	Desmedipham (Betanex)	1 - 1-1/4	Controls most annual broadleafs. Apply after sugarbeets have four leaves.
	Endothall (Herbicide 273)	3/4 - 1-1/2	Controls wild buckwheat and annual smartweed. Apply when sugarbeets have 4 to 6 leaves.
Sunflowers	Preplanting incorporated		
	Dinitramine (Cobex)	1/3 - 2/3	Controls annual grasses, pigweed, common lambsquarters.
	EPTC (Eptam)	3	Controls annual grasses and some broadleafs.
	Profluralin (Tolban)	3/4 - 1	Controls annual grasses, pigweed, common lambsquarters.
	Trifluralin (Treflan)	1/2 - 1	
	Preemergence		
	Chloramben (Amiben)	2 - 3	Controls annual grasses and most annual broadleafs.

Table 7. Suggestions for wild oat control.[1/]

Chemical	Pounds per acre of active ingredient or acid equivalent broadcast	Time of application	Crop
Barban (Carbyne)	1/4 - 3/8	Wild oat in 2-leaf stage	Wheat, barley, flax
Barban (Carbyne)	3/8		Semidwarf wheat varieties, sunflowers, mustard, soybeans
Barban (Carbyne)	3/4 - 1	Wild oat in 2-leaf stage	Sugarbeets
Diallate (Avadex liquid)	1-1/2 - 2	Preplanting or preemergence, fall or spring	Flax, sugarbeets
Diallate (Avadex granules)	1-1/2 - 2	Preplanting, fall or spring	Sugarbeets
Triallate (Far-go)	1 - 1-1/4 1-1/4 - 1-1/2	Preplanting or preemergence, fall or spring	Wheat Barley
Difenzoquat (Avenge)	5/8 - 1	Wild oat in 3- to 5-leaf stage	Era spring wheat, barley, winter wheat, durum varieties except Lakota and Wascana

[1/] From Cultural and Chemical Weed Control in Field Crops-1978. Extension Bulletin 400, Agricultural Extension Service, University of Minnesota, St. Paul, Minnesota 55108. Check label for detailed use instructions and restrictions on crop use.

HERBICIDES FOR SMALL GRAINS

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THE WEED PROBLEM IN SMALL GRAINS

According to a weed survey conducted during 1976 in Minnesota among county extension directors and county agricultural inspectors, green and yellow foxtail (commonly called pigeon-grass by farmers) were rated collectively as the number one weed problem in small grains. This high rating of green and yellow foxtail may have resulted because foxtail was a particularly serious problem in Minnesota during 1976 and also because there were no herbicides available during 1976 to control foxtails in small grain. Wild mustard was rated as the second worst weed in small grains and another grass weed, wild oats, came in third. Other weeds (including only the top twelve) reported as problems in the survey in order of their importance in the state, were Canada thistle, common lambsquarters, quackgrass, wild buckwheat, pigweed species, smartweed species, perennial sowthistle, common ragweed and barnyard grass.

HERBICIDES FOR BROADLEAF WEED CONTROL

2,4-D amine or ester will effectively control many broadleaf weeds in wheat, barley, oats and rye including the problem broadleaves listed in the survey above, except for wild buckwheat and smartweed. Rates of one-sixth to one-half pounds per acre of 2,4-D ester or one-fourth to two-thirds pound per acre of 2,4-D amine may be used from the tillering stage to the early boot stage of the small grain without serious injury to these crops. Oats are less tolerant to 2,4-D and some injury should be expected. Oat injury may be reduced by using the amine form and no more than one-half pound per acre. Use the low rates listed for small annual broadleaf weeds and the higher rates for established perennials. 2,4-D amine or ester may also be used at one-half to one pound per acre when small grains are in the dough stage to control large weeds that may interfere with harvest.

MCPA amine or ester will control most of the problem broadleaves listed, including the perennial thistles, but will not effectively control wild buckwheat and smartweed species.

Small grains, especially oats, are more tolerant to MCPA than to 2,4-D. Using MCPA permits spraying in the two-to-five-leaf stage of the small grains, whereas using 2,4-D in this early stage would usually result in excessive crop injury. MCPA rates of one-fourth pound per acre of amine or one-sixth pound per acre of ester will control small mustard plants. For other broadleaved weeds or larger mustard, up to two-thirds pound per acre of amine and one-half pound per acre of ester may be required.

Bromoxynil (Brominal, Buctril) controls many annual broadleaf weeds including wild buckwheat and smartweed species when applied at one-fourth to one-half pound per acre when small grain is in the two-leaf to early boot stage and when weeds are small. Bromoxynil may be used in combination with MCPA ester at one-fourth pound per acre of each material when weeds are small to control most all of the problem broadleaf weeds listed. Established Canada thistle and perennial sowthistle plants may not be killed by this low rate of MCPA however.

Dicamba (Banvel) may be used in oats or wheat not underseeded to a legume, with one-fourth pound per acre MCPA amine to control broadleaf weeds that are tolerant to 2,4-D and MCPA. Oats are more tolerant than wheat to dicamba but applications to both crops must be made between the two-to-five-leaf stage of the small grain or severe injury to the crop is likely.

Picloram (Tordon 22K) may be used at rates of one-fourth to three-eighths ounce per acre in a tank mixture with 2,4-D amine at one-fourth to three-eighths pound per acre to control wild buckwheat and most of the other annual broadleaves listed except smartweed. Established perennial weeds will likely not be killed at these rates.

See University of Minnesota Extension Bulletin 400, "Cultural and Chemical Weed Control in Field Crops 1977" for additional information on rates, cautions and EPA limitations on crop use.

HERBICIDES FOR GRASS WEED CONTROL

Trifluralin (Treflan) may be used in spring wheat to control foxtail. Rates of one-half to three-fourths pound per acre should be applied after seeding wheat two to three inches deep with a press drill. Trifluralin should be shallowly incorporated (to two inches deep) with a spike-tooth or flex-tine harrow. Wheat injury is possible if incorporation is too deep or if seeding is too shallow, especially on coarse-textured soils or on soils low in organic matter.

Postemergence applications of propanil (one and one-half pound per acre) when weeds were in the two-to-four-leaf stage has given good control of foxtails and some annual broadleaf weeds which has resulted in increased spring wheat yields. Temporary injury to wheat evident as leaf burn or yellowing, slowed early growth and a several day delay in maturity has occurred in some trials. Efforts are now being made to obtain clearance for use of this compound. CAUTION: As of December, 1977, propanil has not been cleared for use in spring wheat in Minnesota.

Delayed preemergence applications of propachlor at three pounds per acre has given good annual grass control in spring wheat, oats and barley in trials at several locations in Minnesota over a period of several years. Efforts are now being made to clear propachlor for this use. CAUTION: As of December 1977 propachlor has not been cleared for use on small grains in Minnesota.

Triallate (Far-go) liquid or granules may be used for wild oat control on hard red spring or durum wheat at one to one and one-fourth pound per acre applied after seeding and incorporated shallowly into the sod. Barley is more tolerant to triallate and rates of one and one-fourth to one and one-half pounds per acre may be used, applied either before or after seeding and incorporated into the soil. Use the higher rate for granules in each case. Triallate is also cleared for fall application. Granules are suggested for fall use. To minimize crop injury, seed wheat or barley just below the treated soil layer.

Barban(Carbyne) can be used for wild oat control in spring wheat or barley. It should be applied at one-fourth to three-eighths pound per acre when most of the wild oats are in the two-leaf stage (from four to ten days after wild oat emergence). To minimize crop injury, do not spray after the four-leaf stage of the small grain.

Difenzoquat (Avenge) may be used on Era spring wheat and on spring-seeded durum wheat varieties except Lakota and Wascana and should be applied in the three-to-five-leaf stage of the wild oat. Use rates of five-eighths to one pound per acre depending on wild oat density. Difenzoquat may be tank mixed with MCPA and/or bromoxynil.

Glyphosate (Roundup) may be used as a foliar spray to control quackgrass and most other perennial weeds before seeding spring wheat, barley and oats. It must be applied on a good growth of quackgrass in either spring or fall before plowing. The field may be plowed and seeded three days after treatment. Rates of one to one and one-half pounds per acre have been effective on quackgrass.

See University of Minnesota Extension Bulletin 400, "Cultural and Chemical Weed Control in Field Crops 1977" or the product labels for more information.

A ROLLER HERBICIDE APPLICATOR

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In Northern Minnesota, quackgrass [Agropyron repens (L.) Beauv.], reed canarygrass, (Phalaris arundinacea L.), and other tall growing perennial grasses are serious weed problems in Kentucky bluegrass (Poa pratensis L.) seed production fields. These weeds reduce the yield and quality of harvested Kentucky bluegrass seed. There are no herbicides that will selectively control these perennial grasses in Kentucky bluegrass seed fields.

The utility of a roller herbicide applicator was evaluated for selectively applying glyphosate [N-phosphonomethyl)glycine] as a broadcast treatment to tall growing weeds in Kentucky bluegrass seed fields. The applicator consists of a carpet covered horizontal rolling tube which is attached to a frame. The frame is mounted on a "Versatile" swather in place of the header. A variable speed hydraulic motor allows the speed of the roller to be varied from 0 to 150 rpm.

Another variable speed hydraulic motor drives a rotary gear pump which pulls the herbicide solution from a fiberglass tank through a line strainer and propels it through a 1/2 inch nylon tube to a 1.0 inch rigid plastic perforated pipe positioned three inches above the roller. The herbicide solution is applied to the roller under low pressure through numerous .019 inch perforations in the pipe. The quantity of herbicide solution on the roller can be kept constant regardless of weed population by varying the speed of the hydraulic controlled solution pump.

The carpet covered roller wipes the herbicide solution on the tall growing weeds as the swather moves across the field. The herbicide solution is applied only when the weeds come in contact with the roller. The herbicide solution is retained on the roller without dripping due to the rotation of the roller at 50 rpm.

Applications of glyphosate concentrations of 0.05, 0.15, and 0.30 lb/gal. gave excellent control of quackgrass and reed canarygrass with very little Kentucky bluegrass injury.

This type of applicator provides a technique for applying nonselective herbicides with very limited crop injury. No recycling of the herbicide solution is required. The cost of application is reduced, because the herbicide solution is applied only when weeds are present.

NITROGEN IN YOUR PAST AND FUTURE*

INTRODUCTION

Nitrogen may be called the miracle chemical - without it no plants or animals grow. Of the 16 essential elements required by plants, nitrogen is often the first limiting element. This is readily demonstrated, especially on soils low in organic matter and/or coarse textured soils.

OCCURRENCE

Air contains 78.1 percent nitrogen by volume or approximately 75 percent by weight. This equates to nearly 20 million tons of nitrogen per square mile or roughly 35,000 tons of nitrogen over every acre. The only known naturally occurring inorganic compounds of nitrogen are sodium nitrate (Chilian nitrate), calcium nitrate and ammonia.

The earth's crust contains an estimated 0.03 percent nitrogen varying widely according to the quantity of soil organic matter. The nitrogen content of soil humus is about 5 percent.

SOURCES OF NITROGEN FOR GROWING CROPS

Atmosphere: A small but significant amount of nitrogen reacts in the atmosphere by such phenomenon as cosmic radiation, meteor trails and lightening. Hydrocarbons as petroleum fuels and coal contain small quantities of ammonia. The ammonia is released from these fuels upon combustion and combines with moisture in the atmosphere. As much as 10-15 pounds per acre or more may be added to the soil annually depending on total precipitation and atmospheric conditions. The U.S. annual average is approximately 5 pounds N per acre. Stanford, Table 1, has estimated about 1 million tons of N are added to cropland annually in rain and snow.

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* To be presented by Harvey Meredith, Tennessee Valley Authority, at the Soils, Fertilizer and Agricultural Pesticides Short Course, Minneapolis, Minnesota, December 13, 1977.

Table 1. Estimated Nitrogen Balance on Harvested Cropland. [a]

Source	Million Tons N 1930	1947	1969
Inputs			
Fertilizer N	0.3	0.7	6.8
N fixation (legumes)	2.7	2.7	3.0
Crop residues	1.1	1.5	2.5
Manure	1.9	1.3	1.0
Rainfall	0.8	1.0	1.0
Total	6.8	7.2	14.8
Removal			
Harvested crops	4.6	6.5	9.5
Erosion	5.0	4.0	3.0
Leaching of Soil N	4.0	3.0	2.0
Leaching of fertilizer N	0	0	?
Denitrification	?	?	?
Total	13.6	13.5	14.5

a/ Stanford et al. ARS 41:168, USDA. 1969.

Animal manure: The extent to which the nitrogen requirements of agricultural crops has been met by animal manure is not well known. On small farms, at least, it has been extensive. The estimated contribution of manure to the nitrogen input on cropland appears in Table 1.

Crop Residue and Green Manure Crops: The amount of nitrogen added per acre in some green manure crops appears in Table 2.

Table 2. Approximate Accumulation of Nitrogen in Green Manure Crops[b]

Crop	Yield (tons)	Pounds N
Alfalfa	4.0	180
Blue grass	2.0	60
Red clover	2.5	100
Timothy	2.5	60
Soybeans	2.0	90

b/ Our Land and Its Care, The Fertilizer Institute, Washington, D. C. 1962.

It has been estimated that approximately 3 million tons of N are added to cropland via fixation of atmospheric N by legumes and 2.5 million tons of N are added annually with the return of crop residues to the soil, Table 1.

Symbiotic Nitrogen Fixation: Fixation of atmospheric nitrogen by legumes and the beneficial effect upon plant growth by succeeding crops following plowdown of legumes has been observed for centuries. Theophrastus wrote in 300 B.C. that the Greeks used crops of broad beans to enrich the soil. It is now known that this benefit is largely attributed to the Rhizobium bacteria living symbiotically (co-beneficially) in the plant roots of legumes. The bacteria seemingly infect the root hair. The infection extends from the root hair into the cortex cells of the rootlets forming gall-like structures called nodules. Nitrogen fixation occurs in the nodules. Atmospheric nitrogen is reduced to an amino or amide form usable by the plant. The relationship is mutually beneficial as the bacteria obtain energy from the plant.

Nonsymbiotic Nitrogen Fixation: Azotobacter, an aerobic bacterium and Clostridium, a facultative or anaerobic bacterium sometimes are given credit for fixation of atmospheric nitrogen. It is doubtful if these organisms provide much nitrogen in modern productive agriculture

Soil Organic Matter: Nitrogen released during the decomposition of organic matter has been a major source of this critical element throughout the history of agriculture. Following glaciation of the U. S. cornbelt, prairie grasses thrived and soil organic matter accumulated, Table 3. Following intensive cultivation, vast quantities of nutrients were released. Decomposition of soil organic matter following cultivation has been estimated by Stanford, Table 4.

Table 3. Dry Weight of Living Underground Plant Parts in the Surface Four Inches of Soil [a/].

Plant	Lbs/Ac	Plant	Lbs/Ac
Slough grass	13,240	Brome grass	3,926
Big Bluestem	8,200	Alfalfa	3,497
Little Bluestem	6,600	Wheat	1,338
Blue grass	4,800	Corn	1,160

a/ Jenny, Hans. Factors of Soil Formation. McGraw-Hill Book Company, Inc. 1941, p. 208.

Table 4. Organic Matter Oxidation Following Cultivation of Native Prairie Soils, Midwest U. S. [b/]

	Percent Organic Matter Oxidized
First 25 years	25
Second 20 years	10
Third 20 years	7

b/ Stanford, George. Plant Food Review. 15 (1):2, 1969.

Factors as temperature, moisture, soil texture, organic matter content, etc., determine the amount of organic matter oxidized under cultivation and hence the amount of nitrogen mineralized. Only 2-3 percent of the soil organic matter in the plow layer of cultivated soils undergoes decomposition annually. A soil containing 3 percent organic matter would release approximately 75 pounds of N annually. Only about one-half this amount would be available to the growing crop.

Fertilizer Nitrogen: Ammonia was first produced by Priestly in 1774, by heating the hoofs and horns of animals. The name spirits of hartshorn, sometimes used for dilute solutions of ammonia, is based on this early source of the compound. In 1914 Fritz Haber, a German chemist, perfected a method of direct synthesis of ammonia from the gaseous elements hydrogen (H_2) and nitrogen (N_2). This process gave Germany a source of nitrogen to produce explosives and freed them from the dependence upon Chilean nitrates. A simplified reaction for the formation of ammonia is:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

High temperatures and pressures along with suitable catalysts are required to produce ammonia. During the period July 1, 1976 - June 30, 1977, U. S. agriculture used the equivalent of nearly 13 million tons of ammonia. Minnesota used about 5 percent of the U. S. total, 635,000 tons. At $165 per ton, the price tag would be about $105 million for the agricultural ammonia used in Minnesota. A brief summary of N use in Minnesota appears in Table 5.

Table 5. History of Nitrogen Use in Minnesota a/.

Year	AN	U	NH_3	A.S.	N. Soln.	Tons N
1945	534 1/	-	-	2,270 1/	-	1,500
1950	3,362	-	-	143	-	5,853
1955	10,608	87	15,474	1,967	8,457	34,959
1960	18,761 2/	492	19,516	1,957	22,116	54,022
1965	12,329 3/	1,312	24,521 3/	420 3/	15,103 3/	103,595
1970	24,172	1,577	164,189	947	20,033	283,875
1975	42,177	30,477	241,533	743	29,869	450,318
1977	24,517	50,869	293,202	1,066	42,781	521,019

1/ 1946
2/ 1959
3/ 1966

AN = Ammonium nitrate
U = Urea
NH_3 = Anhydrous ammonia
A.S. = Ammonium sulfate
N Soln = Urea-ammonium nitrate solutions 28-32 percent N

a/ Commercial Fertilizers, USDA Crop Reporting Board, Washington, D.C.

THE ROLE OF NITROGEN

Nitrogen encourages growth and development of the vegetative parts of the plant and imparts a deep green color to the leaves. The basic ingredient imparting the green color to plants is chlorophyll. Nitrogen is one of the major elements of the chlorophyll molecule ($C_{33}H_{72}O_5N_4Mg$). When N is deficient, plants exhibit a light green or yellowish color. Nitrogen deficiency is characterized by stunted plants with restricted or poorly developed root systems.

FORMS OF NITROGEN IN THE SOIL

Nitrogen is present in mineral soils as (1) organic nitrogen associated with organic matter or humus, (2) ammonium nitrogen adsorbed on clay surfaces, and (3) soluble inorganic ammonium (NH_4^+) and nitrate (NO_3^-) compounds.

THE NITROGEN CYCLE

Nitrogen enters the soil from the atmosphere, commercial fertilizers, manures, crop residue and fixation of atmospheric nitrogen by microorganisms. Nitrogen is lost from the soil system by leaching and other forms of water drainage, denitrification, volatilization or gaseous loss to the atmosphere and crop removal.

MINERALIZATION OF SOIL NITROGEN

Ammonification: Ammonium is enzymatically hydrolyzed nitrogen from organic matter by a large number of heterotrophic soil microorganisms. The process may be outlined in simple form as follows:

$$\underset{\text{(proteins, amino acids, etc.}}{\text{Organic nitrogen}} \longrightarrow \underset{(NH_4^+)}{\text{Ammonium}}$$

Nitrification: The enzymatic oxidation of ammonium (NH_4^+) is carried out by two distinct groups of bacteria. The reaction involves two steps. Step one is the production of nitrous acid from ammonium nitrogen.

$$2NH_4^+ + 3\ O_2 \xrightarrow[\text{(bacteria)}]{\text{Nitrosomonas}} 2\ NO_2^- + 2\ H_2O + 4H^+$$

Step two involves the oxidation of nitrite (NO_2^-) to the nitrate (NO_3^-) form.

$$2\ NO_2^- + O_2 \xrightarrow[\text{(bacteria)}]{\text{Nitrobacter}} 2\ NO_3^-$$

Both of these bacteria are special purpose autotrophic microorganisms. They obtain their energy by the oxidation of inorganic nitrogen compounds and carbon from carbon dioxide. The oxidation of ammonium (NH_4^+) to nitrate (NO_3^-) occurs rapidly at temperatures above 55°F. Over 20 pounds of N per acre daily have been observed to undergo oxidation from the ammonium to the nitrate form[a].

Whereas the ammonium (NH_4^+) form of soil nitrogen is positively charged and relatively immobile in the soil, the nitrate form (NO_3^-) is negatively charged, highly soluble in water and subject to extensive movement in the soil. Nitrate nitrogen is readily available to plants, may be utilized by microorganisms, lost in drainage water or lost from the soil system in gaseous form as a result of denitrification. Loss of nitrate nitrogen due to leaching from coarse textured (sandy) soils may be extensive, particularly under conditions of moderate to high rainfall.

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[a] Broadbent, F. E. and K. B. Tyler. "Nitrification of Ammonical Fertilizers in Some California Soils," Hilgardia, 27:247-67. 1957.

Denitrification: Oxygen may be stripped off the nitrate ion (NO_3^-) and biologically reduced to gaseous forms of nitrogen, N_2O or N_2, and lost from the soil when the soil contains insufficient atmospheric oxygen. Denitrification most commonly occurs when soils are flooded or contain excess water. Four factors essential for denitrification are:

1. an energy source (organic matter)
2. denitrifying microorganisms
3. low levels of "free" oxygen
4. presence of nitrates (NO_3^-)

The amount of soil nitrogen lost via denitrification is not known. Continuing small losses of nitrogen from pockets of microbial activity in well aerated soils may contribute to extensive losses of nitrogen.

NITROGEN IN THE SOIL SYSTEM

Soil clay and organic matter have negatively charged sites which attract and hold the positively charged ammonium ion (NH_4^+). The nitrate ion (NO_3^-) is negatively charged hence is free to move with the soil water.

Fertilizer nitrogen is added to the soil in both the ammonium and nitrate form depending on the nitrogen carrier, Table 7.

Table 7. Forms of Nitrogen from Selected Fertilizers Following Incorporation into Moist Soils.

Nitrogen carrier	Ammonium (NH_4^+) (Percent)	Nitrate (NO_3^-) (Percent)
Anhydrous Ammonia (NH_3)	100	0
Urea, $CO(NH_2)_2$	100	0
Urea-ammonium nitrate solutions (28-32 percent N)	73	27
Ammonium Nitrate	50	50

As the nitrate ion is subject to loss by leaching and denitrification, there is widespread interest in methods to prevent nitrification or oxidation of the ammonium to the nitrate form. This is of special interest when the ammonium form of nitrogen is applied far in advance of crop usage.

NITRIFICATION INHIBITORS

Treatment of ammonium forms of fertilizers with chemicals to retard or delay the conversion to the nitrate form has been a subject of interest for some time. Although the use of chemical inhibitors to slow the rate of nitrification of ammonical fertilizers is not new, interest has been revitalized in recent years as the cost of energy increases. Currently a number of chemicals are being evaluated as to their usefulness as nitrification inhibitors.

SUMMARY

Nitrogen fertilizers are vital to U. S. Agriculture. Understanding the forms of nitrogen in fertilizers and reactions of nitrogen in the soil are helpful in the selection of a nitrogen carrier.

As the nitrate form of nitrogen is unstable in soil systems, extensive research has and is being conducted on methods to stabilize the ammonium form of nitrogen in the soil. Nitrification inhibitors offer great promise in this regard.