University of Minnesota
Southern Experiment Station
Waseca, Minnesota

Research Report
1988

Southern Experiment Station

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1988

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SOUTHERN EXPERIMENT STATION

RESEARCH REPORT, 1988

This research report includes a complete listing of the research projects in progress at the Southern Experiment Station during 1988. Detailed reports, including summaries and conclusions, are included for a selected number of the projects. This work is a product of the Minnesota Agricultural Experiment Station, involving a cooperative effort between the Southern Experiment Station and a number of departments on the St. Paul Campus. These include:

- Agricultural and Applied Economics
- Agricultural Engineering
- Agronomy and Plant Genetics
- Animal Science
- Entomology
- Horticulture and Landscape Architecture
- Plant Pathology
- Soil Science
- College of Forestry
    - Fisheries and Wildlife
    - Forest Resources
- College of Veterinary Medicine

Special appreciation is extended to those scientists who prepared manuscripts for this report. Appreciation is also extended to the many private donors whose support enhances the entire program of research at the Southern Experiment Station. We wish to make specific mention of the Minnesota farmers who have supported our programs, including our generous neighbors who regularly loan equipment and lend their personal support to our activities and the growers who through the Minnesota Soybean Research and Promotion Council, the Minnesota Wheat Council, Midwest Food Processors Association (Minnesota Region), Minnesota Pork Producers Association, National Pork Producers Association, and the Fats and Protein Research Foundation have contributed in large measure to our research program.

Throughout the report, it will be observed that products on some occasions are identified by their generic name; in other instances, by their trade name. Inclusion of trade names does not imply recommendation or endorsement by the University of Minnesota.

Many treatments included in this report are experimental and are not registered for use. Farmers should consult product labels before using to determine if the product is registered for the intended use.

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INTRODUCTION

The staff of the Southern Experiment Station is pleased to share with the readers of this publication the results of research conducted during 1988. As a prelude to the study of this report, it may be useful for the reader to be familiarized with the organization of the University of Minnesota, with particular reference to this Station. Created and funded by the Minnesota State Legislature, the direction of the University of Minnesota is entrusted to the Board of Regents. The President and Central Officers are the executive body of the University. Most directly responsible is Dr. C. Eugene Allen, Interim Vice President for the Institute of Agriculture, Forestry, and Home Economics, who also serves as Director of the Minnesota Agricultural Experiment Station. Immediately responsible for all branch stations is Dr. Roy Thompson, Assistant Director of the Experiment Station. The resident official holding responsibility is Richard H. Anderson, Superintendent, who together with the research staff, is supported by civil service and bargaining unit employees.

A group of dedicated volunteers from across south-central and southeast Minnesota representing the principal farming enterprises and various agri-businesses make up the Southern Experiment Station Advisory Committee. Committee members serve without salary or remuneration for their personal expenses. The services of the Committee are highly valued by the staff of the Station. Members include:

William Arendt, Plainview
Leonard Binstock, Kasson
Julie Boyum, Hayfield
Ronald Hardesty, St. Peter
Virgil Johnson, Caledonia
Lynn Lagerstedt, Adams
Garry Martin, Blue Earth
Paul Nesseth, Nerstrand
Charles Priebe, Waseca
Ronald Pulley, Chatfield
Bill Sanborn, Pine Island
Jan Schwantz, Plainview
Charles Vollum, Albert Lea
Roger Wilkowske, Faribault
Ben Zweber, Elko

Cooperative research in a coordinated system-wide effort is the essential function of any branch agricultural experiment station. Minnesota has six major stations, together with a number of other research sites, to provide the location opportunity for research that needs to be conducted in major areas of production. These sites have been chosen to represent the significant soil and climatic regions of the State of Minnesota. The area represented by the Southern Experiment Station is a highly intensive agricultural region occupying less than one-sixth of the state's geographic area but accounting for a full third of the state's cash farm income. Most of the research is related to the principal agricultural enterprises of the region, including the production of corn, soybeans, vegetable crops, dairy cattle, dairy cattle raised for beef, and swine. Each year as many as 80 scientists or graduate students from locations other than Waseca utilize the resources in cooperation with resident staff to conduct applied phases of their research. More than 100 separate experiments are in progress at the station during each year.

General information about the station is frequently requested by visitors. Operations began in 1913, following the authorization and funding of the Station by the Minnesota State Legislature in 1911. Observances were made in 1988 of the Diamond Anniversary. The Station began on a 240-acre tract of land selected and purchased in 1912. An additional 358 acres of land were purchased in 1940 and another 231 acres added in 1972. An area of approximately 109 acres was made available for the development of the University of Minnesota Technical College during the early 1970s, leaving the Southern Experiment Station at its present size of 720 acres. Dairy cattle at the Station number approximately 180 head, with a 90-cow milking herd. Ninety Holstein bull calves are purchased each year for use in Holstein steer nutritional studies. They, along with an additional 40 bull calves from the dairy herd, are fed out and marketed. In the swine area, about 2,000 pigs are farrowed annually for use in nutritional and swine management studies. Research plots involved in agronomy, soil science, and horticultural science number in the tens of thousands.

[Editor's Note: The following five-part statement of research objectives is repeated from the 1987 report as the principal statement of this introduction. Public perception of research is often limited to a single issue of paramount interest to the observer. Readers are invited to review this statement in detail as to the scope and diversity that is necessary in a research program that attempts to be reflective of the needs of Agriculture in today's society.]

Adaptive research would best characterize the nature of most experiments conducted at the Southern Experiment Station. Historically, the objective has been the development of technologies useful to farms in production systems. The complexities of modern society combining the pressures of a growing population on limited environmental resources together with our highly developed productive capacity have brought about not only the demand for new approaches but also the ability to consider alternative technologies in the production of food and fiber. Thus, we see an emerging research program that addresses a multitude of questions. Therefore, a modern research program will include efforts in the following directions:

I. Profitability

Reduced Input and Cost - Research conducted on the reduction of fertilizer and other inputs at the Southern Experiment Station during the decade of the 70s was rapidly adopted by farmers during the agricultural crisis which became apparent in the early 80s. For many farmers who have achieved high production goals, reduced inputs offer a major opportunity for increased profitability.

Increased Yield - Even within an agricultural system that from time to time is beset with apparent surpluses, the opportunity for improved profitability by farmers who operate at inefficient production levels continues to exist by increasing yield with new and existing technologies.

Utilization Research - New uses for agricultural commodities have tremendous potential for improvement of profitability, not only of farmers but the entire economy.

Value Added - The area served by the Southern Experiment Station is blessed with a significant food processing industry. Continued research is essential to increase the value of Minnesota crops by manufacturing processes as we prepare them for profitable export from the state.

II. Adequate Food and Fiber Production

For Today's Society - A plentiful supply of safe food at reasonable cost continues to be a statement of need of our current population. We must accept the responsibility for preserving that opportunity for the future.

For Future Societies - The apparent ability to increase production faster than predicted population growth has the danger of developing a "cry wolf" attitude by many people. It should be borne in mind that extraordinarily favorable weather patterns have prevailed for the last two decades. We must also anticipate very significant population increases in the decades ahead. We are far from being in a status quo position as far as future production needs are concerned. Research to assure those future needs will be met, as well as to provide the continuum of training opportunities for tomorrow's scientists, requires a continued strong agricultural research program.

III. Protection of our Environment

Water Quality - Clearly the most pressing issue of this day, water quality concerns demand research attention. The Southern Experiment Station is very actively studying the impact of agricultural practices on water quality in the critical Karst region of southeast Minnesota. A two-pronged effort is aimed toward the maintenance of water quality and assistance to farmers in the development of management practices that will continue profitabile operations in ways that are environmentally sound.

Soil Conservation - Conservation tillage has been a hallmark of Southern Experiment Station research for two decades. Tremendous changes in farm tillage practices can be observed throughout southern Minnesota as a result of this research. As the basic resource that must serve mankind for untold thousands of years into the future, we have no more important single obligation.

Agricultural Chemicals - Strong efforts have been made and are underway to understand the use of these agricultural tools in such a way as to limit their potential impact on the environment. Accomplishments have been made in the reduction of quantities being applied. Research should be concerned with determining:

a. Potential harmful effects of a chemical,
b. Acceptable tolerances,
c. Alternatives to chemical use.

IV. Rural Culture - Socio-economic implications far beyond the scope of agricultural research portend the continuation of farm size increase. The effect on rural communities and agricultural infrastructure have been all too evident during the past several decades. While Agriculture's function is to meet U.S. and world needs for food and fiber in the most effective way possible, opportunities should be sought to pursue those research projects that will be of special significance to preservation of our rural culture.

V. Equitability - All segments of our society should benefit from the results of agricultural research. This includes small farmers, large farmers, and also consumers. While it is seemingly apparent that large farmers have the opportunity to apply research results most effectively, it is important to maintain a high degree of size neutrality in research results. Thus, a small farmer gains the same genetic benefits of a newly-developed variety as does the large farmer. Similar results are possible on a unit basis for much of our research.

Use of This Research Report

Use of this report by the reader will be aided by an understanding of the remaining sections. Part II is a brief listing of each research project in which there was activity at the Southern Experiment Station during the calendar year 1987. A project may include the full scope of work conducted under the direction of a project leader in a specific area and might include several experiments. A brief statement of purpose is made in regard to each project, together with the identity of the scientists involved in the work. Many of the projects listed in Part II have not progressed to the point where conclusive remarks can be made. For this reason, they are included here primarily to inform the reader of the nature of work being conducted at the Station. A comment is made by the author in each instance if additional conclusive information about the study can be found in the more detailed report in Part III.

Part III includes reports of research that has been concluded or is advanced enough to warrant conclusive statements. Acknowledgement is made of those project leaders from other locations in those instances where Southern Experiment Station scientists have reported cooperative research. Their names are indicated in connection with each report.

Acknowledgement is also made of the generous support of the Minnesota Legislature which has facilitated an extensive physical plant development and significant programmatic improvement during the past two decades. Appreciation is also expressed for the leadership, guidance, and support of the Central Administration of the University of Minnesota and the officers of the Institute of Agriculture, Forestry, and Home Economics.

Richard H. Anderson
Superintendent

1988 AGRONOMY PROJECT LIST

SOUTHERN EXPERIMENT STATION

William E. Lueschen, Agronomist

I. CORN

A. Corn Breeding - Dr. Steve Openshaw

The corn breeding project is a long-term project at the Southern Experiment Station with the objective of development and testing of germplasm for improving corn through plant breeding techniques. Included in this project in 1988 was an elite hybrid evaluation trial where several commercial corn hybrids were compared. This project also is responsible for evaluating the relative maturity of corn hybrids registered for sale in the state of Minnesota. This phase of the project was in cooperation with the Minnesota Department of Agriculture. For the past two years we have evaluated the tolerance of inbred lines and corn hybrids to DPX-M6316, a herbicide that has potential for weed control in corn. The data from the corn hybrid evaluation study is included in the detailed report that follows.

B. Cultivation Effects on Corn Weed Control - Dr. William Lueschen and Dr. Jeffrey Gunsolus

The objective of this project was to evaluate the influence of time of cultivation and rotary hoeing on weed control in corn with and without the use of herbicides. In this project, we compared a banded versus a broadcast application of herbicides. The herbicides used in this study were as follows: alachlor (Lasso) at 2.5 lb/A broadcast preemergence, alachlor + cyanazine (Lasso + Bladex) at 2 + 2 lb/A preemergence broadcast and banded as separate treatments, and an untreated check that only received cultivation as the means of weed control.

C. Herbicide Carryover in Corn, Oats and Alfalfa - Dr. Jeffrey Gunsolus and Dr. William Lueschen

The objective of this project was to determine the effects of rate of application and method of incorporation of clomazone (Command) on the carryover potential of this herbicide on corn, oats and alfalfa. Soybeans were treated with clomazone at rates ranging from 0.5 lb/A to 2 lb/A during the 1987 growing season. In 1988, corn was planted on one-half of each area treated with a given rate of clomazone while the other half was planted to oats under-seeded with alfalfa. The effects of the previous year's applications of clomazone were monitored in 1988 on the above crops.

D. Herbicide Screening Trial in Corn - Dr. Jeffrey Gunsolus and Dr. William Lueschen

The objective of this study was to evaluate the performance of preplant, preemergence and postemergence herbicides for weed control in corn. Experimental herbicides as well as combinations of herbicides were compared to labelled treatments in this study. Similar trials were conducted at the Experiment Stations in Lamberton, Morris and Rosemount. This information is used to provide the basis for herbicide recommendations for corn growers in Minnesota.

E. Quackgrass Control in Corn with Postemergence Herbicides - Dr. Donald Wyse

The objective of this project was to evaluate the performance of two new experimental postemergence herbicides for quackgrass control in corn. These two new compounds were DPX-V9360 and CGA-136872; these compounds have potential for controlling annual grasses in corn as well as controlling perennial grasses.

F. Corn Rootworm Control in Different Tillage Systems - Dr. David Andow

The objective of this study was to evaluate the performance of corn rootworm insecticides in four different tillage systems. Tillage treatments included fall moldboard plowing, fall chisel plowing, no-till and ridge-till in a continuous corn cropping system. No detailed report of the results of this study is included in the following section.

G. Corn Rootworm Screening Trial and Rates of Application - Dr. Kenneth Ostlie

The objective of these studies were to evaluate the performance of corn rootworm insecticides. One study was designed to evaluate the performance of corn rootworm insecticides at labelled rates on a site that has been in continuous corn for a number of years and was moldboard plowed in the fall of 1987. The second study was designed to evaluate the performance of corn rootworm insecticides applied at different rates in a ridge-till corn system. No detailed research reported is included.

H. Lorsban T-Band Study - Dr. Ward Stienstra

The objective of this trial was to evaluate the performance of Lorsban applied as a T-band ahead of the presswheel and the influence of this treatment on the performance of two corn hybrids. Data was collected on the effects of the T-band treatment on early growth and development of the above and below ground portions of young corn seedlings. We also evaluated a number of agronomic traits in addition to grain yield.

I. Corn-Soybean Rotation Studies - Dr. Kent Crookston

Two studies were conducted in 1988 to evaluate the influence of rotation on the performance of corn and soybeans. The objective of one study was to evaluate the influence of continuous corn and corn/soybean rotations on the performance of each of these crops where the primary tillage system was fall chisel plowing. The objective of the second study, initiated in 1982, was to evaluate the long-term effects of several corn/soybean rotations under a moldboard plow tillage system. Sixteen rotation treatments were included in this study with all but four of these consisting of five years of corn on a plot followed by five consecutive years of soybeans. Rotations were established in 1982 so in each year there were plots with one, two, three, four, or five year history of either corn or soybeans. Also, included in this study were continuous corn and continuous soybean plots, and plots that were rotated annually to corn and soybeans. Beginning in 1986, the soybean plots were split with one-half of each plot planted to Hodgson 78 and the other one-half planted to BSR101. This was done because Brown Stem Rot was observed in this study and BSR101 has tolerance to this disease while Hodgson 78 has been rather susceptible.

J. Strip Test Comparison Study - Dr. Michael Schmitt and Dr. Steve Openshaw

This project was designed to evaluate the effectiveness of strip trial comparisons for testing corn hybrids. This study was designed to compare a strip test that was non-replicated to a strip test with a tester hybrid planted between every two hybrids and comparing these to a small plot trial that had two replications. The results from this trial have been used to determine the most accurate type of on farm trial for predicting the performance of corn hybrids.

K. Water Quality Studies - Dr. Donald Wyse, Mr. Brent Sorenson and Dr. William Lueschen

Two water quality studies were conducted at the Waseca Station in 1988. The first study was designed to evaluate the influence of tillage practices, including a no-till system, a ridge-till system, a fall chisel plowed system, and a fall moldboard plowed system, on the movement of four pesticides in the soil profile. The four pesticides of concern in this study were alachlor (Lasso), atrazine, dicamba (Banvel) and terbufos (Counter). Water and soil samples were taken to monitor the movement of these compounds in the soil. A second study was designed to more closely evaluate pesticide movement in the soil profile. In this study, 18 inch diameter PVC tubes 3 feet in length were placed in the soil in the fall of 1987. Herbicide treatments were applied to the soil surface in the spring of 1988. The movement of these pesticides within the cylinder are monitored throughout the growing season to evaluate the extent of movement of the parent compound as well as the metabolites.

L. Wild Proso Millet Control in Corn - Dr. William Lueschen, Dr. Jeffrey Gunsolus and Mr. Thomas Hoverstad

The objective of this study was to evaluate soil applied and postemergence herbicide treatments for controlling wild proso millet in corn. Included in this trial were two new postemergence herbicides, DPX-V9360 (Accent) and CGA-136872 (Beacon) that have promise for controlling annual grasses in corn. These two materials were applied at three different stages of weed growth and at different rates of application on this weed species. This study was conducted on the Paul Davison farm south of Morristown, Minnesota.

M. Woolly Cupgrass Control in Corn - Dr. William Lueschen, Dr. Jeffrey Gunsolus and Mr. Thomas Hoverstad

The objective of this study was to evaluate the effects of soil applied and postemergence herbicide treatments on the control of woolly cupgrass in corn. The soil applied treatments included preplant incorporated and preemergence herbicide application. Two new postemergence herbicides, DPX-V9360 (Accent) and CGA-136872 (Beacon), were evaluated in this study. These two materials were applied at three different stages of weed growth and at different rates of application on this weed species. This trial was conducted on the Kevin Remund farm located in Steele County Minnesota.

N. Corn Injury with DPX-M6316 - Dr. Charlotte Eberlein

The objective of this study was to evaluate the effects of rate of application of DPX-M6316 on corn inbreds and hybrids. The primary purpose of this study was to determine the relative tolerance of different corn genotypes to this new herbicide. This study will provide information on the inheritance of tolerance to this compound. No detailed report of the results of this study were included in the 1988 Research Report.

II. SOYBEANS

A. Soybean Breeding - Dr. James Orf

The objective of this long-term project has been to improve soybean production through varietal development. Each year the Southern Experiment Station serves as one of the major test locations for material development in this program. Small plot evaluations include new experimental lines, preliminary tests, uniform regional trials, public and private variety testing, a disease nursery, and an evaluation of early generation crosses. The influence of row spacing and planting date on the performance of soybean varieties was also included in the studies within this project in 1988. A study in cooperation with the Minnesota Crop Improvement Association was designed to evaluate the performance of certified and noncertified seed. Data collected from the soybean variety evaluations are used to provide information to Minnesota soybean growers on the performance of soybean varieties.

B. Cobra for Weed Control in Soybeans - Dr. William Lueschen

The objective of this study was to evaluate velvetleaf control with lactofen (Cobra), a new postemergence broadleaf soybean herbicide. In this study, we evaluated the effects of different additives and different herbicide combinations as well as time of application on the performance of this herbicide.

C. Methods of Incorporation of Command - Dr. William Lueschen and Mr. Samuel Tutt

A study was conducted on the Experiment Station in 1988 to evaluate the influence of different methods of incorporation of clomazone (Command) on weed control in soybeans. In a second study conducted on the Kenneth Roemhildt farm near Waseca, we evaluated the effects of different methods of incorporation of clomazone on the volatility and off-target movement of this compound. Blocks that were 30 by 30 feet were treated with clomazone and incorporated with various tillage tools. This study was established in a set-aside field that had been seeded to oats. The off-target movement of Command was then monitored on the oats that were adjacent to each plot. No research results are included in this report from these trials because the dry weather prevented us from getting good results.

D. Soybean Herbicide Screening Trial - Dr. Jeffrey Gunsolus and Dr. William Lueschen

This project, conducted annually at the Experiment Station, has been designed to evaluate preplant, preemergence and postemergence herbicides for weed control and crop tolerance in soybeans. Major emphasis for this trial was on compounds and combinations of herbicides that are not currently available for general usage. New experimental herbicides and herbicide combinations were evaluated in 1988 to determine their efficacy on giant foxtail, common lambsquarters, pigweed, and velvetleaf. This study is used to provide information to Minnesota soybean growers on the performance of soybean herbicides.

E. Weed Control in No-Till Soybeans - Dr. William Lueschen and Mr. Thomas Hoverstad

The objective of this study was to evaluate a number of herbicide treatments for weed control in no-till drilled soybeans. In 1988, we evaluated early preplant applications that were applied approximately 30 days prior to planting, preemergence herbicide treatments, burndown treatments and postemergence treatments. The area selected for this study has been in a no-till corn and soybean rotation for the past four years. Major emphasis in this study was to evaluate imazethapyr (Pursuit) for potential in no-till soybean production. This project was supported in part by a grant from the Minnesota Soybean Research and Promotion Council.

F. Reduced Rates of Postemergence Soybean Herbicides - Dr. William Lueschen, Dr. Jeffrey Gunsolus and Mr. Thomas Hoverstad

The objectives of this study were to evaluate the influence of reduced rates of postemergence soybean herbicides, timing of application and cultivation on weed control in soybeans planted in 30-inch rows. The rates that were evaluated included one-fourth, one-half and full-label rates of sethoxydim (Poast), bentazon (Basagran) and acifluorfen (Blazer). The times of application evaluated were: sethoxydim applied 13 days following planting with bentazon and acifluorfen applied 14 days after planting; sethoxydim applied 20 days after planting and bentazon and acifluorfen applied 21 days after planting; sethoxydim applied 27 days after planting and bentazon and acifluorfen applied 28 days after planting. We included three treatments which did not receive any herbicide at all, a non-cultivated weedy check, a treatment that received two cultivations and a treatment that was rotary hoed eight days after planting followed by two cultivations.

G. Rye for Weed Control in Soybeans - Dr. Charlotte Eberlein

The objective of this study was to evaluate the effects of winter rye seeded in the previous fall on weed control in soybeans. Rye was planted no-till following early harvest of soybeans or following the removal of corn silage in 1988. Two studies were conducted to evaluate this system in a very heavy weed population, as well as a moderate weed population. In the spring, when the rye was approximately 14 inches tall, it was treated with two rates of glyphosate (Roundup). Soybeans were then planted no-till into the plot area and the rye treatments were compared to more conventional weed control treatments that included the use of herbicides. No detail report of this research is included in this Research Report.

H. Soybean Management - Dr. William Lueschen, Dr. James Orf, Dr. Ward Stienstra Dr. Gyles Randall and Mr. Thomas Hoverstad

The objectives of this study were to evaluate the performance of eight soybean varieties and three seed treatments on soybean performance as influenced by several tillage practices in a corn and soybean rotation. This study was initiated in 1985 by establishing the five primary tillage treatments: no-till, ridge-till, and fall Paraplowing for both corn and soybeans, moldboard plowing after corn and chisel plowing after soybeans and chisel plowing after corn with no-till after soybeans. A second objective was to evaluate soybean response to residual nitrogen left from applying six nitrogen rates to corn prior to soybeans. Similar studies were conducted at the Southwest and West Central Experiment Stations. This project was supported in part by a grant from the Minnesota Soybean Research and Promotion Council.

I. Velvetleaf Eradication - Dr. William Lueschen and Mr. Thomas Hoverstad

The purpose of this study initiated in 1974, has been to evaluate the longevity of velvetleaf seed in the soil under different crop management practices. Variables range from continuous corn, continuous alfalfa, and continuous oats to continuous chemical fallow and continuous cultivation. Soil samples are taken every three years to monitor the demise of velvetleaf seeds in the soil. No velvetleaf plants have been permitted to go to seed in any of the treatments since this study was established. Certain treatments have resulted in a reduction in the velvetleaf seed population in the soil of 95% or more. 1988 was not a sampling year, therefore, there is no detailed report in this Research Report. If you are interested in this study, a summary of the results were published in the 1987 report.

J. Wild Proso Millet Control in Soybeans - Dr. William Lueschen, Dr. Jeffrey Gunsolus and Mr. Thomas Hoverstad

The objective of this study, located on the Paul Davison farm south of Morristown, was to evaluate wild proso millet control obtained with preplant incorporated, preemergence and postemergence soybean herbicides. Our primary objective was to evaluate a number of experimental herbicides as well as additives with these compounds for controlling wild proso millet.

K. Woolly Cupgrass Control in Soybeans - Dr. William Lueschen, Dr. Jeffrey Gunsolus and Mr. Thomas Hoverstad

The objective of this study, located on the Kevin Remund farm, was to evaluate the control of woolly cupgrass with preplant, preemergence and postemergence soybean herbicide treatments. This study was very similar to the wild proso millet study. The treatments in the woolly cupgrass trial were very similar to those in the wild proso millet study with the exception that the rates of application of postemergence compounds were increased because wild proso millet is easier to control than woolly cupgrass with these postemergence soybean herbicides.

L. YEA Seed Treatments for Soybeans - Dr. William Lueschen and Dr. Ward Stienstra

The objective of this study was to determine the effects of YEA, Captan, Apron, and Magnum seed treatments on the performance of six soybean varieties. Seed of all six varieties included in this study were treated with these compounds and were compared to an untreated check with all treatments planted in early May.

M. PCNB Study - Dr. Ward Stienstra and Dr. William Lueschen

The objective of this study was to determine the effects of Apron, Captan, TBZ, PCNB, Magnum and Vitavax as well as combinations of these compounds on the performance of BSR101 and Corsoy 79 soybean. Each variety was treated with one or more of these compounds and was compared to an untreated check. This study was planted in early May.

N. Spider Mite Control in Soybeans - Dr. Kenneth Ostlie and Dr. William Lueschen

Due to the very dry, warm conditions during the summer of 1988, a heavy population of spider mites developed in southern Minnesota in late July and early August. Because of this, we established two trials to evaluate the effects of time of application of insecticides for control of spider mites and to compare different compounds for their efficacy on spider mites in soybeans. These trials were established in early August and the timing of application study included three times of applying dimethoate.

III. SMALL GRAINS

A. Cereal Rust - Dr. Alan Roelfs and Mr. Thomas Hoverstad

The development of rust on wheat, oats, barley, and rye are monitored each year at the Experiment Station in order to establish, over a period of years, the average date of the first appearance of rust and the amount of inoculum that arrives as wind blown spores from states farther south. This project is part of a regional rust survey on small grains.

B. Oat Breeding - Dr. Deon Stuthman and Mr. Thomas Hoverstad

Three studies were conducted in 1988 under this project title. The development of improved oat varieties was the objective of the oat variety evaluation and the evaluation of early advanced oat lines in an oat nursery. These two studies evaluated maturity, lodging, disease resistance and yield of commercially available as well as experimental lines of oats. The third study was designed to evaluate the agronomic traits of oats following five consecutive cycles of recurrent selection. Yield, lodging, disease resistance, and seed quality were the parameters evaluated. A similar study is conducted annually at other locations in Minnesota also.

C. Response to Spring Wheat to Triggrr - Dr. Erv Oelke and Dr. William Lueschen

The objective of this project was to evaluate the performance of spring wheat to two stages of application of Triggrr, a growth regulator that is being sold to improve wheat yield. In addition to the application of Triggrr, the plots were split and two nitrogen rates were applied to wheat to determine if there was a potential interaction between the use of nitrogen fertilizer and the application of Triggrr.

D. Spring Wheat Varieties - Dr. Robert Busch and Mr. Thomas Hoverstad

The objective of this trial was to evaluate the performance of spring wheat varities in southern Minnesota. The trial included standard height and semi-dwarf varieties. Parameters that were investigated include plant height, lodging, maturity, yield, protein, and baking quality.

E. Uniform Regional Winter Wheat Nursery - Dr. Robert Busch and Mr. Thomas R. Hoverstad

Each year a Uniform Regional Winter Wheat Nursery is established to evaluate new experimental lines developed by wheat breeders from several states. One of the primary objectives of this study is to evaluate winter survival and hardiness of new experimental wheat lines. Only three named varieties were included in this evaluation as standards. These plots were evaluated for winter hardiness, lodging resistance, height and yield. Since the data is primarily on new experimental lines not available to producers, a detailed research report is not included in the following sections.

IV. FORAGE CROPS

A. Alfalfa Variety Trials - Dr. Donald Barnes and Dr. William Lueschen

Two alfalfa variety trials were harvested during the 1988 growing season. One trial was seeded in 1984 and the other trial was established in 1986. The objectives of these trials have been to evaluate the long-term performance of alfalfa varieties registered for sale in the state of Minnesota. A new alfalfa variety study was established in the spring of 1988 but was not harvested for yield during the growing season because of the extremely dry weather.

B. Alfalfa for the CRP Program - Dr. Craig Sheaffer

The objective of this trial is to evaluate the use of alfalfa for conservation reserve programs. Alfalfa plots were established in 1987 and have not been harvested for hay. The primary purpose for establishing the plots is to determine the longevity of several alfalfa varieties in an attempt to gain information on the selection of alfalfa varieties for long-term alfalfa establishment programs on CRP acres. Because of this, no detailed research report is included in the following sections.

C. Stress Cutting Management of Alfalfa - Dr. Craig Sheaffer and Dr. Donald Barnes

The objective of this study was to evaluate the effects of several cutting management regimes superimposed on this trial in 1987 on winter survival and performance of each variety in 1988. The 24 varieties included in this study have a range in winter hardiness and disease resistance. The trial was harvested on a four-cut system in 1988. One of the primary purposes in conducting this trial was to determine if stress management superimposed during the seedling year could be used as a predictor of long-term alfalfa performance. Based on the results from this study, it appears that alfalfa breeders can utilize this technique for evaluating winter hardiness and performance of alfalfa varieties.

V. NEW AND LITTLE GROWN CROPS

A. Canola Studies - Dr. Dan Putnam

The objective of these studies are to evaluate the productivity of canola varieties in southern Minnesota as influenced by planting date and nitrogen rates. Both spring and winter canola varieties were evaluated. One trial that was seeded in the fall of 1987 experienced severe winter kill and nearly all of the varieties were killed by the cold temperatures during the winter. The only data obtained from the winter canola study was an evaluation of winter survival in the spring of 1988.

C. Sweet Sorghum for Ethanol Production - Dr. William Lueschen and Mr. Brian Kanne

Five studies were conducted in 1988 to evaluate the performance of sweet sorghum as a source of readily fermentable sugar for the production of ethanol fuels. The first study involved an evaluation of nitrogen response of two sweet sorghum varieties, the second study involved the influence of plant population on two sweet sorghum varieties and the third study was conducted to evaluate the effects of planting date on performance of four sweet sorghum varieties. A fourth study evaluated the performance of twelve sweet sorghum varieties with the primary objective of determining sugar and biomass yields. A fifth study evaluated the effects of planting depth on stand establishment of sweet sorghum. These studies were conducted in cooperation with the Mankato Technical Institute and Sorgo Fuels Incorporated.

VI. ENTOMOLOGY

A. Armyworm Survey - Dr. Paul Taylor

This project was conducted in cooperation with Dr. Paul Taylor, an entomologist at Cornell University. The objective of this study was to use pheromone traps to attract armyworm moths as a method of predicting armyworm outbreaks. This project is part of a cooperative study that Dr. Taylor has in progress throughout the United States. There is no summary of this project in the more detailed part of this report.

B. Corn Borer Survey - Dr. David Andow

This project has been conducted at the Southern Experiment Station for many years with the objective of monitoring the appearance and degree of severity of European Corn Borer in early planted corn. On a weekly basis, a corn field was monitored to assess the damage caused by European Corn Borer and to monitor the stage of development of corn borer.

C. Black Light Trap - Dr. Dharma Sreenivasam and Dr. William Lueschen

Nightly insect collections were made from late May to early August to monitor the presence of economically important agronomic insects. This data provided information on the potential for insect outbreak in corn, soybeans, small grains and alfalfa as well as canning crops. This project is conducted annually in cooperation with the Minnesota Department of Agriculture.

1988 Animal Science Project List

Southern Experiment Station

Hugh Chester-Jones

I. Swine

A. Determining nutrient levels for tomorrow's economy: A new approach - Hugh Chester-Jones, Jim Pettigrew, Vernon Eidman, Larry Jacobson, Ron Moser and Steve Cornelius.

This study is designed to quantify the response in performance and carcass quality of growing and finishing pigs to diets containing varying energy (fat) and lysine (soybean) levels at various environmental temperatures. The response in performance will then be used to estimate economically optimal marketing and environmental conditions. Data from this study is too preliminary to report.

B. Estimates of in vivo body composition of sows following parturition - Brian Knudson, Ron Moser, Sayed El-Kandelgy, Steve Cornelus, Hugh Chester-Jones and Arnold Hoepner.

Scientists and producers have traditionally employed live weight, backfat thickness or reproductive measures as response criteria in assessing nutritional needs of sows. Realistically, this thinking may be flawed because other factors such as environment and health, etc. may be confounded with nutrition. A preferred alternative would be to assess changes in the sow's body fat, protein or ash stores. The logistics of accomplishing this have been difficult. The objectives of this study are: (1) to assess the efficacy of: a) deuterium oxide, b) tenth rib back fat and live weight, either alone or in combination, to estimate in vivo body composition of sows 2 days after parturition, and (2) to determine the distribution of fat in the sow. Data is too preliminary for a meaningful summary to be reported.

C. Efficacy of litter milk for piglets - Brian Knudson, Ron Moser, Hugh Chester-Jones, David Ziegler and Arnold Hoepner.

Much interest has been generated regarding the artificial rearing of neonatal piglets. Land O'Lakes has developed a product, Littermilk, which has received some success in field trials. This study was designed to further evaluate Littermilk for piglets taken from the sow at birth up to weaning. A final report can be found in Part III.

D. Determination of the growth curve of pigs around weaning - Steve Cornelius, Dean Koehler and Hugh Chester-Jones.

It is generally accepted that after weaning, pigs undergo a period of decreased growth rate and loss in weight. This "slump" varies in length but is followed by a period of compensatory growth. This study was designed to develop a procedure to objectively measure the weaning performance of pigs and assess factors that affect this performance immediately post weaning. Data from this study has yet to be completely summarized.

E. Influence of an oral dose of L-Tyrosine or L-Phenylalanine on sow productivity - M. D. Tokach, S. G. Cornelius, J. W. Rust, H. Chester-Jones, L. J. Johnston and D. M. Ziegler.

It has been shown that L-Tyrosine increases catecholamine synthesis which has been shown to increase litter size. West German researchers have shown that an oral dose of 100 mg/kg body weight of L-Tyrosine administered 24 hours after weaning will increase litter size by 2.7 pigs/litter. As tyrosine can provide 50% of the phenylalanine + tyrosine requirement, an oral dose of L-phenylalanine may respond similarly. This study objective is to evaluate the influence of L-tyrosine, L-phenylalanine or glutamic acid (usable N-source) on sow productivity. Data too preliminary to report.

II. Dairy Beef

A. Performance of growing Holstein steers fed diets containing sweet corn processing waste ensiled at different moisture levels - Hugh Chester-Jones, Jay Meiske, Don Otterby, Marshall Stern and Dave Ziegler.

An earlier study has indicated that substituting 50% of the corn silage with ensiled sweet corn processing waste (80% moisture) resulted in similar performance to steers fed the control diet (60:40 corn silage:corn, dry basis). Replacing all the corn silage with processing waste silage reduced feed intake and subsequent daily gains but was similar in dry matter required per lb gain. This subsequent study will evaluate the effect of reducing moisture content of the processing waste silage and subsequent effect on nutritional quality as related to performance of growing Holstein steers. Sweet corn processing waste taken from General Foods in Waseca after being chopped and squeezed was ensiled in horizontal plastic storage bags at either 83, 76 or 67% moisture levels. These silages will be fed as replacement for 100% corn silage dry matter with corn and protein supplement in diets fed to Holstein steers from 400 lbs. A final report can be found in Part III.

B. Evaluation of hydrolyzed feathermeal vs urea as main nitrogen sources in pelleted protein supplements fed in high energy diets to Holstein steers from 400 to 850 lbs. - H. Chester-Jones, D. M. Ziegler, J. Meiske, B. Larson, M. Stern and D. Otterby.

Urea has been traditionally fed to Holstein steers after 400 lbs as the main nitrogen source. Other workers have indicated a potential improvement in efficiency of production if a higher rumen by-pass protein source is included in the diet. Feathermeal is a high by-pass protein source and the hypothesis of this study is that inclusion of feathermeal as the main protein source in high energy diets fed to Holstein steers from 400 lbs enhances performance compared to the use of urea as the main nitrogen source. A progress report is given in Part III.

C. Effects of season and environment on estimated protein requirements of young male Holstein calves fed high corn diets from weaning to 400 lbs. - H. Chester-Jones, J. C. Meiske and D. M. Ziegler.

Typically a constant percentage of dietary protein fed daily is an accepted practical method. Results from previous studies at the Southern Experiment Station suggest that NRC requirements for young large frame calves may be over-estimated at certain stages of growth. This study will evaluate protein requirements by making weekly adjustments of actual protein intake based on body weight to meet 85,100 or 115% of NRC requirement estimates. In addition interactions between date of birth, environmental temperature and protein feeding levels will be evaluated. Data is too preliminary to report.

D. Effect of supplementary fat and forage/concentrate ratio in finishing diets fed to Holstein steers on carcass composition - H. Chester-Jones, J. C. Meiske and D. M. Ziegler.

This study attempts to test the hypothesis that by increasing energy density of finishing diets, by supplementary fat, a higher forage to concentrate ratio can be maintained and still enable performance to be maximized. This may also have a positive effect on carcass composition in terms of consistency. Data is too preliminary to report.

E. Performance of Holstein steers fed starter diets containing either whole or rolled corn with pelleted supplement - H. Chester-Jones, D. M. Ziegler, J. C. Meiske and R. D. Goodrich.

Feeding strategies for these young Holstein calves should take advantage of their efficient growth characteristics by feeding high corn diets. Objectives of this study are to compare feeding strategies using whole corn vs rolled corn in high energy starter diets fed to weanling Holstein steers with a pelleted protein supplement to supply a minimum of 10 to 12% fiber/roughage source in the total daily ration and b) evaluate the effect of switching from a rolled corn base to a whole corn base when steers reach 220 to 230 lb body weight. A final report is given in Part III.

III. Dairy

A. Improving cattle through breeding with special emphasis on selection for: a) milk yield and b) lbs protein - Les Hansen, Charles Young, Hugh Chester-Jones and David Ziegler.

A detailed report on the breeding project emphasizing selection for milk yield appeared in the 1985 Southern Experiment Station Annual Report pp 270-275. Data is still being collected for this phase of the original breeding project. In addition a commitment was made in 1986 to build on the existing genetic base of the dairy herd and establish a third herd which emphasizes selection for milk protein. A detailed outline of this new project appeared in the 1986 Southern Experiment Station Annual Report pp 218-219. Data will not be collected on this phase until 1989.

B. Effect of recombinant bovine somatotropin on lactation of dairy cows - Don Otterby, Bill Hansen, Hugh Chester-Jones, Les Hansen and David Ziegler.

Recombinant bovine somatotropin (BST) is now readily synthesized under laboratory conditions. It has been shown that daily injections of BST given to lactating cows can enhance milk production substantially. The objectives of this study are to measure the production responses to daily injections of BST given to lactating cows from two genetic lines (the control and selection herds at the Southern Experiment Station). Data from this research is not in a form to enable a final report to be presented.

C. Post-partum reproductive performance under identical management of dairy cows genetically selected for two levels of milk production - Brad Seguin, Hugh Chester-Jones, Les Hansen and David Ziegler.

The study is designed to establish an indication of stage of estrus utilizing milk progesterone levels as an aid to monitor problem cows or "silent heat" cows more closely. Evaluation is based on the interval from the first post-partum luteal activity and subsequent estrus cycle patterns in the selection and control herds at the Southern Experiment Station. Data analysis has yet to be completed.

D. Evaluation of the growth of environmental mastitis pathogens in chopped straw vs shredded paper in free stalls during the dry period for multiparous cows and first calf heifers - Bob Appleman, Hugh Chester-Jones, Jeff Reneau, Ralph Farnsworth and David Ziegler.

Environmental organisms found in confinement housing systems can contaminate a cows udder and cause a toxic mastitis that can be fatal if not treated promptly or correctly. The most susceptible periods for the possibility of pathogenic organisms entering through the teat canal are at drying off at the end of lactation and during the last month of gestation. This study will compare two extreme bedding materials in terms of media for bacterial growth and categorize environmental pathogen build-up in a typical year. The contamination of the dry cow and late gestating heifer by the organisms will be established for the dry period and the initial part of the subsequent lactation. Data from this study is not in a form to enable a final report to be given.

E. Relationship of feed utilization to growth patterns and body compositional changes in dairy heifers from divergent genetic lines - K. D. Murphy, H. Chester-Jones, D. E. Otterby, R. D. Appleman, J. D. Linn, L. B. Hansen, B. A. Crooker and David Ziegler.

There is a dearth of information on individual feed intake by dairy heifers from 3-4 months old to first calving. This study has the objectives to: a) establish a database of known feed intakes in heifers to enable feeding programs to be refined; b) establish base lines of circulating growth related hormones, and c) to validate two indirect body composition measurements, deuterium oxide and urea space dilution, to enable reliable in vivo body composition estimates to be obtained. Data is too preliminary to report.

F. Growth hormone and testicular development in bull calves as genetic markers for milk production - Bo Crabo, Les Hansen, Hugh Chester-Jones, Jon Wheaton and David Ziegler.

Primary objectives of this study are to find a genetic marker for milk production in bull calves and to characterize the relationship between GH and testicular development in bulls. Data from this study is too preliminary to report.

1988 HORTICULTURE PROJECTS

Vincent A. Fritz

HORTICULTURIST

SOUTHERN EXPERIMENT STATION

I. SWEET CORN

A. Common Rust Epidemiology - Vincent Fritz, James Groth and Richard Zeyen

The primary objective of this study is to evaluate the effects of different plant populations at different planting dates on the incidence and progression of common maize rust (*Puccinia sorghi*) and yield recovery in sweet corn. The long term goal of this study is to develop a computer predictive model which would help maximize control strategy effectiveness. Rust severity will be measured objectively by using a video leaf area meter which should enhance the quality of the eventual computer model. Data from this research are not reported herein.

B. Fungicide Evaluation for Common Rust Control - Vincent Fritz, Alicia Borowski ad James Hebel

In conjunction with the rust epidemiology study listed above, several systemic fungicides were evaluated for rust control potential. The possible adoption of the use of systemic fungicides over contact fungicides for rust control by the processing industry will change control strategies significantly. A detailed report can be found in Part III.

C. The Effect of Ethephon on Plant Height, Lodging, and Various Components of Yield in Three Sweet Corn Genotypes - Vincent Fritz, Alicia Borowski and James Hebel

Due to the increased interest in high sugar sweet corn by the processing industry in southern Minnesota, new production related problems have surfaced. One of these problems has been lodging. Initial research has shown that the use of Ethephon, a growth regulator, has resulted in a significant reduction in plant height and lodging. However, its effect on yield recovery is not known. The purpose of this study is to evaluate the effects of ethephon on plant height and yield recovery in several sweet corn varieties. A detailed report can be found in Part III.

D. Seed Production and Handling in Supersweet (sh_2 Sweet Corn Hybrids - Alicia Borowski, Vincent Fritz and Luther Waters, Jr.

The major problem associated with high sugar sweet corn varieties is germination/stand establishment. This study was initiated to determine if specific physical and physiological characteristics

I. SWEET CORN

D. Seed Production and Handling in Supersweet (sh_2 Sweet Corn Hybrids (continued)

(seed moisture, seed coat integrity, carbohydrate analysis, embryo:endosperm ratio, etc.) contribute to reduced seed viability in high sugar sweet corns. Seed handling and drying procedures will also be evaluated for optimum germination/stand establishment. A preliminary report can be found in Part III.

E. Grass and Broadleaf Weed Control in Sweet Corn - Leonard Hertz and Vincent Fritz

The objective of this study was to evaluate sweet corn performance under 25 preemergence and postemergence weed control treatments. Experimental and labeled herbicides were included. A detailed report can be found in Part III.

F. Common Rust Screening Trial - James Groth, Richard Zeyen, David Davis and Vincent Fritz

This is an ongoing study to evaluate several sweet corn varieties for resistance to common rust (Puccinia sorghi). The study is planted late in the summer for maximum disease pressure. Data from this research are not reported herein.

G. Nitrogen, Population and Planting Date Effects on Yield and Quality - Carl Rosen and Vincent Fritz

This study is to evaluate the effects of different plant populations at various dates throughout the extended sweet corn planting season. In addition, various rates of nitrogen fertilization are being evaluated for optimal fertilization efficiency in each plant population and planting date. Data from this research are not being reported herein.

II. PEAS

A. The Pea Disease Nursery at Waseca, MN - David Davis, Frank Pfleger and Vincent Fritz

This is a continuing study which was initiated in 1976 to screen breeding lines and commercial varieties for root rot resistance. For the second year, many of the entries were planted in both an inoculated and uninoculated site to evaluate both disease resistance and performance without disease pressure, respectively. A detailed report can be found in Part III.

B. Root Rot (Aphanomyces) Ecology Study - Ray Allmaras, Vincent Fritz, David Davis, Frank Pfleger, and Jim Percich

The study was initiated this year to observe the effects of previous crop history and compaction on soil moisture, bulk

II. PEAS

B. Root Rot (Aphanomyces) Ecology Study (continued)

density, pea root development, and Aphanomyces populations at various soil depths. A preliminary report is found in Part III. Data from this research are not being reported herein.

C. Annual Weed Control in Canning Peas - Leonard Hertz and Vincent Fritz

The objective of this study is to evaluate preplant, preemergence, early postemergence, and postemergence weed control strategies using several herbicides at various concentrations and in combination with other herbicides. A total of 18 treatments will be evaluated. A detailed report is found in Part III.

III. ONIONS

A. Raised Bed Study - Vincent Fritz and James Hebel

This study was initiated in southeast Minnesota (Hollandale) in 1986 to evaluate the performance of yellow storage onions on raised beds when compared to flat culture on peat soils. Two varieties were evaluated in both cultural systems. Data from this research are not reported herein.

B. Effects of Various Onion Populations on Components of Yield - Vincent Fritz, Alicia Borowski, James Hebel and Patricia Hung

This study will investigate the effects of various plant populations on marketable bulb size and maturity in yellow storage onions. An open pollinated variety, "Trapps", was used for the study. Seeds were planted at 5-7, 9-11, and 13-15 per foot. A preliminary report is found in Part III.

IV. POTATOES

A. Variety Trial - Florian Lauer and Vincent Fritz

This is an ongoing study that was initiated in 1982 in southeast Minnesota (Hollandale). The objective of the study is to evaluate breeding lines and other commercial varieties for production potential in peat soils. This year fifteen varieties will be evaluated. Data from this research are not reported herein.

B. The Use of Ethephon for Improved Color in Red Potatoes - Vincent Fritz, Alicia Borowski, Patricia Hung and James Hebel

The use of 2,4-D for periderm color enhancement has yielded inconsistent results. The application of 2,4-D promotes the production of ethylene, a growth regulator which regulates anthocyanin, the pigment responsible for red color in potatoes.

IV. POTATOES

B. The Use of Ethephon for Improved Color in Red Potatoes (continued)

The objective of this study is to evaluate ethephon's effect on periderm color, yield, quality, and storability of red potatoes produced on peat soils in southeast Minnesota (Hollandale). A detailed report can be found in Part III.

V. ASPARAGUS

A. Asparagus Nursery - David Davis and Vincent Fritz

This nursery was planted in 1984 to evaluate the performance of 24 breeding lines. This year the nursery was harvested for the first time for a period of four weeks. Data from this research are not reported herein.

VI. TREES AND FLOWERS

A. NC-7 Regional Ornamental Plant Trials - Mark Widrlechner, James Hebel, Harold Pellet and Vincent Fritz

This continuous study is to observe plant material from different parts of the world for adaptability to southern Minnesota. The study was initiated in 1959. Data from this research are not reported herein.

B. Chrysanthemum Evaluation Trial - Richard Widmer and Vincent Fritz

The purpose of this study is to evaluate the performance of several chrysanthemum breeding lines for possible release in Minnesota. This is a continuing study. Three varieties are to be available to gardeners in 1989. Data from this research are not reported herein.

1988 SOIL SCIENCE PROJECTS

G. W. Randall

SOIL SCIENTIST

SOUTHERN EXPERIMENT STATION

A. FERTILIZATION PROJECTS

1. Nitrogen

a. Nitrogen Application Methods for Improved Efficiency in Ridge-Plant Tillage Systems - Gyles Randall and Bert Bock (TVA)

A cooperative study between the University of Minnesota and the National Fertilizer Development Center at TVA was initiated in 1986. Nitrogen was applied as UAN and AA to ridge-planted corn that followed either corn or soybeans. Application time ranged from preplant (PP) to split applications at the PP and 8-leaf or PP and 15-leaf stages. A point injector, sometimes called a spoke-wheel injector, was used to inject the UAN either directly into the ridge at planting or sidedressed into the row-middles. A detailed report is contained in Part III.

b. Influence of Nitrogen and Potassium Fertilization on the Yield and Nutrient Accumulation of Different Corn Hybrids - Gary Malzer and Gyles Randall

A study was established in 1987 to determine the interactive effects of nitrogen with and without N-Serve and potassium fertilization on 1) the yield and nutrient accumulation of four genetically different corn hybrids and 2) the soil NH_4/NO_3 status during the growing season. Nitrogen was applied at the V-6 stage as anhydrous ammonia at rates of 0, 80 and 160 lb/A with and without N-Serve. Potassium was applied and incorporated in the fall of 1986 at rates of 0 and 100 lb K/A. The hybrids used were Pioneer 3732, Pioneer 3475, LH74 x LH51, and A632 x LH38. Soil samples from the 0-1' zone and whole corn plant samples were taken at four stages of growth (V12, R1, R4 and R6) to monitor soil inorganic N and N accumulation patterns of the hybrids. Data are not reported herein.

c. Soybean Response to Residual Effects of N Treatments Applied to Corn in 1987 - Gary Malzer and Gyles Randall

Soybeans were grown following the 1987 Hybrid x N x K Study (see b. above) to determine whether residual effects from these treatments influence soybean yields. Soybean yields averaged over 40 bu/A but were not influenced by the previous year's N treatments. Data are not reported herein.

A. FERTILIZATION PROJECTS

1. Nitrogen (continued)

d. Corn Hybrid Screening for Improved N Efficiency Following Alfalfa - Chris Zadak, Gyles Randall and Michael Russelle

Studies were initiated in 1988 at the Southern Experiment Station, Waseca; Agricultural Experiment Station, Rosemount; and in Winona County to determine if six genetically different 105-d RM hybrids differ in yield and in the pattern and extent of N accumulation following alfalfa. A second objective was to determine the effect of tillage (moldboard plow vs no tillage) on N uptake and yield of corn and on residual soil N. Yields and N uptake varied inconsistently among hybrids and were increased by moldboard tillage at one site. A detailed report of the soil nitrate results is contained in Part III.

e. Nitrogen Placement in a Ridge Tillage System - George Rehm and Gyles Randall

A study was initiated in the fall of 1987 to determine the effect of N placement and time of N application on corn production in a ridge-plant system. Urea was placed in the ridge in the fall, while UAN was injected into the ridge at planting. These treatments were compared to fall-applied ammonia and urea midway between the ridges. In this very dry year, yields were increased slightly by N but were not affected differently by the specific N treatments. Data are not reported herein.

2. Decline Rates of Soil Test P and K in a Corn-Soybean Rotation - Gyles Randall and Sam Evans

High rates of P and K were applied over a 12-year period (1973-84) in studies at Waseca and Morris. These rates created a wide range of soil test values upon which the decline rates of soil test P and K can be followed when no additional fertilizer P and K are added. A detailed report is contained in Part III.

3. Phosphorus Application Methods for Improved Efficiency in a Corn-Soybean Rotation - John Lamb, George Rehm, Gyles Randall and Wallace Nelson

The primary objective of this study initiated in the fall of 1985 is to evaluate the efficiency of various placement methods (2 x 2" row, broadcast, and subsurface band [6" deep]) of P fertilizer. The test crops are corn and soybeans at Waseca and Lamberton, and wheat and soybeans at Crookston. Annual application rates to these low testing soils are 0, 10, 20, 30 and 40 lb P/A. A detailed report is contained in Part III.

A. FERTILIZATION PROJECTS

4. Potassium Placement in a Ridge Tillage System - George Rehm and Gyles Randall

A study was initiated in the fall of 1987 to determine if K banded directly into the ridge is either harmful or beneficial to corn production. Rates used were 0, 20, 40, 80 and 160 lb K_2O/A. Neither final stand nor yield were influenced by these K treatments in this extremely dry year. Data are not reported herein.

B. TILLAGE PROJECTS

1. Conservation Tillage for Corn and Soybeans - Gyles Randall and Jim Swan

This study was initiated in 1974 to compare new conservation methods of tillage with some of the established practices. The five treatments have been: (1) no tillage, (2) fall moldboard plow, (3) fall chisel plow, (4) ridge planting, and (5) till-plant without ridging. All plots have been split to determine the effect of starter vs no starter fertilizer with reduced tillage. All tillage and fertilizer treatments remain the same except treatment 5 which is disked each spring rather than till-planted. A detailed report is contained in Part III.

2. Tillage Systems for Corn and Soybean Crop Sequences - Gyles Randall and Ray Allmaras

A study had been established on this Webster clay loam site in the fall of 1980 to determine the relationship between primary tillage and the incidence of corn and soybean diseases in continuous corn, continuous soybeans and a corn-soybean rotation. The tillage systems were fall moldboard plow (MP), fall chisel plow (CP), and no tillage (NT). After this 5-yr study was completed in 1985, the initial tillage plots and some of the monoculture plots were kept intact to take advantage of the past tillage and cropping history. Some of the monoculture plots were changed to a corn-soybean sequence so that there are now four cropping systems over each tillage system. The cropping systems are continuous corn, corn-soybean, soybean-corn, and continuous soybeans. A detailed report is contained in Part III.

3. Subsoil Compaction and Depth of Subsoiling - Ward Voorhees and Gyles Randall

A new compaction study was initiated in the fall of 1986 to determine: 1) the effect of annual vs one-time high axle-weight loads on the degree of subsoil compaction and related soil properties in a corn and soybean rotation, 2) the effect of subsoiling depth on the ameliorіation of the compacted soil, and 3) the influence of both compaction and subsoiling depth on plant growth and yield. The compaction was accomplished using a 800-bu grain cart with an axle weight of 23 T/A. Subsoiling depths were 0" 13" and 21". Corn yields were not affected by the compaction but were reduced with the greater subsoiling depth in 1988. Soybean yields were not affected by deep compaction nor subsoiling depth. Data are not reported herein.

B. TILLAGE PROJECTS

4. P and K Placement for Reduced Tillage - George Rehm and Gyles Randall

The purpose of this study has been to evaluate the placement of P and K on production of corn and soybeans in rotation as affected by tillage and soil test levels. P and K were first applied in the fall of 1983 at rates of 0, x, 1.5x and 10x where x = 370 lb/A of 4-12-24. The x and 1.5x rates were either broadcast, dribbled or banded and the 10x rate was deep banded 12 inches below the row or between the row. Superimposed over these fertilizer treatments has been the application of 0 or 100 lb/A of 7-21-7 liquid starter fertilizer applied in a 2" x 2" band. The residual effects of these 4-year fertilizer treatments were evaluated in 1988. The project leader is Dr. George Rehm, Department of Soil Science. Data from this research are not being reported herein.

5. Tillage Systems for Corn in a Corn/Soybean Management Study - William Lueschen, John Moncrief and Gyles Randall

As part of an ongoing corn/soybean management study, a new study was established in the fall of 1985 to determine the effect of tillage following soybeans on corn production; specifically, yield, the N requirements of corn, and the performance of five different corn hybrids. The tillage systems evalauted are: (1) continuous no tillage (NT), (2) continuous paraplow, (3) continuous ridge-tillage, (4) NT following soybeans/chisel plow (CP) following corn, and (5) CP following soybeans and moldboard plow following corn. Nitrogen was spring-applied as anhydrous ammonia at 0, 40, 80, 120, 160 and 200 lb N/A. A detailed report is contained in Part III.

C. ENVIRONMENTAL PROJECTS

1. Nitrogen Movement into Underground Drainage Systems as Influenced by Tillage - Gyles Randall and Brian Anderson

In the fall of 1981 two primary tillage treatments (moldboard plow and no tillage) were established on eight tile plots. Nitrogen (ammonium nitrate) was spring-applied to all plots at a rate of 180 lb N/A. Samples from the tile water, soil to a depth of 8', corn leaves, silage, and grain along with corn silage and grain yields were taken to determine the effect of tillage for continuous corn on N efficiency and movement. Detailed report is contained in Part III.

2. Pesticide Movement into Tile Drainage Water as Affected by Tillage - Gyles Randall

Water samples were taken from the 1988 tile flow and were analyzed immediately for the pesticides of concern. Data from this research are not reported herein.

C. ENVIRONMENTAL PROJECTS

3. Nitrate Losses to Tile Drainage as Affected by Nitrogen Fertilization of Corn in a Corn-Soybean Rotation - Gyles Randall, Gary Malzer and Brian Anderson

A study was established in the fall of 1986 to determine the influence of time of N application and the use of a nitrification inhibitor on NO_3 movement and accumulation in the soil, NO_3 losses via tile drainage, and yield and N uptake by corn grown in a rotation with soybeans. A detailed report is contained in Part III.

4. Water Quality Investigations in Southeastern Minnesota - Gyles Randall, Brian Anderson and Jim Anderson

Studies were conducted in Olmsted, Winona and Goodhue Counties to pursue the effects of agricultural chemical management (N fertilizer and pesticides) on the occurrence of these chemicals in the groundwater. These studies will be conducted over the next 5 years and will be coordinated by the Center for Agricultural Impacts on Water Quality on the St. Paul Campus. Yield data from these studies are reported in Part III.

D. WEATHER

1. Climatological Data Measurements - Don Baker, Mark Seeley and Gyles Randall

Every day at 8:00 A.M. a series of weather measurements are recorded at the Southern Experiment Station. Data gathered throughout the year include max and min air temperatures, max and min soil temperatures at 2, 4, 8 and 20", precipitation, wind movement and solar radiation. In addition, summer measurements include evaporation and water temperatures while winter measurements include snow depth and frost depth. A new addition to the weather station is an automatic recording system which records nine weather parameters on an hourly basis 24 hours a day. This system has been installed and is supervised by Mark Seeley. All data are compiled and sent to Dr. Baker and the National Weather Service. The data are published in CLIMATOLOGICAL DATA with a local mailing available upon request. Also, the data are entered weekly into the University computer bank for access and use by research and extension personnel. A detailed annual summary is contained in Part III.

2. Soil Moisture - Don Baker, Mark Seeley and Gyles Randall

A continuous monitoring of soil water was conducted again this year on a bimonthly basis. All data are sent to Dr. Baker as part of his soil water network. A detailed summary of the bi-weekly data is contained in Part III.

University of Minnesota
1988 Elite Field Corn Hybrid Test Results

Corn Breeding Project, Dept. of Agronomy & Plant Genetics, U of M, 1991 Buford Circle, St. Paul, MN 55108 612/625-0260 (S.J.Openshaw, R.H.Peterson, M.G.Lund)

--In cooperation with:

Central Minn. Demo. Res. Irrigation Center, AVTI, Staples, (M.J.Wiems)
Northwest Experiment Station, Crookston (J.V.Wiersma)
Rosemount Experiment Station, Rosemount (D.O.Sandstrom)
Southern Experiment Station, Waseca (W.E.Lueschen)
Southwest Experiment Station, Lamberton (J.H.Ford)
West Central Experiment Station, Morris (D.D.Warnes)

The primary objective of these tests is to provide some information on the relative performance of many field corn hybrids that are newly registered for sale in the state each year. Because the data are limited to only two locations in one year for any group of hybrids, this information should be used only as a guide to choosing some new hybrids for additional evaluation, e.g. in strip tests or on a few acres. These data alone are NOT sufficient for choosing one or a few hybrids for large-scale commercial use.

Seed of all registered hybrids was requested from the owners of these hybrids, and hybrids for which seed was obtained were included in these tests. Several other hybrids were included for comparison in these tests by the branch experiment stations and the corn breeding project. No fee was requested or paid by the owner of any hybrid entered. The presence or absence of any hybrid is these tests does NOT constitute a warranty for or against that hybrid.

The newly registered hybrids were tested in the maturity zone for which they are relatively full-season according to the Minnesota Relative Maturity (RM) assigned by their owners, i.e., hybrids rated 105-115 RM were tested in southern Minnesota, 90-100 RM hybrids were tested in central Minnesota, and 70-85 RM hybrids were tested in northern Minnesota. Other hybrids included varied in their RM ratings. Hybrid comparisons should include consideration of RM rating.

Management information for each location is summarized below. Row spacing at all locations was 30 inches. Plots at Lamberton, Waseca, Rosemount and Morris were 2 rows 22 feet long and were planted and harvested by a modified planter and combine. Plots at Staples were 1 row 25 feet long and planted and harvested by hand and shelled by machine. Crookston was discarded due to drought.

At Waseca, Rosemount and Staples, three plots of each hybrid were grown and measured, and data in the tables are averaged over the three plots (replications). Only two replications were used at Lamberton and Morris due to soil variability.

Data given in the following tables is:

H2O = % grain moisture at harvest.
YLD = shelled grain yield in bushels per acre at 15.5% moisture.
RL = % plants leaning more than 30 degrees from vertical.
STAND = number of plants per acre at harvest.
RM = Minnesota Relative Maturity rating assigned by the owner of the hybrid. RM of newly registered hybrids is subject to change. NR indicates the hybrid was not registered for sale in Minnesota in 1988.

Management information summary:

CMDRIF, Staples: Previous crop - Edible beans; primary tillage - spring disk; fertilizer - 55# N, 20# P, 40# K, 18# S plus 220# N (split applic.); herbicide - Dual (1.5 pts.) - bladex (1.3 qts.) - Buctril (1.25 pts.) planted 26 April, harvested 11 October.

NW Exp Stn, Crookston: Discarded due to drought.

Rosemount Exp Stn, Rosemount: Previous crop - soybeans; primary tillage - fall chisel plow; fertilizer - 0-0-60 fall, 150# anhydrous spring; herbicide - Bladex (0.5 gal.) + Lasso (0.5 gal.) premerge; planted 13 May, harvested 17 Oct.

So. Exp Stn, Waseca: Previous crop - soybeans; primary tillage - chisel fall plow; fertilizer - 160# spring anhydrous(w/n-serve); herbicide - Lasso (3.5#) + Atrazine (1.5#) + Bladex (1.5#) premerge; planted 5 May, harvested 18 Oct.

SW Exp Stn, Lamberton: Previous crop - soybeans; primary tillage - soil saver, fall; fertilizer - 150# anhydrous; herbicide - Eradicane (2.5#) + Bladex (1.5#) PPI plus Lasso (3#) premerge; planted 3 May, harvested 24 Sept.

WC Exp Stn, Morris: Previous crop - oats; primary tillage - moldboard plow, fall; fertilizer - 140-100-100 fall;herbicide - lasso (3.0#) + Bladex (2.2#) premerge; planted 11 May, harvested 13 October.

1988 Uinversity of Minnesota Corn Breeding
Expt.361 - Medium Hybrid Test

		ROSEMOUNT				MORRIS		
BRAND - VARIETY	RM	H20 %	YLD BU.	BS. %	STAND	H20 %	YLD BU.	STAND
Ag Venture 280	95	17.7	67	0	23496	22.3	109	21780
Ag Venture 303	100	17.7	93	9	22308	23.5	89	21978
Ag Venture 6033	NR	16.4	56	28	22440	20.4	106	22176
Ag Venture 8058	NR	14.1	59	27	23364	18.7	101	23364
Ag Venture 8060	NR	15.8	62	8	23496	20.3	110	24750
Ag Venture 8065	NR	12.9	62	11	22440	18.8	114	22176
Agri Gene 3250	95	13.8	60	21	20196	18.7	155	22374
Agri Gene 3950	100	17.4	77	8	23100	23.9	88	22374
Agri Pro 270	90	13.9	67	17	22044	17.0	111	23364
Agri Pro 560	100	18.5	64	7	23232	21.6	105	22374
Agri Pro AP148	90	15.9	65	4	23232	17.3	117	24750
Agri Pro AP175	95	15.9	76	5	22968	21.8	84	22374
Agri-Gene 3860	100	17.8	101	16	23100	22.9	101	23562
Agri-Gene 3980	105	19.7	90	10	23628	23.1	125	23166
Anderson SX6050	100	15.8	92	14	23496	23.0	103	24156
Anderson SX8000	90	13.1	49	25	21648	17.7	113	22374
Asgrow 2330	105	17.0	88	30	22044	26.7	99	23760
Asgrow Rx 406	95	15.8	69	32	23232	20.9	101	22770
Asgrow Rx 498	100	23.0	51	2	21780	25.9	121	22572
Betagold Ingrid	95	16.4	74	12	22176	18.1	150	21978
Betagold Karla	100	18.3	70	10	21780	21.9	125	16830
Betagold Kristine	100	18.4	84	6	22440	20.3	97	20592
Bettagold Hanna	105	19.8	77	5	23100	23.8	146	23364
Brown BR4490	100	14.8	39	18	22968	16.9	160	22572
Brunner S3800	95	15.4	69	14	22836	20.3	161	22374
Brunner SX4800	100	17.3	75	6	22440	19.5	150	22572
Cargill 2787	90	15.6	62	16	22572	21.5	92	21780
Cargill 3027	95	14.7	70	16	22968	20.1	112	22572
Cargill 3327	100	16.9	68	4	23496	22.7	124	23364
Cargill 3477	NR	14.1	70	7	21516	20.3	114	22770
Cargill 809	80	12.9	70	13	22044	18.6	96	22968
Cargill SX123	85	15.5	49	49	22176	16.6	89	22968
Crystal CS1095	95	15.3	78	6	20856	20.0	134	21978
Crystal CS3099	100	17.8	94	6	22572	21.2	140	22770
Customaize (CFS) 2223	95	12.6	56	24	22836	23.0	139	23562
Customaize (CFS) 2301	90	14.9	58	20	22308	18.6	123	23760
Customaize (CFS) 4010	100	18.6	55	8	22968	25.4	106	21978
Customaize (CFS) 4052	100	18.5	62	9	22440	23.8	86	23364
Customaize (CFS) 5510	100	20.1	107	5	23364	23.5	124	24354
Dahlman SX986	100	18.0	70	7	22308	22.1	88	22770

1988 Uinversity of Minnesota Corn Breeding
Expt.361 - Medium Hybrid Test (cont.)

		ROSEMOUNT				MORRIS		
BRAND - VARIETY	RM	H2O %	YLD BU.	BS. %	STAND	H2O %	YLD BU.	STAND
Dairyland DX1095	95	16.4	63	17	22440	20.5	117	23760
Dekalb DK397	90	14.6	45	7	21648	15.4	140	22176
Dekalb DK415	95	12.8	54	7	23100	23.5	103	23562
Dekalb DK435	95	16.8	79	4	22176	20.4	134	23958
Dekalb DK461	95	14.5	72	20	23760	19.8	121	24156
Dekalb DK464	100	15.2	87	4	22308	21.8	132	23364
Dekalb DK484	100	19.3	89	23	21120	27.2	131	23166
Dekalb DK535	105	23.2	59	2	22836	24.6	137	24750
Dekalb DK547	105	22.4	90	5	22968	26.2	119	23958
Double T 985	100	17.5	84	9	22572	23.4	103	23364
Enestvedt E650	100	17.1	71	11	22836	19.8	140	23562
Fontanelle/Sar 3635	95	13.6	56	4	22704	21.6	120	23166
Fontanelle/Sar 3935	100	19.7	83	5	22440	20.5	138	22770
Funks G2040X	NR	15.9	91	9	22572	18.4	158	21780
Funks G4027	90	15.9	71	33	22968	20.6	128	21780
Funks G4211	95	17.1	54	7	22044	24.2	88	22176
Funks G4234	100	18.5	66	5	22704	23.7	124	22374
Funks G4299	100	16.1	77	10	22308	19.9	133	22968
Georges 8091	90	15.9	80	7	23100	19.5	135	23166
Georges 8100	100	18.5	97	8	22836	23.3	141	22572
Golden Harvest H2277	90	14.4	63	15	23232	22.2	86	22176
Golden Harvest H2327	95	16.5	83	10	20196	20.8	145	22176
Golden Harvest H2343	100	17.4	60	7	21912	22.6	113	22770
Golden Harvest H2344	100	15.3	65	13	22968	22.5	94	22374
Heritage Mortgage Lifter	100	17.2	92	17	22044	27.7	111	22968
Heritage Uff Da	90	13.1	63	12	20064	20.0	100	19800
Herried 8892	90	13.9	64	13	21780	18.3	97	21384
Herried 8894	95	15.7	97	18	22572	19.9	123	23166
Herrried 8800	100	17.9	81	13	21120	23.9	115	21582
Hoegemeyer SX2559	95	15.3	76	12	21252	18.2	107	22572
Hoegemeyer X623	100	18.5	94	9	23760	20.0	123	22374
Hyland HL2412	95	15.2	89	4	23496	17.9	128	22968
Hy-Vigor 4400	95	15.3	80	10	20064	22.8	126	22374
Interstate IS406	90	14.6	86	8	24948	17.8	152	24156
Interstate IS463	95	15.6	63	28	22044	20.3	136	23166
Interstate IS503S	100	19.2	62	26	22572	24.8	121	24750
Interstate IS523	100	16.2	73	13	22836	22.1	150	23166
Jacques 4100	90	14.6	50	29	20592	19.6	91	20790
Jacques 4700	95	14.5	66	25	21780	23.4	89	21780
Jacques 4750	100	18.5	75	3	23760	23.5	126	22770

1988 Uinversity of Minnesota Corn Breeding
Expt.361 - Medium Hybrid Test (cont.)

BRAND - VARIETY	RM	ROSEMOUNT H20 %	ROSEMOUNT YLD BU.	ROSEMOUNT BS. %	ROSEMOUNT STAND	MORRIS H20 %	MORRIS YLD BU.	MORRIS STAND
Jacques 4900	100	15.1	86	14	22308	23.7	136	22572
Kaltenberg K4800	95	16.5	92	9	22968	22.2	145	22374
Keltgen 2270	90	14.6	74	11	21516	19.3	109	20988
Keltgen 2380	95	14.6	84	14	23364	18.5	151	23166
King Grain K448	100	19.0	102	9	23232	23.4	149	23760
Lynks LX261	100	15.9	108	14	21384	24.1	132	22770
Mallard UC396	90	15.6	84	13	22440	16.9	147	18018
Mn. Farm Bureau FB93	95	15.8	87	16	21648	19.9	160	22770
Nietfeld NFS930	95	18.7	84	8	20724	19.1	143	22968
Northrup King 1194	90	14.7	66	10	22044	19.1	109	22572
Northrup King 2216	95	14.4	60	9	24156	23.0	95	23166
Northrup King N3624	95	15.4	66	13	23100	23.0	85	21582
Northrup King N4350	100	15.2	83	7	22836	21.8	156	23958
Northrup King PX9151	90	13.0	64	10	23760	24.0	103	21384
Northrup King PX9161	90	14.6	63	13	24024	15.2	108	23760
Northrup King PX9292	100	16.4	67	7	22308	22.1	107	22968
Northrup King S3303	95	14.9	86	16	22308	20.6	106	22968
Payco 3X587	95	16.0	74	4	21516	22.7	112	22572
Payco 408	90	12.9	75	7	22836	19.2	115	24156
Payco 448	95	15.8	84	10	23364	18.4	112	21582
Payco 686	100	16.9	79	11	23364	22.2	129	22176
Payco 687	100	18.6	64	9	22968	21.8	120	22968
Payco SX 486	90	14.5	59	16	22044	21.0	100	22176
Payco SX586	95	19.1	67	3	22572	21.0	129	22968
Payco SX687	100	16.1	72	10	22572	21.2	146	23562
Phoenix PH2391	95	14.3	88	13	21780	18.2	152	24552
Phoenix PH2432	95	15.4	52	8	22572	20.1	118	22770
Pioneer 3737	100	16.5	98	5	23100	21.8	111	20394
Pioneer 3751	100	14.7	81	11	21516	20.6	138	22176
Pioneer 3772	95	14.0	80	10	21912	16.1	123	23364
Pioneer 3790	95	14.2	63	7	21516	17.6	116	22176
Pioneer 3902	90	13.2	68	5	22308	18.1	105	22374
Pioneer 3906	95	16.2	70	6	23232	17.9	139	23958
Renk RK505	95	18.6	76	3	20856	25.8	104	21978
Renk RK607	100	18.3	68	10	21780	22.0	120	22176
Sigco 1588	90	15.3	55	12	23892	18.8	133	23958
Sigco 1701	100	19.8	92	6	24684	25.5	113	23166
Sigco 1793	95	15.2	65	15	22572	14.4	143	21780
Sigco 1799	100	18.2	92	8	22440	23.4	76	22572
Sindelar X0078	95	17.9	57	15	21648	21.8	108	19998

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Expt.361 - Medium Hybrid Test (cont.)

		ROSEMOUNT				MORRIS		
BRAND - VARIETY	RM	H2O %	YLD BU.	BS. %	STAND	H2O %	YLD BU.	STAND
Sunrise SR1010	100	17.9	68	10	22308	21.4	119	22176
Sunrise SR920	90	16.1	51	24	19668	16.8	90	20196
Sunrise SR950	95	17.2	76	12	22176	18.2	112	23958
Top Farm 392	90	13.0	64	8	22704	19.2	122	22968
Top Farm SS100	100	18.8	55	18	21648	26.9	98	23166
Top Farm SS90	90	15.3	45	41	23496	17.6	88	22176
Top Farm TF1102	90	16.5	86	11	22308	20.8	141	23760
Top Farm TFSX195A	95	15.0	63	21	22308	19.7	123	22176
Tracy T1694	NR	13.1	75	15	22704	22.6	93	23958
Tracy T2040	105	21.0	92	7	24420	25.7	148	22770
Tracy T2930	95	14.5	81	24	20988	20.2	112	19998
Viking SX400	100	16.8	81	15	20328	22.3	135	23364
Viking SX450	100	17.4	63	17	22308	22.9	103	22176
Viking SX6000	100	19.5	76	7	21648	23.5	138	23364
MEAN		16.2	73	12	22440	21.2	119	22670
C.V.(%)		11.2	21	60	5	15.1	22	7
LSD(.30)		1.6	13	6	982	3.3	28	1573

1988 University of Minnesota Corn Breeding
Expt.341 - Late Hybrid Test

		LAMBERTON			WASECA		
BRAND - VARIETY	RM	H2O %	YLD BU.	STAND	H2O %	YLD BU.	STAND
Ag Venture 303	100	16.8	100	23166	15.7	122	23628
Ag Venture 362	105	24.9	75	24354	18.6	113	22440
Ag Venture 410	440	26.1	69	22572	19.3	96	22704
Ag Venture 8052	105	19.2	88	23364	16.1	129	23364
Ag Venture 8053	NR	25.0	83	21780	18.0	104	23364
Ag Venture 8056	NR	27.5	77	21186	19.8	122	23364
Ag Venture AX350WX	105	21.4	77	21780	19.3	103	21648
Agri Gene 3980	105	18.0	85	21384	16.3	127	24024
Agri Pro 560	100	18.1	69	21780	16.2	91	21912
Agri Pro AP175	95	15.6	87	23760	15.0	99	23364
Agri Pro AP339	105	14.8	67	21384	15.0	107	23760
Agri Pro AP364	105	15.6	84	20988	15.7	100	23100
American Hybrids 6082	105	16.2	90	22572	15.1	114	23232
Anderson SX6000	105	18.4	83	23562	16.6	101	22308
Asgro 2330	105	17.8	77	22176	16.3	117	22968
Asgro 6880	105	22.4	74	21780	18.3	104	22044
Asgro RX498	100	17.8	75	20790	15.2	115	23496
Asgro RX578	110	17.8	121	21978	16.5	134	22704
Asgro RX626	110	19.4	89	22176	16.6	111	22704
Asgro RX746	115	22.9	107	23364	18.9	141	24024
Betagold HANNA	105	19.2	86	23562	16.3	120	23628
Betagold HEIDI	110	17.9	80	22770	15.8	89	23100
Betagold KARLA	100	17.0	92	23562	15.7	126	23892
Betagold KRISTINE	100	18.4	60	22572	17.0	85	21648
Betagold MARIA	110	27.5	97	22770	18.8	105	22836
Brown BR5247	105	15.0	83	21582	14.6	107	23760
Cargill 3327	100	14.8	79	22374	15.2	104	23628
Cargill 3477	95	14.1	74	21582	14.6	116	22836
Cargill 4227	105	17.9	104	23166	15.8	106	22440
Cargill 5157	105	24.1	86	22176	17.7	141	23232
Cargill 5927	110	25.8	80	21978	19.6	117	24156
Cargill 6127	110	24.1	89	22770	18.1	100	22704
Crystal CS1105	105	18.2	101	23958	15.7	127	23232
Crystal CS1108	110	19.6	103	23166	16.5	123	23364
Crystal CS1110	110	26.9	57	19998	18.9	106	21120
Crystal CS3103	105	18.0	101	22572	16.1	93	23364
Customaize 5510	100	18.8	86	22572	16.8	122	23892
Customaize 6127	NR	28.6	77	21186	19.2	106	22308
Customaize 6203	110	26.4	76	22968	19.0	115	22704
Customaize W5753	110	22.0	85	23364	18.8	122	23760

1988 University of Minnesota Corn Breeding
Expt.341 - Late Hybrid Test (cont.)

		LAMBERTON			WASECA		
BRAND - VARIETY	RM	H20 %	YLD BU.	STAND	H20 %	YLD BU.	STAND
Customaize W6253	110	28.3	74	22968	19.0	114	22440
Dairyland DX305	105	20.4	76	21780	19.6	103	22968
Dekalb DK464	100	14.6	81	23166	15.6	91	22440
Dekalb DK484	100	18.4	81	22374	16.8	94	22176
Dekalb DK524	105	15.4	75	21780	14.9	113	22176
Dekalb DK535	105	18.3	103	24156	16.9	117	24816
Dekalb DK547	105	18.7	105	22374	16.9	122	22836
Dekalb DK572	110	26.8	68	22968	18.0	129	23364
Frontanelle/Sar 4030	110	18.5	89	24750	15.9	115	22176
Frontanelle/Sar 4030A	105	17.4	92	22572	15.6	117	23892
Frontanelle/Sar 4035	105	20.6	111	23562	17.5	133	23232
Garst 8555	115	22.8	73	22374	19.3	110	23364
Garst 8708	105	18.7	97	24354	16.1	110	22968
Garst 8882	95	12.3	80	21384	15.1	81	18612
Golden H2442	105	24.7	93	22176	20.1	119	23364
Golden Harvest H2343	100	16.2	62	22374	16.2	95	22968
Golden Harvest H2344	100	23.4	47	22968	15.9	78	21384
Golden Harvest H2404	105	19.4	90	21978	16.1	109	17952
Golden Harvest H2438	105	27.5	65	22374	19.2	108	21912
Golden Harvest H2486	110	19.7	82	22374	17.2	122	22968
Herried 8304	110	25.6	67	22572	18.3	113	22704
Herried 8702	105	16.8	79	21582	15.9	111	23628
Hy-Vigor 4500	105	17.2	74	21582	17.4	86	22308
Hy-Vigor 4600	105	17.7	84	23958	17.1	90	22836
Hy-Vigor 5800	105	17.0	92	22572	16.2	119	23496
Hy-Vigor 6200	110	23.9	74	24156	17.9	126	24024
Interstate IS543	105	18.3	93	22374	16.0	128	24156
Interstate IS613	110	25.1	71	22572	19.4	125	23364
Jung 2640	110	17.9	86	19008	16.2	117	22968
Keltgen 2590	105	18.1	90	24552	18.2	122	22836
Keltgen 2670	110	21.2	115	23364	18.2	125	22704
Kruger K8100A	105	15.0	85	21978	15.6	103	22308
Kruger K8105	110	19.0	100	23562	16.5	108	22704
Meows M2330	105	15.4	80	21384	16.4	101	22572
MN. Farm Bureau FB102	105	16.4	94	23760	16.5	111	23100
Nietfeld NFS105A	105	21.8	87	22770	17.1	117	23364
Northrup King N4350	100	13.2	77	21978	15.4	103	24288
Northrup King N4545	105	17.4	88	22968	18.3	96	23100
Northrup King N4545	105	16.7	72	22374	17.1	105	23232
Northrup King PX9292	100	12.3	81	22176	14.8	104	24024

1988 University of Minnesota Corn Breeding
Expt.341 - Late Hybrid Test (cont.)

		LAMBERTON			WASECA		
BRAND - VARIETY	RM	H20 %	YLD BU.	STAND	H20 %	YLD BU.	STAND
Northrup King S4590	105	18.7	76	23562	16.6	123	22836
Northrup King S5340	110	24.6	84	24750	18.7	133	25080
Payco 648	NR	17.8	87	22770	17.1	123	23232
Payco 748	NR	27.4	80	22572	19.0	106	24156
Payco 872	110	26.8	71	24156	18.7	113	23100
Payco SX786	105	25.2	81	21978	20.2	125	23232
Pfister 1550	110	18.9	89	21582	17.2	112	23364
Pfister 1680	110	17.7	80	22968	16.4	112	22308
Pioneer 3475	115	16.4	84	22968	16.4	128	22044
Pioneer 3569	105	15.2	95	22968	14.5	96	21252
Pioneer 3585	105	14.7	86	23562	16.0	128	23364
Pioneer 3615	105	15.9	91	22374	15.5	139	22704
Pioneer 3732	105	13.7	90	22572	15.0	100	22704
Pioneer 3737	100	11.6	80	21780	14.1	97	22572
Pioneer 3751	100	12.1	89	22968	14.7	114	22836
Pioneer XC272	NR	14.4	104	22176	15.9	114	22968
Renk RK627	105	19.4	89	23166	16.1	125	22704
Renk RK873	110	21.1	96	20988	18.4	156	23628
Seed Tec KX60	110	22.2	80	21978	19.0	123	22836
Seed Tec ST7351	110	24.3	85	21582	19.3	130	22572
Seed Tec ST7500	110	24.7	103	21780	19.3	137	22836
Sigco 1701	100	18.0	78	21780	16.3	120	23100
Sigco 1793	95	12.7	91	23166	14.8	122	23760
Sigco 1799	100	16.0	88	23364	15.7	116	23496
Solid Gold HERITAGE	110	25.4	73	22770	18.4	115	23496
Top Farm SS105	105	19.3	48	21384	16.7	71	14520
Top Farm SX1103	105	17.4	90	22770	16.3	136	23628
Top Farm SX1106	105	19.4	86	21780	15.5	111	22968
Tracy T2040	105	18.5	95	23166	16.5	131	14916
Viking MS5000	105	20.9	95	21780	17.6	128	22572
MEAN		19.6	84	22585	17.0	113	22798
C.V.(%)		9.6	12	6	5.1	15	10
LSD(.30)		2	10	1380	0.7	14	1835

1988 Effects of Cultivation on Corn Weed Control

W.E. Lueschen, J. Gunsolus and T. Hoverstad

The objectives of this study were: 1) to evaluate the effects of cultivation on weed control in corn with and without herbicide application, 2) to evaluate the effects of band vs. broadcast herbicide applications and 3) to evaluate the effectiveness of a rotary hoe for improving weed control in corn.

This experiment was designed as a randomized complete block with a split-plot arrangement of treatments and four replications. The main plots were a combination of cultivation treatment and a rotary hoe treatment. Subplots were four herbicide treatments. The site selected for this study was a Webster clay loam soil with 6.0% organic matter and the following soil chemical properties: pH=5.9, P=72 lb/A and K=391 lb/A. The study was planted on May 3 to Pioneer '3906'. There were three cultivation treatments: 1) no cultivation, 2) one cultivation four weeks after planting and 3) two cultivations, one three weeks after planting with a repeat cultivation five weeks after planting. Herbicide treatments evaluated included Lasso 2.5 lb/A broadcast, Lasso 2 lb/A + Bladex 2 lb/A broadcast, Lasso 2 lb/A + Bladex 2 lb/A applied in a 15-inch band, and a check treatment with no herbicide. All herbicide and cultivation treatments were evaluated with and without rotary hoeing. The rotary hoeing was done once on May 13 when weeds were emerging to 1 inch tall and corn was just beginning to break the soil surface. All herbicide treatments were applied preemergence on May 4. At the time of herbicide application, the temperature was 72°F with 30% relative humidity and the soil was dry. Rainfall total one week following application 1.6 inches.

The results from this study are presented in Table 1. Although rainfall accumulation following herbicide application was adequate to activate soil applied herbicides, weed control in this study was generally very poor. Weed control evaluations made in early September showed herbicide treatments improved weed control by only 5 to 15 percent compared to untreated plots and there was very little difference in control among herbicide treatments. Cultivation enhanced weed control substantially. Plots cultivated once averaged 40 percent better giant goxtail control and 60 percent better broadleaf weed control than the uncultivated treatments. The benefits of cultivating twice were minimal due primarily to very dry conditions that prevented later germination of weed seeds. The plots cultivated twice averaged only 5 percent better weed control than plots cultivated once. The rotary hoe significantly improved weed control, however, this improvement was only 5 to 10 percent. To be most effective the rotary hoe must be used before weeds establish a good root system. Therefore, rotary hoeing must be done before weeds are 0.5 inch tall to be effective. Depending on weather conditions after planting, rotary hoeing should be done 7 to 10 days after planting in most cases. In this study rotary hoeing would have been more effective if it would have been done one or two days sooner. Because of warm temperatures weeds emerged rapidly in 1988. Because of the severely dry conditions experienced in 1988, corn yields in this study were very low. Herbicide treated plots averaged only 5 bu/A more than untreated plots, however, this 5 bu/A represents approximately a 100 percent increase in yield, which is representative of an average season. Cultivation improved corn yield by 10 to 15 bu/A while the rotary hoe resulted in a 5 bu/A yield advantage.

A similar study was conducted in 1987, however, the effects of the rotary hoe were not evaluated in 1987. Table 2 shows the effects of cultivation and herbicide treatment on weed control in corn in both 1987 and 1988. Weed control and grain yields were better in 1987, also a dry season, than in 1988. Averaged across all cultivation treatments, herbicides improved weed control by approximately 20 percent in 1987 and 1988 combined. This improved weed control accounted for a 10 to 20 bu/A yield increase. Averaged over 1987 and 1988 and all herbicide treatments, one cultivation improved weed control by 30 to 40 percent as compared to no cultivation. Averaged over the two years, two cultivations improved weed control when compared to one cultivation. Although the improvement in weed control with two cultivations as compared to one were not large, two cultivations resulted in a 12 bu/A yield increase over one cultivation. Most of this difference was in 1987 where two cultivations with herbicide yielded quite well. Because of extremely dry conditions in 1988, yield differences were hard to determine. Based on this two-year study cultivation is an effective tool to improve weed control. Two cultivations were most important where herbicides were banded.

Table 1. Effects of Herbicide, Cultivation and Rotary Hoe on Corn Weed Control at Waseca in 1988.

Herbicide	Rate	Method of Application	Rotary Hoe	Cult.	1] Gift	2] Corw	3] Vele	4] Colq	5] Rrpw	Yield
	(lb/A)				--- (% control)				---	(bu/A)
Lasso	2.5	Broadcast	0	0	32	0	0	8	8	0.0
Lasso + Bladex	2.0 + 2.0	Broadcast	0	0	25	0	0	8	15	0.0
Lasso + Bladex	2.0 + 2.0	Band	0	0	22	8	8	0	10	0.0
Weedy Check	---	---	0	0	0	0	0	0	0	0.0
Lasso	2.5	Broadcast	0	1	66	61	60	60	60	13.0
Lasso + Bladex	2.0 + 2.0	Broadcast	0	1	64	59	59	60	60	11.5
Lasso + Bladex	2.0 + 2.0	Band	0	1	60	59	59	61	61	10.0
Weedy Check	---	---	0	1	52	55	55	55	55	3.3
Lasso	2.5	Broadcast	0	2	66	60	60	60	60	12.4
Lasso + Bladex	2.0 + 2.0	Broadcast	0	2	65	61	61	61	61	12.1
Lasso + Bladex	2.0 + 2.0	Band	0	2	65	61	61	64	64	11.9
Weedy Check	---	---	0	2	60	59	59	59	59	6.9
Lasso	2.5	Broadcast	1	0	41	8	8	25	36	0.0
Lasso + Bladex	2.0 + 2.0	Broadcast	1	0	38	0	0	0	0	1.9
Lasso + Bladex	2.0 + 2.0	Band	1	0	22	10	8	8	8	0.0
Weedy Check	---	---	1	0	5	0	0	0	0	0.0
Lasso	2.5	Broadcast	1	1	70	61	60	64	66	11.1
Lasso + Bladex	2.0 + 2.0	Broadcast	1	1	65	59	60	64	62	15.9
Lasso + Bladex	2.0 + 2.0	Band	1	1	69	64	64	68	68	22.7
Weedy Check	---	---	1	1	58	59	59	59	59	5.0
Lasso	2.5	Broadcast	1	2	71	66	66	66	66	23.8
Lasso + Bladex	2.0 + 2.0	Broadcast	1	2	73	69	69	75	75	18.0
Lasso + Bladex	2.0 + 2.0	Band	1	2	72	68	70	71	71	22.6
Weedy Check	---	---	1	2	64	64	64	64	64	11.1

Average for Herbicide :

Herbicide	Rate	Method of Application	Gift	Corw	Vele	Colq	Rrpw	Yield
Lasso	2.5	Broadcast	58	43	42	47	49	10.1
Lasso + Bladex	2.0 + 2.0	Broadcast	55	41	42	45	46	9.9
Lasso + Bladex	2.0 + 2.0	Band	52	45	45	45	47	11.2
Weedy Check			40	40	40	40	40	4.4
	LSD(0.05)		5	4	3	5	6	3.8

Average for Cultivation :

	Cult.	Gift	Corw	Vele	Colq	Rrpw	Yield
	0	23	3	3	6	10	0.2
	1	63	60	60	61	61	11.6
	2	67	64	64	65	65	14.9
LSD(0.05)		7	4	4	4	5	3.3

Average for Rotary Hoe :

	Rotary Hoe	Gift	Corw	Vele	Colq	Rrpw	Yield
	0	48	40	40	41	43	6.8
	1	54	44	44	47	48	11.0
Significance		*	*	*	*	*	*

* - Significant at p<.05

1] - giant foxtail
2] - common ragweed
3] - velvetleaf
4] - common lambquarters
5] - redroot pigweed

Table 2. Effects of Herbicide and Cultivation on Corn Weed Control at Waseca in 1987 and 1988.

Year	Herbicide	Rate	Method of Application	Cult.	Gift 1	Vele 2	Colq 3	Rrpw 4	Yield
		(lb/A)			---	(% control)		---	(bu/A)
1987	Lasso	2.5	Broadcast	0	28	79	54	48	61.5
"	Lasso + Bladex	2.0 + 2.0	Broadcast	0	35	65	76	68	105.1
"	Lasso + Bladex	2.0 + 2.0	Band	0	23	78	41	64	67.0
"	Weedy Check	---	---	0	0	23	25	25	74.3
"	Lasso	2.5	Broadcast	1	39	59	55	63	105.7
"	Lasso + Bladex	2.0 + 2.0	Broadcast	1	65	83	81	79	126.1
"	Lasso + Bladex	2.0 + 2.0	Band	1	25	75	49	73	75.9
"	Weedy Check	---	---	1	35	80	73	56	89.1
"	Lasso	2.5	Broadcast	2	65	94	81	79	128.9
"	Lasso + Bladex	2.0 + 2.0	Broadcast	2	64	76	81	90	135.5
"	Lasso + Bladex	2.0 + 2.0	Band	2	78	89	90	93	148.1
"	Weedy Check	---	---	2	43	80	55	43	78.1
1988	Lasso	2.5	Broadcast	0	33	0	8	8	0.0
"	Lasso + Bladex	2.0 + 2.0	Broadcast	0	25	0	8	15	0.0
"	Lasso + Bladex	2.0 + 2.0	Band	0	23	8	0	10	0.0
"	Weedy Check	---	---	0	0	0	0	0	0.0
"	Lasso	2.5	Broadcast	1	66	60	60	60	13.0
"	Lasso + Bladex	2.0 + 2.0	Broadcast	1	64	59	60	60	11.5
"	Lasso + Bladex	2.0 + 2.0	Band	1	60	59	61	61	10.0
"	Weedy Check	---	---	1	53	55	55	55	3.3
"	Lasso	2.5	Broadcast	2	66	60	60	60	12.4
"	Lasso + Bladex	2.0 + 2.0	Broadcast	2	65	60	61	61	12.1
"	Lasso + Bladex	2.0 + 2.0	Band	2	65	60	64	64	11.9
"	Weedy Check	---	---	2	60	59	59	59	6.9
	Average for year :								
1987					42	73	63	65	99.6
1988					48	40	41	43	6.8
			Significance		**	**	**	**	**
	Average for Herbicide :								
	Lasso	2.5	Broadcast		50	59	53	53	53.6
	Lasso + Bladex	2.0 + 2.0	Broadcast		53	57	61	62	65.1
	Lasso + Bladex	2.0 + 2.0	Band		46	62	51	61	52.2
	Weedy Check				32	50	45	40	42.0
		LSD(0.05)			8	10	14	14	13.1
	Average for Cultivation :								
				0	21	32	27	30	38.5
				1	51	66	62	63	54.3
				2	63	72	69	69	66.7
		LSD(0.05)			5	7	9	9	9.0

** - Significant at p<.01

1| - giant foxtail
2| - velvetleaf
3| - common lambsquaters
4| - redroot pigweed

Herbicide Carryover in Corn, Oats and Alfalfa

J. Gunsolus and W. E. Lueschen

The objective of this project was to determine the effects of rate of application and method of incorporation of clomazone (Command) for weed control in soybeans on the carryover potential of this herbicide to corn, oats and alfalfa.

The site selected for this study was a Webster clay loam soil with a pH=6.4 and 7.0% organic matter. Soil test levels indicated P=73 lb/A and K=413 lb/A at the experimental location. This experiment was designed as a randomized complete block with a split-split plot arrangement of treatments. Main plots were 1987 Command incorporation methods, subplots were the 1988 crop and sub-subplots were 1987 Command rates. On May 19, 1987, Command was applied at rates ranging from 0.5 lb/A to 2 lb/A and incorporated with either a field cultivator or a spike-tooth harrow. The field cultivator was set to till 3 to 4 inches deep and was operated at 5 mph. The spike-tooth harrow was set with spikes vertical and operated at 5 mph. Soybeans were planted in 1987 following incorporation of Command to facilitate normal use conditions. Basagran at 1 lb/A + Blazer at 0.25 lb/A + Poast at 0.1 lb/A + crop oil concentrate at 1 pt/A was applied in 1987 to keep plots weed-free. No fall tillage was performed in 1987 following soybean harvest.

In the spring of 1988, the plots were relocated. The Command incorporation blocks were split with one-half planted to corn, the other to oats under-seeded with alfalfa. Spring tillage consisted of one field cultivation just prior to planting each of the crops. The oats/alfalfa plots received 30 lb N/A as urea incorporated with the field cultivator. 'Steele' oats were planted on April 13, 1988 with a grain drill set to seed 60 lb/A. 'DK 120' alfalfa was planted with a Brillion seeder at a rate of 12 lb/A immediately following oat seeding. The corn plots received 150 lb N/A as urea incorporated with the field cultivator. Pioneer '3732' hybrid seed corn was planted on April 21, 1988 at a rate of 27,700 seeds/A. Corn plots were 15 feet (6-30-inch rows) by 30 feet. Oat/alfalfa plots were 15 feet by 30 feet. Lasso at 3.5 lb/A + Bladex at 2.5 lb/A was applied preemergence for weed control in the corn plots. No herbicide was applied to the oats/alfalfa plots. Before corn emerged, 10 feet of each of the center two rows were staked and monitored for emergence. Emergence counts were taken as soon as plants were seen emerging until no additional plants emerged. Oat/alfalfa stands were monitored by counting all plants in three-1 ft^2 areas near the center of each plot. Visual estimates of chlorosis were recorded for oats on May 12, 1988 and for all crops on May 20, 1988. Plant height at maturity was measured on oats. Oats were harvested on July 25, 1988. No alfalfa yield evaluations were made because of the extremely dry weather and poor alfalfa growth. Corn plots were harvested on September 16, 1988 and grain yield, test weight and grain moisture were evaluated.

Table 1 shows the effects of Command herbicide carryover on corn at Waseca in 1988. Corn populations ranged from 21,800 to 26,400 plants/A with no significant treatment effects. Method of incorporation of Command in 1987 resulted in no significant difference for any of the parameters measured on corn in 1988. Command application rate in 1987 affected corn chlorosis on May 20, 1988. However, chlorosis exhibited by corn in 1988 was slight and did not cause significant corn injury. Corn yields ranged from 97 to 107 bu/A and were not affected by 1987 Command rate. No difference was measured in grain moisutre or test weight as influenced by 1987 Command rates.

Table 2 shows the effects of Command herbicide carryover on oats and alfalfa in 1988. Both oats and alfalfa exhibited severe chlorosis in 1988 where Command was applied at rates equal to or greater than 1.0 lb/A. Chlorosis ranged from 11% with the 0.56 lb/A Command rate to 66 to 76% chlorosis following 2.0 lb/A Command.

Although chlorosis ratings for oats where Command was incorporated with a field cultivator were higher, these differences were very small and probably not meaningful. No difference was observed in alfalfa chlorosis due to incorporation method. No difference in oat or alfalfa population was observed comparing methods of Command incorporation. Oat height and yield also was not affected by Command incorporation method. Command application rate in 1987 significantly affected both oat and alfalfa chlorosis in 1988.

Oat populations were reduced with the two highest rates of Command application. Later in the season, the only oat plots that exhibited low populations were those that were following 2.0 lb/A of Command. Alfalfa population evaluated on May 23 was not affected by Command treatments. By mid-summer alfalfa stands following 2 lb/A of Command were 100% higher than those following no Command. This is likely the result of reduced competition from oats during the extremely dry weather experienced in June and July. Although oat injury was probably substantial enough to cause yield reductions at the higher rates of Command application, the dry weather experienced in 1988 limited the yield of oats and eliminated any yield differences that would normally be expected.

Table 1. Effects of Command Carryover on Corn at Waseca, 1988.

TRT	1987 Command Rate	1987 Incorporation	Chlor 1| 5/20	Population 5/16	5/18	5/20	H2O	Test Weight	Yield 2|
			(%)	(plt/A x 1000)			(%)	(lb/bu)	(bu/A)
1	0.00	Drag	0	22.4	22.7	23.1	21.7	54.0	111.1
2	0.00	F. Cultivate	1	24.2	24.6	24.4	20.7	54.5	102.5
3	0.56	Drag	0	24.4	24.6	24.6	21.3	55.2	104.6
4	0.56	F. Cultivate	0	24.4	24.2	24.8	21.7	54.8	93.8
5	0.75	Drag	0	23.1	22.7	23.1	21.6	54.6	91.0
6	0.75	F. Cultivate	1	25.7	26.1	26.4	21.2	54.1	110.6
7	1.00	Drag	2	21.8	22.0	22.4	21.1	54.6	104.8
8	1.00	F. Cultivate	1	24.4	24.8	24.4	21.3	54.3	97.0
9	1.50	Drag	2	22.9	22.7	23.1	21.4	53.9	108.6
10	1.50	F. Cultivate	3	23.7	23.7	23.5	21.5	54.4	85.8
11	2.00	Drag	6	24.0	23.3	24.4	21.9	54.2	107.1
12	2.00	F. Cultivate	5	23.7	23.7	24.2	20.8	54.5	91.4

Average for incorporation :

Incorporation	Chlor 5/20	Population 5/16	5/18	5/20	H2O	Test Weight	Yield
	(%)	(plt/A x 1000)			(%)	(lb/bu)	(bu/A)
Drag	2	23.1	23.0	23.5	21.5	54.4	104.5
F. Cultivate	2	24.3	24.5	24.6	21.2	54.4	96.9
LSD(0.05)	ns	ns	ns	ns	ns	ns	ns

Average for Command rate :

Command Rate	Chlor 5/20	Population 5/16	5/18	5/20	H2O	Test Weight	Yield
	(%)	(plt/A x 1000)			(%)	(lb/bu)	(bu/A)
0.00	0	23.3	23.7	23.8	21.2	54.3	106.8
0.56	0	24.4	24.4	24.7	21.5	55.0	99.2
0.75	1	24.4	24.4	24.8	21.4	54.4	100.8
1.00	1	23.1	23.4	23.4	21.2	54.5	100.9
1.50	2	23.3	23.2	23.3	21.5	54.2	97.2
2.00	5	23.9	23.5	24.3	21.4	54.4	99.3
LSD(0.05)	2	ns	ns	ns	ns	ns	ns

1| - chlor = chlorosis via visual observation
2| - yield = bu/A @ 15.5% moisture

Table 2. Effects of Command Carryover on Oats/Alfalfa at Waseca, 1988.

TRT	1987 Command Rate	1987 Incorporation	Chlorosis ---Oats-- 5/12	5/20	-Alf- 5/20	Oat Pop. 5/23	7/19	Alf Pop. 5/23	7/19	Oat Height	Yield 1
			------(%)		----	(plt/ft 2)		(plt/ft 2)		(inch)	(bu/A)
1	0.00	Drag	0	0	0	18.2	20.0	10.9	7.5	31.0	48.3
2	0.00	F. Cultivate	2	0	0	17.6	20.0	9.8	7.3	30.0	41.0
3	0.56	Drag	11	10	7	16.0	22.2	12.9	6.2	31.2	46.2
4	0.56	F. Cultivate	10	12	8	17.5	22.5	10.5	9.5	29.8	42.9
5	0.75	Drag	18	21	12	18.3	23.5	13.9	8.8	30.2	42.3
6	0.75	F. Cultivate	12	20	11	17.8	19.7	12.3	7.5	30.8	45.5
7	1.00	Drag	35	35	24	17.4	23.7	12.3	10.3	31.8	48.1
8	1.00	F. Cultivate	45	36	28	15.7	21.2	12.2	11.5	30.2	45.8
9	1.50	Drag	45	51	42	15.3	21.2	11.2	15.3	30.8	53.5
10	1.50	F. Cultivate	58	62	55	15.4	19.6	11.1	13.7	29.8	40.7
11	2.00	Drag	72	72	65	12.9	20.2	11.3	14.0	31.8	42.1
12	2.00	F. Cultivate	74	79	66	13.1	15.6	9.6	15.5	31.0	35.6

Average for incorporation :

Incorporation	Chlorosis ---Oats-- 5/12	5/20	-Alf- 5/20	Oat Pop. 5/23	7/19	Alf Pop. 5/23	7/19	Oat Height	Yield
	------(%)		----	(plt/ft 2)		(plt/ft 2)		(inch)	(bu/A)
Drag	30	32	25	16.4	21.8	12.1	10.4	31.1	46.8
F. Cultivate	34	35	28	16.2	19.8	10.9	10.8	30.3	41.9
LSD(0.05)	**	*	ns	ns	ns	ns	ns	ns	ns

Average for Command rate :

Command Rate		Chlorosis ---Oats-- 5/12	5/20	-Alf- 5/20	Oat Pop. 5/23	7/19	Alf Pop. 5/23	7/19	Oat Height	Yield
		------(%)		----	(plt/ft 2)		(plt/ft 2)		(inch)	(bu/A)
0.00		1	0	0	17.9	20.0	10.4	7.4	30.5	44.7
0.56		11	11	8	16.8	22.4	11.7	7.9	30.5	44.6
0.75		15	21	12	18.1	21.6	13.1	8.2	30.5	43.9
1.00		40	36	26	16.6	22.5	12.3	10.9	31.0	47.0
1.50		52	57	49	15.4	20.4	11.2	14.5	30.3	47.1
2.00		73	76	66	13.0	17.9	10.5	14.8	31.4	38.9
	LSD(0.05)	12	8	7	1.7	3.3	ns	4.1	ns	ns

1 - yield =bu/A @ 13.5 % moisture

Herbicide performance in corn at Waseca, MN-1988. Gunsolus, Jeffrey L. and William E. Lueschen. The purpose of this experiment was to evaluate various soil applied and postemergence herbicides and herbicide combinations for efficacy and corn tolerance. Timing of postemergence broadleaf herbicide applications were also evaluated. Oats were grown in 1987 and the plot area was chisel plowed in the fall of 1987 and field cultivated in the spring of 1988. The plot area received 150 lb/A of urea N. The study was conducted on a Webster clay loam soil with 6.3.% organic matter, pH 6.5, and soil test P and K levels of 58 and 388 lb/A, respectively. All herbicides were applied with a self-propelled plot sprayer using 20 gpa, 30 psi, 3 mph, and 8002 flat-fan nozzles. Preplanting herbicide applications were incorporated to a depth of 2 to 3 inches by one pass with a disk followed by another pass with a field cultivator in the opposite direction to the first pass. The entire postemergence broadleaf herbicide study was sprayed on May 3 with 2.5 lb/A of metolachlor to keep grass weeds from interfering with the study. On May 3, 'Pioneer 3906' corn was planted 1.5 inches deep at 27,500 seeds/A. A randomized complete block design with four replications was used. Plots were 10 by 30 ft and contained four 30-inch rows. Weed densities/ft^2 were 51 giant foxtail, 3.1 common lambsquarters, 1.6 redroot pigweed, 2.5 common ragweed, and 0.6 velvetleaf. Weed control, crop injury, and stand reduction evaluations were taken visually June 1 for all soil applied treatments. All postemergence broadleaf herbicide evaluations were taken June 16 and total postemergence weed control evaluations were taken June 26. All plots were cultivated after visual ratings were taken. Yield data were obtained only from the preplant incorporated and total postemergence weed control plots. Poor grass control, due to extremely dry conditions, resulted in unharvestable conditions in the preemergence and postemergence broadleaf herbicide studies. Yield data were obtained from 25 ft of the two center rows and corrected for 15.5% moisture. Application dates, environmental conditions, and plant sizes are listed below:

Date	May 3	May 3	May 23	June 3	June 13
Treatment	PPI	Pre	Post	Post	Post
Temperature (F)					
air	63	77	77	76	85
soil (4 inch)	54	63	70	74	79
Soil moisture	dry	dry	dry	dry	dry
Wind (mph)	10-15 SE	10-20 SE	10-15 S	5-10 SE	15-20 S
Sky	clear	clear	clear	clear	clear
Rainfall after application					
Week 1 (inch)	1.47	1.47	0.27	0	0.35
Week 2 (inch)	0.15	0.15	0	0.12	0.55
Relative humidity (%)	30	20	20	60	40
Corn					
leaf no.	-	-	2-3	4	6
height (inch)	-	-	5	8	12-14
Giant foxtail					
leaf no.	-	-	1-3	1-3	5-6
height (inch)	-	-	0.5-1	1-3	6-8
Common lambsquarters					
leaf no.	-	-	2-4	4-8	8-10
height (inch)	-	-	0.5-1	1-3	5-6
Redroot pigweed					
leaf no.	-	-	-	2-6	8-10
height (inch)	-	-	-	1-3	5
Common ragweed					
leaf no.	-	-	2-4	2-6	8
height (inch)	-	-	0.5-1	1-3	7
Velvetleaf					
leaf no.	-	-	2	2-4	6
height (inch)	-	-	0.5-1	1-3	6

Performance of preemergence herbicides was poor due to the dry weather before and after herbicide application. Overall, the early application of postemergence broadleaf herbicides outperformed the late applications. DPX-V9360 was effective in controlling giant foxtail but due to its slow activity, took longer for symptoms to develop relative to the atrazine + tridiphane treatment. DPX-M6316 was not effective in controlling common ragweed, but was very effective in controlling common lambsquarters, at any of the rates tested. (Minn. Agric. Exp. Stat., University of Minnesota, St. Paul).

Table 1. Preplant incorporated and preemergence weed control in corn at Waseca, MN. (Gunsolus and Lueschen).

Treatment	Rate	Corn (6-1) Injury	Control (6-1) Gift	Colq	Corw	Rrpw	Vele	Corn Yield
	(lb/A)	(%)	(%)	(%)	(%)	(%)	(%)	(Bu/A)
Preplant incorporated (May 3)								
Alachlor + atrazine	3.0 + 2.0	0	74	74	28	88	41	37
Alachlor + AC 513,655	3.0 + 1.2	0	80	83	40	95	64	53
EPTC & dichlormid + atrazine	4.0 + 2.0	0	88	86	58	79	58	55
Butylate & dichlormid + atrazine	4.0 + 2.0	3	73	94	40	91	69	35
EPTC & dichlormid & dietholate + atrazine	4.0 + 2.0	0	93	94	69	91	89	58
Weedy check								5
LSD (0.05)		NS	15	NS	25	NS	NS	25
Preemergence (May 3)								
Alachlor + atrazine	3.0 + 2.0	0	53	55	25	43	23	
Alachlor + AC 513,655	3.0 + 1.2	3	66	50	23	38	13	
Pendimethalin + AC 513,655	1.5 + 1.2	3	34	36	23	44	28	
CGA-180937 + atrazine	2.5 + 2.0	0	53	41	19	40	13	
CGA-180937 & atrazine[a]	2.4 & 2.1	0	56	46	15	50	41	
Metolachlor + atrazine	2.5 + 2.0	0	46	51	18	50	25	
Metolachlor & atrazine[b]	2.5 & 2.0	0	45	33	13	31	15	
EL-177 + atrazine + alachlor	0.3 + 1.0 + 1.0	0	30	33	10	40	5	
EL-177 + atrazine + alachlor	0.3 + 1.25 + 1.0	0	34	40	19	46	13	
EL-177 + atrazine + cyanazine	0.3 + 1.0 + 1.0	0	19	40	13	39	39	
EL-177 + atrazine	0.3 + 1.25	0	24	41	13	29	73	
EL-177	0.3	0	15	18	6	33	38	
Alachlor MT & atrazine[c]	2.5 & 1.5	0	48	35	16	63	18	
Acetochlor + atrazine	1.5 + 1.1	0	63	38	26	63	15	
Acetochlor + atrazine	1.75 + 1.3	0	65	48	19	58	16	
Acetochlor + atrazine	1.5 + 1.5	0	65	70	29	63	23	
LSD (0.05)		NS	17	NS	NS	NS	22	

[a] premix = Bicep 5.9F.
[b] premix = Bicep 6.0F.
[c] premix = Bullet 4F.

Table 2. Postemergence broadleaf weed control in corn at Waseca, MN. (Gunsolus and Lueschen).

Treatment	Rate	Corn (6-16) Injury	Stand[a]	Control (6-16) Colq	Corw	Rrpw	Vele
	(lb/A)	(%)	(%)	(%)	(%)	(%)	(%)
Postemergence June 3							
Atrazine + C.O.C.[b]	0.5 + 1.25%	0	0	97	61	99	36
Bentazon & atrazine[c] + C.O.C.	0.52 & 0.52 + 1.25%	0	0	100	92	100	70
Dicamba	0.25	0	0	95	95	81	46
Dicamba & atrazine[d]	0.27 & 0.51	0	0	100	93	98	90
Bromoxynil	0.25	3	0	100	84	75	71
Bromoxynil & atrazine[e]	0.25 & 0.5	0	0	100	99	95	73
2,4-D dimethylamine	0.25	3	0	91	74	87	45
2,4-D dimethylamine + dicamba	0.125 + 0.25	0	0	97	95	95	94
Pyridate	0.94	0	0	98	50	84	64
Pyridate + atrazine	0.47 + 0.6	0	0	100	64	100	50
Bentazon & atrazine + 28%N[f]	0.52 & 0.52 + 5.0%	0	0	100	98	95	93
Bentazon & atrazine + BCH-815S[g]	0.52 & 0.52 + 1.25%	0	0	100	88	100	88
Pendimethalin + AC 513,655	1.5 + 1.2	0	0	93	85	98	98
Postemergence June 13							
Atrazine + C.O.C.	0.5 + 1.25%	0	0	69	44	60	28
Bentazon & atrazine + C.O.C.	0.52 & 0.52 + 1.25%	0	0	85	41	86	49
Dicamba	0.25	0	0	76	83	59	38
Dicamba & atrazine	0.27 & 0.51	0	0	88	83	61	78
Bromoxynil	0.25	0	0	96	89	33	73
Bromoxynil & atrazine	0.25 & 0.5	0	0	99	98	81	83
2,4-D dimethylamine	0.25	0	0	65	76	84	59
2,4-D dimethylamine + dicamba	0.125 + 0.25	0	0	88	85	93	71
Pyridate	0.94	0	0	76	21	60	46
Pyridate + atrazine	0.47 + 0.6	0	0	93	50	93	63
LSD (0.05)		NS	NS	16	25	30	40

[a] Stand reduction.
[b] C.O.C. = Howe crop oil concentrate.
[c] premix = Laddok 3.3F.
[d] premix = Marksman 3.2F.
[e] premix = Buctril + Atrazine 3F.
[f] 28%N = 28% UAN fertilizer solution.
[g] BCH-815S = Dash, additive from BASF.

Table 3. Total postemergence weed control in corn at Waseca, MN. (Gunsolus and Lueschen).

Treatment	Rate	Corn (6-26) Injury	Corn (6-26) Stand[a]	Control (6-26) Gift	Control (6-26) Colq	Control (6-26) Corw	Control (6-26) Rrpw	Control (6-26) Vele	Corn Yield
	(lb/A)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(Bu/A)
Postemergence (May 23)									
Pyridate + atrazine	0.9 + 1.5	0	0	55	100	100	100	94	19
Pyridate + cyanazine	0.9 + 1.25	0	0	55	100	98	100	95	22
Atrazine + tridiphane + C.O.C.[b]	2.0 + 0.5 + 1.25%	0	0	85	100	96	100	96	61
Cyanazine + tridiphane	2.0 + 0.5	0	0	45	100	99	100	93	18
Atrazine + cyanazine + tridiphane	1.0 + 1.0 + 0.5	0	0	54	100	100	100	100	23
DPX-V9360 + DPX-M6316 + surfactant[c]	0.027 + 0.004 + 0.25%	0	0	95	97	58	100	75	45
DPX-V9360 + DPX-M6316 + surfactant	0.023 + 0.008 + 0.25%	0	0	86	100	60	100	65	45
DPX-V9360 + DPX-M6316 + surfactant	0.019 + 0.012 + 0.25%	0	0	83	98	64	100	98	39
Weedy check									3
Weedfree check									80
LSD (0.05)		NS	NS	12	NS	24	NS	NS	17

[a] Stand reduction.
[b] C.O.C. = Howe crop oil concentrate.
[c] surfactant = DuPont Surfactant WK.

Quackgrass control in corn with DPX V9360 and CGA-136872 at Waseca, MN in 1988. Donald L. Wyse, William Lueschen, and Joseph M. Spitzmueller. This study was conducted at the Southern Experiment Station in Waseca, MN to evaluate the efficacy of DPX V9360 and CGA-136872 for quackgrass control in corn. Each herbicide was applied at three rates to quackgrass in the 2- to 3-leaf stage of development on June 7, 1988 and at two rates to quackgrass in the 4- to 5-leaf stage of development on June 20, 1988. Quackgrass control was rated at 31 and 99 after herbicide treatment, and the corn was harvested for yield.

DPX V9360 and CGA-136872 provided satisfactory quackgrass control at all rates and both application dates. The highest rates of DPX V9360 and CGA-136872 applied to quackgrass in the 2- to 3-leaf stage resulted in greater control when compared to the low rates of either herbicide, evaluated 31 days after herbicide treatment. No other differences in control were observed at either 31 or 99 days after treatment.

Corn yields were erratic. Because of the hot and dry growing condition of 1988, no conclusions can be drawn.

Quackgrass control in corn with DPX V9360 and CGA-136872 at Waseca, MN - 1988.

Treatment	Rate	Stage	Quackgrass Control -DAT 31	99	Corn yield	
	(g/A)				(bu/A)	(kg/ha)
1. CGA-136872 + X-77	10.0	2-3	82	88	112	5705
2. CGA-136872 + X-77	20.0	2-3	88	86	96	4884
3. CGA-136872 + X-77	40.0	2-3	93	95	117	5860
4. CGA-136872 + X-77	10.0	4-5	84	85	72	3583
5. CGA-136872 + X-77	20.0	4-5	82	85	94	4712
6. DPX V9360 + X-77	14.2	2-3	82	86	110	5670
7. DPX V9360 + X-77	28.3	2-3	86	86	89	4692
8. DPX V9360 + X-77	42.5	2-3	94	93	75	3757
9. DPX V9360 + X-77	14.2	4-5	89	87	95	4760
10. DPX V9360 + X-77	28.3	4-5	85	86	96	4781
11. No treatment	00.0		0	0	85	4265
LSD 0.05			10	12	25	1250

X-77 at 0.25% (v/v).

'Hodgson 78' soybeans were planted May 14, 1988. Alachlor and dicamba (3 and 0.5 lb/A) preemergence on May 18, 1988 for general weed control. Early postemergence tretaments were applied June 7, 1988. Temperature 90°F, wind calm. Corn 6 lvs., 10 inches tall, quackgrass 2 to 3 lvs., 5 inches tall. Late postemergence June 20, 1988. Temperature 94°F, wind E 5 mph. Corn 10 lvs., 18 inches tall, quackgrass 5 lvs., 6 to 8 inches tall.

Chlorpyrifos Effects on Corn Growth and Yield

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The reported growth and yield enhancements in Lorsban treated plots from Illinois were of such interest that the follow studies were attempted. The reported increased leaf area and increased root mass when "T band" applications of Lorsban were made also suggested a fungicidal effect. Therefore it was our desire to reproduce the reported effects and attempt to determine if root populations of Fusarium species were affected. Two corn lines Pioneer 3737 and the hybrid from the cross A632 X LH38 were planted and observed in 1988.

Stand, height, weight, leaf area and other measurements are presented for several dates. Ear development and cob data are presented for the Waseca location. Seedling roots were observed for Fusarium species present at the 4-6 leaf stage.

The results of 1988 are clearly most affected by the extreme drought and heat. Corn yields at Waseca were 60% of a normal year and Rosemount yields were even lower. Waseca rainfall for May, June and July was 1.77, 3.13 and 3.41 inches below average while at Rosemount rainfall was 3.21, 0.11 and 2.33 inches total/month. A 1.04 inch rain on May 9 was followed with 6 rain events of 0.34, 0.1, 0.05, 0.06, 0.78 + 0.44 inches until 7/20 when a 1.01 inch of rain was recorded. This Rosemount plot did not have an adequate soil moisture reserve such as Waseca and the period from early May through mid July (approximately 60 days) was too great a stress to allow for normal corn development. The trend of fewer Fusarium colonies per primary seedling root was observed with both corn lines when nematodes were not observed on roots.

A similar stress environment (Temp and Moisture) was present at Waseca yet better corn growth was obtained. Fusarium colonization of primary roots was much more variable at Waseca and this may be due to nematode activity. The greatest number of nematodes were observed in A632 x LH38 treated with Lorsban and some were also observed on roots from Pioneer 3737 treated with Lorsban while none were observed when either hybrid was grown without Lorsban. The nematode observations were made on roots when plated on PCNB agar. No identification was attempted. It is of interest that the greatest # of roots free of Fusarium infection was in the Lorsban treated plots and highest Fusarium colonization was recorded when nematodes were present. This interaction is consistent with Fusarium colonization data and rootworm damage/feeding recorded later in the growing season.

This data set is very limited and was not significant at the 50% level for any paired comparisons tested. Drought and heat were the major factors in 1988 plot studies.

Table 1. Waseca Data Table Planted 4/29.

	Pioneer 3737		A632 x LH38	
	Lorsban	None	Lorsban	None
May 20				
Stand (plants/17.5′)	26.0	27.5	20.0	19.0
Shoot Height (cm)	6.9	7.1	6.9	6.6
Leaf Dry Weight (gm)	1.0	0.9	1.0	0.9
Root Dry Weight (gm)	1.2	1.2	1.4	1.4
Total Leaf Area (cm^2)	156	154	150	144
Fusarium Colonies/10 cm[a]	2.0	1.5	5.0	1.0
June 15				
Shoot Height (cm)	81.6	77.3	77.7	76.1
Root Length (cm)	24.4	26.6	23.0	23.0
Root Wet Weight (gm)	14.4	14.1	15.5	16.6
Root Dry Weight (gm)	3.75	3.81	4.12	4.35
Total of Area (cm^2)	914	876	1099	1020
Harvest 9/21				
% Plants with 1st Ear	100	100	98	100
% Plants with 2nd Ear	10	14	0	3.5
Plant Height (cm)	175	173	173	173
Ear Leaf Area (cm^2)	378	395	415	319
Yield (Bushel)	81.5	78.7	79.1	89.1
Cob Data				
Rows/Ear	16.7	16.9	15.3	15.1
Kernels/Row	30.0	31.1	32.8	31.8
Cob				
Length (cm)	16.0	16.9	17.1	17.0
Weight (gms)	132.3	154.7	158.1	153.3
Kernel Weight (gms)	.254	.249	.284	.299
# Kernels/50 cm	154.2	160.0	142.0	134.2

[a] No rootworm damage evident but nematodes were present in some plots. Pioneer 3737 with Lorsban had 50% of the samples free of Fusarium. Nematodes were present in A632 x LH38 with Lorsban.

Table 2. Rosemount Data Table Plant May 5.

	Pioneer		A632 x LH38	
	Lorsban	None	Lorsban	None
May 27				
Stand (plants/17.5')	28.8	29.0	22.7	23.3
Shoot Height (cm)	14.8	14.4	14.4	13.9
Root Length (cm)	14.6	13.7	12.9	12.7
Root Wet Weight (gm)	1.3	1.2	1.3	1.3
Root Dry Weight (gm)	0.32	0.30	0.36	0.38
Total Leaf Area (cm^2)	16.0	15.1	17.0	17.3
Fusarium Colonies/10 cm[a]	3.4	4.8	4.6	5.4
June 3				
Stand (Plants/17.5')	28.9	28.9	23.6	23.6
Shoot Height (cm)	29.9	29.0	30.7	32.2
Root Length (cm)	20.9	18.9	20.5	19.6
Root Wet Weight (gm)	6.6	6.0	6.4	6.8
Root Dry Weight (gm)	1.39	1.28	1.30	1.31
Total Leaf Area (cm^2)	83.9	77.4	77.0	79.1
June 17				
Shoot Height (cm)	79.6	81.4	83.5	84.1
Root Length (cm)	25.2	24.1	21.8	24.3
Root Wet Weight (gm)	15.5	17.6	18.9	21.3
Root Dry Weight(gm)	2.73	3.02	3.05	3.55
Leaf/Area (cm^2)	1074	1102	1331	1299
Mature Plants				
% Plants with Ear	86	83	49	57
Ear Leaf Area (cm^2)	413	393	418	430
Plant Height (cm)	173	173	163	163
Yield Not Harvested	--	--	--	--

[a] No rootworm damage and no evidence of nematodes in the samples.

I) Corn/Soybean Rotations

A. Ten Year Corn/Soybean Rotation. R. Kent Crookston, Harlan Ford, Bill Lueschen and Jim Kurle.

Objectives

The long term effect of various rotations of corn and soybeans has not been investigated. The objectives of this study are: 1) To determine the effect on yield of crop sequences of one to five years of corn following soybeans or one to five years of soybeans following corn and 2) to investigate possible sources of yield differences resulting from different crop sequences. Rotation sequences for both Lamberton and Waseca are illustrated in Table 1.

Procedure

The design of the study consists of 16 treatments arranged in a randomized complete block design replicated four times. The sixteen treatments (Table 1) are:

1) 1 to 4 years of corn following 1 to 4 years of soybeans (ssssc, ssscc, sscсc, scccc).
2) Continuous corn for the duration of the study (ccccc-7 or 8 years) and 5 years of continuous corn following soybeans (ccccc-5 years).
3) 1 to 4 years of soybeans following 1 to 4 years of corn (cccсs, cccss, ccsss, cssss).
4) Continuous soybeans for the duration of the study (sssss-7 or 8 years) and 5 years of continuous soybeans following corn (sssss-5 years).
5) Continuous corn with hybrids rotated.
6) Continuous soybeans with varieties rotated.
7) Corn/Soybean (scscs) and soybean/corn rotation (cscsc) in alternate years.

Hybrids or Varieties

The prinicipal soybean varieties grown are Hodgson 78 and BSR 101. (Prior to 1986 only Hodgson 78 was grown). They are alternated with Corsoy 79 in treatment 16. The principal corn hybrid grown is Pioneer 3737 which is alternated with Pioneer 3732.

Waseca - Cultural Practices

The study area was moldboard plowed in the fall of 1987 and field cultivated in the spring of 1988. Fertilizer application consisted of N applied as urea at the following rates;

a) 175# N/A to corn following corn.
b) 150# N/A to corn following soybeans.

Because soil test indicated that the soil phosphorous level was 95 lb/A and the soil potassium level was 439 lb/A, no P or K was applied. pH was 7.0. Weed control was maintained by application of Lasso (3.5 lb ai/A) and Lorox (1.5 lb ai/A) applied for preemergence weed control. Plots were also cultivated and hand weeded as necessary. Counter (8oz/1000 ft of row) was applied at planting to plots where corn followed corn. Because of an outbreak of two spotted spider mites, Lorsban insecticide was applied to corn and soybean plots on 28 July at .5 lb/acre.

Plots at Waseca are four rows 55 feet long planted at 30" row spacing. Corn plots are planted to a single hybrid in all rows. 104 feet of row (2 rows) are harvested. Soybean plots consist of four rows 26 feet long. The plots are split at 27 feet for the planting of the two soybean varieties. 48 feet of row are harvested in each variety. Corn plots were planted on 2 May and harvested on 26 September. Soybean plots were planted on 6 May and harvested on 26 September.

Lamberton

The study area was moldboard plowed in the fall of 1987 and disked in the spring of 1988. Fertilizer application consisted of:

Nitrogen - 125 lb/A
Phosphorous - 100 lb/A
Potassium - 100 lb/A

applied in the spring. Soil test indicated soil P level of 49 lb/A and a K level of 245 lb/A. Soil pH was 5.9. Weed control was maintained by application of Lasso (3 lb ai/A) and Lorox (1.5 lb ai/A) applied preemergence.

Furadan was applied at planting (8oz/1000 ft of row) for corn rootworm protection on all plots where corn followed corn. Because of an infestation of two spotted spider mites, Capture insecticide was applied to corn and soybean plots on 30 July at 8oz/acre.

Plots at Lamberton are twelve rows 32' long planted at 30" row spacing. Corn plots are planted to a single hybrid. Soybean plots are split lengthwise and four rows are planted to each soybean variety. The 2 center rows which are 25-feet long (125ft^2), are harvested for each crop.

Corn plots were planted on 7 May and harvested on 27 September. Soybean plots were planted on 10 May and harvested on 4 October.

Corn Rootworm and Nematode Observations

The plots at both Lamberton and Waseca were surveyed for corn rootworm damage on 4 August. Five plants were taken from each plot in the four treatments; ccccc (5 years), cscsc, ssssc, and ssscc. The roots were washed and rootworm damaged evaluated on a scale of 0 to 5 with "0" indicating no damage and "5" indicating severe root pruning by rootworm.

Soil samples from both locations were analyzed by the University of Minnesota plant disease clinic for the presence of plant parasitic nematodes. Soil samples were taken from soybean plots at both Waseca and Lamberton in early Auguest and mid September. Soil samples were taken from corn plots only at Waseca and were taken after harvest in early October.

Results and Discussion

The growing season at both Lamberton and Waseca was unusually hot and dry. In addition soybean plots at both locations were damaged by an infestation of two spotted spider mites. As a result corn and soybean yields at both locations were reduced by 30 to 50% from average yields.

Corn

For corn (Table 2 and 3) the overall yield reduction did not effect the yield relationship among sequences in previous years. At both locations the planting of corn the first year after four years of soybeans (ssssc) resulted in a 21% average yield increase when compared to corn grown continuously for five years (ccccc-5 years). The second year of corn (cccss) produced lower yields than the continuous corn sequence. Growing corn in alteration with soybeans produced inconsistent results, which is similar to the experience of previous years. At Waseca corn alternated with soybeans yielded 27% more than continuous corn. At Lamberton yields of the soybean-corn alteration were 1% less than continuous corn. Analysis of variance combined over locations indicated that the main effects, rotation sequence and block were significant (Table 4a and 4b). The interaction of block by sequence was also significant. The significant effect involving block has occurred in previous years and is the result of fertility gradients at both locations and in wet years is compounded by a drainage problem in one replicate at Waseca. Analysis of variance indicated no significant difference for rotation sequence at either location.

None of the four nematode genera detected at Waseca (Table 8) were present in numbers thought to be large enough to cause yield losses. However, there were significant differences between sequences for two genera, Paratylenchus and Pratylenchus. Pratylenchus was present in significantly greater numbers following continuous corn (ccccc) than in the other three sequences sampled. Paratylenchus was present in significantly higher numbers on the first year of corn following soybeans (ssssc) than in the other three sequences sampled.

Corn rootworm damage was observed at low levels in the four rotation sequences sampled at both locations (Table 9). There were significant differences among rotation sequences at both Waseca and Lamberton and when locations were combined. The lowest levels were observed in first year corn. The highest average levels were observed in continuous and second year corn (ccccc and ssscc.)

Soybeans

In soybeans (Table 5 and 6) the yield increase noted in previous years when soybeans were grown after four years of corn was not observed. Instead continuous soybeans produced the highest yields in three of the variety X location combinations. The main effect of crop sequence was significant in the analysis combined over locations (Table 7a and 7b). The effect of blocks (reps) was also significant as a result of the mite infestation at both locations. Analysis of variance by location indicated that the main effect of block was significant at both locations and that the variety by rotation interaction was significant at Waseca.

Soybean Nematode Observations

Five genera of nematodes were detected at Waseca (Table 11) including soybean cyst nematode (Heterodora). However, of the five genera reported only Paratylenchus was present in numbers large enough to be considered significant and then only in the continuous soybean areas (sssss). The population differences did not appear to be related to yield differences. Soybean cyst nematode was present only in continuous soybean plots in two replicates.

At Lamberton (Table 12) Pratylenchus was present in moderate numbers while Paratylenchus was almost absent. Soybean cyst nematode was not detected at Lamberton.

Table 1. Treatments applied to plots in ten year rotation study. Study began at Lamberton in 1981 and at Waseca in 1982.

Waseca	82	83	84	85	86	87	88	89	90	91
Lamberton	81	82	83	84	85	86	87	88	89	90
TREATMENT #										
1	C	C	C	C	C	SB	SB	SB	SB	SB
2	SB	C	C	C	C	C	SB	SB	SB	SB
3	SB	SB	C	C	C	C	C	SB	SB	SB
4	SB	SB	SB	C	C	C	C	C	SB	SB
5	SB	SB	SB	SB	C	C	C	C	C	SB
6	SB	SB	SB	SB	SB	C	C	C	C	C
7	C	SB	SB	SB	SB	SB	C	C	C	C
8	C	C	SB	SB	SB	SB	SB	C	C	C
9	C	C	C	SB	SB	SB	SB	SB	C	C
10	C	C	C	C	SB	SB	SB	SB	SB	C
11	C	C	C	C	C	C	C	C	C	C
12	SB	SB	SB	SB	SB	SB	SB	SB	SB	SB
13	C	SB	C	SB	C	SB	C	SB	C	SB
14	SB	C	SB	C	SB	C	SB	C	SB	C
15*	C	C*	C	C*	C	C*	C	C*	C	C*
16*	SB	SB*	SB	SB*	SB	SB*	SB	SB*	SB	SB*

*Alternate hybrid or variety.

	Regular	Alternate
Corn	Pioneer 3780	Pioneer 3732
Soybeans	Hodgson 78 BSR 101	Corsoy 79

Table 2. Long Term Corn Soybean Rotation Waseca - 1988: Corn Yields.

Rotation Cycle	Yield bu/acre	Yield as % of ccccc(5yr)
ssssc	95	124
ssscc	75	98
sscсc	85	111
scccc	86	112
ccccc(5yr)	77	100
ccccc(7yr)	73	95
cscsc	97	127
ccccc*	78	102

*Alternate hybrids. In 1988 the hybrid planted was P3737.

Table 3. Long Term Corn Soybean Rotation Lamberton - 1988: Corn Yields (P3737).

Rotation Cycle	Yield bu/acre	Yield as % of ccccc(5yr)
ssssc	100 a**	118
ssscc	83 a	88
sscсc	90 a	106
scccc	80 a	94
ccccc(5yr)	85 a	100
ccccc(8yr)	84 a	99
cscsc	86 a	101
ccccc*	78	

*Alternate hybrids. In 1988 the hybrid planted was P3737. The yield is given for purposes of comparison only.

Table 4a. Long Term Corn - Soybean Rotation - 1988: Corn Yields Corn Yields Combined Over Locations. Alternate Varieties are not included.

Rotation Sequence	Yield bu/acre	Yield as % of ccccc(5yr)
ssssc	97 a	120
ssscc	79 b	98
sscccc	87 ab	107
scccc	83 ab	102
ccccc(5yr)	81 ab	100
ccccc(7yr)	78 b	96
cscsc	92 ab	114

Table 4b. Analysis of Variance for Long Term Corn Soybean Rotation at Waseca and Lamberton - 1988: Corn Yields.

a) Analysis by location (Waseca includes alternate hybrid)

Source	Lamberton bu/acre	Waseca bu/acre
Rep	*	ns
Rotation	ns	ns

b) Analysis with locations combined. Includes ssssc, ssscc, ssccc, scccc, ccccc(5yr), ccccc(7 or 8yrs) and cscsc rotations.

Source	bu/acre
Rep (B)	*
Location (L)	ns
Error a	--
Rotation (R)	*
B * R	*
L * R	ns
Error b	--

Table 5. Long Term Corn Soybean Rotation Waseca - 1988: Soybean Yields.

Rotation Cycle	BSR 101 bu/acre	Yield as % of sssss(5 yrs)	Hodgson 78 bu/acre	Yield as % of sssss(5 yrs)
ccccs	34	93	33	107
cccss	32	89	33	105
ccsss	34	94	27	86
cssss	25	70	28	89
sssss(5 yr)	36	100	31	100
sssss(7 yrs)	29	81	28	88
scscs	29	80	25	82
sssss*	30	83	26	83

*Alternate varieties. In 1988 the variety planted was Hodgson 78.

Table 6. Long Term Corn Soybean Rotation Lamberton - 1988: Soybean Yields.

Rotation Cycle	BSR 101 bu/acre	Yield as % of sssss(5 yrs)	Hodgson bu/acre	Yield as % of sssss(5 yrs)
ccccs	29	89	31	93
cccss	33	99	29	87
ccsss	34	104	30	91
cssss	32	96	28	86
sssss(5 yr)	33	100	34	100
sssss(8 yrs)	28	86	28	83
scscs	28	86	33	99

Table 7a. Long Term Corn Soybean Rotation - 1988: Soybean Yields Combined Over Locations. Alternate varieties are not included.

Rotation Sequence	BSR101 bu/acre	Hodgson 78 bu/acre	$\bar{x}$ bu/acre	Yield as % of ccccc(5yr)
ccccs	32	32	32 ab	97
cccss	32	31	32 ab	97
ccsss	34	29	32 ab	97
cssss	28	28	28 b	85
sssss(5yr)	34	32	33 a	100
sssss(7yr)	29	28	29 b	88
scscs	29	29	29 b	88

Table 7b. Analysis of Variance for Long Term Corn Soybean Rotation at Waseca and Lamberton - 1988: Soybeans.

a) Analysis by location (Waseca includes alternate variety).

Source	Lamberton bu/acre	Waseca bu/acre
Rep (B)	*	*
Rotation (R)	ns	ns
R x B -Error A	--	--
Variety (V)	ns	ns
V x R	ns	*
B x V x R -Error B	--	--

b) Analysis with locations combined. Includes ccccs, cccss, ccsss, cssss, scscs, sssss(5 yr) and sssss(7 or 8 yrs) rotations.

Source	bu/acre
Rep (B)	*
Location (L)	ns
B(L) -Error A	--
Rotation (R)	*
L x R	ns
B(L x R) -Error B	--
Variety (V)	ns
L x V	ns
R x V	ns
L x R x V	ns
B(L x R x V) -Error C	--

Table 8. Corn Nematode populations in soil at Waseca in 1988.

Sequence	Paratylenchus	Pratylenchus	Helicotylenchus	Xiphenema
ccccc	18 b*	346 a	114 a	0 a
cscsc	3 b	80 b	115 a	0 a
ssscc	31 b	32 b	32 a	3 a
ssssc	78 a	97 b	21 a	0 a

*Values followed by same letter are not significantly different at a=.05 level of significance.

Source	Waseca
Rep	n.s
Sequence	**

Table 9. Corn Rootworm damage observed at Lamberton and Waseca in 1988. Scale of 0 to 5 0= no damage, 5 = severe damage.

Sequence	Locations Lamberton	Waseca	$\overline{X}$
ccccc	2.2 ab*	2.1 a	2.2 a[1]
cscsc	1.9 bc	2.1 a	2.0 a
ssscc	2.4 a	2.0 a	2.2 a
ssssc	1.6 c	1.3 b	1.4 b

*Values followed by same letter are not significantly different at a=.05 level of significance when analyzed within locations.

[1]Multiple comparison of means combined over locations.

Table 10. Analysis of variance within locations and combined over locations for corn rootworm damage observations in 1988.

Source	Lamberton	Waseca
Rep	n.s	n.s
Sequence	**	**

Source	bu/acre
Rep (B)	ns
Loc (L)	ns
B x L (Error A)	--
Sequence (S)	**
B x S	ns
L x S	ns
B x L X S (Error B)	--

n.s. - not significant

Table 11. Soybean Nematode populations in soil at Waseca in 1988.

A) August Observation

Sequence	Paratylenchus	Pratylenchus	Helicotylenchus	Xiphenema	Heterodora
sssss	952 9*	15 b*	16	0	14
scscs	115 b	62 a	28	6	0
cccss	29 b	2 b	32	5	0
ccccs	4 b	30 ab	41	9	0
lsd	305	42			

B) September Observation

Sequence	Paratylenchus	Pratylenchus	Helicotylenchus	Xiphenema	Heterodora
sssss	1472 a	28 b	10	0	21
scscs	37 b	166 a	29	0	0
cccss	29 b	22 b	40	0	0
ccccs	5 b	54 b	36	6	0
lsd	528	52			

*Means followed by same letter are not significantly different at the 0.5 level of significance when analyzed within an observation date.

Table 12. Soybean Nematode populations in soil at Lamberton in 1988.

A) August Observation

Sequence	Paratylenchus	Pratylenchus	Helicotylenchus	Xiphenema	Heterodora
sssss	2.5	226	11	6	0
ccccs	0	524	10	15	o

B) September Observation

Sequence	Paratylenchus	Pratylenchus	Helicotylenchus	Xiphenema	Heterodora
sssss	0	260	65	5	0
scscs	3	285	27	0	0
cccss	0	307	26	36	0
ccccs	0	392	21	11	0
lsd					

B. Six Year Corn Soybean Rotation Study R. Kent Crookston, Harlan Ford, Bill Lueschen, and Jim Kurle.

Objectives

The short term (6-year) rotation studies were established to supplement the long term (10-year) rotation studies planted at Waseca and Lamberton. This study consists of rotation sequences which are not present in the long term study.

Procedures

Corn hybrid, P3780, and soybean variety, Hodgson 78, were planted at all locations. The treatment arrangement at all locations is given in Tables 1 and Table 2.

Lamberton - The plots were chisel plowed in the fall. Fertilizer consisted of 125 lb/A of N applied as urea side dressed on the plots. 100 lb/A of P and 100 lb/A of K was applied to the plots. Herbicide application consisted of Lasso (2.5#/A) and Lorox (1.5#/A) applied preemergence. Furadan (8 oz/1000 ft of row) was applied at planting for corn rootworm control. Capture (8 oz/A) was applied on 30 July for control of two-spotted spider mites in both corn and soybeans. Corn plots were planted on 7 May and harvested on 27 September. Soybean plots were planted on 10 May and harvested on 4 October.

Waseca - The plots were chisel plowed in the fall of 1987and field cultivated in the spring. Fertilizer consisted of N applied as urea at the following rates:
a) 175# N/A to corn following corn.
b) 150# N/A to corn following soybeans.
No P or K was applied. Weed control consisted of herbicide applications of Lasso (3.5 lb ai/A) and Lorox (1.5 lb ai/A) applied preemergence. Plots were cultivated and hand weeded as necessary. Counter (8 oz/1000 ft row) was applied at planting to plots where corn followed corn. Lorsban indecticide was applied to corn and soybean plots on 28 July at .5 lb/Acre. Corn plots were planted on 2 May and Harvested on 26 September. Soybean plots were planted on 6 May and Harvested on 26 September.

Rosemount - The plots were chisel plowed in the fall of 1987. Fertilizer consisted of 180#/A N applied as ammonium nitrate to corn following corn and 160#/A to corn following soybeans. No P or K was applied. Counter (8 oz/1000 ft of row) was applied as insecticide on previous corn areas. The plots were irrigated once at silking. Plots were planted on 4 May and and harvested on 13 September.

Results

The effect of crop sequence on yield was not consistent among locations for either corn or soybeans. Yields were reduced by as much as 30% for both corn and soybeans when compared to average yields from the past five years in this study. Corn yields (Table 1) were highly variable with CV's of 25% and 26% at Rosemount and Waseca and for this reason were analyzed only within locations.

At Rosemount there were no significant differences between crop sequences although continuous corn yielded 15% more than corn grown for two years after soybeans and 4% more than corn grown in alternation with soybeans.

At Waseca there were also no significant differences among the three crop sequences although continuous corn yielded 26% more than the second year of corn after soybeans and 15% less than corn grown in alternation with soybeans.

At Lamberton continuous corn yielded 30% less than either of the sequences containing soybeans. The yield difference was significant.

There were no significant differences between crop sequences for soybeans (Table 2) when compared within locations or with locations combined. The effect of location was significant in the combined analysis.

Table 1. Corn yields of 6 year corn soybean rotation - 1988.

Sequence	Lamberton		Rosemount		Waseca	
	bu/Acre	% of ccccc	bu/Acre	% of ccccc	bu/Acre	% of ccccc
ccccc	54 b*	100	82 a	100	85 a	100
ccscc	70 a	130	70 a	85	63 a	74
cscsc	71 a	131	79 a	96	98 a	115
$\bar{X}$	65		77		82	
CV	12%		25%		26%	
LSD	14		34		37	

* Yields followed by same letter not significantly different at 5% level when compared within location.

Analysis of variance over locations for corn yields

Rep (B)	n.s.
Location (L)	n.s.
Error a	- -
Sequence (S)	n.s.
R x S	n.s
L x S	n.s.
Error b	- -

n.s. = Not Significant

Table 2. Soybean yields of 6 year corn - soybean rotation - 1988.

Sequence	Lamberton bu/Acre	Lamberton % of sssss	Rosemount bu/Acre	Rosemount % of sssss	Waseca bu/Acre	Waseca % of sssss
sssss	35a	100	22 a	100	27 a	100
sscss	32a	91	24 a	109	25 a	93
$\bar{X}$	33		23		26	
CV	10%		7%		4%	
LSD	7		4		2	

* Yields followed by same letter not significantly different at 5% level when compared within location.

Analysis of variance over locations for soybean yields.

Rep (R)	n.s.
Location (L)	**
B x L Error a	
Sequence (S)	n.s.
R x S	n.s
L x S	n.s.

** = Highly significant n.s. = Significant at 5% level.

INFLUENCE OF EXPERIMENTAL DESIGNS ON ON-FARM TRIAL INTERPRETATIONS

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ABSTRACT

Experimental designs used in on-farm research trials are largely responsible for the precision of the research results. Three experimental designs (unreplicated strip, unreplicated strip with "tester", and randomized complete block (RCB)) were compared from modeled uniformity trial data from four uniformity trial experiments in the Upper Midwest and from seven field trials conducted in Minnesota (Schmitt and Openshaw, 1988). True error variances were 20-45% less for the RCB (3 reps) compared to the strip design. The strip with "tester" design's true error was highest. Treatment mean differentiation based on either a set confidence interval or least significant differences (LSD) was directly correlated to the relative size of the error terms. Field results from 1988 indicate that the RCB (2 reps) estimated error was 25-50% less than the strip design. There were no differences between the strip and strip with "tester" design errors in the field trials conducted at University of Minnesota Agricultural Experiment Stations at Waseca and Lamberton and five on-farm trials.

INTRODUCTION

On-farm research trials provide information used to make decisions affecting the productivity and profitability of a farming operation. Virtually all practices and products warrant on-farm trials because their effects depend heavily on the management and environment of each farm. Because these two components are unique to each farm, research results conducted by neighbors, local farm groups, private companies, and university research are not always directly transferable.

As the trend develops to place increasing emphasis on on-farm trials, the validity of these trial results must be emphasized. The role of experimental design and statistics in determining trial validity is often neglected, yet without validity, interpretation of results have little impact. In conducting on-farm large-plot research trials, the experimental design is often determined by logistical convenience rather than by statistical desirability.

On-farm trials cannot be expected to involve intricate experimental designs that researchers may use under controlled station plots. Those designs are impractical and probably unnecessary in order to provide useful, interpretive results. Although many basic designs have been suggested for on-farm trials, no data has compared designs with respect to their error terms or final interpretations.

The objectives of this project are two-fold. First, we want to compare the precision of three experimental designs used in large-plot research. Second, we want to investigate how experimental design might affect interpretation of the results.

MATERIALS AND METHODS

Two sources of data were used. One set of data is from four uniformity trials previously conducted by other researchers at land grant universities in the Upper Midwest. The second pool of data--which will be reported here--was collected from a series of field trials established for the purpose of this project.

Three basic experimental designs commonly used in large plot, on-farm trials were compared. These three designs are: 1) a nonreplicated strip (strip), in which the number of plots equals the number of treatments, 2) a nonreplicated strip that has a common treatment placed in every second or third plot (strip with "tester"), in which the number of plots equals the number of treatments times (2 or 1.5) plus 1, and 3) a randomized complete block (RCB), in which the number of plots equals the number of treatments times the number of replications.

The experimental design used in the field trials (Figure 1) incorporated each of the three experimental designs investigated in this study. Five of the locations in Minnesota were on farmers' fields, with each plot having a width of 30 feet and a length from 330 to 1320 feet. Two sites were at University of Minnesota experiment stations, the width was 10-15 feet and the length between 100 and 200 feet. All of the sites were selected based on visual uniformity of the soil.

Management practices were followed at each site that were parallel to that practiced by top corn producers. There were five treatments at each location, consisting of different hybrids: Pioneer brands 3737, 3751, 3732, 3585, and XC272. Pioneer brand 3737 was used as the "tester" in the strip with "tester" design. Grain yields were measured after physiological maturity using a combine and weigh wagons, and grain yields were adjusted to 15.5% moisture.

Approximate errors associated with the three experimental designs were estimated. One main assumption of the analysis is that the size and number of plots do not change depending on the experimental design used. So for the design in Figure 2, assume there are 18 plots (rather than 19 for mathematical logistics), providing the space for 18 treatments in a strip design, 12 treatments in a strip with "tester" design using a "tester" in every third plot, and 9 treatments in an RCB with the minimum of 2 replications.

The error variance for a strip design having as many treatments as there are strips can be approximated by calculating the residual mean square from a completely random design (CRD) analysis (Eq. 1) that used the unadjusted yields of the nontester plots. By using a CRD, only the treatment effects are partitioned from the trial variance--not any block effects.

Eq. 1: $$S^2 = \sum_{1}^{n} \sum_{1}^{r} (X_{ij} - \overline{X}_{i.})^2 / n(r-1)$$

The strip with "tester" design's error variance is approximated in a similar manner as the strip design's error. First, however, the yields are adjusted according to Eq. 2. The adjusted yields for the nontester hybrids are then used in a CRD analysis, partitioning out the treatment effect, resulting in the error variance associated with the total plot area as if a strip with "tester" design were used (Eq. 3).

Eq. 2: $X^{I} = X - (9.667)t_{left} + (.333)t_{right}) + t..$, when the tester to the left is adjacent to the treatment

$X - ((.333)t_{left} + (.667)t_{right}) + t..$, when the tester to the right is adjacent to the treatment

Eq. 3: $S^2 = \sum_{1}^{n} \sum_{1}^{r} (X^{I}_{ij} - X^{I}_{i.})^2/n(r-1)$

The estimated experimental error for a RCB design can only be given as a range based on the assumption that there can be 2 replicates of 9 treatments in the given plot area. The error variance associated with the 1 block of 9 plots is the experimental error of a treatment mean for those 9 plots. By analyzing the unadjusted treatment means as an RCB (with 3 blocks, as the design is laid out), the residual mean square is actually the error associated with 6 plots of a strip design. The estimated error variance for 9 plots will lie between the estimates for 6 and 18 plots. With 2 replicates, the error variances are divided by 2 to obtain the error associated with a treatment mean.

RESULTS AND DISCUSSION

Field data:

Calculated error variances from the 7 field locations are reported in Table 1. When the analysis was made without adjustmeant for the "testers", simulating a strip design, the range of the unreplicated error variance of a treatment mean was 18.6-91.3. If the treatment means were adjusted for the "tester", the error variance of a treatment mean ranged from 3.2-110.8. The mean of the error variances were almost identical (51.2, 51.0) when combined over locations. There was a wide range of error variances between locations while the relative relationship between the two analyses was similar. The severe drought throughout Minnesota created large variations in yields among locations.

Table 1. Treatment mean error variances as affected by experimental design, 1988.

Location	Strip	Strip w/"Tester"	R.C.B.
			--range--
Woodlake	18.7	3.2	3.3- 9.3
Litchfield	22.0	64.9	11.0-12.2
Utica	30.6	35.9	14.0-15.3
Hector	59.4	51.5	15.0-29.7
Sleepy Eye	59.5	11.4	4.8-29.7
Waseca-AES	91.3	110.8	8.0-45.6
Lamberton-AES	76.9	79.2	30.4-38.4

The error variance of a treatment mean for an RCB design with 2 replicates were estimated to average between 12.5 and 25.6 (Table 2). This represents a reduction in the error variance of 50-75% as compared to the strip design. While the treatment mean error variance is greatly reduced in the RCB design compared to the two strip designs, the compromising factor is that for the given amount of plots, fewer treatments can be evaluated.

Table 2. Mean and range of treatment mean error variances from 7 Minnesota locations as affected by experimental design, 1988.

Design	Plots	Trt	Mean Error Variance
Strip	18	18	51.2
Strip w/"Tester"	18	12	51.0
R.C.B.	18	9	25.6>E>12.5

SUMMARY

Results from the field data provide similar conclusions as those from previous uniformity trial data. In terms of precision, error variances were consistently smaller for the RCB design than for the strip or strip with "tester" designs. The strip with "tester" design did not provide any more precision than the strip design.

The results of this study favor the practice of replication. The precision of error and the resulting interpretations are all enhanced using a replicated design. Although the logistical argument of increased plotwork is generally presented, the confidence in the results should provide the incentive. The amount of time and effort necessary to lay out an on-farm trial using an RCB or strip with "tester" design are not very different, yet the use of the strip with "tester" (or control) design is greater than for the replicated design.

References:

Schmitt, M.A. and S. J. Openshaw. 1988. Influence of experimental designs on on-farm trial interpretations. Paper presented at 1988 American Society of Agronomy meetings, Anaheim, CA.

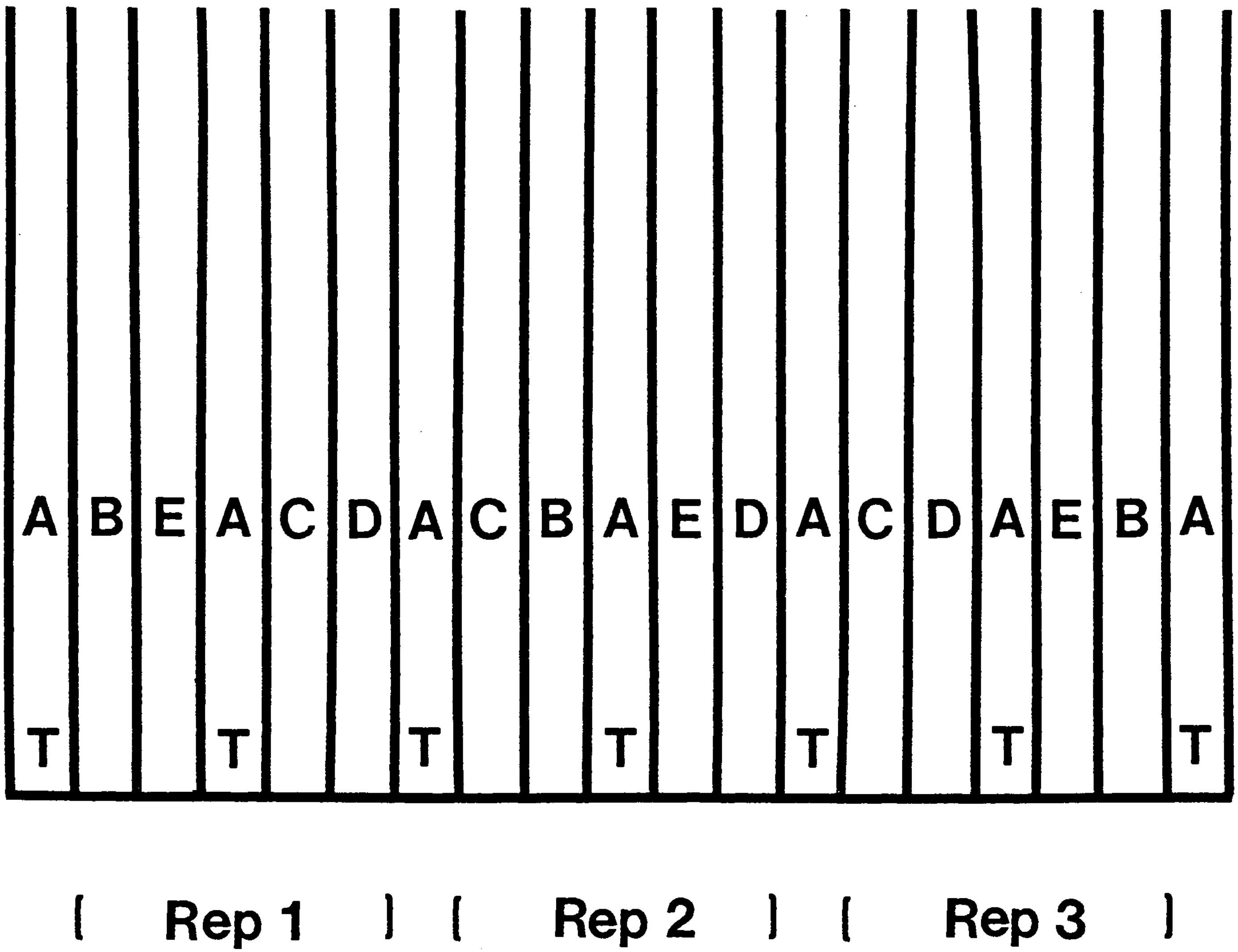

Figure 1. Experimental design used in field trials.

HERBICIDE RESEARCH IN THE CENTER FOR AGRICULTURE IMPACTS ON WATER QUALITY.

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ABSTRACT

In response to the growing concern over groundwater quality in Minnesota, the University of Minnesota Agricultural Experiment Station, the College of Agriculture and USDA-Agricultural Research Service developed the Center for Agricultural Impacts on Water Quality. Studies conducted by the Minnesota Departments of Agricultural and Health from 1985-1987 indicated groundwater contamination by agricultural pesticides in 39% of 725 wells tested. Three areas in the state were identified which are most susceptible to groundwater contamination. The sensitive areas include the Central Sand Plains, the Karst region in the Southeast, and the extreme southwestern counties of Minnesota. These studies indicated that atrazine and alachlor are the most commonly found pesticides in groundwater. Atrazine and alachlor were detected in 95 and 15% of contaminated wells, respectively.

As a result of these studies the center has established research sites in two of the susceptible areas (Westport, Central Sand Plains, and Rochester, Karst region), and in one nonsusceptible area (Waseca, Southcentral Minnesota) in the state. Herbicide research has focused on atrazine, alachlor and dicamba. The three main objectives of herbicide research through the Center are to determine the effect of tillage on herbicide dissipation and leaching in soil, determine the extent of metabolite formation and leaching in soil and determine the effect of macropores on herbicide leaching in soil.

To evaluate the first objective, field studies were initiated in 1986 to determine the effect of tillage on the dissipation and leaching of atrazine, alachlor, and dicamba. Continuous corn is being grown under conventional tillage (moldboard plow), reduced tillage (chisel plow), ridge tillage and no-tillage for 5 years. KBr is applied as a conservative tracer to monitor water movement through the soil. Herbicides are applied as a preemergence tankmix in early May and soil sampling conducted to 1 m seven times per year. Suction lysimeters were placed in each plot at 1.5 and 2.3 m in 1986 and soil samples are taken in 3 week intervals following herbicide application. Soil and water samples are analyzed for herbicide and Bromide concentration. Herbicides are extracted using organic solvents and quantified using gas chromatography. KBr is extracted with water and analyzed using an ion specific electrode. Differences in pesticide leaching was observed between locations, however, no difference between tillages has been observed after one year.

To evaluate the second objective, field studies were initiated in 1986 to determine the extent of atrazine, alachlor and dicamba metabolite formation and leaching at all three locations. PVC pipe (30 x 90 cm) at Waseca and Rochester, and (30 x 128 cm) at Westport were driven into soil plots in the fall of 1986. Radio-labeled atrazine, alachlor and dicamba were applied to separate columns in May 1987. Lysimeters were removed 5 times in 1988 with 2 more times scheduled in 1989. The lysimeters will be divided into 4-inch depth increments. Each increment will be divided into 5 samples. The samples will be extracted for herbicide and metabolites using organic solvents. Quantification of herbicide residues will be conducted using gas chromatography and high performance liquid chromatography.

To evaluate the third objective, greenhouse studies were initiated in 1986 to determine the potential for preferential flow of atrazine and alachlor in root-mediated macropores. Waukegan silt loam soil was seised and uniformly packed into containers (20 x 30 x 60 cm). 'Nitro' alfalfa was planted in half the containers to establish pore structure. After 6 months the alfalfa was killed with glyphosate. Herbicides were applied to separated containers at zero, partial, and complete root decomposition and herbicide movement was compared with containers having no alfalfa. KBr was applied to all columns to monitor water movement through the soil. Immediately following herbicide application 18 liters of water was applied to

displace one pore volume. Soil columns were divided into 5.0 cm^3 samples. Soil samples were extracted with water and Bromide concentration determined using ion specific electrodes. Herbicides were extracted using organic solvents and quantified using liquid scintillation spectrometry. Data indicates greater movement of atrazine and alachlor in columns with roots than without roots.

Wild proso millet control in corn, 1988. Lueschen, William E., Jeffrey L. Gunsolus and Thomas R. Hoverstad. The objective of this study was to evaluate preplant, preemergence and postemergence herbicides for control of wild proso millet and to evaluate influence of time and rate of application of DPX-V9360 and CGA-136872 on control of wild proso millet in corn. This study was conducted on a Webster clay loam soil containing 5.3% organic matter with a soil pH of 5.6 and soil test P and K levels of 110 and 298 lb/A, respectively. A randomized complete block design with three replications and a plot size of 10 by 30 ft was used. The site had been in continuous corn with fall moldboard plowing prior to establishing this experiment. The herbicide in 1986 was EPTC + dichlormid followed by postemergence cyanazine + tridiphane. In 1987, post-emergence cyanazine + tridiphane followed by atrazine + oil concentrate was used on the site. The entire experimental area was field cultivated once to a depth of 4 inches prior to applying any herbicides. Following the application of the preplant incorporated EPTC treatments, the entire experimental area was field cultivated once to a depth of 4 inches. The alachlor and metolachlor preplant treatments were then applied and the entire site was field cultivated once to a depth of 3 to 4 inches. The field cultivator was equipped with 7-inch wide sweeps and a three-bar mulcher. The soil was in ideal condition for herbicide incorporation. Pioneer '3790' single cross hybrid corn was planted on May 4, 1988 at a rate of 27,500 seeds/A. The entire experimental area was treated postemergence with 0.38 lb/A of bromoxynil on May 25, 1988 which resulted in excellent broadleaf weed control. Extremely hot, dry conditions were experienced in May and June with rainfall 4.9 inches below normal for these two months and temperatures averaged 7.3 and 6.8 F above normal for the two months, respectively. When the postemergence treatments were applied on June 14, 1988, the wild proso millet and the corn were exhibiting moisture stress symptoms from the dry soil and high temperatures. The wild proso millet was beginning to head when the treatments were applied on June 14, 1988. None of the treatments were cultivated. The plots were evaluated for weed control and crop injury but no yield data was obtained. Application dates, sprayer settings, environmental conditions, plant sizes and rainfall data are listed below:

Date	May 4	May 11	May 27	June 8	June 14
Treatment	PPI or Pre	L. Pre	E. Post	Post	L. Post
Sprayer					
gpa	20	20	20	20	20
psi	30	30	30	30	30
Temperature (F)					
air	76	73	82	80	91
soil (4 inch)	60	59	80	81	84
Soil moisture					
Wind (mph)	5-10E	5-10S	0-5S	10-15E	10-15S
Sky	clear	P. cloudy	P. cloudy	clear	clear
Relative humidity(%)	20	30	61	48	30
Corn					
leaf no.	--	--	3	5-6	8
height (inch)	--	--	6	12	18
Wild proso millet					
leaf no.	--	--	0.5-2	4-6	5-8
height (inch)	--	--	2-3	6	6-14
infestation	5 ft^2	5 ft^2	5 ft^2	5 ft^2	5 ft^2
Rainfall after application (inches)					
1 week	1.9	0.0	0.3	0.0	0.3
2 week	0.0	0.3	0.0	0.3	0.2
3 week	0.3	0.3	0.2	0.2	0.0

Cyanazine + vegetable oil applied on May 27, 1988 caused slight stunting and yellowing of the corn but the injury did not persist. Postemergence DPX-V9360 and CGA-136872 with surfactant caused stunting and leaf malformation. The highest levels of injury with these two herbicides were associated with treatments applied on June 8 and June 14, 1988. With CGA-136872, degree of injury was associated with rate of application for the early postemergence treatments but this was not true for the other stages of application. Injury with DPX-V9360 was not rate dependent. EPTC + dichlormid and EPTC + dichlormid + dietholate generally resulted in 60 to 70% control of wild proso millet. Where alachlor at 3 lb/A preemergence was applied following preplant EPTC + dichlormid + dietholate at 6 lb/A, control of wild proso millet was increased to 90 to 99%. Metolachlor at 2.5 lb/A preemergence following this same EPTC treatment, improved control of wild proso compared to the EPTC + dichlormid + dietholate applied alone at 6 lb/A. However, control was generally not as good as where alachlor was applied preemergence following preplant EPTC + dichlormid + dietholate. Alachlor applied at 4 lb/A preemergence on May 4 followed by an additional 2 lb/A on May 11, 1988 provided nearly 90% control of wild proso millet. Where metolachlor was applied at 2 lb/A preplant incorporated followed by an additional 2 lb/A preemergence, wild proso millet control was only 50 to 60%. All rates of DPX-V9360 applied on May 27 gave more than 90% control of wild proso millet when rated on July 5, 1988. At later application dates, wild proso millet control with DPX-V9360 decreased and there was little response to rate of application. Regardless of the time or rate of application, CGA-136872 provided very poor control of wild proso millet. (Minn. Agric. Exp. Stn., Paper No. 16,450; Misc. Jour. Series, University of Minnesota, St. Paul).

Table. Wild proso millet control in corn, 1988 (Lueschen, Gunsolus and Hoverstad).

Treatment[a]	Rate	Injury 6/13	Injury 6/24	Wild Proso Millet 5/31	Wild Proso Millet 6/13	Wild Proso Millet 6/24	Wild Proso Millet 7/5
	(lb/A or %)	----(%)----		--------(% control)------			
Preplant incorporated applied May 4, 1988							
EPTC + dichlormid	6	3	13	68	63	53	72
EPTC + dichlormid + dietholate	6	0	2	70	57	35	70
Preplant incorporated EPTC + dichlormid + dietholate at 6 lb/A applied May 4, 1988 with the following preemergence applied on May 4, 1988							
Alachlor	6 / 3	0	0	90	94	93	99
Metolachlor	6 / 2.5	2	3	78	84	74	90
Preplant incorporated applied May 4, 1988 / preemergence applied May 4, 1988							
Metolachlor / Metolachlor	2 / 2	0	0	53	55	48	63
Preplant incorporated applied May 4, 1988 / delayed preemergence applied May 11, 1988							
Alachlor / Alachlor	4 / 2	0	3	87	91	84	90
Preplant incorporated EPTC + dichlormid + dietholate at 6 lb/A applied May 4, 1988 with the following postemergence applied May 27, 1988							
Cyanazine	2	0	2	77	78	78	87
Cyanazine + vegetable oil	2 + 1.25%	13	7	85	82	78	85
Cyanazine + pendimethalin	2 + 1.5	3	3	78	84	77	85
Cyanazine + tridiphane	2 + 0.75	0	5	82	89	85	93
Early postemergence applied May 27, 1988							
DPX - V9360 + Surf	0.016 + 0.25%	3	0	69	86	83	92
DPX - V9360 + Surf	0.031 + 0.25%	5	3	60	91	86	92
DPX - V9360 + Surf	0.049 + 0.25%	7	8	65	91	84	93
DPX - V9360 + Surf	0.062 + 0.25%	10	2	58	91	88	94
CGA-136872 + Surf	0.018 + 0.25%	8	8	63	38	23	27
CGA-136872 + Surf	0.027 + 0.25%	10	15	60	32	23	43
CGA-136872 + Surf	0.036 + 0.25%	23	20	55	40	25	42
Postemergence applied June 8, 1988							
DPX - V9360 + Surf	0.016 + 0.25%	--	27	17	35	47	53
DPX - V9360 + Surf	0.031 + 0.25%	--	10	33	47	63	78
DPX - V9360 + Surf	0.049 + 0.25%	--	27	13	50	71	78
DPX - V9360 + Surf	0.062 + 0.25%	--	13	15	43	73	77
CGA-136872 + Surf	0.018 + 0.25%	--	18	0	18	15	0
CGA-136872 + Surf	0.027 + 0.25%	--	15	10	37	33	35
CGA-136872 + Surf	0.036 + 0.25%	--	23	20	17	25	23
Late postemergence applied June 14, 1988							
DPX - V9360 + Surf	0.016 + 0.25%	--	15	30	32	40	65
DPX - V9360 + Surf	0.031 + 0.25%	--	20	47	33	60	72
DPX - V9360 + Surf	0.049 + 0.25%	--	15	22	8	50	77
DPX - V9360 + Surf	0.062 + 0.25%	--	12	33	25	52	73
CGA-136872 + Surf	0.018 + 0.25%	--	18	20	15	20	23
CGA-136872 + Surf	0.027 + 0.25%	--	7	20	17	40	45
CGA-136872 + Surf	0.036 + 0.25%	--	12	0	0	17	48
Checks							
Weedy check	---	0	0	0	0	0	0
Hand-weeded (EPTC + dichlormid 6 lb/A PPI + alachlor 3 lb/A Pre)	---	0	0	84	100	99	100
BLSD (0.05)		7	10	17	24	22	25

[a]Vegetable oil=R-Way, Surf=nonionic surfactant=Ortho X-77

Woolly cupgrass control in corn, 1988. Lueschen, William E., Thomas R. Hoverstad and Jeffrey L. Gunsolus. The objectives of this study were to evaluate preplant incorporated EPTC plus dichlormid with and without dietholate applied alone or in combination with preemergence or postemergence treatments, and to evaluate the effects of time and rate of application of DPX-V9360 and CGA-136872 on control of woolly cupgrass in corn. This study was conducted on a Lester clay loam soil containing 3.4% organic matter with a pH of 6.2 and soil test P and K levels of 45 and 265 lb/A, respectively. The previous crop was soybeans which was heavily infested with woolly cupgrass. Following soybean harvest the site was fall chisel plowed. A randomized complete block design with three replications and a plot size of 10 by 30 ft was used. Prior to applying any herbicide treatments, the site was field cultivated once to a depth of 4 inches. Following the application of the preplant incorporated EPTC treatments, the entire experimental area was field cultivated once to a depth of 4 inches. Alachlor and metolachlor preplant treatments were then applied and the entire site was field cultivated once to a depth of 3 to 4 inches. The field cultivator was equipped with 7-inch wide sweeps and a three-bar mulcher. Pioneer '3790' single cross hybrid corn was planted on May 5, 1988 at a seeding rate of 27,500 seeds/A. The entire experimental area was treated postemergence with 0.38 lb/A of bromoxynil on May 23, 1988 for broadleaf weed control. Extremely dry conditions were experienced in May and June since rainfall was 4.9 inches below normal for these two months and temperatures averaged 7.3 and 6.8 F above normal for the two months, respectively. When the postemergence treatments were applied on June 14 and June 21, 1988, the woolly cupgrass and the corn were exhibiting moisture stress symptoms. None of the plots were cultivated. Plots were evaluated for weed control and crop injury but no yield data was obtained. Application dates, sprayer settings, environmental conditions, plant sizes and rainfall data are listed below:

Date	May 5	May 11	May 27	June 14	June 21
Treatment	PPI or Pre	L. Pre	E. Post	Post	L. Post
Sprayer					
gpa	20	20	20	20	20
psi	30	30	30	30	30
Temperature (F)					
air	75	73	77	91	101
soil (4 inch)	56	60	74	88	94
Soil moisture	moist	moist	dry	very dry	very dry
Wind (mph)	5-10E	10-15NW	10W	10-15SW	10-15S
Sky	clear	clear	clear	clear	clear
Relative humidity(%)	20	30	65	25	25
Corn					
leaf no.	--	--	2	5	5-6
height (inch)	--	--	4	6-10	6-12
Woolly cupgrass					
leaf no.	--	--	1-2	3	5
height (inch)	--	--	0.5-1.5	3-4	5
infestation	15 ft^2	15 ft^2	15 ft^2	15 ft^2	15 ft^2
Rainfall after application (inches)					
1 week	1.4	0.0	0.3	0.6	0.3
2 week	0.5	0.5	0.0	0.3	0.0
3 week	0.0	0.3	0.5	0.0	0.0

Preplant incorporated EPTC + dichlormid at 6 lb/A or EPTC + dichlormid + dietholate at 6 lb/A provided approximately 90% control of woolly cupgrass through July 5, 1988. Preemergence alachlor at 3 lb/A or metolachlor at 2.5 lb/A or early postemergence applications of cyanazine, cyanazine + vegetable oil, cyanazine + pendimethalin or cyanazine + tridiphane following EPTC + dichlormid + dietholate at 6 lb/A did not improve control of woolly cupgrass compared to EPTC + dichlormid + dietholate at 6 lb/A applied alone. This lack of improved control may be attributed to reduced weed flushes caused by dry soil conditions. Metolachlor at 2 lb/A preplant incorporated with an additional 2 lb/A preemergence did not give adequate control of woolly cupgrass. Alachlor applied at 4 lb/A preemergence followed by an additional 2 lb/A 6 days later did not provide acceptable control of woolly cupgrass. None of the postemergence DPX-V9360 + X-77 or CGA-136872 + X-77 treatments provided acceptable control of woolly cupgrass, regardless of the rate or stage of application. Further evaluation of these two compounds for control of woolly cupgrass is necessary because of the adverse environmental conditions experienced when the postemergence treatments were applied. (Minn. Agric. Exp. Stn., Paper No. 16,449; Misc. Jour. Series, University of Minnesota, St. Paul).

Table. Woolly cupgrass control in corn, 1988 (Lueschen, Hoverstad and Gunsolus).

Treatment[a]	Rate	Woolly Cupgrass 5/31	6/13	6/24	7/5
	(lb/A or %)	-------(% control)------			
Preplant incorporated applied May 5, 1988					
EPTC + dichlormid	6	93	90	87	90
EPTC + dichlormid + dietholate	6	92	88	84	82
Preplant incorporated EPTC + dichlormid + dietholate at 6 lb/A applied May 5, 1988 with the following preemergence applied on May 5, 1988					
Alachlor	3	96	89	87	94
Metolachlor	2.5	95	95	89	95
Preplant incorporated applied May 5, 1988 / preemergence applied May 5, 1988					
Metolachlor / metolachlor	2 / 2	73	63	45	55
Preplant incorporated applied May 5, 1988 / delayed preemergence applied May 11, 1988					
Alachlor / alachlor	4 / 2	80	60	48	65
Preplant incorporated EPTC + dichlormid + dietholate at 6 lb/A applied May 5, 1988 with the following postemergence applied May 27, 1988					
Cyanazine	2	96	94	89	92
Cyanazine + vegetable oil	2 / 1.25%	99	90	90	92
Cyanazine + pendimethalin	2 + 1.5	87	89	90	91
Cyanazine + tridiphane	2 + 0.75	97	96	92	94
Early postemergence applied May 27, 1988					
DPX - V9360 + Surf	0.016 + 0.25%	--	68	52	53
DPX - V9360 + Surf	0.031 + 0.25%	--	73	60	58
DPX - V9360 + Surf	0.049 + 0.25%	--	74	68	70
DPX - V9360 + Surf	0.062 + 0.25%	--	77	60	67
CGA-136872 + Surf	0.018 + 0.25%	--	35	22	40
CGA-136872 + Surf	0.027 + 0.25%	--	13	10	17
CGA-136872 + Surf	0.036 + 0.25%	--	47	23	38
Postemergence applied June 14, 1988					
DPX - V9360 + Surf	0.016 + 0.25%	--	22	13	40
DPX - V9360 + Surf	0.031 + 0.25%	--	0	7	15
DPX - V9360 + Surf	0.049 + 0.25%	--	38	38	47
DPX - V9360 + Surf	0.062 + 0.25%	--	15	42	50
CGA-136872 + Surf	0.018 + 0.25%	--	7	7	10
CGA-136872 + Surf	0.027 + 0.25%	--	7	17	17
CGA-136872 + Surf	0.036 + 0.25%	--	35	30	35
Late postemergence applied June 21, 1988					
DPX - V9360 + Surf	0.016 + 0.25%	--	7	10	10
DPX - V9360 + Surf	0.031 + 0.25%	--	0	0	0
DPX - V9360 + Surf	0.049 + 0.25%	--	33	23	35
DPX - V9360 + Surf	0.062 + 0.25%	--	37	28	52
CGA-136872 + Surf	0.018 + 0.25%	--	0	10	22
CGA-136872 + Surf	0.027 + 0.25%	--	13	13	23
CGA-136872 + Surf	0.036 + 0.25%	--	33	40	63
Checks					
Weedy check	---	0	0	0	0
Hand-weeded (EPTC + dichlormid 6 lb/A PPI + alachlor 3 lb/A Pre)	---	99	100	97	98
BLSD (0.05)		37	25	23	32

[a]Vegetable oil=R-Way and Surf=nonionic surfactant=Ortho X-77

1988 Soybean Breeding

James Orf, Thomas Hoverstad and William Lueschen

This project is designed to improve soybean production through developing superior genetic material. Each year the Southern Experiment Station serves as one of the major testing locations for material developed in this program. Evaluations conducted at Waseca include new experimental line tests, preliminary yield trials, uniform regional trials, privately and publicly developed variety tests, a disease nursery and evaluation of early generation crosses. Data collected from these studies throughout Minnesota are used to provide growers and industry personnel with variety performance data. Results from these studies are published in 'Varietal Trials of Farm Crops'.

All soybean breeding trials were designed as randomized complete blocks. The previous crop for each trial was oats. Each site was fall chisel plowed after applying P and K fertilizer based on soil tests. Seed for each trial was packaged for individual plots and planted with a cone-type planter. Weeds were controlled in all plots with Treflan at 0.75 lb/A plus Command at 0.75 lb/A PPI followed by Amiben at 2.5 lb/A Pre. Publicly developed variety evaluations included three studies: (1) late maturing varieties planted on May 3, (2) medium maturing varieties planted on May 3 and (3) a range of maturities planted on June 10. All these tests were planted in 10-inch row spacings. Privately developed varieties were tested in 10-inch rows planted on May 3. New experimental line tests and preliminary yield trials were all planted in 10-inch rows on May 3. Planting date was evaluated in 1988 by planting several varieties at dates ranging from April 25 to June 25. In the planting date trial we evaluated varietal performance in 30 and 10-inch rows. Uniform regional trials for both Group I and Group II maturity soybeans were planted on May 3. Harvested plot size for 30-inch rows was 5 (two 30-inch rows) by 7.5 feet. Harvested plot size for 10-inch rows was 3.3 (4-10-inch rows) by 7.5 feet. All plots were harvested with a modified plot combine.

Notes on maturity, lodging and plant height were taken on all yield traials. Evaluation of early generation material for maturity, plant type, disease tolerance and other agronomic traits were made on plots consisting of one 30-inch row 6 feet long. Information on these observations is not included in this report. Disease reactions on similar size plots were also evaluated on a site with poor internal drainage that has been in continuous soybeans for 20 consecutive years. No yields were taken on these very small plots.

The dry conditions in 1988 caused extreme variations in soybean yields. Rainfall in August relieved drought stress but for many soybeans the relief was too late. Consequently, the early planted and early maturing varieties suffered the most. Yields of medium maturity varieties ranged from 8.5 to 40.3 bu/A (Table 1). Sibley was the highest yielding medium maturing variety in 1988. In the late maturity variety test (Table 2) Century 84 yielded 40.3 bu/A as the top variety. Yields in this study ranged from 9.6 to 40.3 bu/A. Varieties tested in a trial planted on June 10 performed very well in 1988 with yields ranging from 37.9 to 51.2 bu/A (Table 3). An experimental line was the highest yielding variety in this test, while Weber 84 was the highest yielding named variety. In the planting date trial (Table 4) yields ranged from 22.0 to 53.4 bu/A. The May 26 planting generally resulted in the highest yields in 1988. This is abnormal to what has occurred in other years, normally the earliest planted soybeans have had the highest yields. Table 5 shows the results over 100 privately developed soybeans tested in 1988. Several publicly developed soybeans are included in this trial for comparison. Yields ranged from 15.4 to 41.8 bu/A and Pioneer 9161 was the highest yielding variety in this trial. In the uniform regional trial of Group I maturity, yields ranged from 5.0 to 43.6 bu/A and Corsoy 79 was the highest yielding variety (Table 6). In the Group II uniform regional trial yields ranged from 26.1 to 48.1 bu/A (Table 7). Experimental lines performed best in the Group II trial while Zane was the highest yielding named variety at 42.3 by/A.

Data collected on several of these trials are published in 'Varietal Trails of Farm Crops'. Recommended public soybean varieties for Southern Minnesota are: Simpson, Hodgson 78, Sibley, Weber 84, Hardin, BSR101 and Corsoy 79.

Table 1. Medium Maturing Soybean Variety Trial. Waseca 1988.

	DF	SS	MS	F
REP	2	27.39	13.70	0.95
TRT	14	3520.03	251.43	17.48
ERROR	28	402.83	14.39	
TOTAL	44	3950.26		

CV = 15.6
LSD.05 = 6.3
YIELD MEAN = 24.4

RANKING BY YIELD

ENT	NSN	PEDIGREE		1 PHY-CHL	2 MEAN%	3 YIELD	4 MAT	5 LDG	6 HT	7 QUAL	8 SDWT	9 PRO	10 OIL
6	SIBLEY	M68-256 X HODGSON		R40	165.4	40.3	39	1.0	23	2.7	17.0	40.3	21.0
4	HODGSON 78	HODGSON*7 X MERIT		R30	154.2	37.6	38	1.0	25	3.7	15.5	39.1	21.8
13	M83-766	EVANS X II-74-394		R35	134.1	32.7	27	1.0	21	2.7	13.7	39.1	21.8
7	SIMPSON	STEELE X HODGSON		R38	126.6	30.9	26	1.0	20	3.7	13.4	38.7	22.2
15	MAPLE DONOVAN	MAPLE ARROW X HARCOR	RPS6	R38	121.6	29.6	27	1.0	24	2.0	14.5	39.9	21.2
1	DASSEL	EVANS X M66-18	RPS6	R26	113.1	27.6	32	1.0	20	3.7	14.6	39.2	21.8
2	DAWSON	EVANS X II-63-217Y		R20	112.9	27.5	32	1.0	19	3.3	15.0	38.6	22.2
12	M83-744	II-73-129 X II-73-37		R22	99.9	24.4	33	1.0	18	3.0	15.8	39.1	21.7
14	M83-770	II-70-260 X ASGROW 1564		R36	92.4	22.5	25	1.0	22	3.0	13.4	39.7	21.4
10	M83-715	II-73-62 X SIMPSON		R31	83.0	20.2	28	1.0	18	3.7	11.7	38.7	22.1
9	M81-18	EVANS X II-65-442		R26	78.0	19.0	26	1.0	19	3.3	14.2	39.6	21.5
11	M83-727	II-73-62 X SIMPSON		R32	75.5	18.4	24	1.0	17	3.7	12.7	39.1	21.8
3	EVANS	MERIT X HAROSOY		R31	54.2	13.2	25	1.0	17	3.7	11.4	38.8	22.0
8	GLENWOOD	EVANS X PETERSON 85		S32	54.1	13.2	27	1.0	16	4.0	14.5	39.1	21.7
5	OZZIE	WILKIN X II-63-217Y		R26	35.0	8.5	24	1.0	15	4.0	12.7	39.6	21.4

Table 2. Late Maturing Soybean Variety Trial. Waseca 1988.

	DF	SS	MS	F
REP	2	3.28	1.64	0.06
TRT	23	4508.95	196.04	7.62
ERROR	46	1183.53	25.73	
TOTAL	71	5695.75		

CV = 18.5
LSD.05 = 8.4
YIELD MEAN = 27.5

RANKING BY YIELD

ENT	NSN	PEDIGREE		1 PHY-CHL	2 MEAN%	3 YIELD	4 MAT	5 LDG	6 HT	7 QUAL	8 SDWT	9 PRO	10 OIL
2	CENTURY 84	CENTURY*5 X WILLIAMS 82	1K	R34	146.6	40.3	44	1.0	27	2.3	16.8	41.2	20.0
4	ELGIN 87	ELGIN*5 X WILLIAMS 82	1K	R36	141.4	38.9	43	1.0	23	3.3	15.6	39.2	21.6
16	M83-108	HODGSON 78 X PELLA		R35	132.1	36.3	43	1.0	22	3.7	17.4	39.8	21.1
3	CORSOY 79	CORSOY*6 X LEE 68	1C	R40	130.0	35.7	42	1.3	27	3.0	15.9	43.4	18.8
23	M83-899	II-74-270 X A78-123018		R39	129.0	35.5	42	1.7	23	3.3	17.9	38.9	21.7
10	VICKERY	CORSOY*4 X (MACK X L65-1342 OR ANOKA)		R36	121.5	33.4	42	1.3	23	3.7	16.2	40.2	21.0
14	M82-106	II-73-105 X VICKERY	1C	R24	120.8	33.2	40	1.0	22	3.7	16.6	41.5	20.1
1	BSR 101	L69U40016-4 X A76-304020		R29	119.2	32.8	41	1.0	24	3.3	15.0	39.2	21.4
5	MACK	L70T-5436 X K1028		R40	117.5	32.3	43	1.0	18	3.0	17.0	39.0	21.7
24	M84-1005	HARDIN X GLENWOOD		R32	112.4	30.9	42	1.0	22	3.7	18.6	39.7	21.3
7	HODGSON 78	HODGSON*7 X MERIT		R30	109.7	30.2	38	1.3	21	4.0	16.8	39.2	21.6
13	M81-384	II-70-127 X CENTURY		R22	105.8	29.1	42	1.0	20	4.0	20.1	38.8	21.8
11	WEBER 84	WEBER*5 X CENTURY		R22	95.2	26.2	40	1.0	19	2.3	13.1	39.3	21.4
18	M83-504	II-71-52 X II-74-23		R28	93.3	25.6	42	1.0	18	4.0	20.2	40.8	20.6
9	SIBLEY	M68-256 X HODGSON		R40	92.2	25.3	40	1.0	20	3.0	18.7	40.9	20.3
6	HARDIN	CORSOY*3 X CUTLER 71		R41	90.8	25.0	39	1.0	19	3.7	13.6	40.0	21.0
12	M81-382	II-70-127 X CENTURY		R18	90.6	24.9	39	1.0	18	4.7	20.7	41.6	20.0
8	HOYT	HARCOR X ELF	dt1	R38	84.1	23.1	44	1.0	14	2.7	15.0	40.6	20.7
17	M83-357	II-71-52 X ASGROW 2656		R38	76.6	21.1	38	1.0	20	4.3	17.1	41.1	20.4
22	M83-830	EVANS X CENTURY		R24	75.4	20.7	39	1.0	15	4.0	17.2	40.8	20.5
15	M82-559	VICKERY X CENTURY	1C	R34	74.8	20.6	37	1.0	16	4.0	18.2	41.1	20.3
20	M83-792	II-71-38 X II-74-417		R18	66.8	18.4	36	1.0	17	4.0	15.6	41.2	20.2
21	M83-819	EVANS X CENTURY		R34	39.0	10.7	36	1.0	14	4.0	18.1	41.1	20.3
19	M83-767	II-70-260 X ASGROW 1564		R34	35.0	9.6	34	1.0	14	4.0	13.1	39.7	21.1

* see footnote at end of Table 7.

Table 3. Soybean Variety Trial - Mid June Planting. Waseca 1988.

	DF	SS	MS	F
REP	2	229.28	114.64	3.52
TRT	14	557.30	39.81	1.22
ERROR	28	912.09	32.57	
TOTAL	44	1698.66		

CV = 12.9
LSD.05 = 9.5
YIELD MEAN = 44.4

RANKING BY YIELD

ENT	NSN	PEDIGREE		1| PHY-CHL	2| MEAN%	3| YIELD	4| MAT	5| LDG	6| HT	7| QUAL	8| SDWT	9| PRO	10| OIL
15	M91-384	M70-127 X CENTURY		R20	115.3	51.2	57	1.0	31	1.7	16.1	37.5	22.7
12	WEBER 84	WEBER*5 X CENTURY		R22	109.5	48.6	55	1.7	35	1.7	12.3	37.9	22.3
10	SIBLEY	M68-256 X HODGSON		R	109.4	48.5	55	1.0	32	2.3	15.3	38.0	22.3
11	SIMPSON	STEELE X HODGSON		R38	107.1	47.5	48	1.0	28	2.3	14.3	37.4	22.8
7	HODGSON 78	HODGSON*7 X MERIT		R30	106.3	47.2	53	2.0	32	2.3	14.2	37.7	22.6
6	HARDIN	CORSOY*3 X CUTLER 71		R41	102.4	45.5	56	1.3	33	2.3	13.8	37.5	22.7
3	DAWSON	EVANS X II-63-217Y		R20	100.7	44.7	49	1.0	26	2.7	13.7	37.1	23.0
9	DIZIE	WILKIN X II-63-217Y		R26	98.7	43.8	44	1.0	24	2.3	14.4	37.9	22.4
2	DASSEL	EVANS X II-66-18	RPS6	R26	96.9	43.0	52	1.0	25	2.3	14.3	37.9	22.4
13	BSR 101	L69U40016-4 X A76-304020		R29	95.5	42.4	56	1.3	33	2.0	14.8	37.1	22.9
1	CORSOY 79	CORSOY*6 X LEE 68	1C	R40	94.4	41.9	58	1.7	36	1.7	12.9	37.8	22.3
5	EVANS	MERIT X HAROSOY		R31	93.3	41.4	46	1.0	25	2.7	13.0	37.6	22.6
4	ELGIN 87	ELGIN*5 X WILLIAMS 82	1K	R36	93.1	41.3	59	1.7	32	1.7	13.0	37.5	22.7
14	GLENWOOD	EVANS X PETERSON 85		S32	92.0	40.8	46	1.0	22	2.3	15.1	37.6	22.5
8	MCCALL	(ACME X CHIPPEWA) X HARK		S28	85.4	37.9	40	1.0	23	2.3	13.8	37.2	22.9

* see footnote at end of Table 7.

Table 4. Effect of Planting Date on Soybean Yield. Waseca 1988.

	DF	SS	MS	F
REP	3	154.67	51.56	1.14
TRT	39	9883.53	253.42	5.59
ERROR	117	5304.55	45.34	
TOTAL	159	15342.75		

CV = 16.8
LSD.05 = 9.4
YIELD MEAN = 40.0

RANKING BY YIELD

ENT	NSN		PEDIGREE	PHY-CHL	MEAN%	YIELD	MAT	LDG	HT	QUAL	SDWT	PRO	OIL
				1	2	3	4	5	6	7	8	9	10
33	SIBLEY	30"	May 26		133.5	53.4	45	0.0	0	2.5	17.5	38.8	22.0
23	HARDIN	30"	May 26		131.1	52.5	45	0.0	0	2.5	13.6	37.5	22.8
3	CORSOY 79	30"	May 26		126.5	50.6	46	0.0	0	2.8	14.0	38.0	22.5
12	BSR 101	30"	May 12		125.3	50.1	43	0.0	0	3.0	14.9	37.9	22.5
22	HARDIN	30"	May 12		122.9	49.2	39	0.0	0	3.2	16.8	39.4	21.7
13	BSR 101	30"	May 26		122.3	48.9	45	0.0	0	2.0	14.8	36.8	23.3
2	CORSOY 79	30"	May 12		121.9	48.8	41	0.0	0	3.0	16.4	39.1	21.8
32	SIBLEY	30"	May 12		121.1	48.5	38	0.0	0	3.2	19.6	39.2	21.8
34	SIBLEY	30"	June 10		120.3	48.1	53	0.0	0	2.2	14.4	38.1	22.4
8	CORSOY 79	10"	May 26		118.7	47.5	47	0.0	0	1.8	13.6	36.4	23.5
4	SIMPSON	30"	June 10		116.0	46.4	46	0.0	0	2.5	13.7	38.5	22.2
24	HARDIN	30"	June 10		115.7	46.3	51	0.0	0	2.0	12.5	37.8	22.6
28	HARDIN	10"	May 26		110.9	44.4	45	0.0	0	3.0	13.5	38.6	22.1
35	SIBLEY	30"	June 26		109.2	43.7	58	0.0	0	2.0	14.7	37.7	22.6
38	SIBLEY	10"	May 26		108.5	43.4	46	0.0	0	2.5	15.9	38.3	22.3
14	EVANS	30"	June 10		106.9	42.8	46	0.0	0	2.8	12.6	38.2	22.3
39	SIBLEY	10"	June 10		106.6	42.7	54	0.0	0	2.0	14.1	36.8	23.2
18	BSR 101	10"	May 26		103.6	41.5	46	0.0	0	2.5	14.6	36.6	23.5
15	EVANS	30"	June 26		102.6	41.1	53	0.0	0	2.8	13.7	38.0	22.4
1	CORSOY 79	30"	April 29		101.8	40.7	41	0.0	0	3.0	15.7	38.7	22.0
21	HARDIN	30"	April 29		101.2	40.5	38	0.0	0	3.5	15.8	38.6	22.2
29	HARDIN	10"	June 10		99.6	39.9	57	0.0	0	2.2	13.5	38.0	22.5
40	SIBLEY	10"	June 26		99.4	39.8	60	0.0	0	2.2	14.8	38.1	22.2
20	EVANS	10"	June 26		96.1	38.5	54	0.0	0	2.5	13.9	37.9	22.5
9	SIMPSON	10"	June 10		93.4	37.4	47	0.0	0	2.2	14.2	37.0	23.1
7	CORSOY 79	10"	May 12		93.4	37.4	42	0.0	0	3.0	16.2	39.3	21.7
5	SIMPSON	30"	June 26		92.8	37.1	50	0.0	0	1.8	12.4	37.0	23.1
16	BSR 101	10"	April 29		88.6	35.5	41	0.0	0	3.2	15.3	38.3	22.4
31	SIBLEY	30"	April 29		88.4	35.4	39	0.0	0	2.8	17.4	39.1	21.9
11	BSR 101	30"	April 29		86.6	34.7	40	0.0	0	3.2	15.7	38.6	22.1
27	HARDIN	10"	May 12		84.8	33.9	42	0.0	0	3.2	15.1	39.3	21.6
26	HARDIN	10"	April 29		84.2	33.7	40	0.0	0	3.2	15.7	40.1	21.2
19	EVANS	10"	June 10		78.8	31.5	47	0.0	0	2.8	12.7	36.9	23.2
17	BSR 101	10"	May 12		76.4	30.6	42	0.0	0	3.2	15.7	38.1	22.4
10	SIMPSON	10"	June 26		75.5	30.2	54	0.0	0	1.8	14.0	37.7	22.6
37	SIBLEY	10"	May 12		75.1	30.1	41	0.0	0	3.0	19.2	40.9	20.6
6	CORSOY 79	10"	April 29		74.1	29.7	42	0.0	0	2.8	13.5	39.3	21.7
36	SIBLEY	10"	April 29		68.2	27.3	39	0.0	0	3.0	18.1	39.7	21.4
30	HARDIN	10"	June 26		62.8	25.1	62	0.0	0	2.2	11.4	37.6	22.6
25	HARDIN	30"	June 26		54.9	22.0	62	0.0	0	2.2	11.6	38.8	21.8

* see footnote at end of Table 7.

Table 5. Public and Private Variety Trial. Waseca 1988.

	DF	SS	MS	F
REP	2	1224.91	612.45	15.59
TRT	143	11975.16	83.74	2.13
ERROR	286	11235.34	39.28	
TOTAL	431	24435.41		

CV = 22.1
LSD.05 = 10.0
YIELD MEAN = 28.3

RANKING BY YIELD

ENT	NSN	PEDIGREE		1 PHY-CHL	2 MEAN%	3 YIELD	4 MAT	5 LDG	6 HT	7 QUAL	8 SDWT	9 PRO	10 OIL
132	PIONEER 9161	PIONEER HI-BRED		P S40	147.6	41.8	40	1.0	24	0.0	0.0	40.4	20.9
82	PB-192	PRAIRIE BRAND SEED CO. INC.		P S48	144.0	40.8	40	1.3	24	0.0	0.0	39.6	21.3
5	ASGROW A1937	ASGROW SEED CO.		P R38	136.6	38.7	39	1.3	29	0.0	0.0	38.4	22.2
8	ATLAS 190	ATLAS SEED COMPANY		P S35	134.4	38.0	41	1.7	24	0.0	0.0	38.9	21.8
107	STAR 8820	STAR BRAND SEEDS		P S30	131.9	37.4	39	1.0	26	0.0	0.0	37.6	22.7
35	HOFLER H88-2198	HOFLER SEED COMPANY		P S35	131.3	37.2	39	1.0	25	0.0	0.0	38.7	22.0
12	CFS 213	CUSTOM FARM SEED		P S28	130.1	36.8	42	1.3	27	0.0	0.0	40.8	20.5
96	S BRAND S-40C	SCHECHINGER SEED COMPANY		P S28	130.1	36.8	40	1.3	30	0.0	0.0	37.8	22.6
32	HOFFMAN 8301	HOFFMAN SEED FARMS INC.		B S30	128.2	36.3	45	1.0	23	0.0	0.0	41.3	20.3
52	KE EXP. 510011	KAISER ESTECH		B S30	126.8	35.9	42	1.0	26	0.0	0.0	39.3	21.5
42	JACQUES J-231	JACQUES SEED CO. J-2386	E84100	P R30	124.9	35.4	41	1.0	25	0.0	0.0	40.0	21.0
128	WIL'N BLEND 2145	WILSON HYBRIDS INC.		B M38	124.4	35.2	42	1.0	23	0.0	0.0	39.3	21.7
6	ASGROW A2187	ASGROW SEED CO.		P R30	124.2	35.2	43	1.0	27	0.0	0.0	39.0	21.6
58	KRUGER 330+3	KRUGER SEED CO.		B S35	123.7	35.0	42	1.3	28	0.0	0.0	36.9	23.1
79	FRS 119	PETERSON SEED COMPANY		P S40	123.5	35.0	42	1.0	26	0.0	0.0	39.8	21.3
121	THOMPSON T-3180	THOMPSON FARMS SEEDS		P S32	121.6	34.4	40	1.3	26	0.0	0.0	37.6	22.6
138	ELGIN 87	IOWA A.E.S.	1K	R32	121.6	34.4	41	1.0	25	0.0	0.0	37.8	22.5
68	MASCO 8616	MCALLISTER SEED CO.	1C	P R35	121.6	34.4	41	1.3	28	0.0	0.0	40.0	21.0
139	HACK	ILLINOIS A.E.S.		R40	120.7	34.2	41	1.0	22	0.0	0.0	39.4	21.5
95	S BRAND S-43G	SCHECHINGER SEED COMPANY		P S28	120.5	34.1	41	1.0	24	0.0	0.0	39.5	21.3
67	MASCO 8633	MCALLISTER SEED CO.	1C	P R42	119.8	33.9	39	1.7	27	0.0	0.0	39.9	21.1
83	PB-223	PRAIRIE BRAND SEED CO. INC.		P S38	119.4	33.8	44	1.0	23	0.0	0.0	40.3	20.9
72	MIDWEST OIL 2500	MIDWEST OILSEEDS INC.		B R42	118.4	33.5	40	1.0	24	0.0	0.0	36.4	23.6
123	TF EXP 168	TILNEY FARMS		P S30	118.2	33.5	39	1.0	26	0.0	0.0	38.4	22.2
54	KALTENBERG KB231	KALTENBERG SEED FARMS		P S30	117.6	33.3	45	1.0	24	0.0	0.0	40.7	20.5
25	FEVOLD EX 283	FEVOLD SEED FARM. INC.	1C	P R38	116.3	32.9	42	1.0	28	0.0	0.0	39.6	21.3
59	LATHAM 401	LATHAM BROS. FARM		B S22	115.6	32.7	43	1.0	24	0.0	0.0	41.0	20.4
7	ASGROW A2234	ASGROW SEED CO.	1K	R30	115.1	32.6	41	1.0	23	0.0	0.0	39.8	21.2
90	SOI 267	SAND SEED SERVICES. INC.	RPS3	P R40	115.0	32.6	41	1.3	29	0.0	0.0	38.4	22.1
84	PS 1152	PROFISEED INC.		S32	113.6	32.2	44	1.0	23	0.0	0.0	40.8	20.6
19	CX226	DEKALB - PFIZER GENETICS		P S40	113.4	32.1	43	1.3	23	0.0	0.0	38.3	22.1
3	AGRIPRO AP1989	AGRIPRO	1C	R35	113.3	32.1	39	1.0	26	0.0	0.0	36.6	23.4
94	S BRAND S-43K	SCHECHINGER SEED COMPANY		P S45	112.7	31.9	41	1.0	26	0.0	0.0	37.8	22.5
142	SIBLEY	MINNESOTA A.E.S.		R40	112.7	31.9	39	1.3	24	0.0	0.0	37.8	22.5
137	CORSOY 79	ILLINOIS A.E.S.	1C	R40	111.4	31.5	40	1.3	29	0.0	0.0	39.2	21.6
18	CX264	DEKALB - PFIZER GENETICS		P S25	111.4	31.5	43	1.0	21	0.0	0.0	42.0	19.8
15	DSR-252	DAIRYLAND SEED COMPANY INC.		S25	111.3	31.5	43	1.0	25	0.0	0.0	40.3	21.0
125	TF 1507	TOP FARM HYBRIDS		P S45	111.1	31.5	42	1.0	24	0.0	0.0	40.7	20.5
126	PRESCOTT 108	WILLETTE SEED FARM INC.		B R35	110.9	31.4	39	1.0	26	0.0	0.0	39.0	21.8
143	WEBER 84	IOWA A.E.S.		R25	110.8	31.4	39	1.0	25	0.0	0.0	39.1	21.7
9	ATLAS EX 190	ATLAS SEED COMPANY		P S32	110.3	31.2	41	1.0	22	0.0	0.0	38.3	22.3
88	LAKSIDE 106	ROSS-BSEED FARM		B R38	110.1	31.2	39	1.0	25	0.0	0.0	39.0	21.8
104	SRF EX.61830	SOYBEAN RESEARCH FOUNDATION	RPS3	P R45	110.0	31.1	40	1.0	26	0.0	0.0	39.9	21.1
102	SX 1090	THE SEXAUER COMPANY		P R42	110.0	31.1	41	1.3	25	0.0	0.0	40.9	20.4
22	DIAMOND D200	DIAMOND BRAND SEED COMPANY		P S28	109.6	31.0	41	1.0	26	0.0	0.0	39.7	21.4
45	GOLD HVST X235	J.C.ROBINSON SEED CO.		B S30	109.6	31.0	43	1.0	22	0.0	0.0	40.7	20.6
129	ZILLER EXP.43	ZILLER SEED CO.	1C	P R38	109.5	31.0	37	1.0	22	0.0	0.0	38.9	21.8
34	HOFLER JADE	HOFLER SEED COMPANY		P S30	109.4	31.0	36	1.0	23	0.0	0.0	37.2	23.0
63	LATHAM 650	LATHAM SEED CO.		P S28	109.4	31.0	43	1.0	24	0.0	0.0	39.0	20.5

Table 5 cont.

				1	2	3	4	5	6	7	8	9	10
ENT	NSN	PEDIGREE		PHY-CHL	MEAN%	YIELD	MAT	LDG	HT	QUAL	SDWT	PRO	OIL
38	H-V DERBY 9	HY-VIGOR SEEDS. INC.		P S32	108.6	30.7	41	1.7	30	0.0	0.0	39.4	21.5
16	DSR-247	DAIRYLAND SEED COMPANY. INC.	1C	P R38	108.3	30.7	42	1.0	28	0.0	0.0	39.8	21.1
135	CENTURY 84	INDIANA A.E.S.		R38	108.1	30.6	43	1.0	26	0.0	0.0	41.6	19.9
36	HOFLER H88-2199	HOFLER SEED COMPANY		P R40	107.8	30.5	37	1.3	27	0.0	0.0	39.6	21.3
86	PS 1730	PROFISEED		P R28	107.7	30.5	38	1.0	23	0.0	0.0	39.2	21.7
50	KE EXP. 111009	KAISER ESTECH		P S30	107.1	30.3	42	1.0	25	0.0	0.0	37.7	22.5
127	WIL'N BLEND 1880	WILSON HYBRIDS INC.		B M28	107.1	30.3	39	1.0	24	0.0	0.0	37.7	22.6
10	ATLAS EX 200	ATLAS SEED COMPANY		P S32	107.1	30.3	40	1.0	23	0.0	0.0	39.3	21.4
30	HL. 333	HI-LINE SEEDS		B S28	107.0	30.3	41	1.3	25	0.0	0.0	39.1	21.6
99	ST 701	SEEDTEC		P S30	107.0	30.3	40	1.0	27	0.0	0.0	38.7	22.0
110	STINE 2940	STINE SEED FARM. INC.		P S32	106.7	30.2	40	1.0	22	0.0	0.0	40.1	20.9
78	NK S 23-03	NORTHRUP KING CO.		P S25	106.5	30.1	42	1.0	23	0.0	0.0	40.1	21.0
89	SOI 285	SAND SEED SERVICE. INC.		P S32	106.1	30.0	43	1.0	24	0.0	0.0	40.5	20.9
47	KE 169	KAISER ESTECH		P S40	106.0	30.0	39	1.0	22	0.0	0.0	39.2	21.7
114	TERRA EXP.180+	TERRA INTERNATIONAL. INC.		B S32	106.0	30.0	38	1.0	25	0.0	0.0	38.7	22.0
23	DIAMOND D201	DIAMOND BRAND SEED COMPANY		P S22	105.4	29.8	42	1.0	23	0.0	0.0	39.4	21.4
65	LYNKS SEEDS 5160	LYNKS SEEDS		P S38	104.8	29.7	37	1.0	24	0.0	0.0	39.2	21.6
120	THOMPSON T-30P	THOMPSON FARMS SEEDS		B S28	104.5	29.6	43	1.0	22	0.0	0.0	40.0	21.1
31	HOFFMAN 8701	HOFFMAN SEED FARMS INC.		B S40	104.1	29.5	40	1.0	25	0.0	0.0	39.0	21.7
109	STINE EX2010	STINE SEED FARM. INC.		P S32	103.8	29.4	40	1.0	21	0.0	0.0	39.4	21.4
101	SX 1080	THE SEXAUER COMPANY		P R45	103.4	29.3	39	1.3	26	0.0	0.0	39.5	21.3
29	GFS 107	GREEN FIELD SEED		B R32	102.7	29.1	37	1.0	25	0.0	0.0	38.5	22.1
100	SX EX.1050	THE SEXAUER COMPANY		P R42	102.3	29.0	37	1.0	24	0.0	0.0	38.4	22.2
116	THOMPSON EX 366	THOMPSON AGRONOMICS INC.		P S40	101.5	28.7	40	1.0	28	0.0	0.0	38.0	22.4
140	HARDIN	IOWA A.E.S.		R42	100.7	28.5	37	1.0	28	0.0	0.0	39.7	21.2
20	CX174	DEKALB - PFIZER GENETICS		P S40	100.3	28.4	43	1.0	24	0.0	0.0	39.7	21.2
37	H-V EX. DRW-9	HY-VIGOR SEEDS. INC.		B S35	100.1	28.3	40	1.0	25	0.0	0.0	38.6	22.0
1	AGRACETUS 108	AGRACETUS		P R30	100.0	28.3	41	1.3	26	0.0	0.0	38.5	22.1
122	TF1871	TILNEY FARMS		P S32	99.6	28.2	38	1.0	23	0.0	0.0	38.8	21.9
93	S BRAND S-38A	SCHECHINGER SEED CO.		P S38	98.4	27.9	39	1.0	21	0.0	0.0	39.4	21.5
49	KE 258	KAISER ESTECH		P S30	98.3	27.8	45	1.0	25	0.0	0.0	41.0	20.3
133	PIONEER 9181	PIONEER HI-BRED INTERNATIONAL	1C	P R28	98.2	27.8	41	1.0	22	0.0	0.0	40.8	20.5
106	STAR 8819	STAR BRAND SEEDS		P S42	97.0	27.5	39	1.0	23	0.0	0.0	39.0	21.8
124	TF EXP.1404	TOP FARMS HYBRIDS		P S42	96.4	27.3	38	1.0	25	0.0	0.0	38.4	22.2
108	STINE EX1070	STINE SEED FARM. INC.		P S38	96.1	27.2	38	1.0	21	0.0	0.0	39.4	21.5
43	JACQUES 8721	JACQUES SEED COMPANY	1C	P R40	95.7	27.1	39	1.0	27	0.0	0.0	39.7	21.3
27	FUNKS G3180	FUNK SEEDS INTERNATIONAL		P S32	94.9	26.9	36	1.3	23	0.0	0.0	39.4	21.6
98	ST 655	SEEDTEC		P S40	94.8	26.8	39	1.0	22	0.0	0.0	38.7	22.0
76	NK B152	NORTHRUP KING COMPANY	1C	R35	94.6	26.8	35	1.3	23	0.0	0.0	37.7	22.9
75	NK S 14-60	NORTHRUP KING CO.		P S28	94.4	26.7	38	1.0	20	0.0	0.0	39.5	21.4
112	RUNNER III +	TERRA INTERNATIONAL		B M30	94.2	26.7	39	1.0	21	0.0	0.0	38.6	22.1
46	KE 156	KAISER ESTECH		P S38	94.0	26.6	37	1.0	20	0.0	0.0	37.3	22.9
48	KE 212	KAISER ESTECH		P R38	94.0	26.6	42	1.0	22	0.0	0.0	39.8	21.2
77	NK S 15-50	NORTHRUP KING CO.	1C	R45	94.0	26.6	38	1.0	24	0.0	0.0	38.4	22.2
4	AGRIPRO AP2021	AGRIPRO		P R38	93.9	26.6	39	1.0	23	0.0	0.0	38.2	22.4
71	MDWST OIL EX1090	MIDWEST OILSEEDS. INC.		P R45	93.8	26.6	40	1.0	22	0.0	0.0	38.9	21.9
69	RIVERSIDE 1405	MCCURDY SEED CO.		P R32	93.7	26.5	38	1.0	22	0.0	0.0	38.6	22.0
81	PB-181	PRAIRIE BRAND SEED CO. INC.		P S42	93.3	26.4	37	1.0	22	0.0	0.0	40.0	21.1
57	KRUGER KB153	KRUGER SEED COMPANY		B R35	93.2	26.4	41	1.0	24	0.0	0.0	38.9	21.8

Table 5 cont.

ENT	NSN	PEDIGREE		1 PHY-CHL	2 MEAN%	3 YIELD	4 MAT	5 LDG	6 HT	7 QUAL	8 SDWT	9 PRO	10 OIL
134	PIONEER 9202	PIONEER HI-BRED INTERNATIONAL INC.		P S38	92.1	26.1	38	1.0	21	0.0	0.0	39.5	21.5
11	CFS 158	CUSTOM FARM SEED		P S30	92.0	26.0	36	1.0	22	0.0	0.0	38.1	22.4
66	LNKS SDS LX8165	LYNKS SEEDS		P S38	91.2	25.8	37	1.0	23	0.0	0.0	37.8	22.6
74	NC+ 1K98	NC+ HYBRIDS		P R32	90.4	25.6	38	1.0	24	0.0	0.0	38.9	21.8
64	LATHAM 301	LATHAM SEED CO.		B M30	90.3	25.6	38	1.0	22	0.0	0.0	39.1	21.7
80	PB-171	PRAIRIE BRAND SEED CO. INC.		P S40	89.8	25.4	37	1.0	21	0.0	0.0	33.1	22.4
51	KE EXP. 510010	KAISER ESTECH		B S25	88.8	25.1	37	1.0	24	0.0	0.0	39.7	21.3
117	THOMPSON E416	THOMPSON AGRONOMICS. INC.		P S30	88.7	25.1	37	1.0	25	0.0	0.0	39.4	21.6
97	ST 6408	SEEDTEC		B S45	88.4	25.0	39	1.0	23	0.0	0.0	39.8	21.2
28	GFS 206	GREEN FIELD SEED		P S38	88.4	25.0	36	1.0	21	0.0	0.0	38.4	22.2
92	SOI 186 BL	SAND SEED SERVICE. INC.		B M32	88.2	25.0	39	1.0	22	0.0	0.0	39.2	21.6
115	TERRA EXP.085+	TERRA INTERNATIONAL. INC.		B R20	87.1	24.7	30	1.0	22	0.0	0.0	39.8	21.4
87	PS 1755	PROFISEED	1C	P M25	86.9	24.6	38	1.0	22	0.0	0.0	39.2	21.7
44	GOLD HVST H1170	J.C.ROBINSON SEED CO.		B S40	86.7	24.5	37	1.3	24	0.0	0.0	39.2	21.7
2	AGRIPRO AP1776	AGRIPRO SEEDS EX 31101		P R32	86.4	24.4	37	1.0	18	0.0	0.0	37.1	23.0
141	HODGSON 78	MINNESOTA A.E.S.		R30	86.0	24.4	37	1.0	21	0.0	0.0	38.8	21.9
56	KRUGER 302-11	KRUGER SEED CO.		B R32	84.9	24.0	38	1.0	22	0.0	0.0	37.9	22.6
70	MW OIL 1910	MIDWEST OILSEED INC.		P R45	84.5	23.9	37	1.0	21	0.0	0.0	39.7	21.4
131	ZILLER BT 2650	ZILLER SEED CO.		P S28	84.5	23.9	38	1.0	21	0.0	0.0	38.0	22.5
111	STINE 1865	STINE SEED FARM INC.		B S38	82.9	23.5	39	1.0	20	0.0	0.0	39.6	21.4
13	DSR-177	DAIRYLAND SEED COMPANY. INC.		P R42	80.8	22.9	39	1.0	22	0.0	0.0	41.1	20.4
14	DSR-204	DAIRYLAND SEED COMPANY INC.	1C	R40	80.5	22.8	37	1.0	21	0.0	0.0	39.3	21.6
119	THOMPSON T-12	THOMPSON FARMS SEEDS		P S42	79.7	22.6	40	1.0	21	0.0	0.0	39.1	21.8
130	ZILLER BT 2290	ZILLER SEED CO.		P S25	79.6	22.5	38	1.0	20	0.0	0.0	38.7	22.0
113	TR 2318+	TERRA INTERNATIONAL. INC.		B M28	79.2	22.4	42	1.0	24	0.0	0.0	39.6	21.3
26	FEVOLD EX 164	FEVOLD SEED FARM. INC.	1C	P R28	79.2	22.4	36	1.0	20	0.0	0.0	38.4	22.2
39	H-V EX.ROW 99	HY-VIGOR SEEDS		P R35	78.5	22.2	36	1.0	20	0.0	0.0	38.7	22.0
21	DIAMOND D150	DIAMOND BRAND SEED CO.		P S28	78.4	22.2	38	1.0	22	0.0	0.0	39.2	21.7
41	JACQUES J-181	JACQUES SEED COMPANY		B S22	77.7	22.0	41	1.0	20	0.0	0.0	39.2	21.7
24	EHRICH E-86	EHRICH SEED FARMS		P S35	76.8	21.7	36	1.0	21	0.0	0.0	37.8	22.6
73	NC+ 1L81	NC+ HYBRIDS		P S38	76.0	21.5	37	1.0	21	0.0	0.0	38.9	21.8
40	H-V RKR-9	HY-VIGOR SEEDS. INC.		R40	74.5	21.1	37	1.0	23	0.0	0.0	40.9	20.4
136	BSR 101	IOWA A.E.S.		R28	73.9	20.9	39	1.0	23	0.0	0.0	39.4	21.4
118	THOMPSON T-11	THOMPSON FARMS SEEDS		P S42	73.0	20.7	37	1.0	22	0.0	0.0	37.3	22.9
53	KALTENBERG KB116	KALTENBERG SEED FARMS		P S35	72.1	20.4	35	1.0	22	0.0	0.0	37.6	22.7
85	PS 2198	PROFISEED INC.		P S32	69.9	19.8	37	1.0	20	0.0	0.0	39.7	21.3
55	KRUGER K1012	KRUGER SEED COMPANY		P S28	67.9	19.2	38	1.0	20	0.0	0.0	37.8	22.6
103	SIGCO 92	SIGCO RESEARCH INC.		P S40	65.7	18.6	38	1.0	21	0.0	0.0	38.6	22.1
91	SOI 276 BL	SAND SEED SERVICE. INC.		B R38	65.5	18.6	43	1.0	20	0.0	0.0	38.6	22.4
17	CX187	DEKALB-PFIZER GENETICS		P S35	65.2	18.4	37	1.0	19	0.0	0.0	38.6	22.0
33	HOFLER SAPPHIRE	HOFLER SEED COMPANY	1C	P R28	63.5	18.0	37	1.0	18	0.0	0.0	37.6	22.8
62	LATHAM 2008	LATHAM SEED CO.		B S30	63.3	17.9	37	1.0	20	0.0	0.0	38.0	22.5
61	LATHAM EX. 120	LATHAM BROTHERS FARMS		P S45	62.5	17.7	35	1.0	18	0.0	0.0	40.3	20.9
144	FUNKS G3197	FUNKS		S30	59.3	16.8	37	1.0	17	0.0	0.0	38.6	22.0
60	LATHAM 570	LATHAM BROTHERS FARMS		P S45	58.2	16.5	37	1.0	21	0.0	0.0	41.2	20.2
105	STAR 8815	STAR BRAND SEEDS		P S38	54.2	15.4	36	1.0	20	0.0	0.0	38.6	22.1

* see footnote at end of Table 7.

Table 6. Uniform Regional Trial - Group I Varieties. Waseca 1988.

	DF	SS	MS	F
REP	2	1614.65	807.32	44.95
TRT	20	7382.14	369.11	20.55
ERROR	40	718.41	17.96	
TOTAL	62	9715.20		

CV = 16.8
LSD.05 = 7.0
YIELD MEAN = 25.3

RANKING BY YIELD

ENT	NSN	PEDIGREE		1 PHY-CHL	2 MEAN%	3 YIELD	4 MAT	5 LDG	6 HT	7 QUAL	8 SDWT	9 PRO	10 OIL
21	CORSOY 79	CORSOY*6 X LEE 68		R40	172.2	43.6	42	1.0	25	3.7	17.8	40.5	20.9
20	M83-899	II-74-270 X A78-123018		R39	167.8	42.4	42	1.3	22	3.7	18.3	39.2	21.8
2	ELGIN 87	ELGIN*5 X WILLIAMS 82		R40	161.2	40.8	42	1.0	22	4.0	14.3	38.4	22.3
8	HODGSON 78	HODGSON*7 X MERIT		R30	135.1	34.2	39	1.0	21	4.0	16.9	38.9	22.0
10	M81-384	II-70-127 X CENTURY		R22	133.7	33.8	41	1.0	20	3.7	18.1	39.6	21.6
9	M81-382	II-70-127 X CENTURY		R18	129.7	32.8	39	1.0	19	4.3	19.8	42.3	19.7
5	A85-192034	A80-344003 X ASGROW A1937		26	128.9	32.6	41	1.0	20	3.3	18.0	40.9	20.5
13	M83-108	HODGSON 78 X PELLA		R35	124.8	31.5	42	1.0	20	4.0	19.4	40.4	21.0
6	A86-101009	HACK X ASGROW A1937		26	114.6	29.0	42	1.0	18	4.3	15.9	41.2	20.3
4	SIBLEY	M68-256 X HODGSON		R40	112.5	28.4	38	1.0	19	3.7	17.2	40.5	20.9
3	HARDIN	CORSOY*3 X CUTLER 71		R40	99.9	25.3	38	1.0	19	4.3	14.6	41.0	20.6
11	M82-106	II-73-105 X VICKERY	1C	R24	92.1	23.3	39	1.0	18	4.0	16.4	42.5	19.6
18	M83-819	EVANS X CENTURY		R34	90.8	23.0	41	1.0	17	4.0	16.1	41.1	20.5
15	M83-504	II-71-52 X II-74-23		R28	85.0	21.5	41	1.0	17	4.0	19.4	41.3	20.5
19	M83-830	EVANS X CENTURY		R24	74.0	18.7	40	1.0	14	4.0	19.2	40.5	21.0
1	DAWSON	EVANS X II-63-217Y		R20	63.0	15.9	28	1.0	14	4.3	14.3	39.2	21.8
12	M82-559	VICKERY X CENTURY	1C	R34	59.7	15.1	34	1.0	14	4.3	18.4	41.3	20.3
17	M83-792	II-71-38 X II-74-417		R18	59.7	15.1	33	1.0	17	4.3	15.6	40.7	20.7
16	M83-767	II-70-260 X ASGROW 1564		R34	40.4	10.2	28	1.0	13	4.0	13.0	40.3	21.0
14	M83-357	II-71-52 X ASGROW 2656		R38	35.2	8.9	36	1.0	15	4.3	17.6	41.6	20.2
7	GLENWOOD	EVANS X PETERSON 85		R30	19.8	5.0	29	1.0	12	5.0	15.1	39.7	21.5

* see footnote at end of Table 7.

Table 7. Uniform Regional Trial - Group II Varieties. Waseca 1988.

	DF	SS	MS	F
REP	2	2130.95	1065.48	27.41
TRT	29	1965.77	67.79	1.74
ERROR	58	2254.28	38.87	
TOTAL	89	6351.00		

CV = 15.5
LSD.05 = 10.2
YIELD MEAN = 40.2

RANKING BY YIELD

ENT	NSN	PEDIGREE	1 PHY-CHL	2 MEAN%	3 YIELD	4 MAT	5 LDG	6 HT	7 QUAL	8 SDWT	9 PRO	10 OIL
9	A86-102004	A80-244036 X ASGROW A1937	30	119.8	48.1	45	1.0	27	3.3	18.9	38.4	21.9
24	LN84-8527	HACK X HARPER	40	113.2	45.5	43	1.0	28	2.0	18.7	38.2	22.1
14	A86-203034	A81-356022 X ZANE	35	112.3	45.1	48	1.0	32	2.3	18.3	38.9	21.5
23	LN82-9648	K74-113-76-486 X CENTURY	22	112.3	45.1	49	1.0	30	1.7	15.4	40.2	20.6
22	HS84-6247	ZANE (3) X HW79149	38	108.0	43.4	49	1.3	29	2.3	18.0	38.4	21.9
8	A85-291001	ELGIN X ASGROW A1937	32	107.8	43.3	42	1.3	30	3.7	14.2	38.5	21.9
27	M84-1005	HARDIN X GLENWOOD	R38	107.5	43.2	42	1.0	24	4.0	19.5	39.0	21.6
21	HS84-6224	HW79015 (2) X HW79149	40	107.3	43.1	49	1.3	34	2.0	15.4	37.9	22.2
4	ZANE	CUMBERLAND X PELLA	X40	105.4	42.3	49	1.0	32	2.3	17.4	39.3	21.2
10	A86-103002	JACQUES J103 X A81-356022	30	105.2	42.3	44	1.0	24	4.0	15.7	40.7	20.2
13	A86-203004	HACK X ZANE	20	104.8	42.1	48	1.0	30	2.3	15.3	38.5	21.7
6	HC AMCOR DT		42	104.2	41.9	44	1.3	33	2.7	16.2	37.8	22.3
15	A86-204022	HACK X ZANE	32	104.1	41.8	43	1.0	31	2.0	16.1	38.7	21.5
28	CORSOY 79	CORSOY*6 X LEE 68	R40	103.8	41.7	42	1.0	29	3.7	16.2	40.0	20.9
1	ELGIN 87	ELGIN*5 X WILLIAMS 82	R40	102.9	41.3	45	1.0	27	3.7	15.1	38.5	21.7
12	A86-104011	A80-244036 X A80-344003	28	102.6	41.2	42	1.0	22	3.0	20.2	39.7	21.1
19	HM8634	ZANE (3) X HW79149	30	102.2	41.0	49	1.0	34	2.3	17.2	39.4	21.1
30	HACK	L70T-543G X K1028	R40	99.5	39.9	45	1.0	19	2.7	17.0	39.2	21.4
20	HM8635	ZANE (3) X HW79149	35	99.4	39.9	48	1.0	30	2.0	18.3	39.0	21.3
7	A85-193023	A79-135010 X ASGROW A1937	30	99.1	39.8	43	1.0	24	4.0	16.4	40.0	20.8
25	LN84-15574	LN80-9447 X ASGROW A3127	42	97.2	39.0	48	1.0	31	1.7	12.4	38.8	21.5
11	A86-103027	HACK X ASGROW A1937	22	97.1	39.0	42	1.0	24	3.7	16.9	39.8	21.0
17	E85171	A80-244003 X MIAMI	42	95.7	38.4	43	1.0	25	3.0	18.3	39.2	21.3
26	M81-384	II-70-127 X CENTURY	R22	94.8	38.0	42	1.0	23	4.3	20.0	39.6	21.1
16	E85110	A80-244003 X U76168	35	94.3	37.8	42	1.3	25	2.3	18.5	40.9	20.3
5	AMCOR	AMSOY 71 X CORSOY	30	93.3	37.5	43	1.3	32	2.7	15.0	39.2	21.3
29	BSR 101	L69U40-16-4 X A76-304020	R28	90.2	36.2	41	1.0	27	4.0	16.3	39.1	21.4
18	HC83-613-1 dt	A77-314013 X HOBBIT	38	84.8	34.1	50	1.0	19	2.3	16.8	38.4	21.9
3	HOYT	HARCOR X ELF dt1	R40	66.5	26.7	44	1.0	15	2.0	15.5	40.9	20.2
2	HARDIN	CORSOY*3 X CUTLER 71	R40	64.9	26.1	39	1.0	21	4.0	14.0	39.6	21.3

1| - PHY-CHL - Phytopthora , chlorosis score
phytopthora; R=resistant S=suceptible
chlorosis; 10=excellent 50=very poor

2| - MEAN% = % of the test average yield

3| - YIELD = yield in bu/A

4| - MAT = maturity ; days past July 1, 8/1=1

5| - LDG = lodging score; 1=erect, 5=flat

6| - HT = height in inches

7| - QUAL = seed quality; 1=excellent, 5=very poor

8| - SDWT = seed weight; g/100

9| - PRO = % protein

10| - OIL = % oil

Time of application and adjuvants with bentazon and lactofen for velvetleaf control in soybeans, 1988. Lueschen, William E., Jeffrey L. Gunsolus and Thomas R. Hoverstad. The objectives of this study were to investigate the effects of time of application of bentazon and lactofen and the effects of spray additives on velvetleaf control in soybeans. This trial was conducted on a Webster clay loam soil containing 7.4% organic matter, a soil pH of 7.5 and soil test P and K values of 53 and 512 lb/A, respectively. The site was in corn in 1987 with no fall tillage performed. Prior to establishing the study, the site was disked twice in early May, 1988. Then the entire experiment was treated with trifluralin at 0.75 lb/A and incorporated twice with a field cultivator prior to planting 'Glenwood' soybeans on May 14, 1988 in 30-inch wide rows at a rate of 150,000 seeds/A. Sethoxydim at 0.2 lb/A + oil concentrate at 1.25% v/v was applied on June 3, 1988 to the entire experiment to control escaped giant foxtail. None of the plots were cultivated. This experiment was designed as a randomized complete block with four replications and a plot size of 10 by 30 ft. The early postemergence treatments were applied on June 7, 1988 when the soybeans were in the first trifoliolate leaf stage and were 4 to 5 inches tall. The velvetleaf had two to four leaves and was 0.5 to 3 inches tall. Air temperature was 93 F with 25% relative humidity and winds were south at 10 mph. The soil temperature was 93 F at a depth of 4 inches and was 125 F at the soil surface. When the late postemergence treatments were applied on June 15, 1988, the air temperature was 77 F with 40% relative humidity and winds were northwest at 0 to 5 mph. The soil temperature at a depth of 4 inches was 76 F. Soybeans were in the third trifoliolate leaf stage and were 7 inches tall; velvetleaf had four to six leaves and was 3 to 6 inches tall. All postemergence treatments were applied with a total spray volume of 20 gpa at 40 psi. All additives were applied on a v/v basis as listed in the accompanying table. Velvetleaf was the primary weed species in this study and in the weedy check plots averaged 1.2 plants/ft^2. Rainfall from June 7 to June 14, 1988 totalled 0.12 inches. An additional 0.5 inches accumulated during the next seven days. Very dry conditions prevailed in June and July.

When evaluated on July 5, 1988, bentazon applied on June 7, 1988 at 0.75 lb/A with either crop oil concentrate or 28% N as the spray additive gave better than 90% control of velvetleaf. However, bentazon at 0.75 lb/A applied the same day without an additive provided only 62% velvetleaf control. The early application of bentazon at 0.5 lb/A + lactofen at 0.15 lb/A + 28% N at 5% provided 95% velvetleaf control. None of the lactofen treatments applied on June 7, 1988 provided adequate velvetleaf control. When applied on June 15, 1988, bentazon at 0.75 lb/A + 28% N at 5% or bentazon at 0.5 lb/A + lactofen at 0.15 lb/A + 28% N at 5% provided 94% velvetleaf control on July 5, 1988. All of the lactofen treatments applied on June 15, 1988 provided better velvetleaf control than the same treatments applied June 7, 1988. Use of 28% N as a spray additive with lactofen did not consistently enhance velvetleaf control. However, there appeared to be a slight advantage for 28% N as a spray additive with lactofen for the second date of application. Significant crop injury in the form of leaf necrosis resulted from all of the lactofen treatments. The least injury was observed with lactofen applied alone or in combination with 28% N. The most severe injury was observed when lactofen was combined with crop oil concentrate or 28% N + surfactant and applied on June 15, 1988. Crop injury symptoms disappeared by early July. Soybean yields were variable in this study due to very dry conditions in June and July. Therefore, there were no significant differences in yield among the treatments. (Minn. Agric. Exp. Sta., Paper No. 16,444; Misc. Jour. Series, University of Minnesota, St. Paul.)

Table. Time of application and adjuvants with bentazon and lactofen for velvetleaf control in soybeans, 1988 (Lueschen, Gunsolus and Hoverstad).

Treatment[a]	Rate	Soybean Injury 6/14	Soybean Injury 6/24	Velvetleaf 6/14	Velvetleaf 6/24	Velvetleaf 7/5	Velvetleaf 9/8	Yield
	(lb/A or %)	------(%)-----		----(% control)-----				(bu/A)
Early postemergence applied June 7, 1988								
Bentazon	0.75	0	0	68	61	62	75	40.2
Bentazon+COC	0.75+1.25%	0	0	85	83	93	82	44.0
Bentazon+28% N	0.75+5%	0	0	94	85	92	83	40.1
Bentazon+lactofen+28% N	0.5+0.15+5%	10	4	94	88	95	80	40.6
Lactofen	0.2	10	10	35	48	44	57	34.3
Lactofen+COC	0.2+0.31%	12	10	58	40	46	43	36.0
Lactofen+COC	0.2+0.63%	16	8	62	48	45	40	36.6
Lactofen+28% N	0.2+2.5%	10	8	41	38	40	54	38.6
Lactofen+28% N	0.2+5%	12	12	49	49	49	46	36.8
Lactofen+Surf+28% N	0.2+0.13%+2.5%	15	6	56	42	58	46	38.6
Lactofen+Surf+28% N	0.2+0.13%+5%	14	8	52	39	45	34	34.7
Lactofen+Surf+28% N	0.2+0.25%+2.5%	15	11	66	58	64	51	33.6
Lactofen+Surf+28% N	0.2+0.25%+5%	15	6	50	42	38	29	35.1
Late postemergence applied June 15, 1988								
Bentazon	0.75	--	0	--	55	52	46	38.2
Bentazon+COC	0.75+1.25%	--	0	--	54	69	58	37.1
Bentazon+28% N	0.75+5%	--	0	--	77	94	80	38.1
Bentazon+lactofen+28% N	0.5+0.15+5%	--	10	--	88	94	81	43.9
Lactofen	0.2	--	9	--	66	81	62	37.4
Lactofen+COC	0.2+0.31%	--	20	--	68	82	68	39.9
Lactofen+COC	0.2+0.63%	--	21	--	64	76	58	34.0
Lactofen+28% N	0.2+2.5%	--	14	--	74	91	79	39.0
Lactofen+28% N	0.2+5%	--	10	--	62	65	51	38.8
Lactofen+Surf+28% N	0.2+0.13%+2.5%	--	20	--	72	80	60	37.4
Lactofen+Surf+28% N	0.2+0.13%+5%	--	20	--	73	84	72	36.5
Lactofen+Surf+28% N	0.2+0.25%+2.5%	--	21	--	76	88	77	38.8
Lactofen+Surf+28% N	0.2+0.25%+5%	--	21	--	80	94	80	39.8
Checks								
Weed-Free (bentazon+28% N+COC	0.75+2.5%+1.25%)	4	5	96	100	100	93	41.0
Weedy Check		0	0	0	0	0	0	30.6
	BLSD (0.05)	3	5	10	17	25	30	13.0

[a]Trifluralin at 0.75 lb/A was applied and incorporated to the entire experimental area. Sethoxydim at 0.2 lb/A + 1.25% COC was applied postemergence on June 3, 1988 to the entire experiment. Bentazon=Basagran 4S, lactofen=Cobra 2L, COC=crop oil concentrate=Clean Crop, Surf=nonionic surfactant=Ortho X-77, 28% N=an aqueous solution of urea and NH_4NO_3.

<u>Herbicide performance in soybeans at Waseca, MN - 1988.</u> Gunsolus, Jeffrey L. and Willi E. Lueschen. The purpose of this experiment was to evaluate various herbicides and herbicide combinations for efficacy and soybean tolerance. Oats were grown in 1987 and the plot area wa chisel plowed in the fall of 1987 and field cultivated in the spring of 1988. No fertilizer wa applied. The soil was a Webster clay loam with 6.5% organic matter, pH 6.3, and a P and K soi test of 78 and 410, respectively. All herbicides were applied with a self-propelled plot spra using 20 gpa, 3 mph, and 8002 flat-fan nozzles. Postemergence broadleaf herbicides were appli at 40 psi and soil-applied herbicides were applied at 30 psi. Preplanting herbicide applicati were incorporated to a depth of 2 to 3 inches by either one pass with a field cultivator and harrow (1X) or one pass with a disk followed by another pass with a field cultivator and harro (2X). Incorporations in the twice-incorporated plots were done in opposite directions to each other. Metolachlor at a rate of 2.5 lb/A was applied on May 13 to the postemergence broadleaf herbicide study, for grass control. However, due to dry conditions it was necessary to apply 0.19 lb/A of sethoxydim + COC to control escaped grasses. Control with sethoxydim + COC was n complete. On May 13,'Hardin' soybeans were planted 1.5 inches deep at 150,000 seeds/A. A randomized complete block design with four replications was used. Plots were 10 by 30 ft and contained four 30-inch rows. Weed densities/ft^2 were 32 giant foxtail, 1.6 common lambsquarter 1.1 redroot pigweed, and 0.25 velvetleaf. Weed control, crop injury, and stand reduction evaluations were taken visually on June 14 for all preplanting incorporated treatments. Postemergence applications were evaluated on June 17 for crop injury and stand reduction and w evaluated July 7 for weed control. Plots in the second through fourth replications were cultivated after the visual ratings were taken and yield data were obtained from 25 ft of the t center rows of these plots. Yield data were corrected for 13% moisture and are presented in t table. Application dates, environmental conditions, and plant sizes are listed below:

Date	May 13	June 2
Treatment	PPI	Post
Temperature (F)		
air	52	84
soil (4 inch)	62	75
Soil moisture	dry	dry
Wind (mph)	0-5 E	0-5 S
Sky	clear	clear
Rainfall after application		
Week 1 (inch)	0.10	0
Week 2 (inch	0	0.12
Relative humidity (%)	40	40
Soybeans		
leaf no.	--	1
height (inch)	--	2
Giant foxtail		
leaf no.	--	1-3
height (inch)	--	1-3
Common lambsquarters		
leaf no.	--	Cotyl-4
height (inch)	--	0.5-2
Redroot pigweed		
leaf no.	--	2-6
height (inch)	--	1-3
Velvetleaf		
leaf no.	--	Cotyl-2
height (inch)	--	0.5-2

Under the extremely dry conditions of 1988, imazethapyr applied preplant incorporated di not perform as well as in past years. However, two-pass incorporation of imazethapyr or imazethapyr + pendimethalin did provide better weed control than the one-pass incorporation. Postemergence tank mixtures of DPX-M6316 + chlorimuron, bentazon or imazethapyr and bentazon + imazethapyr demonstrated broad spectrum broadleaf weed control with no significant crop injury Since grass control was generally poor in the postemergence broadleaf study, the only yields t were equivalent to the weed free check were where broadleaf herbicides were tank mixed with imazethapyr, a herbicide with postemergence grass activity. (Minn. Agric. Exp. Stat., Univers of Minnesota, St. Paul).

Table 1. Preplant incorporated weed control in soybeans at Waseca, MN. (Gunsolus and Lueschen).

Treatment	Rate	Soybean (6-14) injury	Soybean (6-14) stand[a]	Control (6-14) Gift	Control (6-14) Colq	Control (6-14) Rrpw	Control (6-14) Vele	Soybean Yield
	(lb/A)	(%)	(%)	(%)	(%)	(%)	(%)	(Bu/A)
Preplant incorporate 2X (May 13)								
Pendimethalin + imazethapyr	0.88 + 0.063	3	0	83	88	81	75	18
Imazethapyr	0.063	1	0	59	74	70	68	13
CGA-180937 + metribuzin	2.5 + 0.5	0	0	59	39	33	10	10
Metolachlor + metribuzin	2.5 + 0.5	3	0	61	43	51	35	10
Imazethapyr + clomazone	0.045 + 0.75	0	0	65	69	70	80	13
Imazethapyr + clomazone	0.031 + 0.75	0	0	60	58	55	46	10
Ethafluralin + imazethapyr	0.94 + 0.063	5	0	90	91	81	78	18
Ethafluralin + imazethapyr	0.94 + 0.045	5	0	86	76	72	60	17
Trifluralin + imazethapyr	1.0 + 0.063	8	0	90	81	85	70	19
Trifluralin + imazethapyr	1.0 + 0.045	3	0	83	70	72	59	16
Clomazone & trifluralin[b]	0.75 & 1.0	4	0	86	63	68	56	17
Clomazone & trifluralin + metribuzin	0.75 & 1.0 + 0.5	1	0	88	74	80	78	18
Imazethapyr + metribuzin	0.063 + 0.5	1	0	70	80	80	83	16
Weedy check								5
LSD (0.05)		NS	NS	11	24	20	29	3
Preplant incorporate 1X (May 13)								
Alachlor & trifluralin[c]	1.87 & 0.38	0	0	55	39	51	38	10
Alachlor & trifluralin	2.5 & 0.5	0	0	56	56	54	53	9
Alachlor & trifluralin + clomazone	1.87 & 0.38 + 0.5	0	0	49	53	54	54	8
Alachlor & trifluralin + clomazone	2.5 & 0.5 + 0.5	0	5	51	43	50	55	9
Alachlor & trifluralin + metribuzin	1.87 & 0.38 + 0.5	0	0	48	50	48	64	6
Alachlor & trifluralin + metribuzin	2.5 & 0.5 + 0.5	0	0	63	58	56	20	7
Trifluralin	0.75	0	0	68	35	35	33	5
Metolachlor	3.0	0	0	51	25	34	26	4
Metolachlor + clomazone	2.5 + 0.5	0	0	55	38	39	50	7
Metolachlor + metribuzin	2.5 + 0.5	0	0	44	44	35	40	5
Trifluralin + clomazone	0.75 + 0.5	0	0	69	54	43	53	12
Trifluralin + metribuzin	0.75 + 0.5	0	0	67	46	49	45	9
Alachlor + clomazone	3.0 + 0.5	0	0	60	53	49	48	9
Pendimethalin + imazethapyr	0.88 + 0.063	0	0	58	45	49	48	9
Imazethapyr	0.063	0	0	40	46	43	48	3
Weedy check								5
LSD (0.05)		NS	NS	14	15	NS	NS	4

[a] Stand reduction.
[b] premix = Commence 5.25E.
[c] premix = Cannon 3E.

Table 2. Broadleaf weed control in soybeans at Waseca, MN. (Gunsolus and Lueschen).

Treatment	Rate	Soybean (6-17)		Control (7-7)			Soybean
		injury	stand[a]	Colq	Rrow	Vele	Yield
	(lb/A)	(%)	(%)	(%)	(%)	(%)	(Bu/A)
Postemergence (June 2)							
Lactofen + C.O.C.[b]	0.2 + 0.312%	13	0	10	98	31	6
Lactofen + C.O.C.	0.2 + 0.625%	15	0	18	100	37	6
Lactofen + 28%N[c]	0.2 + 5.0 %	10	0	25	97	33	8
Lactofen + bentazon + C.O.C.	0.15 + 0.5 + 0.625%	13	0	70	100	91	7
DPX-M6316 + surf[d] + 28%N	0.003 + 0.125% + 1.25%	5	0	91	99	75	3
DPX-M6316 + surf + 28%N	0.004 + 0.125% + 1.25%	4	0	91	100	84	4
DPX-M6316 + surf + 28%N	0.008 + 0.125% + 1.25%	1	0	98	100	96	4
Chlorimuron + surf + 28%N	0.002 + 0.125% + 1.25%	0	0	30	73	58	6
Chlorimuron + surf + 28%N	0.003 + 0.125% + 1.25%	0	0	45	64	59	6
Chlorimuron + surf + 28%N	0.004 + 0.125% + 1.25%	6	0	51	68	68	6
DPX-M6316 + chlorimuron + surf + 28%N	0.003 + 0.002 + 0.125% + 1.25%	4	0	88	95	78	5
DPX-M6316 + chlorimuron + surf + 28%N	0.003 + 0.003 + 0.125% + 1.25%	6	0	88	99	86	6
DPX-M6316 + chlorimuron + surf + 28%N	0.003 + 0.004 + 0.125% + 1.25%	8	0	93	100	95	5
DPX-M631[illegible]	0.004 + 0.002 + 0.125% + 1.25%	1	0	95	99	97	7
DPX-M6316 + chlorimuron + surf + 28%N	0.004 + 0.003 + 0.125% + 1.25%	4	0	86	98	91	7
DPX-M6316 + chlorimuron + surf + 28%N	0.004 + 0.004 + 0.125% + 1.25%	4	0	92	100	93	6
Bentazon + C.O.C. + 28%N	0.5 + 1.25% + 5.0%	5	0	84	41	96	7
Bentazon + DPX-M6316 + surf + 28%N	0.5 + 0.004 + 0.25% + 1.25%	5	0	100	100	98	6
Bentazon + imazethapyr + surf + 28%N	0.5 + 0.063 + 0.25% + 1.25%	5	0	89	96	87	13
DPX-M6316 + lactofen + surf + 28%N	0.004 + 0.2 + 0.25% + 1.25%	14	0	96	100	78	6
DPX-M6316 + imazethapyr + surf + 28%N	0.004 + 0.063 + 0.25% + 1.25%	8	0	93	98	98	16
Imazethapyr + surf + 28%N	0.063 + 0.25% + 1.25%	6	0	48	98	77	12
Weedy check							3
Weedfree check							11
LSD (0.05)		7	NS	20	29	18	4

[a] Stand reduction.
[b] C.O.C. = Howe crop oil concentrate.
[c] 28%N = 28% UAN fertilizer solution.
[d] surf = X-77 surfactant from Chevron.

Table 3. Postemergence weed control in soybeans at Waseca, MN. (Gunsolus and Lueschen).

Treatment	Rate	Soybean (6-17)		Control (7-7)				Soybean
		injury	stand[a]	Gift	Colq	Rrpw	Vele	Yield
	(lb/A)	(%)	(%)	(%)	(%)	(%)	(%)	(Bu/A)
Postemergence (June 2)								
Lactofen + fluazifop-P + C.O.C.[b]	0.2 + 0.25 + 0.625%	14	0	81	28	100	43	12
Lactofen + clethodim + C.O.C.	0.2 + 0.0625 + 0.625%	14	0	88	40	100	65	11
Lactofen + clethodim + C.O.C.	0.2 + 0.125 + 0.625%	18	0	97	38	100	53	12
Bentazon + clethodim + C.O.C.	0.5 + 0.1 + 1.25%	5	0	88	93	61	86	9
Bentazon + clethodim + C.O.C.	0.5 + 0.15 + 1.25%	3	0	94	98	38	93	7
Weedy check								3
LSD (0.05)		NS	NS	NS	40	44	26	3

[a] Stand reduction.
[b] C.O.C. = Howe crop oil concentrate.

Weed control in no-till soybeans at Waseca, MN in 1988. Lueschen, William E., Jeffrey L. Gunsolus and Thomas R. Hoverstad. The objective of this study was to evaluate early preplant, preemergence and postemergence herbicides for weed control in no-till soybeans. This trial was conducted on a Webster clay loam soil containing 6.3% organic matter with a pH of 7.5 and soil test P and K levels of 69 and 429 lb/A, respectively. This site has been in a no-till system with corn and soybeans rotated for the past five years. The corn stalks were not chopped and residue cover on the soil surface averaged about 80% prior to planting. A randomized complete block design with three replications and a plot size of 10 by 30 ft was used. On May 13, 1988 'Hardin' soybeans were planted in rows 10 inches apart at a seeding rate of 175,000 seeds/A with a no-till planter equipped with coulters in front of the planting units. An excellent stand of soybeans resulted. Application dates, sprayer settings, environmental conditions, rainfall data and plant sizes are listed below:

Date	April 14	May 12	May 14	May 31	June 8
Treatment	EPP	Burndown	Pre	E. Post	Post
Sprayer					
gpa	20	10	20	20	20
psi	30	30	30	40	40
Temperature (F)					
air	44	77	58	92	72
soil (4 inch)	40	65	60	83	82
Soil moisture	moist	moist	moist	dry	very dry
Wind (mph)	15NW	10-15NW	10-15SE	10-15S	15-20NW
Sky	clear	cloudy	cloudy	clear	clear
Relative humidity (%)	60	40	47	16	40
Soybeans					
leaf no.	--	--	--	unif.	1-2
height (inch)	--	--	--	3-4	6-7
Giant foxtail					
leaf no.	--	1	1	2-3	3-5
height (inch)	--	0.5-1	0.5-1	2-3	2-5
infestation	--	--	--	--	$13/ft^2$
Common lambsquarters					
leaf no.	--	cotyl	cotyl	2-6	2-8[a]
height (inch)	--	0.5	0.5	1-2	1-2
infestation	--	--	--	--	$0.3/ft^2$
Redroot pigweed					
leaf no.	--	cotyl-2	cotyl-2	2-3	2-6[a]
height (inch)	--	0.5	0.5-1	1-1.5	1-2
infestation	--	--	--	--	$0.1/ft^2$
Velvetleaf					
leaf no.	--	cotyl	cotyl	cotyl-2	2-6[a]
height (inch)	--	0.5	0.5	0.5-1.5	1-3
infestation	--	--	--	--	$4/ft^2$
Rainfall after application (inch)					
week 1	0.02	0.10	0.10	0.0	0.05
week 2	1.63	0.0	0.27	0.05	0.58
week 3	0.0	0.27	0.0	0.58	0.27

[a]Most broadleaf weeds were dead or dying from previous treatments.

Soybean injury was evaluated but the data are not included since the level of injury was very low. Soybean vigor ratings are listed in the table to reflect the effects of weed competition. The only soil applied treatments that provided adequate weed control were the early preplant (EPP) or EPP + preemergence (Pre) treatments. When applied as an EPP treatment, clomazone + imazethapyr or imazethapyr alone at either 0.06 or 0.09 lb/A or pendimethalin + imazethapyr gave excellent season long weed control. Clomazone EPP followed by imazethapyr Pre was not as effective on giant foxtail or velvetleaf as the EPP tank mixture of both herbicides. Imazethapyr at 0.06 lb/A EPP provided slightly better control of giant foxtail than imazethapyr applied at 0.03 lb/A EPP followed by an additional 0.03 lb/A Pre. Imazethapyr applied at 0.05 lb/A EPP + 0.04 lb/A Pre gave weed control equivalent to 0.09 lb/A applied EPP. Imazethapyr + metribuzin EPP followed by the same treatment Pre provided excellent season long weed control. Neither alachlor + metribuzin nor metolachlor + metribuzin applied EPP followed by a Pre application of the same herbicides resulted in satisfactory control of giant foxtail or velvetleaf. Pre treatments of imazethapyr with surfactant or surfactant + 28% N solution resulted in poor weed control where no burndown treatment was used. Where imazethapyr was applied Pre alone or in combination with either chloramben, metribuzin or pendimethalin following a burndown treatment, weed control was very poor. With one exception, control of giant foxtail was better than 80% for all treatments that received sethoxydim postemergence. Where DPX-M6316 at 0.008 lb/A was applied in combination with bentazon at 0.5 lb/A + surfactant at 0.25% v/v as a single treatment, velvetleaf control was poor as compared to all other postemergence bentazon treatments where the bentazon was applied at 0.5 lb/A followed by an additional 0.38 lb/A 8 days later. Control of redroot pigweed and common lambsquarters was excellent for all postemergence treatment regimes. (Minn. Agric. Exp. Sta., Paper No. 16,446; Misc. Jour. Series, University of Minnesota, St. Paul).

Table. Weed control in no-till soybeans at Waseca, MN in 1988 (Lueschen, Gunsolus and Hoverstad).

Herbicide Treatment[a]	Rate	Vigor[b] 7/22	Gift 6/14	Gift 7/22	Gift 9/6	Vele 6/14	Vele 7/22	Vele 9/6	Rrpw 6/14	Rrpw 7/22	Rrpw 9/6	Colq 6/14	Colq 7/22	Colq 9/6	Soybean Yield
	(lb/A or %)	-(%)-	----	----	----	----	----	----	(% control)	----	----	----	----	----	(bu/A)
Early preplant: April 14, 1988															
Clomazone+imazethapyr	0.75+0.06	82	96	97	94	99	100	100	100	100	100	100	100	100	27.7
Imazethapyr	0.06	80	87	92	80	94	98	93	97	100	100	93	90	88	29.0
Imazethapyr	0.09	91	92	94	93	92	97	94	96	98	97	95	97	93	31.5
Imazethapyr+pendimethalin	0.06+1.5	88	98	98	89	97	100	96	100	100	100	100	100	95	27.1
Early preplant April 14, 1988 / preemergence May 14, 1988															
Alachlor+metribuzin / alachlor+metribuzin	2.5+0.38 / 1.5+0.38	75	77	68	47	57	53	47	100	87	77	100	97	88	16.1
Clomazone / imazethapyr	0.75 / 0.06	67	91	92	87	75	78	65	87	78	80	100	95	91	18.7
Imazethapyr / imazethapyr	0.03 / 0.03	82	84	81	74	88	98	93	97	93	90	95	90	88	29.0
Imazethapyr / imazethapyr	0.05 / 0.04	85	95	93	88	95	100	96	97	95	95	100	90	88	28.1
Imazethapyr+metribuzin / imazethapyr+metribuzin	0.03+0.38 / 0.03+0.38	93	93	99	93	98	99	98	100	100	100	100	100	100	34.2
Metolachlor+metribuzin / metolachlor+metribuzin	2.+0.38 / 1.0+0.38	75	82	67	38	61	67	52	97	85	80	100	85	92	19.5
Preemergence May 14, 1988 - no burndown															
Imazethapyr	0.06	58	75	68	71	27	30	24	83	73	82	47	37	48	9.0
Imazethapyr+Surf	0.06+0.25%	68	80	78	68	20	20	32	52	60	50	33	43	30	6.5
Imazethapyr+Surf+28% N	0.06+0.25%+5%	72	73	70	71	17	25	37	63	67	62	50	53	58	10.5
Imazethapyr+DPX-M6316 + Surf+28% N	0.06+0.008 + 0.25%+5%	73	80	78	80	37	53	43	100	88	92	73	67	65	16.2
Imazethapyr+metribuzin + Surf+28% N	0.06+0.5 + 0.25%+5%	83	73	78	78	45	43	33	87	83	87	99	93	90	17.9
Imazethapyr+pendimethalin Surf+28% N	0.06+1.5 + 0.25%+5%	70	78	81	78	47	45	58	82	72	70	82	72	72	16.1
Burndown glyphosate 0.38+2,4-D(A) 0.25+AMS 3.4 lb/A+Surf 0.5% May 12, 1988 / preemergence May 14, 1988 as follows:															
Alachlor+metribuzin	3.5+0.5	77	76	77	60	45	43	27	70	90	82	83	73	52	15.7
Imazethapyr	0.06	67	48	55	48	17	17	30	72	53	52	53	40	43	12.5
Imazethapyr+chloramben	0.06+2	53	68	37	37	38	22	33	60	57	57	58	40	30	9.9
Imazethapyr+metribuzin	0.06+0.5	70	78	78	77	33	33	23	82	77	73	87	77	87	8.1
Imazethapyr+pendimethalin	0.06+1.5	65	83	80	73	35	40	0	88	67	83	93	68	82	11.2
Metolachlor+metribuzin	3.0+0.5	67	70	47	50	13	15	40	50	43	65	82	40	58	5.7
Burndown May 12, 1988 / early postemergence May 31, 1988 / late postemergence June 8, 1988															
Acif+2,4-D(E)+Dash+28%N / Acif+Bent+COC / Bent+Seth+Dash+28% N	0.13+0.5+1.25%+5% / 0.13+0.5+1.25% / 0.38+0.15+1.25%+5%	72	60	89	85	93	90	75	100	92	92	100	95	96	26.2
Acif+2,4-D(E)+Seth+Dash+28% N / Acif+Bent+COC / Bent+Seth+Dash+28% N	0.06+0.5+1.25%+5% / 0.13+0.5+1.25% / 0.38+0.15+1.25%+5%	65	50	82	80	90	88	70	97	92	68	100	100	71	22.6
2,4-D(E)+Seth+Dash+28% N / Acif+Bent+COC / Bent+Seth+Dash+28% N	0.5+0.1+1.25%+5% / 0.13+0.5+1.25% / 0.38+0.15+1.25%+5%	72	75	94	89	97	98	87	100	100	100	100	100	100	33.0
Acif+2,4-D(E)+Imep+Dash+28% N / Bent+COC / Bent+Seth+Dash+28% N	0.13+0.5+0.03+1.25%+5% / 0.5+1.25% / 0.38+0.15+1.25%+5%	67	67	75	53	88	88	81	100	97	85	100	97	97	22.4
2,4-D(E)+Imep+Dash+28% N / Bent+COC / Bent+Seth+Dash+28% N	0.5+0.03+1.25%+5% / 0.5+1.25% / 0.38+0.15+1.25%+5%	68	72	91	90	97	96	86	97	90	80	100	100	99	30.9
2,4-D(E)+Imep+Seth+Dash+28% N / Bent+COC / Bent+Seth+Dash+28% N	0.5+0.03+0.1+1.25%+5% / 0.5+1.25% / 0.38+0.15+1.25%+5%	73	62	85	86	96	90	84	97	93	85	100	100	98	29.8
2,4-D(E)+Seth+Dash+28% N / Bent+DPX-M6316+Surf. / Seth+Dash	0.5+0.1+1.25%+5% / 0.5+0.008+0.25% / 0.15+1.25%	55	73	92	84	70	68	57	100	100	100	100	100	100	22.0
Checks															
Weedy check		43	0	0	0	0	0	0	0	0	0	0	0	0	4.4
Hand-weeded (burndown=glyphosate 0.38+2,4-D(A) 0.25+AMS 3.4+Surf 0.5% + (Pre=metolachlor+chloramben 3+2.5 lb/A)		88	85	98	96	48	95	84	98	100	100	92	100	100	29.3
	BLSD (0.05)	33	19	21	28	23	23	22	29	31	61	25	19	30	9.1

[a] AMS=spray grade $(NH_4)_2SO_4$, COC=crop oil concentrate=Clean Crop, Dash=spray adjuvant from BASF Corp., Surf=surfactant=Rohm and Haas Ag-98, 28% N=aqueous solution of urea and NH_4NO_3; Herbicide formulations: acifluorfen=Acif=Blazer 2L, alachlor=Lasso 4MT, bentazon=Bent=Basagran 4S, chloramben=Amiben 75DS, clomazone=Command 4E, DPX-M6316=25%DF, glyphosate=Roundup 3S, imazethapyr=Imep=Pursuit 2AS, metolachlor=Dual 8E, metribuzin=Sencor 75DF, pendimethalin=Prowl 4E, sethoxydim=Seth=Poast 1.5E, 2,4-D(A)=2,4-D Amine 3.8L, and 2,4-D(E)=2,4-D Ester 3.8E.

[b] Vigor=estimate of plant growth and development, 0=dead and 100=most vigorous.

TIMING HERBICIDE APPLICATION AND CULTIVATION

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Ten to fifteen years ago the choice of herbicides was very limited for corn and soybeans. Nearly all herbicides were soil applied either preplant incorporated or preemergence. Times have changed and the herbicide choices for weed control in corn and soybeans have become more complex. Weed control, like many other facets of our society has gone "high tech". Todays farmers must know a great deal about weed species, weed pressures, soil type, pH, timing of application, additives, spray volume, etc, etc. Without this base of information, it is difficult to obtain good weed control and keep the cost of weed control at a reasonable level.

OBJECTIVES AND PROCEDURES

In 1988 Dr. Jeff Gunsolus and I initiated a project to evaluate the effects of reduced rates of postemergence herbicides and cultivation on weed control in soybeans at Waseca and Lamberton, MN. Our objectives for this project were to evaluate three rates of application of acifluorfen (Blazer), bentazon (Basagran) and sethoxydim (Poast), three times of application and three cultivation regimes.

The rates chosen were equivalent to approximately one-fourth, one-half and full-label rates; hereafter, these rates will be referred to as 0.25X,0.5X and 1X, respectively. Rates of application were as follows:

Herbicide	Rate of Application 0.25X	0.5X	1X
	----------	lb/A	----------
Basagran	0.25	0.5	1.0
Blazer	0.06	0.125	0.25
Poast	0.05	0.10	0.20

Herbicide treatments included all herbicides at either 0.25, 0.5 or 1X. There were no treatments that invloved one herbicide at 0.25X and another at 0.5X, etc. To keep the number of treatments to a manageable level, oil concentrate at 1 qt/A was the only additive included with each herbicide treatment.

Time of application of each of the above rates was also evaluated. The first application of Poast was made 13 days after planting (DAP) and the Basagran + Blazer treatments were applied 14 DAP. The second and third timing of these same treatments were made 20 and 21 DAP and 27 and 28 DAP. The Poast was applied approximately 24 hours before applying the tank mixture of Basagran and Blazer. We chose to do this to prevent reduced grass control which may have occurred if the Basagran and Blazer were applied first and the grasses were burned by Blazer. Applying the herbicides in this sequence allowed us to evaluate cultivation without interferring with cultivation timing with respect to herbicide application.

Three cultivation treatments were evaluated at Waseca, MN. All of the herbicide treatments were cultivated as follows: no cultivation, one cultivation 14 days after the final herbicide application and two cultivations--one 7 days after the final herbicide application and a second cultivation 7 days later. Therefore, cultivation dates were different for each time of herbicide application. Cultivation was done with a "C" shank cultivator with sweeps set to till about 2 inches deep. None of the plots at Lamberton were cultivated except the cultivated weed checks.

In addition to the above herbicide and cultivation treatments at Waseca we included a treatment that received one rotary hoeing and two cultivations without any herbicide application. The rotary hoeing was done 8 days after planting just as the soybeans and weeds were beginning to emerge. The rotary hoe had a single gang of spike-tooth wheels and was operated at 8 mph. The two cultivations were done 13 and 27 days following rotary hoeing.

At both locatins all herbicide treatments were applied with a total spray volume of 20 gpa using 8002 flat fan nozzle tips. Spray pressure was 30 psi at Lamberton and 40 psi at Waseca.

'Hardin' soybeans were planted at both locations at a seeding rate of 150,000 seeds/A in 30-inch rows. The planting dates were May 11 and May 18, 1988 for Lamberton and Waseca, respectively.

Climatic conditions at both locations were very dry throughout the spring and early summer. These conditions influenced the result somewhat, but herbicide activity was not greatly impaired by these environmental conditions. Temperatures at Waseca exceeded normal by about 7° F for both May and June while rainfall for May through June was 4.9 inches below normal. At Lamberton for this same period temperatures were about 8° F above normal and precipitation was 4.6 inches below normal. Tables 1 and 2 give herbicide application dates, environmental conditions and weed sizes.

RESULTS

At Waseca giant foxtail control was influenced by time and rate of application and cultivation. Without cultivation the 0.25X rate of Poast resulted in about 82% giant foxtail control when applications were made either 13 or 20 DAP (Figure 1). When applied 27 DAP, control was reduced to approximately 70%. Either one or two cultivations improved control of giant foxtail 10 to 25% with the 0.25X rate. These low rates plus cultivation resulted in about 95% control of giant foxtail on July 11. At Lamberton the 0.25X rate of Poast resulted in very poor giant foxtail control when applied 13 and 27 DAP; control was about 95% when applied 20 DAP (Figure 6). The poor control at the earliest stage of application resulted from delayed weed emergence due to dry conditions following planting. Poor performance of the 27 DAP treatment was most likely the result of poor growing conditions and larger weeds. With the exception of the earliest application at Lamberton, which were made prior to emergence of giant foxtail, the 0.5 and 1X rates of Poast at both locations were not greatly affected by time of application (Figures 1 and 6). Although cultivation improved giant foxtail control at Waseca for 0.5 and 1X rates of Poast, it was not as dramatic as was observed with the 0.25X rate (Figure 1).

Broadleaf weed control was influenced by time and rate of application of Basagran + Blazer and cultivation. The response of common lambsquarters and redroot pigweed at Waseca and Lamberton and velvetleaf at Waseca were similar (Figures 2-4 and 7). The earliest applications of the 0.25X rates provided 80 to 90% control of these broadleaf weeds at Waseca on July 11, 1988 where no cultivation was done. The two later stages of application gave very poor broadleaf weed control with the 0.25X rate. Increasing the rate of application improved broadleaf control considerably, especially for the later applications. Since the broadleaf weeds were not emerged at Lamberton when the first applications were made, control was poor for all rates of application. Excellent control was obtained with the second and third stages of applications for all rates at Lamberton. Since the weeds were not emerged when the first applications were made at Lamberton, weeds were relatively small when the last two herbicides applications were made.

At both Waseca and Lamberton soybean yields were directly related to the level of weed control obtained. At Waseca soybean yields ranged from 35 to 40 bu/A where weed control averaged 80% or better (Figure 5). At Lamberton soybean yields ranged from 30 to 35 bu/A where weed control averaged 80% or better (Figure 8).

Although the data is not shown in the figures, the rotary hoe treatment plus two cultivations without any herbicide treatments resulted in excellent weed control at Waseca. Giant foxtail control for this treatment was 90% on July 11, 1988 and broadleaf control ranged from 86 to 99%. This level of control may be more than one would expect. Conditions were ideal in 1988 for getting maximum performance from the rotary hoe. The site where this research was conducted was fall moldboard plowed following corn harvest. The soil was very mellow at planting time and soil moisture was sufficient to allow soybeans and weeds to emerge rapidly, but there were no heavy rains. Following the rotary hoe treatment we experienced low relative humidities that quickly dried any disturbed root systems. Lack of rainfall after rotary hoeing also prevented reestablishment of weeds.

CONCLUSIONS

Both time and rate of herbicide application are important in determining efficiency of postemergence herbicides. Our preliminary results indicated that reduced rates of Basagran + Blazer and Poast can give effective weed control where applications are made to weeds less than two inches tall. Although early postemergence herbicide applications are likely to result in second flushes of weeds, these later emerging weeds can be controlled with cultivations where soybeans are grown in rows 20 inches wide or wider. Since the soybeans will have a growth advantage over the later emerging weeds, cultivation should provide an excellent supplement to the weed control program.

Growers who target their applications early are more likely to obtain consistently good performance from postemergence herbicides, especially with low rates of application. If weather delays application a few days, the grower who plans to apply herbicides early will usually still be able to get the herbicides applied before the weeds are beyond labeled applications. If weeds are larger than 2 inches at the time of applying postemergence herbicides the rate of application should be increased to near label rates to obtain acceptable control and reduce the risk of poor performance.

The 1988 season reassured us that weeds under go stress when dry soil conditions persist and they become difficult to control even with labeled rates of herbicide. When weeds are under stress it may not be wise to reduce rates of herbicides. The same could be said for postemergence herbicides applied during cool, cloudy weather. In both cases, the weeds are not growing vigorous and may take up less herbicide, resulting in poor control.

Growers opting to try below label rates of herbicides need to keep several factors in mind. First, chemical companies are not likely to stand behind herbicide performance when rates are below the label recommendations. Therefore, growers need to be willing to assume the risks that may be associated with reduced rates of herbicide application. Secondly, growers will need to monitor fields closely to determine when weeds are the proper size for postemergence herbicide application. It is very difficult to "cookbook" herbicide applications and make a general recommendation to apply the herbicide "X" days after planting. As a general guideline farmers should target the early postemergence treatments between 14 and 20 days after planting. However, it does no good to apply postemergence herbicides when weeds have not emerged. This was the case at Lamberton 14 days after planting and poor performance resulted. Thirdly, growers need to inspect fields after postemergence herbicides are applied. If weeds are not dying in 5 to 10 days following treatment, it will be necessary to make a second herbicide application or cultivate to improve weed control. For soybeans grown in rows wider than 15 inches cultivation will be essential where herbicides are applied early.

Reduced rates of postemergence herbicides and timely applications can help growers reduce weed control costs. Research in Arkansas, Missouri and Iowa support these findings. Obviously, more research is needed to help define the parameters necessary to make this system work consistantly. The use of reduced rates will require good management to avoid the pitfalls along the way. Certainly, the grower that has problems obtaining good postemergence control with full rates of postemergence herbicides should not look to reduced rates to bail him out or failure will be eminent.

Table 1. Treatment dates, weed sizes and environmental conditions at Waseca in 1988.

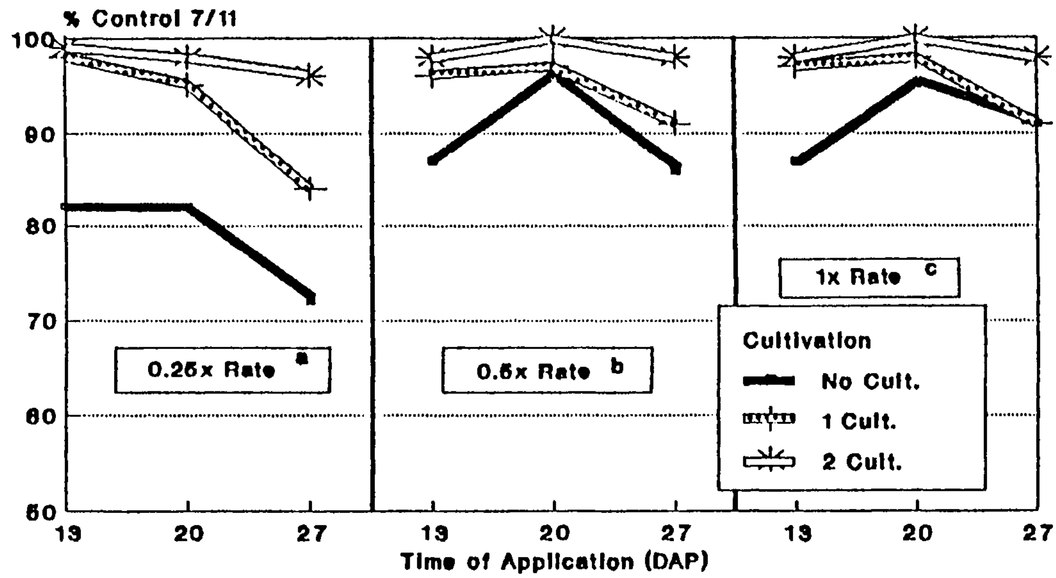
	13 DAP	14 DAP	20 DAP	21 DAP	27 DAP	28 DAP
Date	May 31	June 1	June 7	June 8	June 14	June 15
Temp (F)						
air	88	88	90	79	90	66
soil (4 inch)	73	76	75	77	86	70
Soil moisture	dry	dry	dry	dry	v. dry	v. dry
wind	10-15 S	10-15 S	10-15 SW	10-20 E	15-20 SW	5-10 NW
sky	clear	clear	clear	clear	clear	clear
R. H. (%)	20	35	25	53	30	65
Soybean						
leaf no.	unif	unif	2	2	3	3
height (inch)	1-2	1-2	6	6	8	8
Giant foxtial						
leaf no.	1-2	1-2	3-5	3-5	4-6	4-6
height (inch)	1-2	1-2	3-5	3-5	6	6
infestation					$20/ft^2$	
Broadleaves						
leaf no.	coty-2	coty-2	3-8	3-8	5-10	5-10
height (inch)	0.5-1	0.5-1	2-4	2-4	3-6	3-6
infestation					$2/ft^2$	

Table 2. Treatment dates, weed sizes and environmental condtions at Lamberton in 1988.

	13 DAP	14 DAP	20 DAP	21 DAP	27 DAP	28 DAP
Date	May 24	May 25	May 31	June 1	June 6	June 7
Temp (F)						
air	76	79	86	85	86	91
Soil moisture	moist	moist	dry	dry	v. dry	v. dry
wind	calm	5 S	5-10 SW	5 S	5 S	3-5 S
sky	clear	clear	clear	clear	clear	clear
R. H. (%)	20	29	44	45	22	31
Soybean						
leaf no.	unif	unif	1	1	3	3
height (inch)	1-2	1-2	4	4	8	8
Giant foxtial						
leaf no.	--- [a]	--- [a]	1	1	3-4	3-4
height (inch)	---	---	0.5	0.5	3	3
infestation					$10/ft^2$	
Broadleaves						
leaf no.	---	---	cotyl	cotyl	2-4	2-4
height (inch)	---	---	0.5	0.5	2	2
infestation					$.5\text{-}13/ft^2$	

[a] weeds not emerged

Figure 1. Effects of Herbicide Rate, Timing and Cultivation on Giant Foxtail Control at Waseca in 1988.

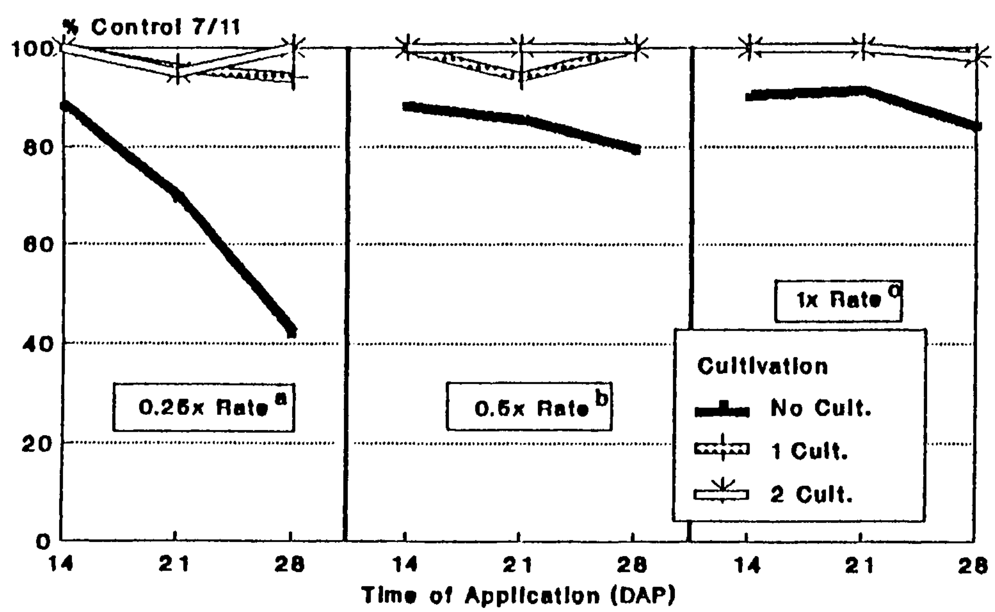


[a]0.25x rate = Poast 0.05 lb/A + COC 1.25%.

[b]0.5x rate = Poast 0.1 lb/A + COC 1.25%.

[c]1x rate = Poast 0.2 lb/A + COC 1.25%.

Figure 2. Effects of Herbicide Rate, Timing and Cultivation on Common Lambsquarter Control at Waseca in 1988.

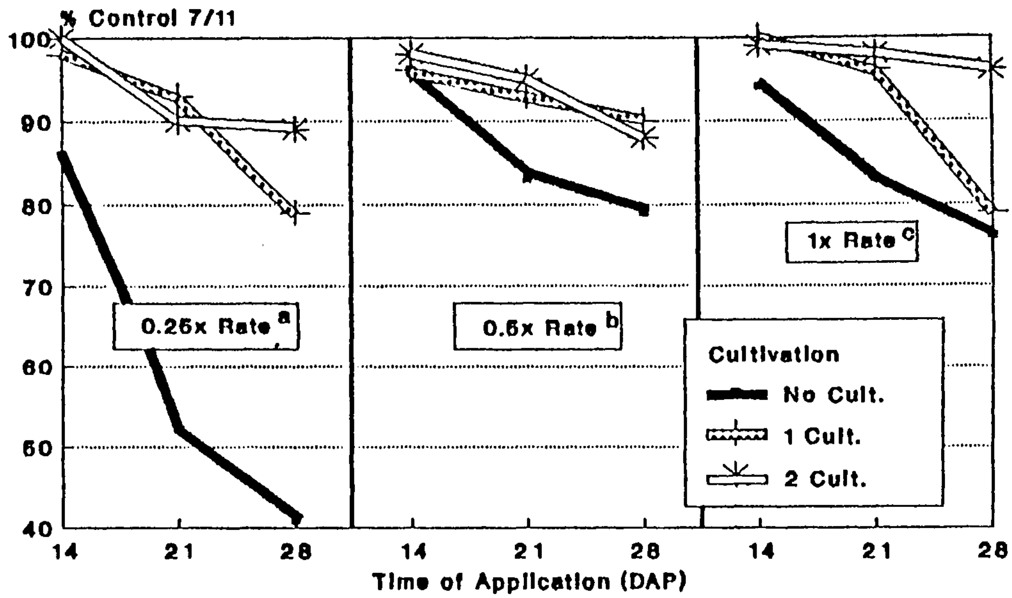


[a]0.25x rate = Basagran 0.25 lb/A + Blazer 0.06 lb/A + COC 1.25%

[b]0.5x rate = Basagran 0.5 lb/A + Blazer 0.13 lb/A + COC 1.25%

[c]1x rate = Basagran 1.0 lb/A + Blazer 0.25 lb/A + COC 1.25%

Figure 3. Effects of Herbicide Rate, Timing and Cultivation on Redroot Pigweed Control at Waseca in 1988.

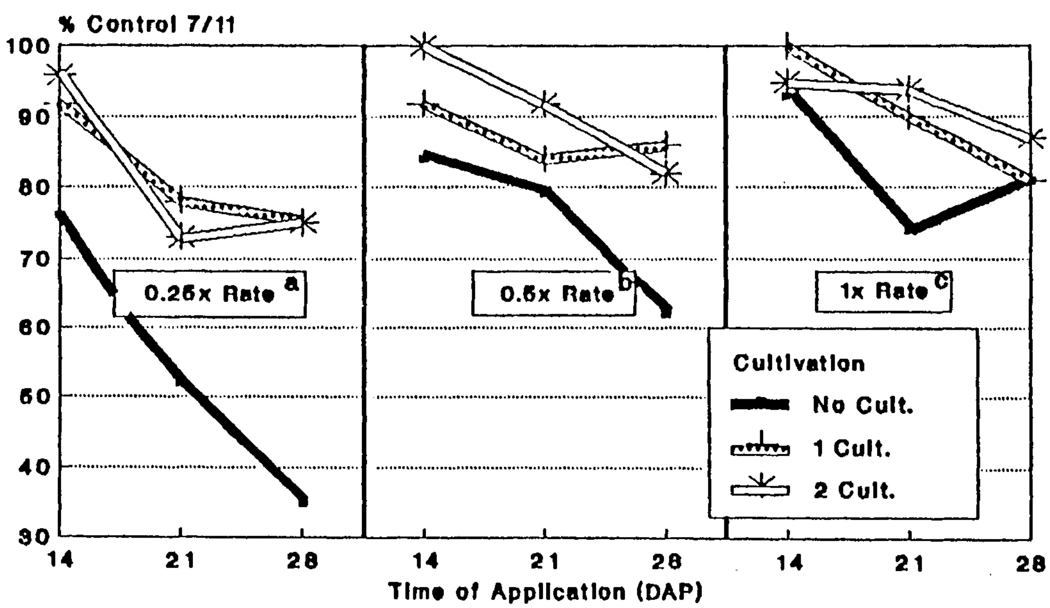


[a] 0.25x rate = Basagran 0.25 lb/A + Blazer 0.06 lb/A + COC 1.25%

[b] 0.5x rate = Basagran 0.5 lb/A + Blazer 0.13 lb/A + COC 1.25%

[c] 1x rate = Basagran 1.0 lb/A + Blazer 0.25 lb/A + COC 1.25%

Figure 4. Effects of Herbicide Rate, Timing and Cultivation on Velvetleaf Control at Waseca in 1988.

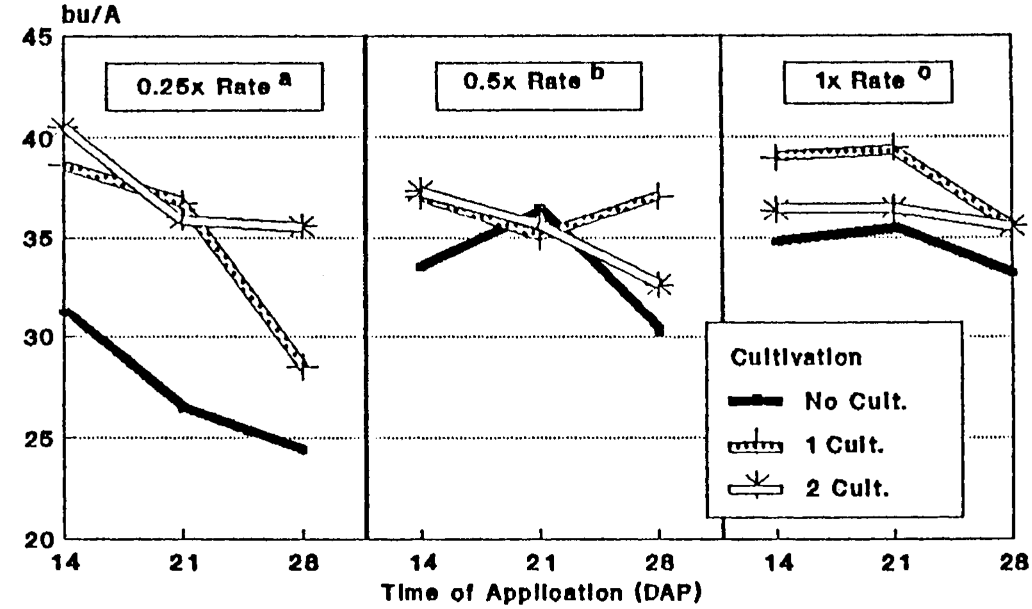


[a] 0.25x rate = Basagran 0.25 lb/A + Blazer 0.06 lb/A + COC 1.25%

[b] 0.5x rate = Basagran 0.5 lb/A + Blazer 0.13 lb/A + COC 1.25%

[c] 1x rate = Basagran 1.0 lb/A + Blazer 0.25 lb/A + COC 1.25%

Figure 5. Effects of Herbicide Rate, Timing and Cultivation on Soybean Yield at Waseca in 1988.

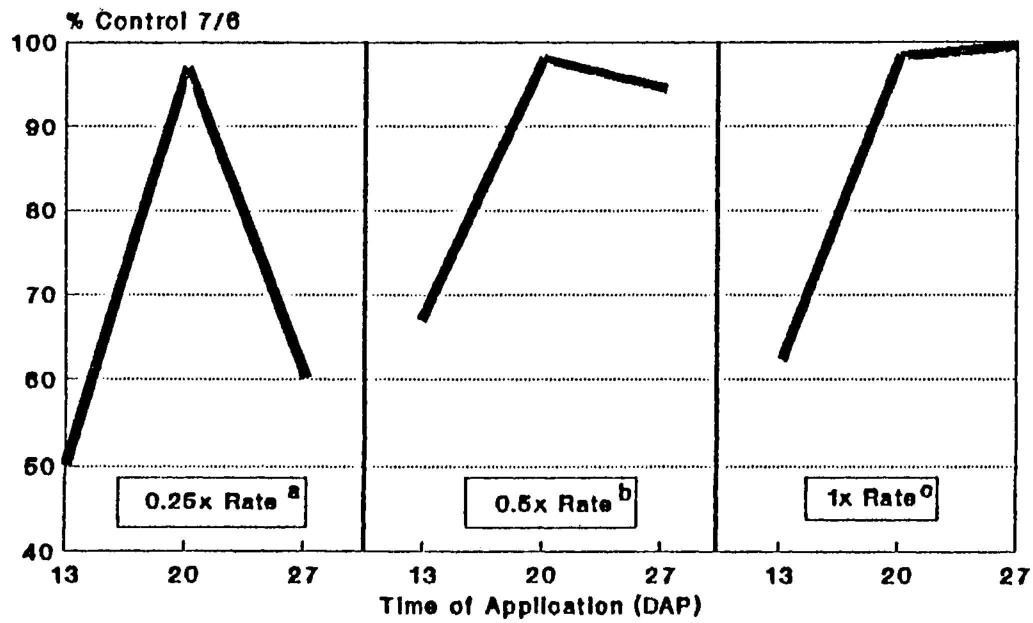


[a] 0.25x rate = Poast 0.05 lb/a +COC 1.25% - Basagran 0.25 lb/A + Blazer 0.06lb/A + COC 1.25%

[b] 0.5x rate = Poast 0.1 lb/A + COC 1.25% - Basagran 0.5 lb/A + Blazer 0.13 lb/A + COC 1.25%

[c] 1x rate = Poast 0.2 lb/A + COC 1.25% - Basagran 1.0 lb/A + Blazer 0.25 lb/A + COC 1.25%

Figure 6. Effects of Herbicide Rate and Timing on Giant Foxtail Control at Lamberton in 1988.

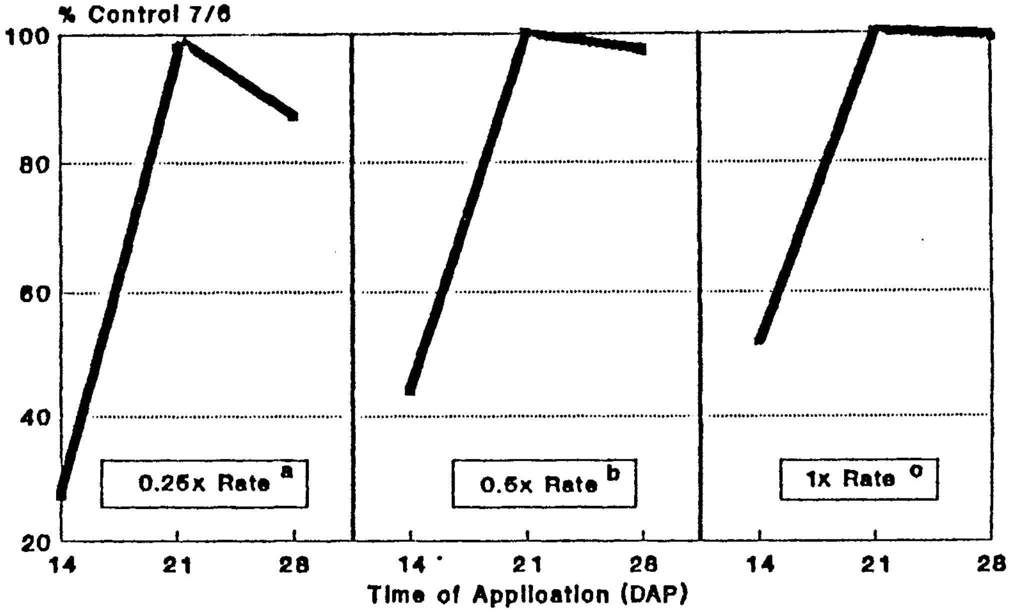


[a] 0.25x rate = Poast 0.05 lb/A + COC 1.25%.

[b] 0.5x rate = Poast 0.1 lb/A + COC 1.25%.

[c] 1x rate = Poast 0.2 lb/A + COC 1.25%.

Figure 7. Effects of Herbicide Rate and Timing on Broadleaf Weed Control at Lamberton in 1988.

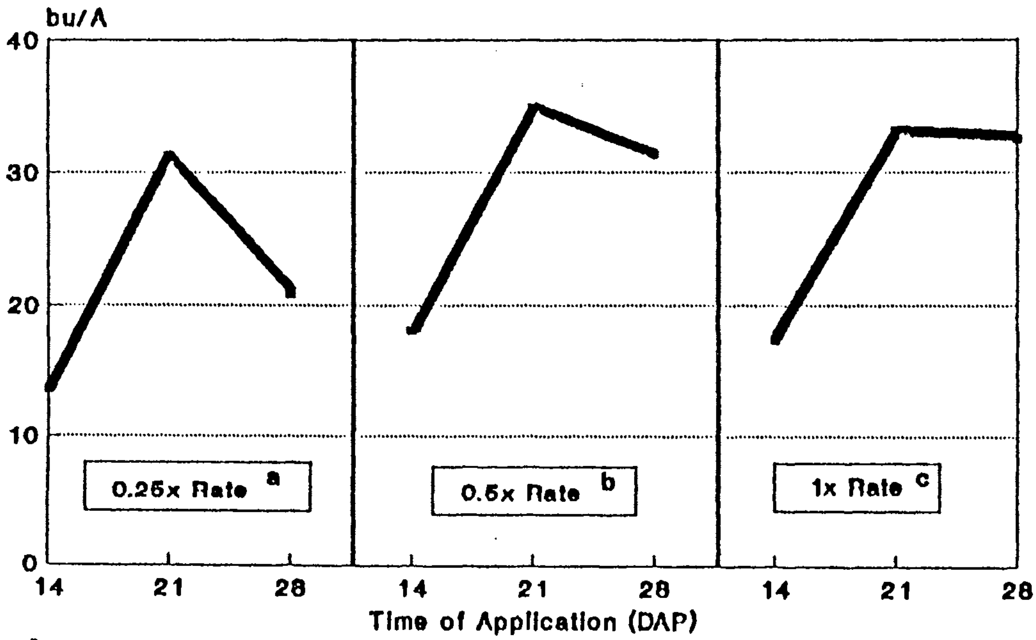


[a] 0.25x rate = Basagran 0.25 lb/A + Blazer 0.06 lb/A + COC 1.25%

[b] 0.5x rate = Basagran 0.5 lb/A + Blazer 0.13 lb/A + COC 1.25%

[c] 1x rate = Basagran 1.0 lb/A + Blazer 0.25 lb/A + COC 1.25%

Figure 8. Effects of Herbicide Rate and Timing on Soybean Yield at Lamberton in 1988.



[a] 0.25x rate = Poast 0.05 lb/a +COC 1.25% - Basagran 0.25 lb/A + Blazer 0.06lb/A + COC 1.25%

[b] 0.5x rate = Poast 0.1 lb/A + COC 1.25% - Basagran 0.5 lb/A + Blazer 0.13 lb/A + COC 1.25%

[c] 1x rate = Poast 0.2 lb/A + COC 1.25% - Basagran 1.0 lb/A + Blazer 0.25 lb/A + COC 1.25%

Soybean Management Study

W. E. Lueschen, J. Orf, W. Stienstra, G. Randall and T. Hoverstad

The objective of this study was to evaluate the influence of tillage, soybean varieties and seed treatments on the performance of soybeans in a corn/soybean rotation. A second study was designed to evaluate any effects of residual nitrogen remaining from nitrogen applied to the previous corn crop on soybeans. This research was also conducted at Lamberton and Morris to evaluate the effects of different environments on these variables. These studies allowed us to evaluate the interactions among the above factors.

Two studies were conducted on a Webster clay loam soil containing 6 to 7% organic matter with the following soil chemical properties: pH=6.9, P=57 and K=285 lb/A. Each study was designed as a randomized complete block experiment with four replications and a split-split plot arrangement of treatments. Since 1986, this site has been in a corn/soybean rotation with the same tillage treatment remaining on a plot for the duration of the experiment.

In the study that evaluated tillage, varieties and seed treatments, five tillage systems were the main plots, 50 by 125 feet. The tillage systems evaluated were: a) no-till following corn and soybeans, b) ridge-till in both corn and soybeans, c) chisel plowing following corn with no-till following soybeans, d) Paraplowing following corn and soybeans and e) moldboard plowing following corn and chisel plowing following soybeans. Tillage depths were as follows: moldboard plow 8 to 9 inches, chisel plow 7 to 8 inches and Paraplow 12 to 14 inches. The ridges for the ridge-till system were formed in the previous crop. Corn stalks were chopped in the fall for the ridge system. Spring tillage just prior to planting consisted of one pass with a field cultivator for moldboard plowing and one pass with a finishing disk for chisel plowing. Both the field cultivator and finishing disk were equipped with a three bar mulcher. No spring tillage was done on the Paraplow treatments. The ridge-till plots were planted with a John Deere 7100 planter equipped with a wide clearing sweep ahead of each planting unit with the sweep set to remove one to two inches of soil from the top of the ridge. All other plots were planted with a John Deere 7100 equipped with a residue cutting coulter ahead of each planting unit. Eight varieties were subplots and sub-subplots were three seed treatments (see Table 1 for a complete treatment list). Seed for each plot was counted and packaged for planting at a seeding rate of 120,000 seeds/A (7 seeds/foot of row). Seed treatments were done prior to packaging seed. All plots were planted on May 16, 1988 using cone planting attachments on the above described planters.

To remove existing weed competition on plots that received no spring tillage, Roundup at 1 qt/A with 0.5% surfactant was applied to no-till, ridge-till and Paraplow plots on May 16, 1988. All plots received a preemergence application of Lasso at 3.5 lb/A plus Amiben at 3.0 lb/A. All plots were hand-weeded to remove any escaped weeds. The no-till and Paraplow plots were not cultivated. The moldboard plow, chisel plow and ridge-till plots were cultivated once on June 16, 1988. Ridges for the following corn crop were formed on July 8, 1988.

The second study consisted of evaluating soybean response to residual nitrogen. The main plots were tillage treatments as described previously. Six nitrogen fertilizer rates (0 to 200 lb/A) applied to corn plots in 1987 were the subplots and sub-subplots were four soybean varieties (see Table 2 for a complete treatment list). This study was planted on May 18, 1988. The same herbicide treatments as described previously were used in this study.

Plant height was measured on July 14, 1988 and again on September 22, 1988. Plant populations were determined by counting emerged plantes in 5 feet of row three times per week from the beginning of emergence until all plants had emerged. Maturity was estimated and recorded as days past July 1 when 90% of the pods were brown. All plots were harvested on October 11, 1987.

The results from the study involving seed treatment in 1988 are presented in Table 1. The extremely dry weather experienced at the research site in 1988 caused yield variations. Because of the variability in this study no significant yield differences due to tillage were observed in 1988. However, yields of tillage treatments followed a similar pattern as previous years. The yield for five tillage systems was 38.7, 37.6, 36.3, 34.7 and 34.6 bu/A for the moldboard plow, no-till, chisel plow, Paraplow and ridge-till treatments, respectively. Ridge-till plots had the highest plant population in 1988 with little difference in population among the other tillages. Plant height varied slightly across tillages, with the tallest plants in the moldboard and chisel plowed treatments. No significant difference in lodging was attributed to tillage. The largest seed size was associated with the moldboard plow treatment and all other tillage systems resulted in seeds of equal size. There were significant differences among varieties for all parameters measured. The highest yielding variety was 'Elgin' and 'Hodgson 78' was the lowest yielding variety in 1988. All other varieties had similar yields. The highest yielding varieties were those that matured later in the growing season. Rainfall and cooler temperatures in August was advantageous to the later varieties.

Seed treatment resulted in small differences in plant population in 1988 with treated plots exhibiting lower populations than the untreated plots. Seed treatment did not affect soybean yield or any other parameters measured.

Table 2 gives the results from the study involving residual nitrogen. Residual nitrogen remaining from the previous corn crop resulted in no significant yield differences in 1988. This was true for each tillage system evaluated. The results of tillage were similar to the results in the previous study. 'Hardin', 'A1937' and 'BSR101' were the highest yielding varieties and Hodgson 78 had the lowest yield.

Table 3 shows the 3-year average of the seed treatment study. Averaged over three years, the moldboard plow resulted in about a 1 bu/A yield advantage over no-till and the chisel plow systems but these differences were not significant (P=0.05). The moldboard plow had a 2 bu/A advantage over the Paraplow system and a 3.2 bu/A advantage over the ridge-till system; these differences were significant (P=0.05). Plant population differences across tillages were small, however, the ridge-till system tended to have higher plant populations than the other tillage systems when seeded at the same rate. Tillage had very little effect on lodging, maturity and seed weight.

Averaged over the three years, the eight varieties can be categorized into two yield groups; the higher yielding varieties were: A1937, BSR101, 'Pioneer 1677' and Hardin. The lower yielding varieties were, Hodgson 78, 'Sibley', 'Corsoy 79' and Elgin. Differences in plant population were observed across varieties. This is a result of poor quality seed of Elgin in 1986 that did not germinate very well. Other differences in population very not? large and probably not responsible for yield differences except with Pioneer 1677 in 1986. Varietal differences were observed for plant height, lodging, maturity and seed weight.

Averaged over three years, differences due to seed treatment were very small. However, careful examination of the data shows that in 1986 Elgin and Pioneer 1677 had a yield response to either seed treatment. This was the result of poor quality seed of Elgin and disease susceptibility of Pioneer 1677. The 1986 growing season was favorable for diseases to develop in soybeans and seed treatment was beneficial with these varieties. In 1987 and 1988 dry conditions prevented seed treatment response.

Table 4 shows the effects of tillage, residual nitrogen and variety on soybean yields at Waseca in 1987 to 1988. Yield patterns in this study were similar to that in the seed treatment study with the moldboard plow resulting in about a 1 bu/A yield advantage compared to no-till and chisel plowing and about a 2.5 bu/A advantage compared to Paraplowing and ridge-till. Residual nitrogen remaining from the previous corn crop had no effect on soybean yield in 1987 or 1988. In this phase of the research Hardin, A1937 and BSR101 produced higher yields than Hodgson 78.

In summary, after three years of this study, our data indicates that soybean growers have a lot of latitude in choosing a tillage system for soybeans following corn. Although the moldboard plow tended to result in higher yields, a grower could not expect to recover the additional costs of moldboard plowing by increased soybean production when compared to more reduced tillage systems. This is especially true when considering the benefits of soil conservation with reduced tillage. Soybean varietal selection should not be influenced by tillage system. Soybean varietal selection should be based on: yield history, disease resistance, agronomic characteristics and seed quality. There does not appear to be a benefit for seed treatment in soybeans except for two cases. In one case seed treatment was beneficial where poor quality seed was used. In the second case a response to seed treatment was observed on a variety that lacks good disease resistance. Nitrogen fertilizer applied to corn had no effect on the subsequent soybean crop in this study. Therefore, the amount of residual nitrogen remaining for soybeans following corn does not appear to influence soybean yields.

These results were obtained on an area that is well tiled and sub-surface drainage is good. Individual growers should take this into account when making decisions about soybean production in reduced tillage systems.

We appreciate the support of the Minnesota Soybean Research and Promotion Council who provided partial funding for this study.

Tillage	Variety	Seed Treatment	Plant Pop. 6/10	Plant Pop. 9/22	Plant Height 7/14	Plant Height 9/22	Lodg 1/	Mat	Seed Weight	Seed H2O	Yield
			(1000's/A)		-(inch)-		(1-5)	(8/1=1)	(g/100)	(%)	(bu/A)
Moldboard	Corsoy 79	Captan	84.5	76.7	31.5	40.0	2.5	48	15.8	10.6	36.0
Moldboard	Corsoy 79	Apron	83.6	68.0	28.5	40.8	2.2	46	15.4	10.6	39.6
Moldboard	BSR 101	Check	93.2	98.4	24.8	35.5	1.5	46	16.3	11.0	40.0
Moldboard	BSR 101	Captan	99.3	87.1	24.0	35.5	1.5	45	16.3	10.8	40.1
Moldboard	BSR 101	Apron	91.5	79.3	25.0	34.8	1.2	46	15.4	11.0	38.3
Moldboard	A 1937	Check	95.0	79.3	29.8	38.5	2.5	46	16.6	10.6	41.2
Moldboard	A 1937	Captan	87.2	75.0	27.5	36.0	2.0	46	16.4	10.5	40.0
Moldboard	A 1937	Apron	90.6	84.5	28.5	38.2	2.0	46	16.8	10.6	41.9
Moldboard	Sibley	Check	74.0	75.8	26.5	32.5	1.8	45	18.6	10.8	33.2
Moldboard	Sibley	Captan	91.5	91.5	26.0	30.8	1.2	44	19.4	10.8	37.4
Moldboard	Sibley	Apron	95.8	87.1	25.5	32.5	1.8	45	18.8	10.8	38.6
Moldboard	Elgin	Check	93.2	72.3	24.0	33.8	1.8	50	15.7	10.8	43.5
Moldboard	Elgin	Captan	89.8	82.8	23.0	31.8	2.0	50	16.0	10.7	42.2
Moldboard	Elgin	Apron	74.1	65.3	22.0	32.8	1.8	50	15.0	10.6	39.2
Moldboard	Hardin	Check	97.6	81.9	26.0	34.0	2.5	46	16.6	10.7	38.4
Moldboard	Hardin	Captan	118.5	96.7	27.2	36.0	2.2	45	16.0	10.8	37.0
Moldboard	Hardin	Apron	106.2	81.9	30.0	34.8	2.5	46	16.6	10.8	46.0
Moldboard	P 1677	Check	117.6	103.7	27.2	32.8	2.0	43	15.6	10.8	38.0
Moldboard	P 1677	Captan	113.2	96.7	27.0	33.0	1.5	43	15.9	10.6	44.5
Moldboard	P 1677	Apron	88.9	90.6	28.0	33.0	1.5	42	16.0	10.6	40.7
Moldboard	Hodgson 78	Check	100.2	95.8	29.0	31.5	1.8	41	17.6	10.7	34.4
Moldboard	Hodgson 78	Captan	104.5	90.6	29.0	29.8	2.2	42	18.1	10.7	31.6
Moldboard	Hodgson 78	Apron	82.8	76.6	28.0	32.5	2.0	42	17.6	10.6	31.4
Chisel	Corsoy 79	Check	78.4	65.3	24.5	38.0	2.5	47	14.4	10.5	35.3
Chisel	Corsoy 79	Captan	72.3	56.6	26.0	39.5	2.5	47	14.8	10.6	30.8
Chisel	Corsoy 79	Apron	84.5	74.9	28.2	39.5	2.8	47	14.8	10.4	31.7
Chisel	BSR 101	Check	82.8	74.0	23.8	32.5	1.5	47	15.8	10.9	37.4
Chisel	BSR 101	Captan	80.2	89.7	23.2	37.0	1.5	45	15.8	10.8	38.5
Chisel	BSR 101	Apron	98.4	94.1	23.5	36.8	1.5	47	15.7	10.9	41.0
Chisel	A 1937	Check	68.0	65.4	26.2	35.8	2.2	44	15.8	10.7	32.9
Chisel	A 1937	Captan	96.7	83.6	27.0	36.5	2.2	44	15.8	10.5	35.3
Chisel	A 1937	Apron	90.6	75.0	28.0	36.0	2.2	44	15.6	10.7	37.6
Chisel	Sibley	Check	87.1	79.3	26.8	34.5	2.0	45	17.9	10.9	35.2
Chisel	Sibley	Captan	87.1	73.2	27.8	34.2	2.2	44	18.6	11.0	36.6
Chisel	Sibley	Apron	79.3	69.7	26.5	33.2	2.2	44	18.0	10.9	35.6
Chisel	Elgin	Check	79.3	88.9	21.5	33.5	2.5	50	15.5	10.7	42.7
Chisel	Elgin	Captan	81.0	67.1	22.2	33.0	2.2	50	15.0	10.6	41.7
Chisel	Elgin	Apron	76.7	78.4	25.5	32.8	1.8	49	14.8	10.6	39.7
Chisel	Hardin	Check	101.1	91.5	26.2	35.2	2.5	44	15.2	10.5	35.5
Chisel	Hardin	Captan	98.4	77.6	25.8	35.0	2.5	44	15.3	10.4	33.3
Chisel	Hardin	Apron	73.2	70.6	27.0	35.0	2.2	43	15.5	10.6	33.0
Chisel	P 1677	Check	108.9	88.9	26.5	34.5	2.0	43	15.6	10.6	41.0
Chisel	P 1677	Captan	87.1	81.9	26.0	33.5	1.8	43	15.1	10.5	40.0
Chisel	P 1677	Apron	81.0	68.8	28.0	36.5	2.2	43	15.1	10.6	36.4
Chisel	Hodgson 78	Check	95.0	94.1	28.0	36.0	2.2	42	16.7	10.8	34.6
Chisel	Hodgson 78	Captan	80.0	68.8	25.5	34.0	2.0	42	17.2	10.7	31.4
Chisel	Hodgson 78	Apron	96.7	76.6	27.5	33.5	2.0	42	17.0	10.6	34.2
Paraplow	Corsoy 79	Check	68.0	63.6	21.0	36.0	2.5	47	15.2	10.6	31.9
Paraplow	Corsoy 79	Captan	88.0	76.7	23.5	34.8	2.2	46	16.1	10.6	36.3
Paraplow	Corsoy 79	Apron	91.5	85.3	23.8	36.2	2.2	48	15.1	10.6	38.0
Paraplow	BSR 101	Check	95.0	69.7	19.5	31.0	1.8	47	15.8	10.9	35.0
Paraplow	BSR 101	Captan	102.8	75.8	20.0	30.8	1.5	47	15.4	11.0	34.7
Paraplow	BSR 101	Apron	87.1	74.9	19.8	32.5	1.8	46	15.1	10.8	33.4

Table 1. Effects of Tillage, Variety and Seed Treatment on Soybeans at Waseca, MN in 1988.

Tillage	Variety	Seed Treatment	Plant Pop. 6/10	Plant Pop. 9/22	Plant Height 7/14	Plant Height 9/22	Lodg 1/	Mat	Seed Weight	Seed H2O	Yield
			(1000's/A)		-(inch)-		(1-5)	(8/1=1)	(g/100)	(%)	(bu/A)
No-till	Corsoy 79	Check	95.8	70.6	21.0	36.2	2.0	49	15.1	10.6	39.3
No-till	Corsoy 79	Captan	83.6	76.6	20.5	35.0	2.0	48	14.9	10.4	40.0
No-till	Corsoy 79	Apron	97.6	73.2	20.7	34.8	2.0	47	15.1	10.6	40.0
No-till	BSR 101	Check	104.5	94.1	20.0	33.2	1.8	47	15.0	10.8	38.2
No-till	BSR 101	Captan	98.4	84.5	21.8	32.8	1.5	47	14.8	10.8	35.4
No-till	BSR 101	Apron	102.8	75.8	19.0	30.5	1.5	45	14.4	10.8	33.1
No-till	A 1937	Check	105.4	80.2	22.5	34.2	2.0	46	15.6	10.6	43.3
No-till	A 1937	Captan	100.2	96.7	21.0	33.8	2.0	45	15.6	10.7	39.5
No-till	A 1937	Apron	94.1	82.8	20.5	35.0	2.2	46	15.6	10.7	39.9
No-till	Sibley	Check	86.2	82.8	21.2	30.0	1.2	45	17.9	10.7	37.8
No-till	Sibley	Captan	79.3	81.9	20.0	28.5	1.5	46	17.9	10.6	36.8
No-till	Sibley	Apron	90.6	80.2	20.2	29.8	1.8	46	17.6	10.8	35.8
No-till	Elgin	Check	94.1	88.0	21.5	32.0	2.0	50	15.2	10.7	41.6
No-till	Elgin	Captan	92.4	79.2	19.8	31.0	1.8	50	14.6	10.7	43.2
No-till	Elgin	Apron	78.4	62.8	18.2	33.2	2.0	51	14.5	10.6	39.2
No-till	Hardin	Check	108.9	86.2	21.8	32.2	2.0	44	15.5	10.4	38.0
No-till	Hardin	Captan	107.2	96.7	22.8	32.2	2.0	45	15.5	10.5	39.3
No-till	Hardin	Apron	85.4	74.9	21.2	33.5	2.0	44	15.2	10.6	36.5
No-till	P 1677	Check	108.0	89.8	21.2	28.5	1.2	44	15.2	10.6	36.3
No-till	P 1677	Captan	95.8	72.3	19.0	28.0	1.2	44	15.0	10.5	35.4
No-till	P 1677	Apron	95.8	88.8	20.5	27.2	1.5	44	14.7	10.6	36.2
No-till	Hodgson 78	Check	113.2	92.4	21.2	30.8	1.5	42	16.8	10.5	31.6
No-till	Hodgson 78	Captan	100.2	85.4	22.0	31.5	1.8	43	17.2	10.6	31.9
No-till	Hodgson 78	Apron	109.8	87.1	22.8	30.5	1.8	42	17.1	10.6	33.7
Ridge-till	Corsoy 79	Check	109.8	80.2	24.5	38.5	2.5	46	14.8	10.6	37.6
Ridge-till	Corsoy 79	Captan	86.2	67.1	24.8	36.8	2.2	46	15.2	10.5	35.0
Ridge-till	Corsoy 79	Apron	101.9	86.2	23.8	37.5	2.5	47	14.7	10.5	36.2
Ridge-till	BSR 101	Check	122.8	105.4	22.8	34.5	1.5	47	14.7	10.8	36.8
Ridge-till	BSR 101	Captan	113.2	107.2	22.0	35.0	1.5	46	15.4	10.8	35.9
Ridge-till	BSR 101	Apron	105.4	90.6	22.0	35.5	1.5	46	15.2	10.9	35.3
Ridge-till	A 1937	Check	109.8	94.1	23.8	32.0	1.2	45	15.9	10.5	32.7
Ridge-till	A 1937	Captan	113.2	95.0	22.0	31.8	1.8	44	15.5	10.6	36.0
Ridge-till	A 1937	Apron	102.0	86.3	23.5	32.0	1.8	44	15.4	10.3	34.0
Ridge-till	Sibley	Check	130.7	114.1	22.5	29.5	1.2	45	17.6	10.7	34.6
Ridge-till	Sibley	Captan	100.2	90.6	23.8	30.0	1.8	44	18.2	10.8	35.9
Ridge-till	Sibley	Apron	100.2	81.9	22.8	30.0	1.5	44	18.6	10.8	36.4
Ridge-till	Elgin	Check	120.2	111.5	21.2	32.2	1.8	50	15.2	10.8	40.7
Ridge-till	Elgin	Captan	94.9	95.8	21.0	31.0	1.8	49	15.5	10.8	40.9
Ridge-till	Elgin	Apron	87.1	92.4	19.0	31.5	1.8	48	15.1	10.8	39.8
Ridge-till	Hardin	Check	116.8	102.8	22.0	33.0	2.2	44	15.0	10.6	36.2
Ridge-till	Hardin	Captan	122.8	125.5	22.0	31.5	2.0	44	15.2	10.5	34.4
Ridge-till	Hardin	Apron	100.2	100.2	22.5	32.5	2.0	44	15.6	10.5	33.6
Ridge-till	P 1677	Check	125.4	108.0	20.0	28.2	1.0	42	15.2	10.4	32.2
Ridge-till	P 1677	Captan	117.6	103.7	22.0	28.8	1.2	42	15.0	10.4	32.2
Ridge-till	P 1677	Apron	104.5	102.0	21.0	29.5	1.2	42	15.2	10.4	33.2
Ridge-till	Hodgson 78	Check	113.2	104.5	22.5	28.5	2.0	40	17.8	10.6	28.4
Ridge-till	Hodgson 78	Captan	96.7	84.5	22.0	27.0	2.0	40	17.6	10.5	26.1
Ridge-till	Hodgson 78	Apron	111.5	97.6	21.0	28.2	1.5	41	16.8	10.5	25.3
Moldboard	Corsoy 79	Check	98.4	78.4	26.5	38.5	2.5	48	16.1	10.7	36.6

Table 1. Effects of Tillage, Variety and Seed Treatment on Soybeans at Waseca, MN in 1988.

Tillage	Variety	Seed Treatment	Plant Pop. 6/10	Plant Pop. 9/22	Plant Height 7/14	Plant Height 9/22	Lodg 1/	Mat	Seed Weight	Seed H2O	Yield
			(1000's/A)		-(inch)-		(1-5)	(8/1=1)	(g/100)	(%)	(bu/A)
No-till	Corsoy 79	Check	95.8	70.6	21.0	36.2	2.0	49	15.1	10.6	39.3
No-till	Corsoy 79	Captan	83.6	76.6	20.5	35.0	2.0	48	14.9	10.4	40.0
No-till	Corsoy 79	Apron	97.6	73.2	20.7	34.8	2.0	47	15.1	10.6	40.0
No-till	BSR 101	Check	104.5	94.1	20.0	33.2	1.8	47	15.0	10.8	38.2
No-till	BSR 101	Captan	98.4	84.5	21.8	32.8	1.5	47	14.8	10.8	35.4
No-till	BSR 101	Apron	102.8	75.8	19.0	30.5	1.5	45	14.4	10.8	33.1
No-till	A 1937	Check	105.4	80.2	22.5	34.2	2.0	46	15.6	10.6	43.3
No-till	A 1937	Captan	100.2	96.7	21.0	33.8	2.0	45	15.6	10.7	39.5
No-till	A 1937	Apron	94.1	82.8	20.5	35.0	2.2	46	15.6	10.7	39.9
No-till	Sibley	Check	86.2	82.8	21.2	30.0	1.2	45	17.9	10.7	37.8
No-till	Sibley	Captan	79.3	81.9	20.0	28.5	1.5	46	17.9	10.6	36.8
No-till	Sibley	Apron	90.6	80.2	20.2	29.8	1.8	46	17.6	10.8	35.8
No-till	Elgin	Check	94.1	88.0	21.5	32.0	2.0	50	15.2	10.7	41.6
No-till	Elgin	Captan	92.4	79.2	19.8	31.0	1.8	50	14.6	10.7	43.2
No-till	Elgin	Apron	78.4	62.8	18.2	33.2	2.0	51	14.5	10.6	39.2
No-till	Hardin	Check	108.9	86.2	21.8	32.2	2.0	44	15.5	10.4	38.0
No-till	Hardin	Captan	107.2	96.7	22.8	32.2	2.0	45	15.5	10.5	39.3
No-till	Hardin	Apron	85.4	74.9	21.2	33.5	2.0	44	15.2	10.6	36.5
No-till	P 1677	Check	108.0	89.8	21.2	28.5	1.2	44	15.2	10.6	36.3
No-till	P 1677	Captan	95.8	72.3	19.0	28.0	1.2	44	15.0	10.5	35.4
No-till	P 1677	Apron	95.8	88.8	20.5	27.2	1.5	44	14.7	10.6	36.2
No-till	Hodgson 78	Check	113.2	92.4	21.2	30.8	1.5	42	16.8	10.5	31.6
No-till	Hodgson 78	Captan	100.2	85.4	22.0	31.5	1.8	43	17.2	10.6	31.9
No-till	Hodgson 78	Apron	109.8	87.1	22.8	30.5	1.8	42	17.1	10.6	33.7
Ridge-till	Corsoy 79	Check	109.8	80.2	24.5	38.5	2.5	46	14.8	10.6	37.6
Ridge-till	Corsoy 79	Captan	86.2	67.1	24.8	36.8	2.2	46	15.2	10.5	35.0
Ridge-till	Corsoy 79	Apron	101.9	86.2	23.8	37.5	2.5	47	14.7	10.5	36.2
Ridge-till	BSR 101	Check	122.8	105.4	22.8	34.5	1.5	47	14.7	10.8	36.8
Ridge-till	BSR 101	Captan	113.2	107.2	22.0	35.0	1.5	46	15.4	10.8	35.9
Ridge-till	BSR 101	Apron	105.4	90.6	22.0	35.5	1.5	46	15.2	10.9	35.3
Ridge-till	A 1937	Check	109.8	94.1	23.8	32.0	1.2	45	15.9	10.5	32.7
Ridge-till	A 1937	Captan	113.2	95.0	22.0	31.8	1.8	44	15.5	10.6	36.0
Ridge-till	A 1937	Apron	102.0	86.3	23.5	32.0	1.8	44	15.4	10.3	34.0
Ridge-till	Sibley	Check	130.7	114.1	22.5	29.5	1.2	45	17.6	10.7	34.6
Ridge-till	Sibley	Captan	100.2	90.6	23.8	30.0	1.8	44	18.2	10.8	35.9
Ridge-till	Sibley	Apron	100.2	81.9	22.8	30.0	1.5	44	18.6	10.8	36.4
Ridge-till	Elgin	Check	120.2	111.5	21.2	32.2	1.8	50	15.2	10.8	40.7
Ridge-till	Elgin	Captan	94.9	95.8	21.0	31.0	1.8	49	15.5	10.8	40.9
Ridge-till	Elgin	Apron	87.1	92.4	19.0	31.5	1.8	48	15.1	10.8	39.8
Ridge-till	Hardin	Check	116.8	102.8	22.0	33.0	2.2	44	15.0	10.6	36.2
Ridge-till	Hardin	Captan	122.8	125.5	22.0	31.5	2.0	44	15.2	10.5	34.4
Ridge-till	Hardin	Apron	100.2	100.2	22.5	32.5	2.0	44	15.6	10.5	33.6
Ridge-till	P 1677	Check	125.4	108.0	20.0	28.2	1.0	42	15.2	10.4	32.2
Ridge-till	P 1677	Captan	117.6	103.7	22.0	28.8	1.2	42	15.0	10.4	32.2
Ridge-till	P 1677	Apron	104.5	102.0	21.0	29.5	1.2	42	15.2	10.4	33.2
Ridge-till	Hodgson 78	Check	113.2	104.5	22.5	28.5	2.0	40	17.8	10.6	28.4
Ridge-till	Hodgson 78	Captan	96.7	84.5	22.0	27.0	2.0	40	17.6	10.5	26.1
Ridge-till	Hodgson 78	Apron	111.5	97.6	21.0	28.2	1.5	41	16.8	10.5	25.3
Moldboard	Corsoy 79	Check	98.4	78.4	26.5	38.5	2.5	48	16.1	10.7	36.6

Tillage	Variety	Seed Treatment	Plant Pop. 6/10	Plant Pop. 9/22	Plant Height 7/14	Plant Height 9/22	Lodg 1/	Mat	Seed Weight	H2O	Yield
			(1000's/A)		-(inch)-		(1-5)	(8/1=1)	(g/100)	(%)	(bu/A)
Paraplow	A 1937	Check	96.7	81.9	24.2	34.8	2.0	46	15.6	10.7	36.4
Paraplow	A 1937	Captan	103.7	95.8	22.5	33.2	2.0	46	16.0	10.6	36.5
Paraplow	A 1937	Apron	83.6	75.0	23.0	34.3	2.2	46	16.5	10.8	40.0
Paraplow	Sibley	Check	95.0	95.0	21.0	30.5	1.8	44	18.0	10.8	34.4
Paraplow	Sibley	Captan	93.0	87.1	21.0	31.2	1.8	43	17.8	10.8	31.4
Paraplow	Sibley	Apron	88.0	79.3	22.5	30.0	1.5	44	18.5	10.8	30.1
Paraplow	Elgin	Check	94.1	93.2	21.2	32.0	2.0	50	15.0	10.7	40.2
Paraplow	Elgin	Captan	90.6	77.6	20.5	31.0	1.5	50	15.4	10.7	38.7
Paraplow	Elgin	Apron	83.6	68.0	22.0	32.0	1.8	50	15.5	10.8	38.1
Paraplow	Hardin	Check	112.4	88.8	20.5	33.0	2.2	45	16.0	10.6	37.2
Paraplow	Hardin	Captan	91.5	81.9	24.2	32.2	2.0	45	16.1	10.7	37.4
Paraplow	Hardin	Apron	91.5	81.0	22.2	35.2	2.2	45	16.2	10.6	38.4
Paraplow	P 1677	Check	110.6	107.2	21.0	30.2	1.0	42	15.0	10.5	34.2
Paraplow	P 1677	Captan	103.7	97.6	21.0	28.8	1.5	42	14.6	10.5	33.1
Paraplow	P 1677	Apron	92.4	80.2	21.8	28.5	1.2	42	15.3	10.4	31.3
Paraplow	Hodgson 78	Check	114.1	93.2	23.8	30.0	1.5	42	16.9	10.7	30.0
Paraplow	Hodgson 78	Captan	86.2	86.2	21.0	32.8	2.2	42	17.0	10.7	27.8
Paraplow	Hodgson 78	Apron	86.2	77.5	21.8	31.5	1.8	42	17.2	10.8	28.8
No-till			97.0	82.6	20.9	31.9	1.8	46	15.7	10.6	37.6
Ridge-till			108.6	97.0	22.3	31.9	1.7	45	15.9	10.6	34.6
Moldboard			94.6	84.0	26.9	34.6	1.9	45	16.6	10.7	38.7
Chisel			86.0	77.3	25.9	35.3	2.1	45	15.9	10.7	36.3
Paraplow			93.7	83.0	21.8	32.2	1.8	45	16.1	10.7	34.7
		BLSD(0.05)	5.9	7.6	2.7	3.3	ns	1	0.6	ns	ns
	Corsoy 79		88.3	73.3	24.6	37.5	2.3	47	15.2	10.6	36.3
	BSR 101		98.5	86.7	22.1	33.9	1.5	46	15.4	10.9	36.9
	A 1937		95.8	83.4	24.7	34.8	2.0	45	15.9	10.6	37.8
	Sibley		91.9	84.6	23.6	31.1	1.7	45	18.2	10.8	35.3
	Elgin		88.6	81.6	21.5	32.2	1.9	50	15.2	10.7	40.8
	Hardin		102.1	89.2	24.1	33.7	2.2	45	15.7	10.6	36.9
	P 1677		103.4	92.0	23.3	30.7	1.5	43	15.2	10.5	36.3
	Hodgson 78		99.4	87.4	24.3	31.2	1.9	42	17.2	10.6	30.7
		BLSD(0.05)	5.2	5.3	1.0	1.2	0.2	1	0.3	0.1	2.0
		Check	100.5	88.3	23.5	33.2	1.9	45	16.0	10.7	36.6
		Captan	95.8	85.4	23.5	32.9	1.9	45	16.1	10.6	36.3
		Apron	91.6	80.6	23.6	33.4	1.9	45	16.0	10.7	36.3
		BLSD(0.05)	3.7	3.9	ns	ns	ns	ns	ns	ns	ns
Interactions : (p-value)											
Tillage x Variety			0.83	0.19	0.29	0.19	0.60	0.76	0.90	0.60	0.08
Tillage x Seed Treatment			0.23	0.88	0.04	0.95	0.71	0.67	0.40	0.50	0.86
Variety x Seed Treatment			0.03	0.09	0.02	0.98	0.59	0.89	0.10	0.91	0.68
Tillage x Variety x Seed Trt			0.63	0.87	0.14	0.87	0.69	0.16	0.24	0.45	0.86

1/- Lodging score; 1=erect 5=flat

Table 2. Effects of Tillage, Residual Nitrogen Rate and Variety on Soybean Yield at Waseca in 1988.

Tillage	1987 Nitrogen Rate	Variety	Plant Pop. 6/10	Plant Pop. 9/22	Plant Height 7/14	Plant Height 9/22	Lodg 1/	Mat	Seed Weight	Seed H2O	Yield
			(1000's/A)		-(inch)-		(1-5)	(8/1=1)	(g/100)	(%)	(bu/A)
No-till	0	BSR 101	119.3	88.8	19.5	31.2	1.8	47	15.2	10.9	37.2
No-till	0	A 1937	102.8	97.6	23.8	34.0	1.8	45	16.4	10.6	40.8
No-till	0	Hardin	108.9	86.2	22.8	33.2	2.2	46	15.2	10.5	39.6
No-till	0	Hodgson 78	117.6	96.7	22.5	30.0	1.5	42	17.5	10.6	33.3
No-till	40	BSR 101	105.4	87.1	19.0	30.5	1.8	47	14.7	10.8	34.5
No-till	40	A 1937	112.4	81.9	21.2	34.0	2.0	46	15.3	10.7	40.1
No-till	40	Hardin	106.3	89.7	22.8	32.8	2.0	46	15.1	10.5	38.6
No-till	40	Hodgson 78	107.2	88.9	21.2	28.2	1.8	42	17.1	10.6	31.5
No-till	80	BSR 101	112.4	74.9	17.0	30.0	1.5	49	15.0	10.9	34.0
No-till	80	A 1937	106.3	84.5	22.8	32.2	2.0	45	15.4	10.5	35.9
No-till	80	Hardin	108.0	104.6	20.8	31.2	2.2	46	15.3	10.5	37.9
No-till	80	Hodgson 78	112.4	86.2	21.0	27.8	1.8	44	16.9	10.6	31.5
No-till	120	BSR 101	114.1	86.3	22.0	33.0	1.5	47	15.1	10.9	39.1
No-till	120	A 1937	112.4	83.6	24.0	35.5	1.8	46	15.7	10.5	37.8
No-till	120	Hardin	103.7	93.2	23.0	32.0	2.0	46	15.4	10.6	40.0
No-till	120	Hodgson 78	101.9	95.0	22.5	29.0	2.0	43	17.4	10.6	35.0
No-till	160	BSR 101	110.6	95.8	21.8	33.5	1.2	48	15.0	10.8	38.6
No-till	160	A 1937	110.7	96.7	23.2	34.5	2.0	46	15.3	10.6	40.6
No-till	160	Hardin	106.3	90.6	21.2	31.5	2.0	46	15.8	10.8	40.2
No-till	160	Hodgson 78	115.0	88.0	22.5	31.8	1.5	44	17.0	10.6	35.9
No-till	200	BSR 101	104.6	80.2	20.5	32.8	1.0	45	14.7	10.7	40.6
No-till	200	A 1937	117.6	93.2	23.5	35.0	2.0	44	15.4	10.6	41.0
No-till	200	Hardin	115.0	88.0	21.5	32.5	2.0	46	14.8	10.4	40.9
No-till	200	Hodgson 78	108.0	84.5	21.0	30.0	1.8	44	17.4	10.6	35.3
Ridge-till	0	BSR 101	109.8	79.3	21.0	30.5	1.2	46	15.5	10.9	34.4
Ridge-till	0	A 1937	107.1	80.2	23.5	33.0	2.0	44	15.7	10.7	34.3
Ridge-till	0	Hardin	97.6	84.5	24.8	31.2	1.8	45	16.3	10.6	35.4
Ridge-till	0	Hodgson 78	106.3	88.0	22.2	29.0	1.8	42	18.2	10.7	27.8
Ridge-till	40	BSR 101	116.8	89.7	21.2	31.0	1.5	46	14.7	10.8	28.6
Ridge-till	40	A 1937	114.1	92.4	21.0	32.8	1.5	43	15.5	10.4	31.0
Ridge-till	40	Hardin	128.9	99.3	23.0	33.8	2.5	45	15.8	10.6	36.2
Ridge-till	40	Hodgson 78	111.5	82.8	22.8	27.2	1.5	42	17.4	10.6	29.6
Ridge-till	80	BSR 101	113.3	100.2	21.5	31.0	1.2	46	15.5	10.8	33.4
Ridge-till	80	A 1937	103.7	81.9	23.8	32.0	2.0	44	16.0	10.6	35.6
Ridge-till	80	Hardin	118.4	109.8	24.5	32.8	1.5	45	16.2	10.5	37.5
Ridge-till	80	Hodgson 78	117.6	95.0	23.5	31.5	1.5	42	17.6	10.7	30.2
Ridge-till	120	BSR 101	111.5	100.2	21.8	33.8	1.0	46	15.4	10.4	32.8
Ridge-till	120	A 1937	99.3	91.4	22.5	32.5	1.8	44	15.6	10.5	32.9
Ridge-till	120	Hardin	118.5	95.8	21.2	30.5	1.5	44	15.0	11.4	32.2
Ridge-till	120	Hodgson 78	111.5	95.8	21.5	28.8	1.8	42	17.6	10.8	27.2
Ridge-till	160	BSR 101	114.1	100.2	24.8	35.0	1.0	44	15.5	10.9	37.3
Ridge-till	160	A 1937	122.0	97.6	25.5	34.0	1.8	45	16.4	10.8	36.5
Ridge-till	160	Hardin	117.6	92.4	24.2	34.2	2.0	45	16.3	10.6	39.2
Ridge-till	160	Hodgson 78	113.2	112.4	23.0	28.8	1.8	42	17.5	10.7	29.4
Ridge-till	200	BSR 101	122.8	115.0	22.5	34.5	1.0	46	15.3	10.8	37.7
Ridge-till	200	A 1937	115.0	116.7	24.2	31.5	1.8	45	16.0	10.5	35.8
Ridge-till	200	Hardin	129.8	106.3	24.2	35.0	1.8	45	15.9	10.6	38.4
Ridge-till	200	Hodgson 78	114.1	100.2	23.2	29.5	1.5	41	17.8	10.6	28.6
Moldboard	0	BSR 101	107.2	90.6	26.2	36.2	1.5	46	15.8	11.0	41.0

Tillage	1987 Nitrogen Rate	Variety	Plant Pop. 6/10	Plant Pop. 9/22	Plant Height 7/14	Plant Height 9/22	Lodg 1/	Mat	- Seed - Weight	H2O	Yield
			(1000's/A)		-(inch)-		(1-5)	(8/1=1)	(g/100)	(%)	(bu/A)
Moldboard	0	A 1937	97.6	91.5	26.8	35.5	2.0	45	16.4	10.6	39.8
Moldboard	0	Hardin	106.3	95.0	28.5	34.2	2.2	44	16.2	10.7	36.2
Moldboard	0	Hodgson 78	87.1	80.1	26.5	32.8	1.8	42	18.1	10.7	33.8
Moldboard	40	BSR 101	92.4	79.3	26.5	36.2	1.5	46	16.4	11.0	39.0
Moldboard	40	A 1937	91.5	81.0	29.0	38.8	2.2	46	16.0	10.6	42.7
Moldboard	40	Hardin	116.7	81.0	30.8	27.5	2.5	46	16.6	10.8	42.6
Moldboard	40	Hodgson 78	90.6	80.1	27.0	34.0	2.0	42	17.5	10.7	37.4
Moldboard	80	BSR 101	100.2	98.4	25.2	35.5	1.5	47	16.8	11.0	41.6
Moldboard	80	A 1937	104.6	88.0	27.8	35.5	2.0	44	15.9	10.6	39.9
Moldboard	80	Hardin	109.8	100.2	28.5	35.5	2.0	46	17.2	10.8	39.6
Moldboard	80	Hodgson 78	88.0	77.6	27.2	32.0	2.0	43	17.8	10.7	35.6
Moldboard	120	BSR 101	109.8	89.8	27.8	36.2	1.2	47	15.7	10.9	40.5
Moldboard	120	A 1937	105.4	94.1	29.0	37.0	2.2	46	16.4	10.6	42.9
Moldboard	120	Hardin	88.8	80.1	29.0	37.5	2.5	45	16.2	10.7	39.6
Moldboard	120	Hodgson 78	94.1	81.0	26.5	34.0	2.0	43	17.6	10.6	36.5
Moldboard	160	BSR 101	92.3	82.8	25.2	38.2	1.2	47	16.2	10.9	41.8
Moldboard	160	A 1937	97.6	94.1	29.0	36.5	2.0	46	16.6	10.5	37.6
Moldboard	160	Hardin	117.6	101.0	29.5	35.5	2.0	46	16.4	10.7	40.1
Moldboard	160	Hodgson 78	81.0	81.0	28.2	34.5	2.5	44	17.5	10.7	34.4
Moldboard	200	BSR 101	117.6	105.4	27.5	37.7	1.2	47	15.8	10.8	42.2
Moldboard	200	A 1937	101.9	87.0	31.2	38.2	2.0	46	16.4	10.7	42.3
Moldboard	200	Hardin	91.5	77.5	34.0	41.2	2.8	46	16.6	10.6	43.7
Moldboard	200	Hodgson 78	98.4	87.1	27.8	34.0	2.0	43	17.3	10.7	37.9
Chisel	0	BSR 101	85.4	82.8	23.5	35.5	1.2	46	15.2	10.8	39.8
Chisel	0	A 1937	108.0	89.8	27.8	39.0	2.0	45	16.3	10.7	43.2
Chisel	0	Hardin	89.7	70.6	27.2	37.5	2.5	45	16.2	10.7	39.7
Chisel	0	Hodgson 78	90.6	84.5	27.2	34.0	2.0	43	17.4	10.7	37.6
Chisel	40	BSR 101	112.4	100.2	23.8	36.0	1.2	46	14.6	10.9	36.7
Chisel	40	A 1937	95.8	92.4	25.0	37.0	2.0	44	15.7	10.6	37.5
Chisel	40	Hardin	88.9	75.5	27.2	36.8	2.5	45	16.0	10.7	41.6
Chisel	40	Hodgson 78	95.8	78.4	23.2	32.2	1.8	42	17.0	10.7	33.3
Chisel	80	BSR 101	94.1	94.1	25.2	38.0	1.5	46	15.6	10.9	40.8
Chisel	80	A 1937	80.2	69.7	25.5	39.5	2.8	46	15.7	10.8	42.2
Chisel	80	Hardin	86.3	83.6	28.5	37.2	2.5	45	16.3	10.7	42.4
Chisel	80	Hodgson 78	95.8	83.6	25.2	32.5	2.0	42	17.0	10.6	35.1
Chisel	120	BSR 101	117.6	94.1	25.5	37.0	2.0	48	16.0	10.9	44.0
Chisel	120	A 1937	94.1	84.5	28.2	38.5	2.5	46	15.8	10.6	40.8
Chisel	120	Hardin	114.1	83.6	29.0	39.8	2.2	45	16.4	10.6	45.4
Chisel	120	Hodgson 78	87.1	82.8	25.5	32.8	2.2	43	17.3	10.8	36.4
Chisel	160	BSR 101	99.3	91.5	24.5	36.0	1.5	46	15.4	10.9	40.5
Chisel	160	A 1937	90.6	80.2	25.5	35.8	1.8	44	16.5	10.6	39.1
Chisel	160	Hardin	92.4	88.0	25.0	34.2	2.2	45	16.1	10.6	41.8
Chisel	160	Hodgson 78	102.8	84.5	24.5	30.8	1.5	42	17.4	10.6	31.0
Chisel	200	BSR 101	88.0	74.9	22.5	33.8	1.8	47	15.5	10.8	36.1
Chisel	200	A 1937	94.1	83.6	24.5	34.0	2.2	44	15.9	10.7	38.8
Chisel	200	Hardin	87.1	69.7	24.5	33.0	2.5	45	15.8	10.6	38.4
Chisel	200	Hodgson 78	86.3	78.4	24.8	31.2	1.8	42	17.2	10.7	32.6
Paraplow	0	BSR 101	106.3	95.0	21.8	32.5	1.8	45	15.2	11.0	36.4
Paraplow	0	A 1937	109.8	98.4	24.0	32.8	2.0	46	16.0	10.6	37.2
Paraplow	0	Hardin	108.0	94.1	24.5	33.8	2.0	44	16.4	10.7	35.6
Paraplow	0	Hodgson 78	107.2	80.2	24.0	29.5	1.8	44	17.8	10.8	31.5
Paraplow	40	BSR 101	103.7	93.4	20.5	33.2	1.5	47	15.6	10.8	36.6
Paraplow	40	A 1937	96.7	93.2	23.8	35.0	2.2	45	15.7	10.7	37.0

Tillage	1987 Nitrogen Rate	Variety	Plant Pop. 6/10	Plant Pop. 9/22	Plant Height 7/14	Plant Height 9/22	Lodg 1/	Mat	Seed Weight	Seed H2O	Yield
			(1000's/A)		-(inch)-		(1-5)	(8/1=1)	(g/100)	(%)	(bu/A)
Paraplow	40	Hardin	80.2	69.7	22.0	33.5	2.2	46	15.8	10.6	34.2
Paraplow	40	Hodgson 78	104.6	85.4	22.2	30.2	1.8	43	17.1	10.6	32.5
Paraplow	80	BSR 101	109.8	106.3	20.8	34.2	1.5	46	15.2	10.9	36.8
Paraplow	80	A 1937	94.1	88.0	24.0	35.5	2.0	44	15.9	10.2	36.8
Paraplow	80	Hardin	112.4	94.1	23.0	33.0	2.0	46	15.8	10.6	37.4
Paraplow	80	Hodgson 78	116.8	92.4	23.0	30.5	1.5	44	17.8	10.8	31.9
Paraplow	120	BSR 101	102.8	99.3	17.8	33.5	1.8	47	15.8	10.8	36.3
Paraplow	120	A 1937	96.7	82.8	22.8	33.2	2.0	46	16.1	10.6	37.8
Paraplow	120	Hardin	106.3	90.6	24.5	34.5	2.0	45	15.8	10.6	37.1
Paraplow	120	Hodgson 78	102.0	93.2	22.0	29.5	1.5	43	17.4	10.6	29.0
Paraplow	160	BSR 101	98.4	79.3	22.5	35.0	1.8	46	15.7	11.0	40.9
Paraplow	160	A 1937	103.7	98.4	25.5	33.8	2.2	45	16.6	10.7	38.7
Paraplow	160	Hardin	101.1	90.6	25.0	32.0	2.8	46	16.4	10.7	37.9
Paraplow	160	Hodgson 78	116.7	95.8	23.8	30.5	1.8	42	17.4	10.8	32.4
Paraplow	200	BSR 101	101.9	93.2	23.2	33.8	1.8	46	15.6	10.8	36.7
Paraplow	200	A 1937	95.8	91.5	25.0	35.8	2.0	45	16.2	10.5	36.2
Paraplow	200	Hardin	91.4	79.3	24.8	33.0	2.0	46	16.2	10.5	36.9
Paraplow	200	Hodgson 78	94.1	83.6	23.5	30.2	1.5	42	17.3	10.6	32.8

Averages :

Tillage	Nitrogen Rate	Variety	Plant Pop. 6/10	Plant Pop. 9/22	Plant Height 7/14	Plant Height 9/22	Lodg	Mat	Seed Weight	Seed H2O	Yield
No Till			110.0	89.3	21.7	31.9	1.8	45	15.8	10.6	37.5
Ridge			113.9	96.1	23.0	31.8	1.6	44	16.2	10.7	33.4
Moldboard			99.5	87.7	28.1	35.6	2.0	45	16.6	10.7	39.5
Chisel			94.9	83.4	25.6	35.5	2.0	45	16.2	10.7	39.0
Paraplow			102.5	90.3	23.1	32.9	1.9	45	16.3	10.7	35.7
		BLSD(0.05)	7.7	9.9	3.2	2.8	0.3	1	0.4	ns	5.3
	0		103.6	87.7	24.4	33.3	1.8	45	16.4	10.7	36.7
	40		103.6	86.1	23.7	33.0	1.9	45	16.0	10.7	36.1
	80		104.2	90.7	23.9	33.4	1.9	45	16.2	10.7	36.8
	120		104.6	89.9	24.3	33.9	1.9	45	16.2	10.7	37.2
	160		105.2	92.0	24.7	33.8	1.8	45	16.4	10.7	37.7
	200		103.8	89.8	24.7	33.8	1.8	45	16.2	10.6	37.6
		BLSD(0.05)	ns	ns	ns	ns	ns	ns	0.3	ns	ns
		A 1937	102.7	89.5	25.1	35.1	2.0	45	16.0	10.6	38.4
		BSR 101	106.5	91.6	22.8	34.2	1.4	46	15.5	10.9	37.9
		Hardin	104.9	88.8	25.3	34.0	2.2	45	16.0	10.7	38.9
		Hodgson 78	102.5	87.4	24.0	30.9	1.8	43	17.4	10.7	32.9
		BLSD(0.05)	ns	ns	0.5	0.6	0.1	1	0.1	0.1	0.8

	Plant Pop. 6/10	Plant Pop. 9/22	Plant Height 7/14	Plant Height 9/22	Lodg	Mat	Seed Weight	Seed H2O	Yield
Tillage x N Rate	0.27	0.40	0.11	0.22	0.64	0.36	0.86	0.69	0.51
Tillage x Variety	0.20	0.31	0.07	0.40	0.07	0.89	0.01	0.74	0.40
N Rate x Variety	0.87	0.15	0.71	0.54	0.68	0.37	0.18	0.43	0.42
Tillage x N Rate x Variety	0.61	0.90	0.60	0.23	0.58	0.18	0.81	0.30	0.99

1/- Lodging score; 1=erect 5=flat

Table 3. Effects of Tillage, Variety and Seed Treatment on Soybeans at Waseca, MN in 1986-1988.

Tillage	Variety	Seed Treatment	Pop	Plant Height 7/14	Plant Height 9/22	Lodg 1/	Mat	Seed Weight	Yield
			(1000's/A)	-(inch)-		(1-5)	(8/1=1)	(g/100)	(bu/A)
No-till	Corsoy 79	Check	101.1	17.1	40.6	1.9	54	14.2	41.0
No-till	Corsoy 79	Captan	101.4	17.5	40.6	1.9	54	14.3	40.4
No-till	Corsoy 79	Apron	98.2	17.5	39.5	1.7	53	14.3	42.2
No-till	BSR 101	Check	98.5	16.3	36.6	1.4	53	15.2	41.4
No-till	BSR 101	Captan	102.3	16.2	36.1	1.3	53	15.2	41.2
No-till	BSR 101	Apron	98.2	15.0	36.5	1.3	52	15.1	40.3
No-till	A 1937	Check	91.6	17.8	37.1	1.7	50	15.0	44.1
No-till	A 1937	Captan	106.8	17.0	36.8	1.7	49	15.4	43.3
No-till	A 1937	Apron	101.7	16.8	37.4	1.9	50	15.2	43.0
No-till	Sibley	Check	99.8	16.6	34.5	1.3	48	17.5	40.0
No-till	Sibley	Captan	87.4	15.4	33.1	1.3	48	17.4	40.6
No-till	Sibley	Apron	82.2	15.8	34.0	1.6	48	16.9	37.3
No-till	Elgin	Check	79.2	15.3	34.1	1.6	56	15.1	41.7
No-till	Elgin	Captan	81.1	15.1	35.2	1.4	56	14.8	42.4
No-till	Elgin	Apron	62.4	14.3	35.4	1.6	56	15.0	40.2
No-till	Hardin	Check	94.1	17.8	36.5	1.9	48	15.5	42.1
No-till	Hardin	Captan	104.9	17.7	36.5	1.9	49	15.6	42.6
No-till	Hardin	Apron	93.5	17.6	37.3	1.9	48	15.3	41.7
No-till	P 1677	Check	95.0	15.9	34.8	1.3	48	14.0	40.4
No-till	P 1677	Captan	106.1	16.1	34.0	1.1	48	13.8	42.2
No-till	P 1677	Apron	101.4	16.5	33.7	1.4	47	13.6	43.7
No-till	Hodgson 78	Check	86.5	16.1	35.6	1.7	46	15.7	36.7
No-till	Hodgson 78	Captan	87.1	16.9	36.0	1.9	47	15.8	38.0
No-till	Hodgson 78	Apron	89.0	17.3	35.6	1.7	46	16.0	38.1
Ridge-till	Corsoy 79	Check	102.6	20.0	40.8	2.3	52	14.1	40.3
Ridge-till	Corsoy 79	Captan	96.9	20.4	39.7	2.1	53	14.3	40.0
Ridge-till	Corsoy 79	Apron	100.1	19.7	39.8	2.3	53	14.1	38.2
Ridge-till	BSR 101	Check	105.8	18.3	37.9	1.3	53	15.1	41.0
Ridge-till	BSR 101	Captan	111.2	18.2	37.5	1.3	53	15.6	40.8
Ridge-till	BSR 101	Apron	99.2	17.8	37.5	1.3	53	15.4	40.8
Ridge-till	A 1937	Check	99.5	19.1	36.5	1.4	49	15.4	38.9
Ridge-till	A 1937	Captan	94.1	18.2	36.5	1.7	48	15.3	41.6
Ridge-till	A 1937	Apron	82.4	18.9	36.5	1.7	48	15.1	40.5
Ridge-till	Sibley	Check	103.0	18.4	34.4	1.3	47	17.6	38.4
Ridge-till	Sibley	Captan	94.7	18.6	35.5	1.4	47	17.6	39.3
Ridge-till	Sibley	Apron	95.0	18.4	35.0	1.3	47	17.8	38.8
Ridge-till	Elgin	Check	88.4	15.3	34.2	1.4	56	15.3	35.8
Ridge-till	Elgin	Captan	87.4	15.4	33.6	1.4	56	15.1	39.3
Ridge-till	Elgin	Apron	79.5	14.6	34.1	1.4	56	15.3	38.6
Ridge-till	Hardin	Check	98.8	19.1	37.2	2.0	48	14.6	40.8
Ridge-till	Hardin	Captan	103.6	19.2	36.2	1.9	48	14.3	39.8
Ridge-till	Hardin	Apron	96.0	18.9	36.6	1.9	48	14.8	38.3
Ridge-till	P 1677	Check	105.8	17.2	33.5	1.0	46	13.9	40.3
Ridge-till	P 1677	Captan	105.8	18.1	34.5	1.3	46	13.7	40.5
Ridge-till	P 1677	Apron	109.0	18.1	33.9	1.1	46	13.9	39.9
Ridge-till	Hodgson 78	Check	90.9	17.7	33.7	1.7	45	15.9	33.6
Ridge-till	Hodgson 78	Captan	85.8	18.0	34.1	1.7	45	15.9	34.6
Ridge-till	Hodgson 78	Apron	89.3	17.7	33.2	1.4	45	15.7	34.8
Moldboard	Corsoy 79	Check	103.3	21.5	41.6	2.3	53	14.9	42.5

Tillage	Variety	Seed Treatment	Pop	Plant Height 7/14	Plant Height 9/22	Lodg 1/	Mat	Seed Weight	Yield
			(1000's/A)	-(inch)-		(1-5)	(8/1=1)	(g/100)	(bu/A)
Moldboard	Corsoy 79	Captan	97.3	22.9	42.1	2.3	53	14.6	38.6
Moldboard	Corsoy 79	Apron	92.2	22.2	42.0	2.1	52	14.6	42.8
Moldboard	BSR 101	Check	97.3	18.4	38.4	1.4	52	15.8	44.1
Moldboard	BSR 101	Captan	96.0	18.2	38.7	1.4	52	15.8	43.0
Moldboard	BSR 101	Apron	95.3	19.1	38.7	1.3	52	15.5	42.6
Moldboard	A 1937	Check	89.7	20.7	39.0	2.1	49	15.7	46.0
Moldboard	A 1937	Captan	91.9	20.3	38.6	1.9	49	15.8	43.8
Moldboard	A 1937	Apron	89.7	20.1	39.4	1.9	49	16.0	44.7
Moldboard	Sibley	Check	85.5	19.9	36.3	1.6	48	17.9	37.7
Moldboard	Sibley	Captan	90.6	19.6	36.0	1.4	49	18.1	39.9
Moldboard	Sibley	Apron	93.1	19.2	36.4	1.7	48	17.9	39.3
Moldboard	Elgin	Check	64.3	17.6	35.5	1.4	56	15.3	40.7
Moldboard	Elgin	Captan	86.8	16.7	34.9	1.6	56	15.4	43.2
Moldboard	Elgin	Apron	68.4	16.7	35.0	1.4	56	15.2	40.2
Moldboard	Hardin	Check	96.3	20.2	38.3	2.1	49	14.9	43.4
Moldboard	Hardin	Captan	96.3	21.4	39.3	2.0	49	14.6	42.4
Moldboard	Hardin	Apron	87.4	21.8	39.5	2.1	49	15.0	45.8
Moldboard	P 1677	Check	97.6	19.6	36.3	1.7	46	14.1	41.8
Moldboard	P 1677	Captan	104.9	20.2	36.8	1.4	46	14.1	46.7
Moldboard	P 1677	Apron	93.5	20.1	37.1	1.4	46	14.1	43.8
Moldboard	Hodgson 78	Check	87.8	20.5	37.1	1.6	45	15.9	39.3
Moldboard	Hodgson 78	Captan	87.4	20.8	36.3	1.9	46	16.2	38.6
Moldboard	Hodgson 78	Apron	75.4	20.1	36.5	1.7	45	16.2	38.3
Chisel	Corsoy 79	Check	94.7	19.5	41.8	0.3	53	13.9	38.7
Chisel	Corsoy 79	Captan	85.9	21.0	42.4	2.3	52	14.2	37.7
Chisel	Corsoy 79	Apron	96.0	22.2	43.1	2.4	52	14.1	38.6
Chisel	BSR 101	Check	100.7	17.9	37.9	1.3	53	15.5	41.8
Chisel	BSR 101	Captan	88.1	17.7	39.3	1.3	53	15.6	43.3
Chisel	BSR 101	Apron	99.8	17.7	38.6	1.3	53	15.6	43.4
Chisel	A 1937	Check	84.9	19.3	38.8	2.0	49	15.5	42.5
Chisel	A 1937	Captan	84.6	19.3	38.9	2.0	48	15.4	43.3
Chisel	A 1937	Apron	78.3	20.2	38.4	1.9	49	15.4	40.5
Chisel	Sibley	Check	93.8	18.9	35.5	1.9	47	17.2	38.8
Chisel	Sibley	Captan	82.7	19.5	36.5	2.0	47	17.6	40.2
Chisel	Sibley	Apron	89.3	18.8	35.5	1.9	47	17.6	39.9
Chisel	Elgin	Check	75.7	15.7	35.5	1.9	56	15.0	41.5
Chisel	Elgin	Captan	72.2	16.1	35.9	1.7	56	14.9	44.0
Chisel	Elgin	Apron	67.5	17.0	35.9	1.4	56	14.8	39.9
Chisel	Hardin	Check	97.6	19.6	38.5	2.1	48	14.4	40.7
Chisel	Hardin	Captan	93.8	20.1	38.1	2.1	48	14.4	41.0
Chisel	Hardin	Apron	83.3	20.2	39.0	2.0	48	14.3	39.0
Chisel	P 1677	Check	84.9	19.1	36.7	1.9	46	14.1	42.1
Chisel	P 1677	Captan	97.9	19.7	36.5	1.6	46	13.9	44.1
Chisel	P 1677	Apron	85.8	19.9	37.7	2.0	46	13.8	42.7
Chisel	Hodgson 78	Check	83.0	20.3	37.9	2.1	46	15.3	40.3
Chisel	Hodgson 78	Captan	76.7	18.5	37.1	2.0	46	15.9	39.8
Chisel	Hodgson 78	Apron	74.8	19.5	36.8	2.0	46	15.6	37.1
Paraplow	Corsoy 79	Check	96.0	18.8	41.4	2.3	53	14.5	37.0
Paraplow	Corsoy 79	Captan	98.5	19.7	40.0	2.1	53	14.9	41.2
Paraplow	Corsoy 79	Apron	103.3	20.0	40.4	2.1	53	14.4	40.4
Paraplow	BSR 101	Check	93.5	16.2	36.7	1.4	53	15.5	43.0
Paraplow	BSR 101	Captan	98.5	16.4	35.8	1.3	53	15.3	42.0
Paraplow	BSR 101	Apron	87.4	16.5	36.9	1.4	53	15.1	42.1

Tillage	Variety	Seed Treatment	Pop	Plant Height 7/14	Plant Height 9/22	Lodg 1/	Mat	Seed Weight	Yield
			(1000's/A)	-(inch)-		(1-5)	(8/1=1)	(g/100)	(bu/A)
Paraplow	A 1937	Check	93.1	18.0	37.3	1.9	50	15.3	42.9
Paraplow	A 1937	Captan	89.3	17.6	36.9	1.9	50	15.6	43.7
Paraplow	A 1937	Apron	79.2	17.6	38.0	1.9	50	15.7	44.8
Paraplow	Sibley	Check	96.3	16.6	35.7	1.9	48	17.7	40.6
Paraplow	Sibley	Captan	88.7	17.4	36.2	2.0	48	17.7	36.5
Paraplow	Sibley	Apron	97.9	17.6	35.9	1.7	48	17.9	35.3
Paraplow	Elgin	Check	78.3	15.7	35.2	1.7	56	15.6	39.9
Paraplow	Elgin	Captan	79.5	15.9	35.7	1.4	56	15.3	40.0
Paraplow	Elgin	Apron	66.5	16.3	34.6	1.6	56	15.4	38.9
Paraplow	Hardin	Check	95.7	17.0	37.2	2.0	50	14.7	42.6
Paraplow	Hardin	Captan	90.3	18.1	37.0	1.9	50	14.6	42.1
Paraplow	Hardin	Apron	88.1	17.5	37.7	2.0	50	14.6	42.1
Paraplow	P 1677	Check	97.6	17.2	35.4	1.4	46	13.8	38.3
Paraplow	P 1677	Captan	104.2	18.1	34.6	1.6	47	13.7	39.9
Paraplow	P 1677	Apron	93.5	17.6	34.9	1.6	46	14.0	40.1
Paraplow	Hodgson 78	Check	81.1	18.2	35.2	1.4	45	15.7	36.0
Paraplow	Hodgson 78	Captan	89.7	17.0	35.8	2.0	45	15.8	37.0
Paraplow	Hodgson 78	Apron	78.2	17.5	35.7	1.6	45	15.7	37.8
Notill			93.9	16.5	36.2	1.6	50	15.1	41.1
Ridge			96.9	18.1	35.9	1.6	50	15.2	38.9
Moldboard			90.3	19.9	37.9	1.7	50	15.6	42.1
Chisel			86.4	19.0	38.0	1.9	50	15.2	40.9
Paraplow			90.2	17.4	36.7	1.8	50	15.3	40.1
		BLSD(0.05)	3.9	1.1	1.2	0.3	0.3	0.3	2.0
	Corsoy 79		97.8	19.9	41.1	2.2	53	14.4	40.0
	BSR 101		98.1	17.3	37.5	1.3	53	15.4	42.0
	A 1937		90.4	18.7	37.7	1.8	49	15.4	42.9
	Sibley		92.2	18.1	35.4	1.6	48	17.6	38.8
	Elgin		75.8	15.9	35.0	1.5	56	15.2	40.4
	Hardin		94.6	19.1	37.7	2.0	49	14.6	41.6
	P 1677		98.9	18.2	35.4	1.5	46	13.9	41.8
	Hodgson 78		84.2	18.4	35.8	1.8	46	15.8	37.3
		BLSD(0.05)	3.3	0.6	0.7	0.2	1	0.2	1.2
		Check	92.7	18.1	36.9	1.7	50	15.3	40.5
		Captan	93.2	18.3	36.9	1.7	50	15.3	41.0
		Apron	88.6	18.2	37.0	1.7	50	15.3	40.4
		BLSD(0.05)	2.1	0.2	0.3	0.1	ns	0.1	0.6
Tillage x Variety			0.26	0.16	0.58	0.55	<.01	0.65	0.16
Tillage x Seed Treatment			0.32	0.35	0.88	0.88	0.36	0.73	0.81
Variety x Seed Treatment			0.02	0.05	0.95	0.65	0.39	0.19	0.33
Tillage x Variety x Seed Trt			0.56	0.59	0.83	0.86	0.02	0.15	0.41

1/- Lodging; 1=erect 5=flat

Table 4. Effects of Tillage, Residual Nitrogen Rate and Variety on Soybean Yield at Waseca, MN in 1987-1988.

Tillage	Corn Nitrogen Rate	Variety	1987 - 1988 Yield
	(lb/A)		(bu/A)
No-till	0	BSR 101	39.4
No-till	40	BSR 101	38.7
No-till	80	BSR 101	39.4
No-till	120	BSR 101	40.8
No-till	160	BSR 101	40.7
No-till	200	BSR 101	40.7
No-till	0	A 1937	42.2
No-till	40	A 1937	42.9
No-till	80	A 1937	39.7
No-till	120	A 1937	39.4
No-till	160	A 1937	43.0
No-till	200	A 1937	39.5
No-till	0	Hardin	43.0
No-till	40	Hardin	41.2
No-till	80	Hardin	42.5
No-till	120	Hardin	45.3
No-till	160	Hardin	42.2
No-till	200	Hardin	43.6
No-till	0	Hodgson 78	39.4
No-till	40	Hodgson 78	38.6
No-till	80	Hodgson 78	36.7
No-till	120	Hodgson 78	38.4
No-till	160	Hodgson 78	38.9
No-till	200	Hodgson 78	35.9
Ridge-till	0	BSR 101	39.2
Ridge-till	40	BSR 101	36.9
Ridge-till	80	BSR 101	39.6
Ridge-till	120	BSR 101	38.5
Ridge-till	160	BSR 101	40.1
Ridge-till	200	BSR 101	40.2
Ridge-till	0	A 1937	40.8
Ridge-till	40	A 1937	38.5
Ridge-till	80	A 1937	42.5
Ridge-till	120	A 1937	39.4
Ridge-till	160	A 1937	40.0
Ridge-till	200	A 1937	40.2
Ridge-till	0	Hardin	40.1
Ridge-till	40	Hardin	39.1
Ridge-till	80	Hardin	40.9
Ridge-till	120	Hardin	39.1
Ridge-till	160	Hardin	41.9
Ridge-till	200	Hardin	43.0
Ridge-till	0	Hodgson 78	32.7
Ridge-till	40	Hodgson 78	36.1
Ridge-till	80	Hodgson 78	36.0
Ridge-till	120	Hodgson 78	32.5
Ridge-till	160	Hodgson 78	35.8
Ridge-till	200	Hodgson 78	37.1
Moldboard	0	BSR 101	41.0

Tillage	Corn Nitrogen Rate	Variety	1987 - 1988 Yield
	(lb/A)		(bu/A)
Moldboard	40	BSR 101	40.3
Moldboard	80	BSR 101	41.2
Moldboard	120	BSR 101	41.0
Moldboard	160	BSR 101	43.3
Moldboard	200	BSR 101	42.6
Moldboard	0	A 1937	42.5
Moldboard	40	A 1937	44.0
Moldboard	80	A 1937	41.6
Moldboard	120	A 1937	43.2
Moldboard	160	A 1937	42.1
Moldboard	200	A 1937	43.0
Moldboard	0	Hardin	39.9
Moldboard	40	Hardin	43.9
Moldboard	80	Hardin	42.7
Moldboard	120	Hardin	43.7
Moldboard	160	Hardin	43.6
Moldboard	200	Hardin	43.6
Moldboard	0	Hodgson 78	36.4
Moldboard	40	Hodgson 78	37.7
Moldboard	80	Hodgson 78	38.5
Moldboard	120	Hodgson 78	37.0
Moldboard	160	Hodgson 78	37.7
Moldboard	200	Hodgson 78	38.8
Chisel	0	BSR 101	41.2
Chisel	40	BSR 101	38.6
Chisel	80	BSR 101	39.6
Chisel	120	BSR 101	42.2
Chisel	160	BSR 101	41.9
Chisel	200	BSR 101	38.6
Chisel	0	A 1937	43.2
Chisel	40	A 1937	40.1
Chisel	80	A 1937	42.2
Chisel	120	A 1937	40.7
Chisel	160	A 1937	40.5
Chisel	200	A 1937	41.9
Chisel	0	Hardin	41.4
Chisel	40	Hardin	41.5
Chisel	80	Hardin	42.9
Chisel	120	Hardin	46.8
Chisel	160	Hardin	42.5
Chisel	200	Hardin	42.4
Chisel	0	Hodgson 78	37.8
Chisel	40	Hodgson 78	34.6
Chisel	80	Hodgson 78	36.8
Chisel	120	Hodgson 78	36.6
Chisel	160	Hodgson 78	33.5
Chisel	200	Hodgson 78	36.2
Paraplow	0	BSR 101	38.1
Paraplow	40	BSR 101	39.7
Paraplow	80	BSR 101	39.7
Paraplow	120	BSR 101	39.1
Paraplow	160	BSR 101	40.9
Paraplow	200	BSR 101	39.0

Tillage	Corn Nitrogen Rate	Variety	1987 - 1988 Yield
	(lb/A)		(bu/A)
Paraplow	0	A 1937	35.7
Paraplow	40	A 1937	41.3
Paraplow	80	A 1937	39.4
Paraplow	120	A 1937	40.4
Paraplow	160	A 1937	39.8
Paraplow	200	A 1937	39.4
Paraplow	0	Hardin	39.2
Paraplow	40	Hardin	39.6
Paraplow	80	Hardin	40.4
Paraplow	120	Hardin	41.0
Paraplow	160	Hardin	42.2
Paraplow	200	Hardin	39.4
Paraplow	0	Hodgson 78	36.0
Paraplow	40	Hodgson 78	35.9
Paraplow	80	Hodgson 78	37.0
Paraplow	120	Hodgson 78	33.6
Paraplow	160	Hodgson 78	32.4
Paraplow	200	Hodgson 78	34.8

Averages :

Notill			40.5
Ridge			38.8
Moldboard			41.2
Chisel			40.2
Paraplow			38.5
			2.4
	0		39.5
	40		39.5
	80		40.0
	120		40.0
	160		40.1
	200		40.0
		BLSD(0.05)	ns
		BSR 101	40.1
		A 1937	41.0
		Hardin	42.0
		Hodgson 78	36.3
		BLSD(0.05)	0.7

Interactions : (p-value)

Tillage x Nitrogen Rate	0.73
Tillage x Variety	0.44
Nitrogen Rate x Variety	0.20
Tillage x N Rate x Variety	0.90

Wild proso millet and volunteer corn control in soybeans, 1988. Lueschen, William E., Thomas R. Hoverstad and Jeffrey L. Gunsolus. The objectives of this study were to evaluate preplant, preemergence and postemergence herbicides for wild proso millet control, to evaluate additives for postemergence herbicides, and to evaluate volunteer corn control in soybeans. This study was conducted on a Nicollet clay loam soil containing 5.4% organic matter with a pH of 6.2 and soil test P and K levels of 109 and 246 lb/A, respectively. The previous crop was sweet corn and the site was moldboard plowed in fall following corn harvest. A randomized complete block design with three replications and a plot size of 10 by 30 ft was used. Prior to applying any treatments, the site was field cultivated once to a depth of 4 inches. Following the application of the preplant incorporated treatments, the entire experimental area was field cultivated twice to a depth of 4 inches; the second pass was at a right angle to the first. The field cultivator was equipped with 7-inch wide sweeps and a three-bar mulcher. 'Hardin' soybeans were planted on May 4, 1988 at a rate of 150,000 seeds/A in rows spaced 30 inches apart. On May 11, 1988, F_2 corn seed, referred to as volunteer corn, was planted with a hand planter at a rate of 10 kernels/hill with hills spaced 5 ft apart between the two center soybean rows. The entire experiment was treated on May 23, 1988 with bentazon at 0.75 lb/A + acifluorfen at 0.13 lb/A + oil concentrate at 1.25% v/v; excellent broadleaf weed control resulted. None of the treatments were cultivated. Application dates, sprayer settings, environmental conditions and plant sizes are listed below:

Date	May 4	May 4	June 3
Treatment	PPI	Pre	Post
Sprayer			
nozzles	8002	8002	8002
gpa	20	20	20
psi	30	30	30
Temperature (F)			
air	79	79	78
soil (4 inch)	64	64	75
Soil moisture	dry	dry	very dry
Wind (mph)	10-15SE	10-15SE	5-10E
Sky	clear	clear	clear
Relative humidity(%)	20	20	50
Soybean			
leaf no.	--	--	1
height (inch)	--	--	5
Wild proso millet			
leaf no.	--	--	2-3
height (inch)	--	--	1-3
infestation	5 ft^2	5 ft^2	5/ft^2
Volunteer Corn			
leaf no.	--	--	4-5
height (inch)	--	--	6-10
Rainfall after treatment (inches)			
1 week	1.9	1.9	0.0
2 week	0.0	0.0	0.2
3 week	0.3	0.3	0.1

Rainfall for May and June was 4.9 inches below normal while temperatures averaged 7.3 and 6.8 F above normal for the two months, respectively.

There was no significant soybean injury or stand reduction with any of the herbicide treatments. The only preplant incorporated treatment that provided adequate control of wild proso millet through early July was ethalfluralin at 1.13 lb/A + clomazone at 0.75 lb/A. Preplant trifluralin at 1 lb/A followed by preemergence alachlor at 3 lb/A gave consistently better control of wild proso millet than trifluralin at 1 lb/A followed by preemergence metolachlor at 2.5 lb/A. Postemergence applications of fluazifop-P at 0.09 lb/A + oil concentrate at 1.25% v/v or sethoxydim at 0.1 lb/A + Dash at 1.25% v/v following trifluralin at 1 lb/A, gave nearly complete control of wild proso millet. However, following the same trifluralin treatment, imazethapyr at 0.06 lb/A + surfactant at 0.25% + 28% N at 5% v/v, did not provide adequate control. Nearly complete control of wild proso millet was obtained with postemergence applications of clethodim, fenoxaprop, and sethoxydim regardless of the adjuvant. With fluazifop-P, HOE-46360, and quizalofop, the addition of 28% N at 5% v/v consistently enhanced control of wild proso millet. Postemergence imazethapyr did not adequately control wild proso millet regardless of the adjuvant. Volunteer corn control was not adequate with any soil applied treatments. Postemergence clethodim, fenoxaprop, fluazifop-P, and HOE-46360 gave nearly complete control of volunteer corn, especially where the spray additive included 28% N. Volunteer corn control was enhanced when quizalofop was applied with either oil concentrate at 1.25% v/v or oil concentrate + 28% N at 1.25% and 5% v/v, respectively, compared to where surfactant was the adjuvant. Sethoxydim at 0.1 lb/A gave fair to poor control of volunteer corn; Dash at 1.25% v/v or Dash at 1.25% + 28% N at 5% v/v, provided better volunteer corn control than where oil concentrate at 1.25% v/v was the additive with sethoxydim. The rates of postemergence herbicides in this study were selected with wild proso millet as the target species and may be below labeled rates recommended for volunteer corn control. (Minn. Agric. Exp. Stn., Paper No. 16,447; Misc. Jour. Series, University of Minnesota, St. Paul).

Table. Wild proso millet and volunteer corn control in soybeans (Lueschen, Hoverstad and Gunsolus).

Treatment[a]	Rate	Wild Proso Millet 5/31	6/13	6/24	7/5	Volunteer Corn 5/31	6/13	6/24	7/5
	(lb/A or %)	(% Control)							
Preplant incorporated applied May 4									
Clomazone	1	47	58	57	60	8	3	7	3
Ethalfluralin	1.13	72	67	60	55	30	17	22	13
Ethalfluralin + clomazone	1.13+0.75	93	82	85	93	48	27	27	53
Imazethapyr	0.06	87	72	70	82	5	0	5	7
Pendimethalin	1.5	67	67	65	53	7	7	6	7
Pendimethalin + clomazone	1.5+0.75	77	72	53	73	5	0	20	7
Trifluralin	1	70	65	69	63	13	0	7	17
Trifluralin + clomazone	1+0.75	82	79	70	77	27	10	15	27
Preplant incorporated / preemergence applied May 4									
Trifluralin / alachlor	1 / 3	90	82	81	85	30	3	20	30
Trifluralin / metolachlor	1 / 2.5	67	59	62	75	8	0	10	17
Preplant incorporated applied May 4 / postemergence applied June 3									
Trifluralin / fluazifop-P + COC	1 / 0.09+1.25%	78	92	92	98	30[c]	87	86	99
Trifluralin / imazethapyr + Surf + 28%N	1 / 0.06 + 0.25%+1.25%	75	78	79	88	22[c]	30	32	10
Trifluralin / sethoxydim + Dash	1 / 0.1+1.25%	88	94	94	99	27[c]	72	62	83
Postemergence applied June 3									
Clethodim + COC	0.075+1.25%	--	84	88	95	--	72	78	89
Clethodim + COC + 28%N	0.075+1.25%+5%	--	94	96	100	--	88	98	100
Fenoxaprop + COC	0.1+1.25%	--	80	81	95	--	67	50	82
Fenoxaprop + COC + 28%N	0.1+1.25%+5%	--	91	85	99	--	80	77	93
Fluazifop-P + COC	0.09+1.25%	--	75	76	89	--	73	73	90
Fluazifop-P + COC + 28%N	0.09+1.25%+5%	--	87	92	100	--	82	89	98
HOE-46360 + COC	0.05+1.25%	--	64	61	67	--	53	53	64
HOE-46360 + COC + 28%N	0.05+1.25%+5%	--	93	91	96	--	80	87	92
HOE-46360 + COC	0.075+1.25%	--	68	73	77	--	49	55	73
HOE-46360 + COC + 28%N	0.075+1.25%+5%	--	94	92	99	--	86	96	99
Imazethapyr + Surf	0.06+0.25%	--	53	23	0	--	2	0	0
Imazethapyr + Surf + 28%N	0.06+0.25%+1.25%	--	62	63	68	--	32	28	38
Quizalofop + Surf	0.06+0.25%	--	69	72	79	--	57	59	66
Quizalofop + COC	0.06+1.25%	--	88	87	92	--	84	83	87
Quizalofop + COC + 28%N	0.06+1.25.%+5%	--	95	97	99	--	96	100	100
Sethoxydim + Dash	0.1+1.25%	--	83	92	97	--	58	53	65
Sethoxydim + Dash + 28%N	0.1+1.25.%+5%	--	87	91	98	--	63	73	72
Sethoxydim + COC	0.1+1.25%	--	79	86	97	--	48	32	30
Checks									
Weedy		--	0	0	0	--	0	0	0
Hand-weeded (sethoxydim + Dash)	0.2+1.25.%	--	100	100	100	--	100	100	100
BLSD (0.05)		--	20	22	25	--	24	33	32

[a]COC=crop oil concentrate=Clean Crop, Dash=an adjuvant from BASF, 28% N=an aqueous solution of urea and NH_4NO_3, Surf=nonionic surfactant=Ag-98

[b]Volunteer corn=F_2 seed of a single cross was planted at a density of 10 kernels/hill with hills spaced 5 ft apart between the two center rows of each plot

[c]Postemergence not applied yet

Woolly cupgrass and volunteer corn control in soybeans, 1988. Lueschen, William E., Jeffrey L. Gunsolus and Thomas R. Hoverstad. The objectives of this study were to evaluate preplant, preemergence, and postemergence herbicides for control of woolly cupgrass, additives for postemergence herbicides, and volunteer corn control in soybeans. This study was conducted on a Webster clay loam soil containing 5.4% organic matter with a pH of 6.0 and soil test P and K levels of 69 and 400 lb/A, respectively. The previous crop was soybeans which were severely infested with woolly cupgrass. Following soybean harvest the site was fall chisel plowed. A randomized complete block design with three replications and a plot size of 10 by 30 ft was used. Prior to applying any treatments, the site was field cultivated once to a depth of 4 inches. Following the application of the preplant incorporated treatments, the entire experimental area was field cultivated twice to a depth of 4 inches; the second pass was at a right angle to the first. The field cultivator was equipped with 7-inch wide sweeps and a three-bar mulcher. 'Hardin' soybeans were planted on May 5, 1988 at the rate of 150,000 seeds/A in rows spaced 30 inches apart. On May 11, 1988 F_2 seed of a single cross hybrid, referred to as volunteer corn, was planted with a hand planter at a rate of 10 kernels/hill with hills spaced 5 ft apart between the two center soybean rows. The entire experiment was treated on May 23, 1988 with bentazon at 0.75 lb/A + acifluorfen at 0.13 lb/A + oil concentrate at 1.25% v/v; excellent broadleaf weed control resulted. None of the plots were cultivated. Weed control and crop injury data were taken but no yield data was obtained. Application dates, sprayer settings, environmental conditions, plant sizes and rainfall data are listed below:

Date	May 5	May 5	June 3
Treatment	PPI	Pre	Post
Sprayer			
nozzles	8002	8002	8002
gpa	20	20	20
psi	30	30	30
Temperature (F)			
air	74	74	80
soil (4 inch)	56	56	78
Soil moisture	dry	dry	very dry
Wind (mph)	10-15E	10-15E	0-5E
Sky	clear	clear	clear
Relative humidity(%)	20	20	50
Soybean			
leaf no.	--	--	1
height (inch)	--	--	5
Woolly cupgrass			
leaf no.	--	--	2-3
height (inch)	--	--	1-3
infestation	19 ft^2	19 ft^2	19 ft^2
Volunteer Corn			
leaf no.	--	--	2-3
height (inch)	--	--	4-6
Rainfall after treatment (inches)			
1 week	1.4	1.4	0.0
2 week	0.0	0.0	0.4
3 week	0.5	0.5	0.2

Rainfall for May and June was 4.9 inches below normal and temperatures were 7.3 and 6.8 F above normal for the two months, respectively.

The bentazon + acifluorfen treatment caused moderate leaf necrosis in all plots. Soybeans recovered quickly and since the injury was uniform across treatments, the data is not presented. Injury on June 24, 1988 which is presented in the accompanying table resulted from drift from dicamba applied on June 9, 1988 to an adjoining corn field. Soybeans in many of the postemergence treatments had more dicamba injury symptoms than the weedy check or the soil applied treatments. Of the preplant incorporated treatments, clomazone and imazethapyr gave the poorest control of woolly cupgrass. Where alachlor or metolachlor was applied preemergence following a preplant incorporated trifluralin treatment, woolly cupgrass control was not improved when compared to trifluralin applied alone. When the postemergence treatments were applied on June 3, 1988, the woolly cupgrass was exhibiting moderate moisture stress due to dry soil conditions. The postemergence treatments with the greatest activity on woolly cupgrass were clethodim, HOE-46360 at 0.15 lb/A, quizalofop + oil concentrate + 28% N solution and sethoxydim + Dash or sethoxydim + Dash + 28% N. Addition of 28% N to quizalofop and oil concentrate enhanced the control of woolly cupgrass substantially compared to quizalofop applied with surfactant or oil concentrate. Oil concentrate with sethoxydim resulted in poor control of woolly cupgrass as compared to using Dash or Dash + 28% N as the adjuvant with sethoxydim. Woolly cupgrass control with postemergence fenoxaprop, fluazifop-P or imazethapyr was poor regardless of the additive. HOE-46360 at 0.15 lb/A gave better control of woolly cupgrass than an equivalent rate of fenoxaprop where either oil concentrate or oil concentrate + 28% N was the adjuvant. Volunteer corn control was poor with all soil applied treatments and with imazethapyr postemergence. Postemergence clethodim, fluazifop-P, HOE-46360, and quizalifop provided excellent control of volunteer corn regardless of the spray additive. When 28% N was combined with oil concentrate, volunteer corn control was increased signficantly with fenoxaprop as compared to where oil concentrate was the additive. Likewise, the addition of 28% N to Dash significantly improved volunteer corn control with sethoxydim as compared to using either Dash or oil concentrate alone as the adjuvant. (Minn. Agric. Exp. Stn., Paper No. 16,448; Misc. Jour. Series, University of Minnesota, St. Paul).

Table. Woolly cupgrass and volunteer corn control in soybeans (Lueschen, Gunsolus and Hoverstad).

Treatment[a]	Rate	Injury[b] 6/24	Woolly Cupgrass 5/31	6/13	6/24	7/5	Volunteer Corn[c] 5/31	6/13	6/24	7/5
	(lb/A or %)	-(%)-	(% Control)							
Preplant incorporated applied May 5										
Clomazone	1	15	68	52	47	27	30	0	8	7
Ethalfluralin	1.13	12	87	79	82	77	52	27	22	20
Ethalfluralin + clomazone	1.13+0.75	10	91	83	80	70	50	25	27	30
Imazathepyr	0.06	18	69	53	35	35	10	10	20	20
Pendimethalin	1.5	15	83	67	70	55	23	25	37	30
Pendimethalin + clomazone	1.5+0.75	13	78	63	61	53	43	20	30	27
Trifluralin	1	15	88	79	81	72	30	25	33	30
Trifluralin + clomazone	1+0.75	15	85	72	79	58	47	30	32	27
Preplant incorporated / preemergence applied May 5										
Trifluralin / alachlor	1 / 3	12	91	81	83	75	8	13	23	23
Trifluralin / metolachlor	1 / 2.5	17	87	84	78	72	28	20	20	27
Preplant incorporated applied May 5 / postemergence applied June 3										
Trifluralin / fluazifop-P + COC	1 / 0.19+1.25%	15	75[d]	72	78	57	22[d]	72	90	97
Trifluralin / imazethapyr + Surf + 28%N	1 / 0.06 + 0.25%+1.25%	18	82[d]	74	70	62	33[d]	13	30	37
Trifluralin / sethoxydim + Dash	1 / 0.2+1.25%	12	83[d]	82	87	90	22[d]	50	50	50
Postemergence applied June 3										
Clethodim + COC	0.1+1.25%	22	--	67	81	85	--	65	81	97
Clethodim + COC + 28%N	0.1+1.25%+5%	23	--	59	76	88	--	63	88	99
Fenoxaprop + COC	0.15+1.25%	22	--	58	57	40	--	47	60	47
Fenoxaprop + COC + 28%N	0.15+1.25%+5%	35	--	53	65	60	--	53	80	95
Fluazifop-P + COC	0.19+1.25%	20	--	68	73	50	--	65	88	100
Fluazifop-P + COC + 28%N	0.19+1.25%+5%	27	--	59	63	43	--	57	88	100
HOE-46360 + COC	0.1+1.25%	37	--	53	68	75	--	63	78	98
HOE-46360 + COC + 28%N	0.1+1.25%+5%	28	--	57	74	63	--	62	82	82
HOE-46360 + COC	0.15+1.25%	38	--	53	72	90	--	60	85	100
HOE-46360 + COC + 28%N	0.15+1.25%+5%	27	--	63	82	90	--	55	87	100
Imazethapyr + Surf	0.06+0.25%	25	--	40	37	27	--	0	0	10
Imazethapyr + Surf + 28%N	0.06+0.25%+1.25%	20	--	57	50	32	--	10	13	13
Quizalofop + Surf	0.09+0.25%	25	--	55	55	38	--	57	91	99
Quizalofop + COC	0.09+1.25%	28	--	63	73	68	--	70	93	99
Quizalofop + COC + 28%N	0.09+1.25%+5%	22	--	65	80	90	--	80	95	100
Sethoxydim + Dash	0.2+1.25%	25	--	67	77	81	--	52	60	75
Sethoxydim + Dash + 28%N	0.2+1.25.%+5%	30	--	57	68	86	--	65	80	98
Sethoxydim + COC	0.2+1.25%	25	--	48	67	52	--	48	53	55
Checks										
Weedy		18	0	0	0	0	7	0	0	0
Hand-weeded (sethoxydim + Dash)	0.2+1.25.%	25	0	100	100	100	0	100	100	100
BLSD (0.05)		11	37	18	17	22	28	21	17	21

[a] COC=crop oil concentrate=Clean Crop, Dash=an adjuvant from BASF, 28% N=an aqueous solution of urea and NH_4NO_3, Surf=nonionic surfactant=Ag-98.
[b] Injury from dicamba drift.
[c] Volunteer corn=F_2 seed of a single cross hybrid was planted at a density of 10 kernels/hill hills spaced 5 ft apart between the two center rows of each plot.
[d] Postemergence treatment not applied yet.

Effects of seed treatment on performance of soybeans at Waseca, MN in 1988. William Lueschen and Ward Stienstra

Objectives: The objective of this study was to evaluate the effects of seed treatments on yield and agronomic charateristics of six soybean varieties.

Procedures: This study was conducted on a Webster clay loam soil containing 6 to 7% organic matter with a pH of 6.5 and soil test P and K levels of 88 and 461 lb/A, respectively. This site was well drained with tile lines spaced every 75 ft. The previous crop was oats and the site was chisel plowed in the fall of 1987. A randomized complete block design with four replications with a plot size of 10 by 12 ft was used. In the early spring the site was field cultivated once to level the soil surface. On April 18, 1988 trifluralin (Treflan) at 0.75 lb/A + clomazone (Command) at 0.75 lb/A was applied and incorporated once with a field cultivator. Chloramben (Amiben) was applied preemergence at 2.5 lb/A on May 16, 1988. Just prior to planting the soybeans on May 5, 1988, the area was tilled again with a field cultivator. Seed was counted and prepacked for a seeding rate of 7 seeds/ft of row for each individual plot prior to planting with a cone-type seeder. Planting depth was 1.5 inches and the row spacing was 30 inches. All seed was treated with a Gustafson laboratory batch seed treater at the following rates of application per 100 lb of seed: Apron 1.5 oz, Captan 2 oz, Magnum 2.5 oz, and YEA 16 oz. All of the seed for this trial was certified and produced in 1987 with exception of II-54-254. Prior to emergence of any soybeans a 5 ft section of each of the two center rows was staked. This area was used for taking stand counts through out the season.

Climatic conditions are given in the following table:

		MONTH				
		April	May	June	July	August
Temperature	(Average F)	44.6	65.0	73.9	74.6	72.9
	Normal[a]	44.7	57.7	67.1	72.1	71.2
Rainfall	(inch)	2.43	1.99	1.35	0.61	4.32
	Normal[a]	2.64	3,76	4.48	4.02	3.99

[a] 30-year average 1951-1980

Results: On May 18, 1988, 'Dawson' had significantly more plants emerged than any other variety. However, stand counts taken two days later did not reveal any difference among the six varieties in the trial. With the exception of the line II-54-254, which tended to have higher plant population throughout the season, plant population did not differ much among the varieties from May 20 through September 8, 1988. Final plant population averaged between 111,000 and 125,000 plants/A, which is an adequate stand to achieve near maximum yields. Seed treatments generally did not affect plant population. Captan, Magnum and the check treatments had very simular plant populations throughout the growing season. There was a trend for the Apron and YEA treatments to have slightly reduced stands as compared to the check; these differences were generally not significant, however.

Plant height at maturity was significantly affected by soybean variety. Dawson was the shortest variety followed in increasing order by 'Hardin,' 'BSR101,''A-1937,' 'II-54-254,' and 'Corsoy 79'. None of the seed treatments influenced plant height.

There was no lodging in this trial for any variety or seed treatment.

Significant differences were observed among the six varieties for maturity. Dawson was the earliest variety and II-54-254 was the latest maturing variety. Seed treatment did not influence maturity.

Seed size, weight/100g of seed, was influenced by soybean variety. Dawson and Hardin had smallest seeds compared to the other varieties. Seed treatment did not influence soybeans seed size.

Soybean yields were significantly affected soybean variety. Dawson and II-54-254 were the lowest yielding varieties, Hardin was intermediate, and Corsoy 79, BSR101 and A-1937 were the highest yielding varieties. Seed treatment did not affect soybean yield.

For all of the traits evaluated there was no significant interaction between soybean variety and seed treatment.

The 1988 growing season was not conducive to obtaining seed treatment response. The warm, dry conditions allowed the soybeans to emerge rapidly and develop good early season growth. There was very little compaction as the result of spring tillage and we did not get any heavy rainfall until early August. After planting we received 0.75 and 0.71 inches of rainfall on May 7 and May 8, respectively. Subsequent rainfall was very light, 0.45 inch or less per 24 hour period until early August. Therefore, we did not have any prolonged saturated soil conditions throughout the year. Since many of the seedling diseases are more prevalent under wet soil conditions, seed treatment was not beneficial in 1988. We did not observe any symptoms characteristic of seedling disease. We also did not detect the presence of phytophthora root rot in this study. This was even true with II-54-254 which is highly susceptable to phytophthora root rot.

Effects of Seed Treatment on Performnace of Soybeans at Waseca in 1988.

Variety	Seed Trt.	5/18	5/20	5/23	5/25	5/27	5/31	9/8	Plant Hgt.	Lodg[a]	Mat[b]	Seed Weight	H20	Yield
		Plant Population (1000's Plants/A)							(inch)	(1-5)	(8/1=1)	(gm/100)	(%)	(bu/A)
II-54-254	Check	4	86	141	147	146	146	134	32.0	1	43	16.2	10.4	33.0
II-54-254	YEA	2	56	126	125	129	129	129	32.2	1	42	16.5	10.5	34.0
II-54-254	Captan	4	69	142	142	140	144	119	30.5	1	43	16.2	10.3	30.0
II-54-254	Apron	2	51	119	120	119	125	122	32.2	1	42	16.0	10.4	33.2
II-54-254	Magnum	5	64	126	126	126	127	120	32.2	1	41	16.1	10.0	30.4
Corsoy 79	Check	1	67	108	112	112	114	110	34.0	1	39	16.9	10.5	40.6
Corsoy 79	YEA	4	57	101	102	103	105	92	33.5	1	38	16.3	10.4	34.6
Corsoy 79	Captan	2	71	117	116	118	119	120	33.2	1	38	16.3	10.6	34.9
Corsoy 79	Apron	2	60	105	111	111	112	108	33.8	1	39	16.0	10.5	38.4
Corsoy 79	Magnum	3	86	122	125	132	129	124	32.5	1	39	16.7	10.8	36.8
BSR 101	Check	2	59	116	119	119	123	119	32.8	1	40	16.9	11.0	40.1
BSR 101	YEA	6	67	106	107	108	107	103	31.8	1	40	16.5	10.8	39.2
BSR 101	Captan	2	74	119	119	126	129	112	29.8	1	38	15.5	10.7	33.7
BSR 101	Apron	3	68	104	106	107	106	107	29.8	1	38	16.4	10.8	33.7
BSR 101	Magnum	1	78	122	129	128	126	119	29.8	1	38	16.3	10.9	33.7
Hardin	Check	8	73	122	122	122	125	119	29.0	1	36	15.4	10.2	34.6
Hardin	YEA	2	44	102	106	114	111	101	30.0	1	38	16.2	10.2	34.0
Hardin	Captan	3	99	139	139	142	145	125	29.8	1	38	16.2	10.4	36.5
Hardin	Apron	4	64	101	105	108	112	109	31.8	1	37	15.8	10.5	36.3
Hardin	Magnum	0	74	116	113	115	117	117	27.8	1	34	14.7	10.1	29.6
Dawson	Check	11	85	118	117	116	119	122	22.8	1	28	15.6	9.0	30.8
Dawson	YEA	5	73	110	112	112	111	112	23.2	1	27	15.2	9.1	30.1
Dawson	Captan	10	80	108	109	112	114	107	21.2	1	27	15.1	9.0	26.7
Dawson	Apron	7	50	115	116	117	119	113	23.2	1	27	15.5	9.2	29.9
Dawson	Magnum	11	91	122	125	121	119	112	23.2	1	28	15.2	9.0	29.6
A 1937	Check	1	49	102	108	110	111	113	30.8	1	36	16.8	10.4	35.9
A 1937	YEA	2	52	122	123	124	120	112	30.8	1	36	16.9	10.4	37.9
A 1937	Captan	1	71	125	128	128	130	117	30.2	1	38	17.8	10.4	38.6
A 1937	Apron	2	58	119	123	127	125	118	33.2	1	38	16.6	10.3	43.0
A 1937	Magnum	4	111	140	142	144	140	132	30.5	1	38	16.4	10.3	38.9

Average for Variety:

Variety		5/18	5/20	5/23	5/25	5/27	5/31	9/8	Plant Hgt.	Lodg	Mat	Seed Weight	H20	Yield
II-54-254		3	65	131	132	132	134	125	31.8	1	42	16.2	10.3	32.1
Corsoy 79		2	68	110	113	115	116	111	33.4	1	39	16.4	10.6	37.1
BSR 101		3	69	113	116	117	118	112	30.8	1	39	16.3	10.8	36.1
Hardin		3	71	116	117	120	122	114	29.7	1	37	15.7	10.3	34.2
Dawson		9	76	114	116	115	116	113	22.7	1	27	15.3	9.1	29.4
A 1937		2	68	122	125	127	125	118	31.1	1	37	16.7	10.4	38.9
BLSD(0.05)		3	ns	14	13	14	13	15	1.1	ns	1	0.6	0.2	2.9

Average for Seed Treatment:

	Seed Trt.	5/18	5/20	5/23	5/25	5/27	5/31	9/8	Plant Hgt.	Lodg	Mat	Seed Weight	H20	Yield
	Check	4	70	118	121	121	123	120	30.2	1	37	16.3	10.3	35.8
	YEA	3	58	111	113	115	114	108	30.3	1	37	16.3	10.2	35.0
	Captan	4	77	125	126	127	130	116	29.1	1	37	16.1	10.2	33.4
	Apron	3	58	111	114	115	117	113	30.7	1	37	16.1	10.3	35.8
	Magnum	4	84	125	127	128	126	121	29.3	1	36	15.9	10.2	33.2
BLSD(0.05)		ns	14	12	12	12	11	12	1.2	ns	ns	ns	ns	ns

Variety x Seed Treatment (p-value):

		5/18	5/20	5/23	5/25	5/27	5/31	9/8	Plant Hgt.	Lodg	Mat	Seed Weight	H20	Yield
		0.60	0.33	0.61	0.53	0.56	0.63	0.85	0.44	0	0.72	0.87	0.33	0.58

[a] Lodging score : 1 = erect ; 5 = flat.

[b] Maturity : days past July 31 ; August 1=1.

Effect of Five Seed Treatments on Two Soybean Varieties

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The two soybean varieties used in this study represent a wide range of soybeans presently grown in southern Minnesota. The seed quality of each lot at planting time was excellent. Germination values were all above 95% in a warm germination test. Seed were treated in April and planted 5/5. Harvest was 9/17 and observations are reported as indicated on Table 1. Seed treatments are indicated as follows: Check, the untreated control, A is Apron, CTPA is Captan + TBZ (Thiabendazole) + PCNB (Pentachloronitrobenzyene) + Apron, CTPM is Captan + TBZ + PCNB + Magnum, CTP is Captan + TBZ + PCNB, CVP is Captan + Vitavax + PCNB.

Seed treatments alone or in multiple combinations did not show significant stand improvement or yield advantage. Season long observations of stand + disease revealed no serious loss of plants or disease developed in this plot. Differences in yield are not significant and yield was not adversely affected by stand.

TABLE 1. Effects of 5 Seed Treatments on Performance of 2 Soybean Varieties.

Variety	Seed Trt.	5/18	5/20	5/23	5/25	5/27	5/31	9/13	Plant Hgt.	Lodg[a]	Mat[b]	H_2O	Yield	Variety Average
		Plant Population (Plants/5 ft. of row)							(in)	(1-5)	(8/1=1)	(%)	(bu/A)	
BSR101	Check	1	19	32	32	33	34	32	32	1	40	10.8	44.5	
	A	1	14	35	35	35	36	34	33	1	40	10.8	43.6	
	CTPA	0	18	38	38	38	39	39	32	1	40	10.8	46.7	
	CTPM	0	23	37	37	37	38	39	32	1	40	10.8	47.4	44.5
	CTP	0	16	33	33	33	34	32	31	1	40	10.9	42.5	
	CVP	1	21	33	34	35	35	33	32	1.5	39	10.7	42.4	
Corsoy 79	Check	0	16	36	37	37	38	33	32	1.3	38	10.1	41.2	
	A	1	20	33	33	34	35	34	33	1.3	38	10.3	42.6	
	CTPA	1	21	32	33	33	33	33	36	1.5	38	10.4	46.1	
	CTPM	1	18	30	31	31	32	31	33	1.3	38	10.2	42.8	43.3
	CTP	1	15	29	29	30	31	32	35	1.5	38	10.4	45.1	
	CVP	1	17	31	32	33	34	33	32	1.3	38	10.6	41.9	

Yield at 13.5% moisture

CONTROLLING TWO-SPOTTED SPIDER MITES IN 1988

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The Drought of '88 brought with it many surprises. Just when farmers focused their hopes on the soybean crop along came a relatively obscure pest, the two-spotted spider mite, that threatened to rob remaining yield potential. While isolated local outbreaks of spider mites have been reported in previous droughts (1976, 1983), the magnitude and severity of this outbreak in Minnesota and the Midwest was unprecedented and unexpected. Nearly overnight, spider mite became a household word, the topic of intense discussion and a management dilemma. Questions like the following were common but sometimes the answers were hard to find.

What are two-spotted spider mites?
How do they affect soybean?
What insecticides worked?
Were insecticide applications worth it?
Why did the outbreak occur in 1988?
Are we going to have a problem in 1989?

WHAT ARE TWO-SPOTTED SPIDER MITES?

Two-spotted spider mites, as their name suggests are more closely related to spiders than insects. These minute arachnids can easily be packed 50 per inch. Like spiders, they have 8 legs and use silk webbing for a variety of purposes; lifelines for travel, protection from natural enemies, a favorable habitat for reproduction and feeding.

The life cycle of two-spotted spider mites is depicted in Fig. 1. The relative size of each pie wedge represents the proportion of the life cycle spent in that stage. After hatching from an egg, juvenile spider mites pass through three stages (6-legged larva, protonymph, deutonymph) before becoming adults. Each molt between stages is preceded by a quiet period of about 1 day. Males emerge slightly before females and seek out quiet females just ready to emerge as adults. After mating, females do not lay eggs for 1-2 days. Thereafter, they lay 5 to 6 eggs per day for the rest of their life. Females may lay up to 200 eggs during their lifetime. Adult mated females are the primary dispersal and diapausing stage.

Development from egg to adult ranges from 5 to 19 days, depending on temperature. Hot temperatures accelerate development rate as indicated in Fig. 2 and shorten the time required to reach adulthood. The optimum temperature for spider mites is ca. 90 °F. With that optimum in mind, its easy to understand why spider mite populations exploded last summer when daytime temperatures hovered near 100 °F and nighttime temperatures hovered at 80+ °F. During favorable periods, the population is continuously cycling so higher temperatures increase the number of generations and the resulting damage.

LIFE CYCLE:

TWO-SPOTTED SPIDER MITE

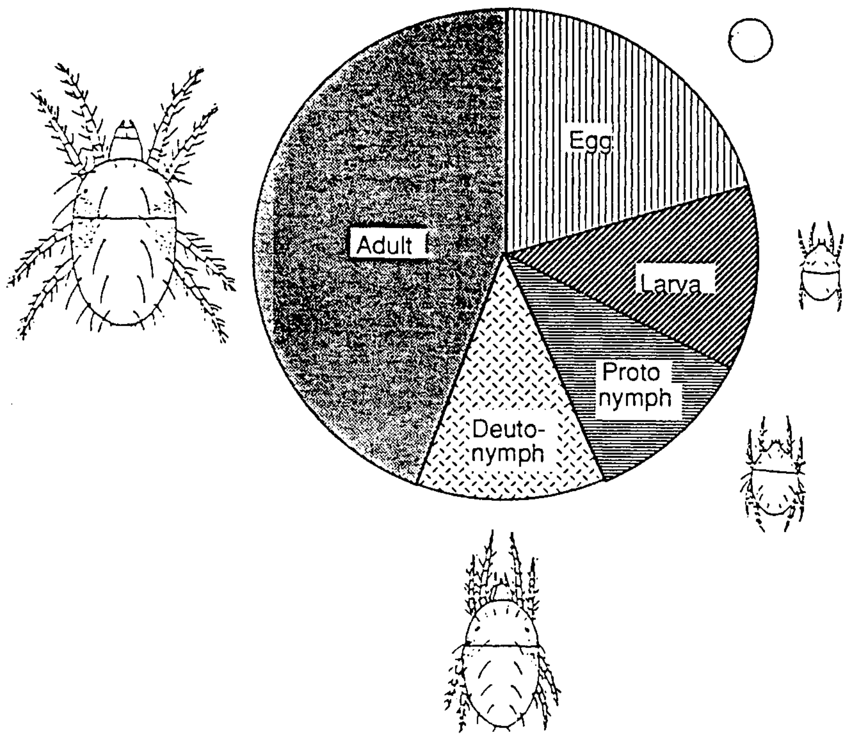

Fig. 1. Life cycle of the two-spotted spider mite.

DISPERSAL TO SOYBEAN

In the Fall, cooling temperatures, shortening daylengths, and declining host plant quality trigger the appearance of larger, orangish diapausing females that mate and seek out overwintering sites in plant debris and soil. When conditions improve in the Spring, these females emerge from their overwintering sites and colonize permanent vegetation in roadside ditches, pastures, alfalfa fields, and other locations. Later mites from expanding populations disperse to colonize developing crops such as soybeans. It's not surprising that early "hot spots" in infested fields were found close to alfalfa, roadside ditches, and other permanent vegetation.

Spider mites disperse by crawling short distances and by passive aerial drift. Dessication, high spider mite density, and declining host plant quality triggera dispersal phase primarily in mated females. The spider mites respond by climbing towards light, which brings them to the periphery of the plant. As wind velocity increases the spider mites raise their forelegs to catch the wind and drift off the plant. Aerial dispersal is passive, giving the spider mites little choice on where they land. Fortunately, their chances of encountering a suitable host are good since their host range is extremely broad including trees, shrubs, forbs, grasses, and crops. If an unsuitable host is detected by feeding, the spider mite will repeat the dispersal process.

INJURY TO SOYBEAN

An individual spider mite may not seem too intimidating but populations exceeding 1000 per leaflet can quickly produce severe injury to soybean. Spider mites feed in colonies primarily on the undersides of leaflets and near leaf veins. Their feeding mouthparts are modified into stylets which are used to penetrate leaf cells and suck out cell contents. This injury affects not only the damaged cell but also surrounding cells. Small, light-colored puncture marks on the leaf expand into irregular whitish spots. As injury increases, these spots coalesce and bronzing of injured areas occurs. Injured leaves may brown and fall off. Growth and pod set may be retarded if injury occurs in early reproductive stages. During later reproductive stages pod fill may be reduced as photosynthetic leaf areas is destroyed.

Physiological impacts of injury center on photosynthesis and transpiration. Injury directly reduces chlorophyll content of leaves and thereby effective photosynthetic leaf area. Injury indirectly affects photosynthesis by closing down stomates and limiting CO_2 uptake. The result is less photosynthate (soluble sugars and amino acids) available for pod fill. Disruption of the waxy cuticle during feeding produces uncontrolled water loss that can intensify water stress the plant may already be experiencing. By disrupting photosynthesis and transpiration, spider mite injury concentrates soluble sugars and amino acid. The end result is a more nutritious plant from the spider mite's perspective.

WHAT CONTROLS SPIDER MITE POPULATIONS?

Normally spider mites pose little threat to soybean because they are held in check by 4 factors: natural enemies, environment, host plant, and time. The two-spotted spider mite is attacked by several natural enemies. The most important include the fungus Neozygites, predatory mites, and various predatory insects. The fungus has caused documented collapses of two-spotted spider mite populations in research at several locations including Iowa. The fungus is most effective under warm (not hot), humid conditions. The fungus requires high humidity to produce spores and for those spores to penetrate into uninfected mites. The dry, hot weather last summer combined with open soybean canopies and prevalent winds effectively stopped this fungus in its tracks. Predatory mites and insects are also more effective under cooler, moister conditions.

Plant sap provides an extremely dilute source of food for spider mites. Consequently, getting rid of excess water is a problem to spider mites because it limits food intake. Spider mites excrete their body weight in only 2.5 hours. Low humidity favors water loss and permits better nutrition. Water stress produces a more concentrated plant sap in soybean and thereby improves the nutritional status of the mites. Finally, temperature and season length (in degree days not physical days) govern the rate at which spider mite populations increase and the potential severity of the infestation. Hot temperatures favor a rapid increase in spider mite populations and more severe injury.

Thus, the Drought of '88 produced ideal conditions for a spider mite outbreak. Dry weather stopped the primary disease, a fungus. Hot temperatures accelerated spider mite development and the severity of injury. Finally, low humidity and water stress on soybean improved its nutritional status for spider mites.

THE MANAGEMENT DILEMMA

The basic question was simple, "Will insecticide treatment of spider mites prevent enough yield loss to more than repay insecticide and application costs"? However, making an insecticide decision about spider mites this summer was anything but simple. The decision involved considering control costs, yield potential, crop price, pesticide effectiveness, the damage potential of the mite population and its implication on remaining yield potential. The uncertainty of weather, lack of threshold information, and shortages of both insecticides and applicators further clouded the decision.

Unfortunately, the two-spotted spider mite on soybean provides one example of a pest situation where no thresholds or treatment guidelines are available. When thresholds are lacking the key to the insecticide decision lies in understanding what's happening to the plant.

The impact of spider mite injury on yield depends on the timing and severity of injury with respect to soybean development. Last summer, spider mite infestations reached treatable levels during R5 (beginning seed) and R6 (full seed) stages. During these stages, soybean canopy is fully developed, lower leaf abscission is occurring, pod set is largely completed, and pod fill is underway. Severe spider mite injury at these stages primarily diminishes the soybean's ability to fill existing seeds, thereby reducing seed size. The effect of timing can be inferred from studies of hail defoliation. For example, 100% defoliation at R5 causes a 75% yield reduction under normal rainfall while 100% defoliation at R6 causes only a 53% yield reduction. The situation can be viewed as a race between pod fill and the spider mite infestation.

The only guideline I can offer involves taking a protective approach to the upper canopy. During R5 and R6, indeterminate soybean varieties commonly have 10 to 12 remaining leaves. For podfill to progress normally, at least 6 to 8 of these leaves must be functioning. In other words, the soybean can tolerate no more than a 15% reduction in effective leaf area. Thus, if spider mites are present and increasing injury threatens to reduce effective leaf area below these levels, treatment is justified.

EMERGENCY LABELS

Because spider mite outbreaks are so unusual, the number of pesticides registered for spider mite control on soybean is small and the information on pesticide performance is limited. As the spider mite outbreak blossomed throughout the Midwest, shortages of recommended pesticides like Cygon and Lorsban quickly developed. Faced with these shortages, the Minnesota Department of Agriculture at my request used Section 18 of FIFRA to declare emergency exemptions on Aug. 1 for propargyte (Comite 6.55E), a selective miticide, and on Aug. 3 for all dimethoate formulations. Later, on Aug. 10, disulfoton (DiSyston) was granted an emergency exemption for six counties in NW Minnesota.

INSECTICIDE PERFORMANCE

How well did these and other nonrecommended insecticides perform against two-spotted spider mite? Were there any yield benefits to treating? To answer these questions, I conducted two insecticide trials in cooperation with Snajeev Chaddha on the St. Paul campus of the University of Minnesota and two additional trials in cooperation with Bill Lueschen at the Southern Experiment Station in Waseca.

The trials at St. Paul were initiated on Aug. 13 to soybean (cv. Weber) late in stage R5. Hot spots were visible in the field. Plants throughout the field exhibited injury in the middle of the canopy and spider mites were readily observed as indicated in the pretreatment counts. In contrast, the trials at Waseca were initiated on Aug. 18 to late planted soybean. These fields contained obvious mite populations but little visible injury. Insecticides were applied using a CO_2 powered backpack sprayer delivering 30 gals of water per acre at 40 psi through 8002 nozzles. Trial 1 involved a spectrum of recommended insecticides (Cygon, Lorsban, Comite, DiSyston) and non recommended insecticides (Penncap-M, Furadan, Ambush). Trial 2 centered on the three insecticides labelled in most of Minnesota, dimethoate (Cygon), chlorpyrifos (Lorsban), and propargyte (Comite). Mite populations in both of these trials were estimated from 20 leaflets per plot, 10 from the fourth node from the top and 10 from the seventh node from the top. Leaf injury was visually estimated from 5 leaflets (nodes 4 to 8 from top) on 5 plants per plot. Trial 3 at Waseca paralleled Trial 2 at St. Paul. Trial 4 at Waseca was a timing study designed to deterine when it was no longer beneficial to treat. Spider mite populations in both Waseca trials were estimated from 5 leaves at each of three positions in the canopy; nodes 4, 6, and 8 from the top.

Effectiveness in reducing two-spotted spider mite infestations is reviewed in Tables 1 and 2 for St. Paul and Tables 3 and 4 for Waseca. Spider mite populations were still increasing at St. Paul despite several rainfall events since Aug. 1 while populations at Waseca were declining. All recommended products significantly reduced spider mite populations compared to the untreated check at 10 days postapplication in Trial 1. Penncap-M, Furadan, and Ambush did not provide acceptable levels of control. Similar to Trial 1, all recommended products and rates significantly reduced spider mite populations in Trials 2 and 3.

Table 1. Pesticide performance against two-spotted spider mites in Trial 1 on soybean (cv. Weber, stage R5). Ostlie and Chaddha. St. Paul, MN. 1988.

Pesticide	Rate	Mites/leaflet Day 0	Mites/leaflet Day 5	Mites/leaflet Day 10	% Control (Day 10)
Cygon 400	0.5	628a	474 d	71 c	87
DiSyston 8E	0.75	613a	388 d	97 c	82
Lorsban 4E	0.25	847a	433 d	104 c	81
Comite 6.55E	1.61	724a	379 d	110 c	80
Lorsban 4E	0.50	644a	509 d	150 c	73
Penncap-M 2F	0.50	784a	740 cd	403 b	27
Furadan 4F	1.00	841a	1036abc	541ab	2
Ambush 2E	0.15	898a	828 bcd	675a	-22
Check1	----	636a	1233ab	573ab	--
Check2	----	877a	1324a	531ab	—

Means followed by the same letter do not differ (p=0.05, DMRT). Log transformation used on data before analysis.

Table 2. Pesticide performance against two-spotted spider mites in Trial 2 on soybean (cv. Weber, stage R5). Ostlie and Chaddha. St. Paul, MN. 1988.

Pesticide	Rate (lb AI/a)	Mites/leaflet Day 0	Mites/leaflet Day 5	Mites/leaflet Day 10	Mites/leaflet Day 16	% Control (Day 10)
Cygon 400	0.50	237a	61 c	61 c	127a	85.7
Lorsban 4E	0.50	272a	106 bc	92 b	181a	78.5
Comite 6.55E	1.61	315a	199ab	147 b	136a	65.6
Check	----	259a	281a	427a	350a	----

Means followed by the same letter do not differ (p=0.05, DMRT). Analysis performed on log-transformed data.

Table 3. Pesticide performance against two-spotted spider mites in Trial 3 on soybean (cv. Weber, stage R5.5). Ostlie and Lueschen. Waseca, MN. 1988.

Pesticide	Rate (lb AI/a)	Mites/leaflet Day 3	Mites/leaflet Day 10	% Control (Day 10)	Yield (bu/acre)	Benefit ($/acre)
Dimethoate 400	0.5	141 b	46 b	77	24.0a	6.25
Lorsban 4E	0.5	248ab	72 b	64	22.5a	-2.75
Comite 6.55E	1.6	183 b	85 b	57	21.2a	-20.25
Check	---	433a	198a	--	21.6a	0.0

Means followed by the same letter do not differ significantly (p=0.05). Log transformation applied to mite counts before analysis.
Initial mite populations: 544/leaflet.

Table 4. Timing of pesticide applications (Dimethoate 400 at 0.5 lb AI/acre) on two-spotted spider mites in Trial 4 on soybean (cv. Weber, stage R5.5). Ostlie and Lueschen. Waseca, MN. 1988.

Application Date	Mites/leaflet Aug. 22	Aug. 29	Sept. 3	Yield (bu/acre)	Benefit ($/acre)
Aug. 18	152 b	88ab	0 c	24.6a	32.50
Aug. 22	-	76 b	34 b	21.3a	7.75
Aug. 26	-	197a	59ab	19.8a	-3.50
Untreated	356a	220a	142a	18.7a	0.0

Means followed by the same letter do not differ significantly (p=0.05). Log transformation applied to mite counts before analysis.
Initial mite populations: 538/leaflet.

INJURY AND YIELD RESPONSE

Injury and yield responses to insecticide treatments are presented in Tables 5, 6, 3 and 4 for Trials 1 to 4, respectively. Injury ratings closely followed insecticide performance. In Trial 1, yields in the "hot spots" of the field averaged only 8.6 bu/acre while yields in the field averaged 14.2 bu/acre. The plots were located in an area of lower infestation that averaged 19.2 bu/acre. Considering infestation levels pretreatment and the degree of soybean podfill, this trial was put out too late for optimal yield benefit. At the time I remembered thinking that if I found an economical return in this trial, I would believe that most farmers experienced a economic return on treating (if it wasn't too late). The best insecticide treatment produced a 6.8 bu/acre yield benefit. All recommended insecticides produced an economical return while the ineffective treatments did not. In Trial 2, the plot area was more typical of the surrounding field as demonstrated by comparable untreated yields, 27.8 bu/acre in the field vs 29.0 in the plots. Injury and mites were easily observed in Trial 2 before treatment but, as Table 2 indicates, the infestation was not as severe as in Trial 1. Pod fill was fairly advanced and for that reason I wondered whether or not injury would jeopardize yields enough to give an economical return on insecticides. The best treatment produced a yield benefit of 7.8 bu/acre. As in Trial 1, all recommended treatments produced an economical return. In Trial 3 only Dimethoate 400 produced an economical return to treatment. Finally, in Trial 4, the diminishing returns to treatment can be noted with time. A significant linear regression of yield benefit on time was obtained from all dimethoate data from Trials 1 through 4. Assuming a two-bushel yield benefit was required to break even, no fields should have been treated after August 24. Considering the fields in these trails were late planted, most treatment should have ceased at least a week earlier. The results of these trials agree fairly well with common reports of yield benefits ranging from 3 to 10 bu/acre.

Table 5. Leaf injury and yield response to insecticide treatments to control two-spotted spider mites in soybean. Ostlie and Chaddha. St. Paul, Minnesota. 1988.

Pesticide	Rate (lb AI/acre)	% of Leaf Surface Injured	Yield (bu/acre)	Cost ($/acre)	Benefit ($/acre)
Lorsban 4E	0.50	15.5 bc	26.0a	9.50	37.75
Cygon 400	0.50	14.8 bc	24.7ab	11.75	25.75
Disyston 8E	0.75	12.3 c	23.4ab	9.75	18.00
Comite 6.55E	1.61	16.9 b	23.3abc	17.25	9.75
Lorsban 4E	0.25	14.0 bc	22.8abcd	7.35	15.90
Furadan 4F	1.00	23.3a	21.8 bcd	18.50	-2.75
Penncap-M 2F	0.50	22.6a	21.5 bcd	9.70	3.80
Check2	----	26.1a	19.7 cd	----	----
Check1	----	24.2a	19.6 cd	----	----
Ambush 2E	0.15	23.3a	18.8 d	11.40	-17.40

Means followed by the same letter do not differ (p=0.05, DMRT).
Benefit calculated from soybean price of $7.50 with the insecticide cost subtracted from each entry.

Table 6. Leaf injury and yield response to insecticide treatments to control two-spotted spider mites in soybean. Ostlie and Chaddha. St. Paul, Minnesota. 1988.

Pesticide	Rate (lb AI/acre)	% of Leaf Surface Injured	Yield (bu/acre)	Cost ($/acre)	Benefit ($/acre)
Cygon 400	0.50	7.7 b	36.8a	11.75	46.75
Lorsban 4E	0.50	10.3 b	36.3a	9.50	45.25
Comite 6.55E	1.61	15.4ab	34.6a	17.25	24.75
Check	----	25.2a	29.0 b	----	----

Means followed by the same letter do not differ (p=0.05, DMRT).

Cereal Rust Epidemiology

Roelfs, A. P., Long, D. L., Hughes, M. E. and Hitman, B. A.

Rust epidemics depend on four major factors, pathogen presence and virulence, host susceptibility, environment favorable for disease development and adequate time for disease development. Cereals are generally spring planted in Minnesota. This results in the necessity of the pathogen arriving from external sources each spring.

Puccinia graminis f. sp. *tritici* causes wheat stem rust, *P. graminis* f. sp. *avenae* oat stem rust, *P. graminis* f. sp. *secalis* rye stem rust. Depending on inoculum densities either *P. graminis* f. sp. *tritici* or f. sp. *secalis* causes barley stem rust. Minnesota developed barley cultivars have the T gene for resistance to *P. graminis* f. sp. *tritici*. The leaf rusts are caused by individual pathogens *P. recondita* f. sp. *tritici*, *P. coronata*, *P. hordei* and *P. recondita* f. sp. *secalis* for the leaf rusts of wheat, oat, barley and rye, respectively.

In Table 1 the time of appearance is given for the small grain cereal rust diseases on susceptible cultivars at six Minnesota locations. Most barley cultivars currently are susceptible to barley leaf rust, and oat cultivars to oat crown rust and oat stem rust. Thus, a virulent pathogen and susceptible host exist annually. Epidemics fail to develop due either to the lack of time from the arrival of inoculum to crop maturity or unfavorable environmental conditions. Thus, by knowing the average date when the disease appears it can be determined in an individual year whether the disease appears earlier than normal which enhances the chance of an epidemic.

Wheat cultivars currently grown in Minnesota are usually protected against leaf and stem rust by resistance. Thus, it makes no difference when the inoculum arrives and in what amount it arrives as far as the commercial crop is concerned. However, the pathogen population is constantly evolving and in the future the cultivars may not be resistant. Thus, it is useful to know the approximate date the disease arrives at various locations in Minnesota. Wheat leaf rust during the last ten years has appeared in mid-June in southern Minnesota and later northward. However, leaf rust has appeared in early June and this has resulted in losses on susceptible cultivars. It would appear that with the current maturity levels severe leaf rust would develop on susceptible cultivars in most years if the inoculum arrived on or before the mean dates given in Table 1. The importance of resistance should be emphasized to the Minnesota farmer. Stem rust appears to have adequate time to result in moderate to severe losses when it is present by the first week in July.

Table 1. Stem and leaf rust onset dates for susceptible trap plots in Minnesota locations from 1978 through 1988.

Stem rusts

	wheat		oat		barley		rye	
Location	mean	1988	mean	1988	mean	1988	mean	1988
Waseca	7/02	6/14	7/18	-	7/14	-	7/28	-
Rosemount	7/06	-	7/19	-	7/16	-	7/17	-
Lamberton	7/08	6/22	7/26	-	7/22	-	7/30	-
Morris	7/16	-	7/21	-	7/27	-	7/30	-
Staples	7/16	7/19	7/24	7/19	7/26	-	7/27	7/19
Crookston	7/21	-	7/28	7/22	7/28	-	7/30	7/22

Leaf rusts

	wheat		oat		barley		rye	
Location	mean	1988	mean	1988	mean	1988	mean	1988
Waseca	6/13	6/14	6/30	-	7/02	-	6/28	-
Rosemount	6/12	5/26	6/28	-	7/07	-	6/27	6/30
Lamberton	6/18	-	7/06	-	7/03	-	6/29	-
Morris	6/23	6/15	7/05	-	7/13	-	7/02	-
Staples	7/10	-	7/14	-	7/14	-	7/12	7/19
Crookston	7/13	7/22	7/16	-	7/15	-	7/13	-

\- Indicates disease not observed at this location in 1988.

1988 OAT BREEDING

Deon D. Stuthman, Thomas R. Hoverstad and William E. Lueschen

Objective: The development of improved oat varieties is the object of this project. Oat varieties grown at Waseca are evaluated for maturity, height, lodging, diesease resistance and grain yield. Results of these tests are published in "Varietal Trials of Farm Crops".

Procedures: Three oat evaluation trials were grown at Waseca in 1988. They included: (1) a statewide uniform oat variety trial, (2) a three-location early advanced nursery, and (3) a multiple-location-year evaluation of the cycle four parents from the project's recurrent selection program.

The variety trial included 12 named varieties, five probable releases from other states and 26 lines from the project's breeding program. This test serves three purposes: (1) provides information for producers on currently available varieties, (2) provides a review of the Minnesota production potential for other state releases, and (3) provides a testing of the advanced lines from the project's breeding program as the material moves through the testing program before release. The "graduates" will be continued in the variety trial and entered into regional testing.

The early advanced nursery contained 96 advanced lines which are in the earliest one-half of the breeding material; three checks: Don, Hazel, Starter and one Minnesota line, MN81229, which is under seed increase. These 108 lines are in "stage II" of the testing, and the better ones will advance to the 1989 variety trial.

The recurrent selection parent trial is part of an evaluation program designed to compare the original CO parents with the latest cycle, C4 parents to determine the amount of progress for grain yield and to determine what has happened to other important traits when yield was the primary trait under selection. A second objective is to determine the stability or consistency of the performance of these lines.

All trials were planted on April 11, 1988. The previous crop was soybeans and the site was fall chisel plowed. Prior to planting, 30 lb N/A was applied and incorporated with a field cultivator to prepare a seedbed. Seed was packaged for planting individual plots at a rate of 80 lb/A using a cone type planter. Plot size was 4 (four 12-inch rows) x 12 feet. All plots were trimmed to a length of 8 feet for harvest. Bromoxynil (0.25 lb/A) plus MCPA (0.25 lb/A) was applied when the oats were in the 4-leaf stage. All plots were also hand-weeded to remove any escaped weeds.

Results: Data on yield and characteristics of oat varieties are listed in tables 1 and 2. The highest yielding varieties at Waseca from 1986-1988 have been Don and Hazel. A recommended variety with good straw production is steele. Oat varieties recommended for Minnesota re: Don, Hazel, Preston, Starter and Steele.

Table 1. Yield of oat varieties by location, 1986-88

Variety	Rosemount	Waseca	Lamberton	Morris	Crookston	Grand Rapids	Average	Roseau	Stephen
	bu/A								
Starter	75	87	72	79	86	63	77	77	67
Preston	72	83	67	74	86	62	74	66	50
Don	72	101	80	107	91	81	89	86	63
Hamilton[2]	71	102	70	89	69	75	79	--	--
Hazel	72	102	75	96	90	75	85	68	64
Hytest[2]	72	74	51	78	76	65	69	65	57
Steele	79	86	64	93	79	84	81	85	81
Trucker[3]	75	56	29	51	--	90	--	--	--
Moore	68	72	47	73	95	72	71	71	70
Valley[2]	75	102	65	117	62	88	85	--	--
Sandy[2]	64	78	34	84	76	75	68	74	63
Proat	68	90	64	86	79	75	77	70	67
LSD .05	7	10	8	7	12	8	4	11	10

[1]1986-87 only; [2] 1987-88 only; [3] 1988 only.

Table 2. Characteristics of oat varieties, 1986-88

Variety	Heading	Height	Lodging	Test Weight	Groat	Protein groat	Protein seed	Protein	Reaction to Disease crown rust	Reaction to Disease smut[3]
	date	inches	score[2]	lbs/bu	percent	percent	lbs/A	lbs/A	rating	rating
Starter	6-14	31	1.2	40	74	19.4	14.2	353	MS-S	HR
Preston	6-15	32	1.5	38	72	20.9	15.0	352	S	R
Don	6-16	30	1.7	40	74	16.7	12.3	355	HR	HR
Hamilton[4]	6-16	30	1.5	38	74	18.0	13.2	325	S	S
Hazel	6-18	30	1.5	38	75	18.7	13.9	381	R	S
Hytest[4]	6-18	37	1.7	41	76	19.3	14.6	340	S	HR
Steele	6-20	36	1.4	38	73	19.1	14.0	353	HR	MS
Trucker[5]	6-21	34	1.5	38	73	19.6	14.2	288	S	MS
Moore	6-21	36	1.6	36	72	18.2	13.1	286	MS	MS
Valley[4]	6-22	32	1.3	39	73	18.2	13.3	340	HR	S
Sandy[4]	6-22	38	1.4	37	73	18.4	13.4	326	MR	MS
Proat	6-22	35	1.7	38	72	20.9	15.1	360	MR	R

[1]Does not include Stephen and Roseau. [2]1 = erect; 5 = flat. [3] HR = highly resistant; R= resistant; MR = moderately resistant; MS = Moderately susceptible; S = susceptible [4]1987-88; [5]1988 only.

Location: West Central Experiment Station, Morris, MN;
Dennis Warnes and Ervin Oelke

Materials and Methods:

The experimental design was a split plot layout with varieties (Marshall and Amidon) as main blocks and with 4 replications. The wheat was planted April 21, 1988. Plots were planted with a Melroe grain drill in plots 8 x 30 feet and a 2 foot space between plots to facilitate spraying with a Spirit Sprayer that straddled each plot. TRIGGRR was applied at 8 oz/A at 30 psi and 26 gpa. Seeding rate was 42 seeds/ft in 6 inch rows. Fertility was 200 lb/A nitrogen (soil N + applied N).

The weather and stage of wheat for each of the 7 spray application dates are as follows.

Date	Zadoks Stage	Wheat Stage	Air Temp ° F	Wind Dir and Speed	Time of Day
May 10	12	1-1 1/2 leaf	60	W 5 mph	8:30 a.m.
May 17	13	3 leaf	50	SW 5 mph	8:00 a.m.
May 26	15	4 1/2 leaf	65	SW 2 mph	8:30 a.m.
June 2	16	6 leaf	85	No Wind	11:30 a.m.
June 6	37	3rd node apparent, flag exposed	90	SE 2 mph	1:30 p.m.
June 9	45	Swollen boot, flag leaf open	70	SE 2 mph	11:00 a.m.
June 13	59	Amidon/heads exposed, Marshall/headed	85	W 1 mph	3:30 p.m.

Precipitation during the growing season was 13.79 inches (6.36 below normal) but only 4.6 inches was received from April 1 to August 1 and this resulted in a severe drouth and the wheat was very short.

Results:

Variety	TRIGGRR treatment	Application stage	Date headed	Plant height	Test weight	Grain yield
	oz/A	Zadoks	June	in.	lb/bu	bu/A
Marshall	8	12	14.5	21.5	58.9	18.4
		13	14.8	22.0	57.8	21.0
		15	14.2	22.0	57.2	20.2
		16	14.8	23.5	59.0	20.6
		33	14.8	22.5	58.4	20.7
		37	15.2	23.2	52.8	23.4
		45	15.0	21.0	57.2	19.5
	check	--	15.5	22.8	57.8	24.9
Amidon	8	12	15.5	18.8	56.8	19.1
		13	16.0	18.8	58.1	19.7
		15	15.8	18.5	56.6	17.2
		16	16.0	19.0	53.1	22.0
		33	16.0	17.8	54.9	18.5
		37	16.2	18.8	54.4	20.5
		45	16.0	18.8	56.7	18.2
	check	--	15.8	18.2	57.7	20.2
	LSD .05		0.9	1.8	9.4	6.7

Location: Southern Experiment Station, Waseca, MN;
William Lueschen and Ervin Oelke

Materials and Methods:

The experimental design was a split layout with fertility (80 and 160 lb/A N applied) as main plots and with 4 replications. The wheat (variety Marshall) was planted on April 18. Plots were planted with a 6 in. row spacing grain drill in 10 x 50 ft plots at 42 seeds/ft^2. TRIGGRR was applied at 8 oz/A at 30 psi and 26 gpa. TRIGGRR was applied on May 17 (Zadoks 13) and on June 8 (Zadoks 42).

Results:

Variety	Nitrogen rate	TRIGGRR treatment	Application stage	Plant height	Test weight	Moisture	Grain yield
	lbs/A	oz/A	Zadoks	in.	lb/bu	%	bu/A
Marshall	80	8	13	18.5	57.6	14.2	23.1
			42	18.0	57.7	14.2	20.3
			Check	18.3	57.9	14.1	23.1
	160	8	13	17.3	57.9	14.0	20.1
			42	18.0	57.7	14.2	21.2
			Check	18.0	57.6	14.0	20.8
Averages:			Check	18.1	57.7	14.0	22.0
			8 oz, Z 13	17.9	57.8	14.1	21.6
			8 oz, Z 42	18.0	57.7	14.2	20.7
			LSD .05	NS	NS	NS	NS
			80 N	18.3	57.7	14.1	22.2
			160 N	17.8	57.7	14.1	20.7
			Level of sign.	.1027	.9168	.8387	.0660
			N x TRIGGRR Level of sign.	.0795	.2985	.8908	.1654

Location: Northwest Experiment Station, Crookston, MN;
Marlin Johnson, John Lamb and Ervin Oelke

Materials and Methods:

The experimental design was a randomized complete block with 4 replications. The wheat (variety Marshall) was planted on May 1, 1988 with a 6 in. row spacing grain drill in 8 by 20 ft plots. Seeding rate was 42 seeds/ft^2 and nitrogen was 200 lb N/A (soil N + applied N). TRIGGRR was applied at 8 oz/A and at 30 psi and 26 gpa. The first application was made on May 20 (Zadoks 13), the second on June 1 (Zadoks 21) and the third on June 15 (Zadoks 37).

Results:

Variety	TRIGGRR treatment	Application stage	Test weight	Grain yield
	oz/A	Zadoks	lb/bu	bu/A
Marshall	8	13	58.8	24.1
		21	58.9	21.0
		37	58.5	22.8
		Check	58.6	23.3
		LSD .05	2.4	2.5

Location: Counties of Kittson, Norman, Clay and Becker;
Ervin Oelke, Marlin Johnson, Curtis Nyegaard, Kenneth Pazdernik, Edmund Bernhardson, Jerome Arneson, Lisa Axton and Leo Brown

Materials and Methods:

Approximately 10 x 30 ft plots were marked out in growers' fields and 8 oz/A of TRIGGRR applied with small hand sprayer at 30 psi and 26 gpa. TRIGGRR was applied at Zadoks 13, 21 and 37. Plot design was a randomized complete block with 4 replications. The variety was Marshall in all counties. The plots in Norman, Clay and Becker were harvested with a small plot combine, while the one in Kittson Co. was harvested by hand.

Results:

TRIGGRR treatment	Application stage	County			
		Kittson*	Norman	Clay	Becker
oz/A	Zadoks	bu/A			
8	13	28.3	30.2	32.8	16.2
	21	28.5	30.5	34.7	16.0
	37	28.4	28.6	34.9	16.3
	Check	29.2	33.0	34.3	13.7
	LSD .05	6.1	2.2	12.6	2.4

*The 2nd and 3rd application dates were both applied at Zadoks 37 because of the rapid development of the crop between the 1st and 2nd date.

1988 WHEAT PROJECT STUDIES AT WASECA

Two cooperative trials were grown at Waseca in 1988. Both of these trials are grown each year to assess genotype performance for yield and quality. The Uniform Regional Northern Winter Wheat Nursey is a trial designed to test experimental lines through out the upper-midwest from winter wheat breeding programs in Nebraska, North Dakota, South Dakota, Idaho, Montana, Canada, and some hybrids from Hybri-Tech. Yield and agronomic performance data are sent to the University of Nebraska for compliation into a comprehensive report. This research report provides wide-area testing in a single year of new lines and is of considerable help in determining if an experimental line will be released for production. Results of the Uniform Regional Northern Winter Wheat Nursery are given in Table 1.

The spring wheat variety trial, called Advanced Yield Trial 1, was grown at Waseca in 1988. This test is grown each year to assess the agronomic performance of spring wheat varieties and experimental varieties before they are released. This trial is grown at six other locations which represent the wheat growing areas in Minnesota. The seed produced is sent to the USDA Spring Wheat Quality Laboratory in Fargo, ND, to assess bread-making quality. Agronomy results from the spring wheat variety trial from Waseca in 1988 are presented in Table 2.

Table 1. NORTHERN REGIONAL WINTER WHEAT TEST 1987 - WASECA
PLOT_SIZE_IN_SQFT: 32 DATE_SEEDED: 9/8/87
SORTED BY YIELD, DESCENDING

VARIETY OR STATE NO.	YIELD BU/AC	TWT LB/BU	HD DAYS	HT CM
NE83432	42.3	62.0	3	58
ND8407	40.7	60.5	4	74
SD82114	40.4	61.5	3	64
ND8212	38.7	60.0	4	73
NA-81-362-5	38.4	62.5	2	64
ND8215	38.2	59.0	4	73
NE84581	36.2	61.0	4	63
WT179	34.8	60.0	4	75
SD76463-16	33.6	62.0	2	72
WT177	33.5	61.5	3	71
NE82438	33.2	61.0	3	63
SD78207-4	32.4	62.5	3	67
ID0180	31.2	59.0	6	63
CI17439	30.6	61.5	3	75
ND8286	29.4	61.0	5	69
MT8039	28.8	59.0	4	64
WT176	27.4	58.5	5	70
CI1442	27.1	61.5	2	75
XNH1354	26.3	61.0	3	53
SD791231	26.0	61.0	2	60
NE82656	25.5	60.0	2	62
ND8460	25.3	61.5	3	69
SD82144	25.2	60.5	2	65
XH947	25.1	59.0	5	56
PI476975	19.8	61.0	3	49
ID0301	19.0	61.0	5	58
MEANS:	31.1	60.7	3	65

TESTS	YIELD	TWT	HD	HT
F-test:	4.5	0.0	2.6	6.1
LSD:	8.5	0.0	1.9	8.2
CV:	16.7	0.0	33.6	7.6

Table. 2

ADVANCED YIELD TRIAL 1 1988 - WASECA

PLOT_SIZE_IN_SQFT: 40 DATE_SEEDED:

SORTED BY YIELD, DESCENDING

VARIETY OR STATE NO.	YIELD BU/AC	TWT LB/BU	HD DAYS	HT CM
STOA	31.8	61.0	11	66
SHIELD	31.5	60.0	6	58
NORDIC	30.9	61.0	14	54
MN85324	29.6	62.0	10	52
ND626	29.1	61.0	8	61
2375	29.1	61.0	7	47
MN85167	27.0	60.0	12	49
W2502	26.7	59.5	9	44
WPB 926	26.6	60.5	7	46
2369	26.6	61.0	9	47
NORAK	26.1	60.0	10	51
TELEMARK	26.1	60.0	12	47
MN81110	25.6	59.0	9	47
2385	25.4	60.0	8	52
WHEATON	25.2	59.5	10	47
W2501	25.0	57.0	9	41
TAMMY	25.0	60.5	10	51
FJELD	24.9	60.5	9	48
AMIDON	24.5	60.0	11	63
GUARD	24.3	59.5	10	43
MN85110	24.2	59.0	8	44
CELTIC	24.2	60.5	13	59
BUTTE 86	24.1	61.0	8	56
MARSHALL	24.1	61.0	13	46
PROSPECT	23.9	61.0	9	52
LEN	23.4	60.5	13	55
NORSEMAN	23.0	59.0	13	44
MN85328	22.6	60.0	8	51
MN82354	22.2	59.0	12	50
APEX 83	20.8	60.5	7	43
LIEF	20.3	59.0	12	60
CHALLENGER	20.1	60.0	7	42
ERA	19.3	60.0	14	45
SUCCESS	18.4	57.0	14	56
A99AR	17.1	57.5	13	69
CHRIS	15.7	60.0	12	61
MEANS:	24.6	60.2	10	51

TESTS	YIELD	HD	HT
F-Trts:	62.6	18.9	99.9
LSD:	5.6	1.6	7.2
CV:	14.1	9.2	8.5
Ref:	0.0	122.9	0.0

Alfalfa Variety Yield Trials

D.K. Barnes, USDA-ARS and D.M. Smith, Department of Agronomy and Plant Genetics in cooperation with W.E. Lueschen

Two variety trials were present on the Waseca Experiment Station during 1988. These trials were seeded in 1984 (40 entries) and 1986 (51 entries). The increasing number of entries in the 1986 trial compared to the 1984 trial reflects the increasing numbers of alfalfa varieties being released. Most new alfalfa varieties are presently being developed by private industry. The Minnesota alfalfa testing policy has been to include all new alfalfa varieties that are eligible for certification or Plant Variety Protection and that are potentially adapted to Minnesota, in yield trials at each branch experiment station. Those varieties sold in Minnesota each year are described in Varietal Trials of Farm Crops (Minnesota Report 24).

The fourth year yields of varieties in the 1984 Alfalfa Variety Yield Trial (Table attached) ranged between 2.51 and 4.45 Tons Dry Matter/A (2.8 and 5.0 Tons 12% M hay). The four-year total yield of varieties ranged between 19.28 and 24.85 T DM/A (21.6 and 27.8 T hay/A. These data illustrate the importance of choosing alfalfa varieties for yield potential. The data also illustrate the importance of considering third and fourth year data when comparing varieties. Total yields for the two extreme varieties indicated above were 14.0 and 14.9 T hay/A for years 1 and 2 combined and 7.8 and 12.9 T hay/A for years 3 and 4 combined. The greatest difference among alfalfa varieties grown under intensive forage management (4 to 5 harvests per year) in S.E. Minnesota is persistence beyond the second year.

The two-year total yields for the 1986 Alfalfa Variety Yield Trial (Table attached) ranged between 13.02 and 16.20 T DM/A (14.6 and 18.1 T hay/A). These yields are exceptional for Minnesota. This is in part due to the first year test average of 10.0 T hay/A. Most of the older check varieties: Agate, DuPuits, Ranger, Saranac and Vernal were slightly lower yielding (15.4 T hay/A) than the more recently developed varieties (16.7 T hay/A). The high yields and relatively small differences among varieties after two years illustrates that intensive management (high fertilization, 4-5 harvests/year) and good weather will produce high yields on most alfalfa varieties. Based on previous experiences, such as the 1984 Alfalfa Variety Yield Trial, the yield differences among varieties will increase greatly in years 3 and 4.

NOT FOR PUBLICATION WITHOUT PERMISSION.

Four Year Forage Yields From 1984 Alfalfa Variety Yield Trial, Waseca, Mn.*

	Forage Yield (Tons DM/A									
				1988						
Entry	1985	1986	1987	5-26	6-21	7-12	8-11	Season Total	4 Year Total	Percent Vernal
Advantage	5.55	6.45	6.34	1.75	0.98	0.48	0.61	3.82	22.16	98
Apollo II	5.30	6.74	5.55	1.59	0.89	0.37	0.45	3.30	20.89	93
Armor	5.59	7.17	6.14	1.77	1.20	0.50	0.66	4.13	23.03	102
Baker	5.51	6.29	6.15	1.95	1.08	0.39	0.51	3.93	21.88	97
Big Ten	5.52	7.01	6.34	1.91	1.06	0.53	0.64	4.14	23.01	102
Challanger	5.47	6.94	5.34	1.59	0.89	0.36	0.45	3.29	21.04	93
Cimarron	5.76	7.03	5.32	1.49	0.94	0.39	0.50	3.32	21.43	95
Decathlon	5.47	7.00	5.07	1.36	0.81	0.37	0.42	2.96	20.50	91
DK 135	5.29	6.86	5.12	1.46	0.82	0.40	0.51	3.19	20.46	91
Drummor	5.42	6.69	5.24	1.57	0.84	0.41	0.57	3.39	20.74	92
Eagle	5.33	7.17	4.47	1.20	0.67	0.31	0.33	2.51	19.48	87
Endure	5.61	7.31	5.79	1.78	0.99	0.37	0.50	3.64	22.35	99
Epic	5.35	6.95	5.79	1.89	1.02	0.37	0.55	3.83	21.92	97
Excalibur	5.75	6.46	4.91	1.45	0.80	0.42	0.57	3.24	20.36	90
G 2818	5.26	7.36	6.12	1.93	1.13	0.44	0.49	3.99	22.73	101
Magnum	5.38	7.39	6.35	1.93	1.00	0.37	0.53	3.83	22.95	102
Maverick	5.14	6.72	5.52	1.90	0.80	0.28	0.41	3.39	20.77	92
Maxim	5.55	6.83	5.50	1.63	0.95	0.46	0.50	3.54	21.42	95
Mn Cargo X (10X7)	4.85	6.67	5.21	1.15	0.75	0.41	0.46	2.77	19.50	87
Mn GRN 2	5.60	7.43	6.93	2.11	1.04	0.50	0.62	4.27	24.23	108
Mn GRN 4	5.67	7.63	7.10	1.98	1.20	0.57	0.70	4.45	24.85	110
Mn SWComp X (10X7)	5.51	7.23	5.26	1.47	0.82	0.32	0.46	3.07	21.07	94
Oneida	5.41	7.33	6.50	2.14	1.05	0.50	0.63	4.32	23.56	105
Preserve	5.34	6.54	5.92	1.74	0.93	0.52	0.60	3.79	21.59	96
Saranac AR	5.29	6.77	4.66	1.32	0.64	0.26	0.34	2.56	19.28	86
Shenandoah	5.71	7.31	5.15	1.40	0.75	0.35	0.45	2.95	21.12	94
Spectrum	5.79	7.23	6.18	1.72	1.07	0.53	0.64	3.96	23.16	103
Spredor 2	4.92	6.04	5.31	1.87	0.73	0.25	0.43	3.28	19.55	87
Trumpetor	5.48	6.90	5.67	1.64	0.90	0.43	0.46	3.43	21.48	95
VERNAL **	5.45	6.76	6.28	1.99	1.07	0.38	0.58	4.02	22.51	100
Webfoot	5.69	7.19	6.68	1.87	1.13	0.49	0.62	4.11	23.67	105
WL 219	5.60	7.61	7.01	1.99	1.22	0.53	0.53	4.27	24.49	109
WL 316	5.51	7.34	5.63	1.50	0.86	0.35	0.45	3.16	21.64	96
WL 320	5.87	7.35	6.80	1.86	1.11	0.54	0.63	4.14	24.16	107
WL So. Special	5.54	7.59	6.32	1.80	1.17	0.53	0.56	4.06	23.51	104
Wrangler	5.44	7.01	6.32	1.98	0.94	0.46	0.49	3.87	22.64	101
120	5.48	7.20	6.26	1.79	1.10	0.41	0.50	3.80	22.74	101
130	5.36	6.91	5.87	1.69	0.87	0.42	0.50	3.48	21.62	96
532	5.70	7.72	6.67	1.96	1.01	0.33	0.50	3.80	23.89	106
555	5.72	7.38	6.92	1.96	1.10	0.57	0.66	4.29	24.31	108
LSD .05 %	.41	.55	.80	.17	.21	.24	.19	.63		
CV %	5.43	5.64	9.73	7.29	15.46	41.24	26.71	12.41		

*Seeded 4-25-84, 1# Balan/A, 50 viable seed/sq ft. , 6' X 20' plots with 4 replicates.

**Average of 2 plots/replication.

NOT FOR PUBLICATION WITHOUT PERMISSION.

Two Year Forage Yields From 1986 Alfalfa Variety Yield Trial, Waseca, Mn.*

Entry	Forage Yield (Tons DM/A)							
		1988						
	1987	5-25	6-21	7-14	8-17	Season Total	4 Year Total	Percent Vernal
Action	8.11	2.10	1.53	0.69	1.06	5.38	13.49	98
Admiral	9.12	2.11	1.66	0.85	1.36	5.98	15.10	110
Agate	8.06	2.13	1.55	0.92	1.16	5.76	13.82	101
Anstar	9.08	2.19	1.59	0.74	1.32	5.84	14.92	109
Arrow	8.98	2.36	1.80	0.94	1.16	6.26	15.24	111
Bell Ringer	8.99	1.96	1.53	0.78	1.18	5.45	14.44	105
Centurian	9.07	1.96	1.61	0.94	1.37	5.88	14.95	109
Commandor	8.96	2.06	1.68	0.88	1.33	5.95	14.91	108
Crown	9.21	1.99	1.55	0.82	1.11	5.47	14.68	107
Dart	9.10	2.29	1.68	0.88	1.26	6.11	15.21	111
DK-125	9.27	1.92	1.52	0.73	1.16	5.33	14.60	106
DS 507	9.04	2.19	1.72	0.86	1.21	5.98	15.02	109
DS 510	9.17	2.05	1.69	0.98	1.34	6.06	15.23	111
DS 512	9.81	2.04	1.82	1.08	1.45	6.39	16.20	118
DuPuits	7.60	1.82	1.52	0.92	1.16	5.42	13.02	95
Dynasty	8.71	2.15	1.68	0.97	1.41	6.21	14.92	109
Edge	8.80	2.17	1.58	0.81	1.18	5.74	14.54	106
Elevation	8.86	2.18	1.71	0.91	1.26	6.06	14.92	109
G 2852	8.78	2.04	1.43	0.77	1.11	5.35	14.13	103
GH737	8.77	2.44	1.74	0.86	1.08	6.12	14.89	108
Husky	9.21	2.14	1.56	0.83	1.32	5.85	15.06	110
Impact	8.92	2.32	1.78	0.85	1.15	6.10	15.02	109
Magnum III	9.11	2.13	1.60	0.91	1.12	5.76	14.87	108
Milkmaker	8.52	2.09	1.62	0.80	1.02	5.53	14.05	102
MnHiEz X Blaz	9.00	2.31	1.63	0.82	1.37	6.13	15.13	110
MnHiEz X Cita	9.26	2.28	1.52	0.95	1.27	6.02	15.28	111
MnHiEz X SarAR	8.90	2.02	1.47	0.82	1.31	5.62	14.52	106
Mohawk	9.00	2.22	1.58	0.88	1.27	5.95	14.95	109
NAPB 21	8.99	2.39	1.71	0.84	1.27	6.21	15.20	111
NAPB 26B	8.85	2.35	1.57	0.67	0.97	5.56	14.41	105
Ranger	8.32	2.25	1.50	0.94	1.12	5.81	14.13	103
Salute	8.54	2.37	1.73	0.87	1.26	6.23	14.77	107
Saranac	8.60	2.16	1.51	0.78	1.11	5.56	14.16	103
Shield	8.73	2.05	1.67	0.86	1.16	5.74	14.47	105
Sparta	9.13	2.48	1.59	0.76	1.06	5.89	15.02	109
Summit	8.82	1.91	1.48	0.77	1.14	5.30	14.12	103
Sure	9.47	1.80	1.44	0.91	1.31	5.46	14.93	109
Surpass	9.33	2.41	1.70	0.90	1.20	6.21	15.54	113
Target	8.70	2.11	1.63	0.78	1.20	5.72	14.42	105
Thorobred	9.28	2.24	1.67	0.79	1.21	5.91	15.19	110
Tomahawk	9.58	2.06	1.60	0.95	1.30	5.91	15.49	113
Vernal **	8.28	2.35	1.42	0.70	1.00	5.47	13.75	100
Verta +	8.85	2.10	1.51	0.69	1.06	5.36	14.21	103
Webfoot	8.88	2.17	1.73	1.02	1.34	6.26	15.14	110
5432	8.74	2.29	1.73	0.89	1.15	6.06	14.80	108
5444	9.80	2.30	1.61	0.94	1.37	6.22	16.02	117
624	9.57	2.40	1.79	0.86	1.30	6.35	15.92	116
629	8.69	2.39	1.58	0.78	0.92	5.67	14.36	104
630	8.24	2.27	1.65	0.78	1.28	5.98	14.22	103
636	9.11	2.09	1.52	0.85	1.17	5.63	14.74	107
LSD .05 %	.88	.30	.25	.27	.30	.66		
CV %	7.04	10.07	11.18	23.32	18.05	8.16		

*Seeded 5-7-86, 1# Balan/A, 50 viable seed/sq ft. , 6' X 20' plots with 4 replicates.

**Average of 2 plots/replicati

PREDICTION OF ALFALFA VARIETY PERSISTENCE BY SEEDING YEAR CUTTING FREQUENCY TESTS

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Department of Agronomy and Plant Genetics

Alfalfa cultivars vary in ability to persist under intensive management. Normally 3 or 4 years are required to evaluate persistence of a cultivar. A critical need in alfalfa breeding research is to quickly and economically evaluate the potential persistence of new cultivars. One method of imposing stress on alfalfa has been to increase the cutting frequency. The objective of this study is to determine if it is possible to impose increased cutting stress on alfalfa cultivars during the seeding year and to evaluate the effects during the first production year.

PROCEDURE: Twenty-four cultivars representing a wide range of cold hardiness and fall growth habit were planted at Waseca, Lamberton, Rosemount, and Morris on about May 1, 1987. Alfalfa at one or more of these locations with diverse climatic conditions can be expected to show severe winter injury. All locations were clipped June 25 followed by cutting at intervals of 24 days (5 cuts, last cut 9/28), 30 days (4 cuts, last cut 9/28), 35 days (4 cuts, last cut 10/5), and 45 days (3 cuts, last cut 9/28).

Winter injury scores and percent stand ratings were collected early in the spring of 1988. Harvests for dry matter yields were taken in May and at early bud three more times during the summer. Another harvest will be taken in May 1989 to determine residual dry matter yields.

RESULTS: May 1988 dry matter yields and winter injury scores at Waseca are presented in Table 1. The least stressful cutting management during the seeding year (45 day) produced the greatest yields and the least winter injury in the subsequent year. Most cultivars, except non-winter hardy Nitro, performed similarily under the least stress treatment. Under the more stressful managements (24 day, 30 day, and 35 day cutting intervals) cultivars varied significantly.

Differences in general winter injury were observed at the four locations. Lamberton had a good snow cover and showed essentially no winter injury on any cultivar under any level of cutting stress. Morris had little snow cover and showed severe winter injury to 8 of the 24 cultivars exposed to the most stressful cutting management.

This type of seeding year stress testing appears to have the potential to rapidly predict those cultivars with the greatest persistence.

Table 1. May 28, 1988 dry matter yields (tons/acre) and WIS (winter injury scores) of alfalfa at Waseca, MN. Alfalfa varieties are listed in order of WHI (winter hardy index).

		1987 Cutting Schedules							
		24-day		30-day		35-day		45-day	
Varities	WHI	Yld	WIS*	Yld	WIS	Yld	WIS	Yld	WIS
Rambler	8.0	1.6	2	1.6	3	1.7	2	2.0	2
Wrangler	7.0	1.5	4	2.0	4	1.6	4	2.2	1
526	6.5	1.5	4	1.8	3	1.7	4	2.2	2
636	6.3	1.4	4	1.8	4	1.9	3	2.2	1
WL 225	6.3	1.4	5	1.8	4	1.5	5	2.1	2
Iroquois	6.0	1.5	4	1.8	4	1.6	4	2.3	2
5432	5.7	1.3	5	1.9	3	1.6	3	2.4	1
Thunder	5.7	1.5	4	1.9	3	1.8	4	2.1	1
Valor	5.5	1.3	4	1.9	3	1.7	4	2.2	1
DK 120	5.5	1.3	5	1.7	4	1.6	5	2.2	2
Dart	5.3	1.5	5	2.0	4	1.9	3	2.3	1
Marathon	5.2	1.4	5	1.5	4	1.4	5	2.1	2
Sparta	5.2	1.4	4	1.8	3	1.6	5	2.3	2
Impact	5.1	1.5	4	1.8	4	1.6	5	2.3	2
Vernema	4.8	1.4	5	1.7	3	1.6	4	2.2	1
Dynasty	4.6	1.5	4	1.5	5	1.5	4	2.0	2
Peak	4.5	1.6	4	2.0	3	1.9	3	2.4	1
Saranac	4.5	1.2	5	1.6	4	1.4	5	2.3	2
Crown	4.1	1.4	5	1.6	4	1.9	5	2.0	3
Epic	3.9	.9	6	1.7	5	1.7	5	2.1	3
Victoria	3.9	1.0	7	1.5	5	1.0	7	2.0	4
Cimarron	3.6	1.4	6	1.7	5	1.4	5	2.0	3
Shenandoah	3.6	1.2	5	1.4	5	1.2	6	2.2	2
Nitro	3.3	.1	9	.7	7	.5	8	.8	8
** LSD (.05)		NS	1.2						
** LSD (.10)		.3							

* WIS: 1=NO injury, 3=Slight damage, 5=Moderate damage, 7=Severe damage, 9=Dead.

** LSD for comparing treatment means over all cutting treatments.

Alternative Crops Project
Department of Agronomy and Plant Genetics

WASECA - 1988

SPRING RAPESEED AND CANOLA VARIETY TRIAL

Ten public and private varieties of canola oilseed and oilseed rape were evaluated in 1988. The trial was planted on 4/18 at a rate of 25 seeds/ft^2 into plot area that had been cultivated twice (4/15 and 4/18). Nitrogen was applied as urea at 100 lbs/A and incorporated on 4/18. Treflan EC (PPI) was applied at 0.75 lbs/A. Furadan was also applied at a 1 lb/A rate at planting to control flea beetles. The plots were harvested on 7/21. Data collected includes seed yield, plant height and lodging score. Seed yields were much lower than previous years due to the dry conditions in 1988. This trial will not be repeated in 1989.

AMARANTH VARIETY TRIAL

Fifteen lines of amaranth were planted at the Waseca Experiment Station in 1988. However, because germination and growth of the plants was poor due to dry conditions, the trial was plowed under. This trial will be repeated in 1989.

WINTER CANOLA - DATE OF SEEDING/NITROGEN STUDY

1987-1988

The objective of this study was to determine the effect of planting and nitrogen fertility on winter canola oilseed production. The experiment was a split plot design with 4 reps, 5 planting dates (July 30, Aug. 12, Aug. 25, Sept. 8 and Sept. 24) and 2 levels of fertility (0 and 150 lbs/A). However, no data is presented because the trial was lost due to severe winter injury. This trial will be repeated in 1989.

Table 1. Seed yield of spring canola and oilseed rape varieties, 1988.

Variety	Seed Yield			
	Rosemount	Grand Rapids	Waseca	Average
	(lbs/A)			
Andor	213	1010	240	488
Global	16	1063	98	392
Hyola 70	210	595	147	317
Reston	120	1202	319	547
R-500	8	641	161	270
Tobin	28	697	142	289
Topas	4	996	87	362
Tribute	10	769	128	302
OAC Triton	66	208	133	136
Westar	146	1285	223	551
LSD 5%	106	358	62	175

Table 2. Characteristics of spring canola and oilseed rape varieties, 1988.

Variety	Plant Height			Planting to Bloom: Begin	Planting to Bloom: 100%	Planting to Maturity		Lodging			Stand	Seeds/lb	Test Wt.	Oil
	Rosemount	Grand Rapids	Waseca	Rosemount	Grand Rapids	Rosemount	Grand Rapids	Rosemount	Grand Rapids	Waseca	Rosemount	Grand Rapids		Grand Rapids
	- - - - - (inches) - - - - - -			- - - - (days) - - - -		- - - - (days) - - - -		- - - - - - (score)[1] - - - - -			(%)	(thousand)	(lbs/bu)	(%)[2]
Andor	30	35	29	41	49	73	90	1.6	1.3	2.8	93	154	47	38
Global	27	42	29	41	53	73	101	1.0	2.3	1.3	93	118	46	38
Hyola 70	28	33	23	32	43	58	95	2.3	1.0	2.0	85	250	43	35
Reston	28	37	28	41	49	74	94	1.1	2.0	3.0	84	134	49	39
R-500	28	33	25	41	48	72	95	1.5	1.5	3.3	81	168	48	31
Tobin	29	36	25	43	52	73	97	1.4	1.0	2.8	84	105	35	38
Topas	30	45	29	--	53	74	100	1.4	1.8	1.0	80	136	48	41
Tribute	25	36	27	--	49	72	95	1.1	1.5	3.5	73	152	49	32
OAC Triton	16	--	20	36	--	67	--	1.9	--	2.0	10	150	47	37
Westar	27	37	26	40	51	72	95	1.4	1.0	2.0	89	125	49	39

[1] 1 = Erect, 9 = Horizontal

[2] 10% moisture basis.

Effect of Nitrogen Rate on Sweet Sorghum Performance in 1988[1/]

William Lueschen, Brian Kanne, Thomas Hoverstad and Gyles Randall

Objective: To evaluate the effects of nitrogen fertilizer rate on total sugar yield and ethanol production of two sweet sorghum varieties.

Procedures: This study was conducted near Waseca, MN on a Nicollet clay loam soil with 5.0% organic matter and the following chemical properties: pH=7.1; P=51 lb/A; K=376 lb/A. Both the P and K levels at this site were very high. Soil nitrate samples were taken in April 1988 by sampling to a 5 ft depth and dividing the core into 1 ft increments. The results from this sampling are presented below:

Table 1. Soil Nitrate Levels in Late April 1988

Soil Depth	NO_3-N	NO_3-N
ft	ppm	lb/A
0-1	8.3	33.0
1-2	3.8	15.0
2-3	2.8	11.1
3-4	1.8	7.2
4-5	3.0	12.0
0-5		78.3

A NO_3 level of 78 lb/A in the top 5 ft of soil would be considered low to medium which should provide for a good response to N. The previous management of this site influenced soil NO_3 levels.

The previous crop on this site was corn harvested for grain which yielded approximately 150 bu/A. N at the rate of 50 lb/A was all of the N applied to the 1987 corn crop. After corn harvest the site was moldboard plowed to a depth of approximately 9 inches. Spring tillage in 1988 consisted of disking before N application and one field cultivation just prior to planting.

This study was designed as a randomized, complete block experiment with four replications and a split-plot arrangement of treatments. Nitrogen rates were the main plots with variety as the subplot. Main plots were 10 by 55 ft and subplots were 10 by 26 ft.

1/ This project was partially supported by a legislative grant obtained through the Mankato Technical Institute for evaluating sweet sorghum as a feed stock for ethanol production.

Anhydrous ammonia was applied on May 2, 1988 at rates of 0, 25, 50, 75, 100, 150 and 200 lb N/A. The depth of injection of the N was approximately 6 inches. Two varieties were used in this study: 'Keller', a sweet sorghum developed by Mississippi State University, and 'NK 405', a semi-sweet sorghum developed by Northrup King. Seed for each plot was counted and packaged prior to planting with seeding rates adjusted according to a germination test to obtain a seeding rate of 60,000 viable seeds/A. All plots were planted one inch deep on May 6, 1988 in 30-inch rows with a John Deere 7100 planter equipped with cone planting attachments. To control weeds, 5 lb/A propachlor (Ramrod) plus 2 lb/A atrazine was applied preemergence. All plots were hand-weeded as necessary to keep weed-free.

Plant heights were measured on July 1, July 11, July 21, August 1, and August 10. Percent lodging was visually estimated on September 21. Lodging is defined as the percent of stalks in the plot leaning 45° from vertical or greater. When each variety began to form heads, the flag leaf from 15 plants in each plot was removed and analyzed for N content. Harvest data were obtained by cutting and weighing all plant material in 5 ft of each of the two center rows of each plot. These data were used to calculate dry matter yield. Five stalks were randomly selected from this sample to determine moisture and sugar content. The seedheads and leaves were removed from these five stalks and weighed separately. These stalks were then squeezed with a small two-roll mill and the sugar content of the juice was determined on a Brix (°B) scale using a Reichert temperature compensated, hand-held refractometer (Model 10430). All three plant parts were dried in a forced-air oven at 150°F until dry and then weighed. The stalks and seedheads from these samples were ground separately and analyzed for N content. Sugar production was calculated using total stalk biomass (excluding leaves and heads) X °B/100 X 75% sugar extraction. Recoverable ethanol yields were calculated assuming one gallon of ethanol/14.7 of sugar. Theoretical ethanol yields were calculated assuming 100% sugar extraction and 12.5 lb sugar/gal ethanol.

Results: N application had no effect on plant height or lodging (Table 2). NK 405 was taller than Keller throughout the growing season but had less lodging. A significant N rate X variety interaction was observed with plant height on August 1, but this interaction was not evident on any other sampling date. No interaction between N rates and varieties was observed for lodging.

N application had no effect on stalk moisture content or on °B level (Table 3). Significant differences were observed in dry matter yield among the N rates (Table 3). The 100 lb N rate produced maximum dry matter yields. N rate did not affect either sugar or ethanol yields of either variety (Table 3). Keller was significantly higher than NK 405 in stalk moisture, °B, dry matter yield and sugar and ethanol yields (Table 3). There were no significant N rate X variety interactions for stalk moisture, °B, dry matter yield or sugar and ethanol yield.

The percentage of the total plant biomass composed of heads, leaves and stalks was not influenced by N fertilization (Table 4). NK 405 produced a greater amount of seed than Keller, which would account for the increased percent head and reduced percent stalk and leaf for NK 405 compared to Keller.

N concentration in the flag leaf increased as N rate was increased from 0 to 50 lb/A (Table 5). There were no differences in flag leaf N content for N rates above 50 lb/A. N concentration in the stalk increased in a linear fashion as N rate increased. No difference was observed in N concentration in the seed head among all rates of N.

A significant difference was observed between the two varieties for N concentration in each of the three plant parts (Table 5). Keller had a higher N concentration in the stalk and seed head, but a lower concentration in the flag leaf than NK 405 (Table 5). There was a significant interaction between the two varieties and N rate for N concentration in the stalk. Keller had higher N concentration in the stalk than NK 405 at low levels of N fertilization. However, the N concentration in the stalks of both varieties was the same at 150 lb N/A, while NK 405 had slightly higher stalk N levels than Keller at 200 lb N/A. This interaction was not significant for N concentration in the flag leaf or seed head.

The N response of NK 405 has been evaluated for two years although the rates of N were adjusted in 1988 because no N response was observed in 1987. Figures 1 to 4 show data for N rates on NK 405 averaged over 1987 and 1988 at Waseca. No significant differences were observed for any of the paramaters measured (°B, stalk moisture, dry matter yield or ethanol yield). The r^2 values for these parameters ranged from 0.0022 to 0.0118, indicating no relationship between N fertilization and these parameters for NK 405.

Summary: It appears that sweet sorghum makes efficient use of nitrogen. The initial soil nitrate N levels were low to medium in the early spring before N application. Given these conditions we anticipated a greater N response than we observed. Although dry matter yield was maximized at 100 lb N/A, the amount of sugar, and consequently ethanol production was not influenced by N rate. The warm environmental conditions experienced in May were likely responsible for conditions conducive to mineralization of N from the soil organic fraction. This coupled with the fact that nitrogen losses from leaching and denitrification were minimal both years due to limited rainfall account for the lack of N response.

In 1987, we obtained little or no response to nitrogen with sweet or semi-sweet sorghum varieties. Based on these 2 years of results, it would appear that N rates for sweet sorghum production for biomass can be much less than needed to produce 150 bu/A of corn. N rate of 50 lb/A would seem adequate for sweet sorghum following corn whereas corn would require about 175 lb N/A to obtain optimum yield. Although we did not investigate the N needs for sweet sorghum following soybeans, it would appear that little or no N would be necessary on high organic matter ($\geq$5%) soils where soybeans are the preceeding crop. We base this on research done on N rates for corn following soybeans on high organic matter soils that indicate the optimum N rate for corn following soybeans is about 120 lb N/A.

Table 2. Plant height and lodging of sweet sorghum as influenced by nitrogen rate for two varieties in 1988.

N RATE	VARIETY	PLANT HEIGHT 7/1	7/11	7/21	8/1	8/10	LODGING 9/21
lb/A		inches					%
0	KELLER	25	38	58	69	85	83
25	KELLER	25	40	57	72	86	73
50	KELLER	27	41	60	75	87	58
75	KELLER	25	38	58	66	84	70
100	KELLER	24	37	57	68	84	78
150	KELLER	25	39	57	64	85	65
200	KELLER	25	38	56	66	81	58
0	NK 405	35	54	72	83	96	18
25	NK 405	34	54	70	78	93	15
50	NK 405	35	55	71	74	93	18
75	NK 405	34	53	71	80	92	25
100	NK 405	35	56	72	83	98	23
150	NK 405	35	56	74	83	93	20
200	NK 405	35	54	70	77	92	30

Nitrogen rate means

	PLANT HEIGHT 7/1	7/11	7/21	8/1	8/10	LODGING 9/21
	inches					%
N rate (lb/A)						
0	30	46	65	76	91	50
25	29	47	63	75	89	44
50	31	48	65	74	90	38
75	29	45	64	73	88	48
100	29	46	64	75	91	50
150	30	47	65	73	89	43
200	30	46	63	71	87	44
LSD (.05)	ns	ns	ns	ns	ns	ns

Variety means

	7/1	7/11	7/21	8/1	8/10	9/21
Variety						
KELLER	25	38	57	68	84	69
NK 405	34	54	71	79	94	21
% sign. level	>99	>99	>99	>99	>99	>99
Nitrogen rate x variety (% sign. level):	55	66	59	>99	47	31

Table 3. Stalk moisture, Brix level, total plant dry matter yield, sugar yield, and ethanol yield of sweet sorghum as influenced by nitrogen rate for two varieties in 1988.

N RATE	VARIETY	STALK MOISTURE	BRIX	DRY MATTER YIELD	SUGAR YIELD [1]	ETHANOL [2] THEOR	ETHANOL [2] RECOV
lb/A		---- % -----		-- 1000 lb/A --		-- gal/A --	
0	KELLER	72	13.5	15.9	3.83	409	261
25	KELLER	72	13.3	19.1	4.47	477	304
50	KELLER	72	13.5	16.6	4.16	444	283
75	KELLER	72	13.5	17.5	4.24	452	288
100	KELLER	72	12.4	19.6	3.98	425	271
150	KELLER	72	14.2	18.4	4.39	468	299
200	KELLER	72	13.1	19.1	4.13	441	281
0	NK 405	70	8.3	16.0	1.64	175	112
25	NK 405	70	8.3	15.7	1.57	167	107
50	NK 405	70	8.6	16.3	1.63	174	111
75	NK 405	70	7.8	16.3	1.49	159	101
100	NK 405	68	8.1	18.0	1.72	183	117
150	NK 405	69	8.4	16.7	1.75	187	119
200	NK 405	68	9.0	17.6	1.89	202	129

Nitrogen rate means

	STALK MOISTURE	BRIX	DRY MATTER YIELD	SUGAR YIELD	ETHANOL THEOR	ETHANOL RECOV
	---- % -----		-- 1000 lb/A --		-- gal/A --	
N rate (lb/A)						
0	71	10.9	15.9	2.74	292	186
25	71	10.8	17.4	3.02	322	205
50	71	11.0	16.5	2.90	309	197
75	71	10.7	16.9	2.87	306	195
100	70	10.2	18.8	2.85	304	194
150	70	11.3	17.5	3.07	327	209
200	70	11.0	18.3	3.01	321	205
LSD (.05)	ns	ns	1.5	ns	ns	ns

Variety means

Variety	STALK MOISTURE	BRIX	DRY MATTER YIELD	SUGAR YIELD	ETHANOL THEOR	ETHANOL RECOV
KELLER	72	13.3	18.0	4.17	445	284
NK 405	69	8.4	16.7	1.67	178	114
% sign. level	>99	>99	96	>99	>99	>99
Nitrogen rate x variety (% sign. level):	50	30	29	10	10	10

[1] Sugar yield calculated by the following formula: stalk yield/A (wet basis) x Brix/100 x 75% extraction.

[2] Theoretical ethanol yield calculated assuming 100% sugar extraction and 12.5 lb sugar/gal ethanol. Recoverable ethanol yield calculated using 14.7 lb sugar/gal ethanol @ 75% sugar extraction.

Table 4. Sweet sorghum stalk, leaves, and heads, expressed as percent of dry matter, as influenced by nitrogen rate over two varieties in 1988.

N RATE	VARIETY	STALK	LEAF	HEAD
lb/A			%	
0	KELLER	78	19	3
25	KELLER	76	21	4
50	KELLER	79	19	3
75	KELLER	77	20	3
100	KELLER	73	19	8
150	KELLER	75	21	4
200	KELLER	73	22	4
0	NK 405	64	16	20
25	NK 405	62	16	22
50	NK 405	62	16	22
75	NK 405	62	17	21
100	NK 405	63	16	21
150	NK 405	65	17	19
200	NK 405	65	17	18

Nitrogen rate means

	STALK	LEAF	HEAD
		%	
N rate (lb/A)			
0	71	17	12
25	69	18	13
50	70	17	12
75	69	18	12
100	68	18	14
150	70	19	11
200	69	20	11
LSD (.05)	ns	ns	ns

Variety means

	STALK	LEAF	HEAD
Variety			
KELLER	76	20	4
NK 405	63	16	20
% sign. level	>99	>99	>99
Nitrogen rate x variety (% sign. level):	>99	36	>99

Table 5. Nitrogen concentration of sweet sorghum plant components as influenced by nitrogen rate over two varieties in 1988.

N RATE	VARIETY	FLAG LEAF (AUGUST)	STALK -----(OCTOBER)-----	HEAD
lb/A		--------------	%	--------------
0	KELLER	2.32	0.36	1.46
25	KELLER	2.29	0.40	1.50
50	KELLER	2.36	0.40	1.45
75	KELLER	2.42	0.46	1.51
100	KELLER	2.37	0.48	1.46
150	KELLER	2.60	0.47	1.47
200	KELLER	2.46	0.49	1.44
0	NK 405	2.34	0.27	1.34
25	NK 405	2.65	0.32	1.35
50	NK 405	3.02	0.35	1.37
75	NK 405	2.81	0.36	1.42
100	NK 405	2.73	0.38	1.41
150	NK 405	2.80	0.47	1.37
200	NK 405	2.82	0.53	1.41

Nitrogen rate means

	FLAG LEAF (AUGUST)	STALK -----(OCTOBER)-----	HEAD
	--------------	%	--------------
N rate (lb/A)			
0	2.32	0.31	1.40
25	2.47	0.36	1.43
50	2.69	0.37	1.41
75	2.62	0.41	1.47
100	2.55	0.43	1.44
150	2.70	0.47	1.42
200	2.64	0.51	1.42
LSD (.05)	0.34	0.06	ns

Variety means

Variety			
KELLER	2.40	0.43	1.47
NK 405	2.74	0.38	1.38
% sign. level	>99	>99	>99
Nitrogen rate x variety (% sign. level):	81	>99	57

Figure 1. Effect of nitrogen fertilizer rate on Brix level of NK 405 sorghum at Waseca in 1987-88.

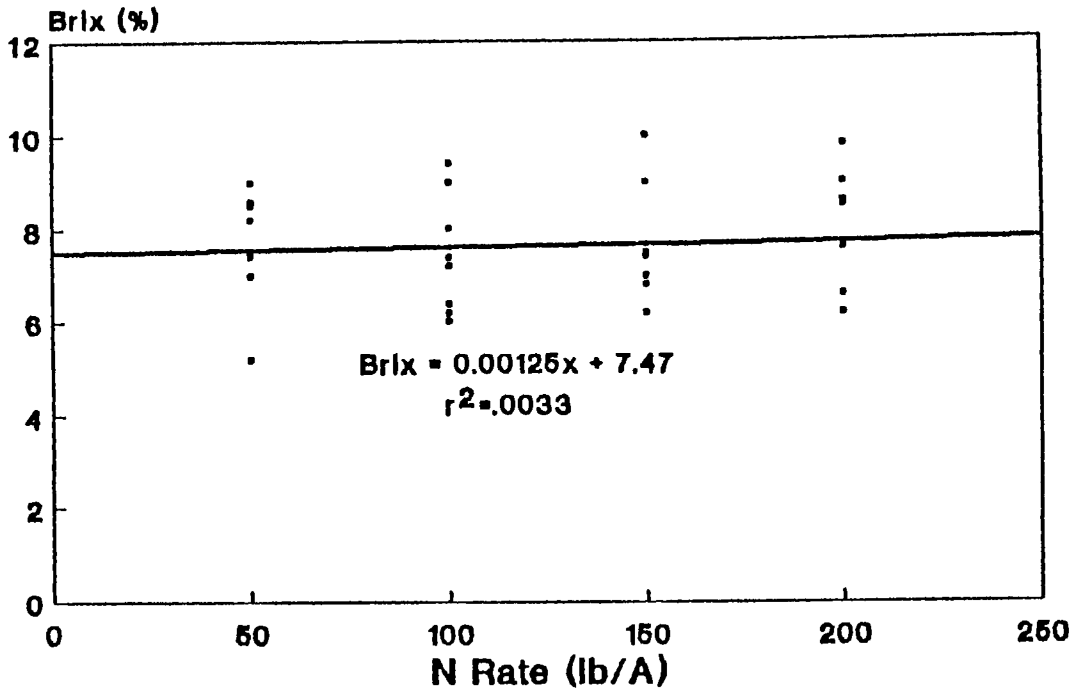


Figure 2. Effect of nitrogen fertilizer rate on stalk moisture of NK 405 sorghum at Waseca in 1987-88.

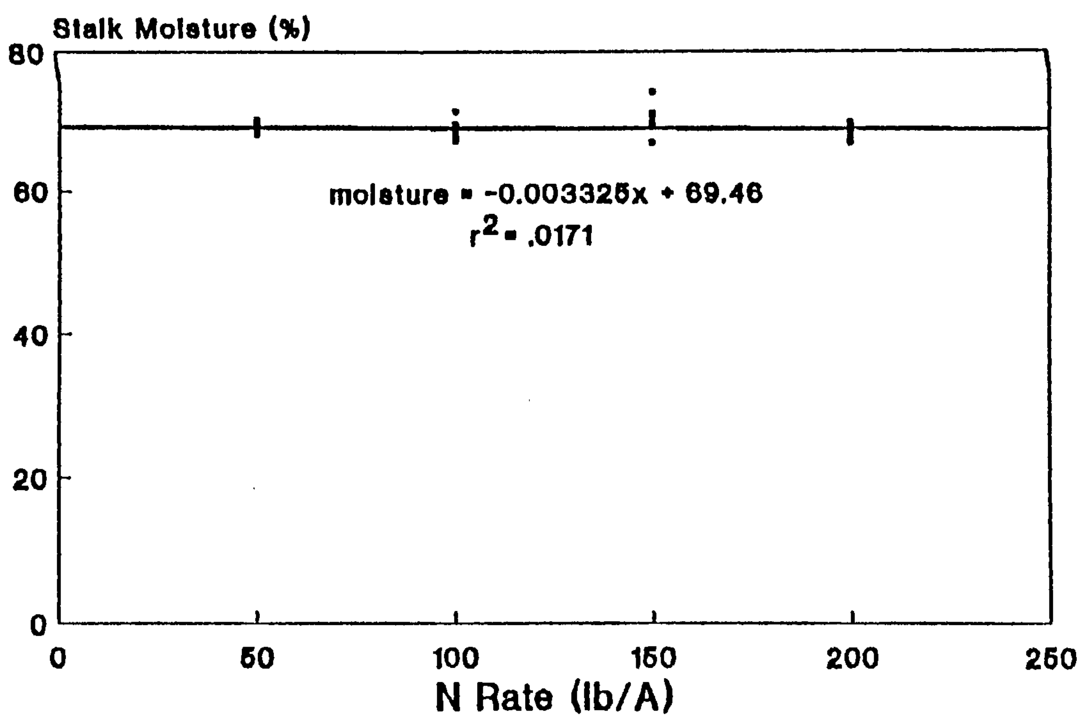


Figure 3. Effect of nitrogen fertilizer rate on total plant dry matter yield of NK 405 sorghum at Waseca in 1987-88.

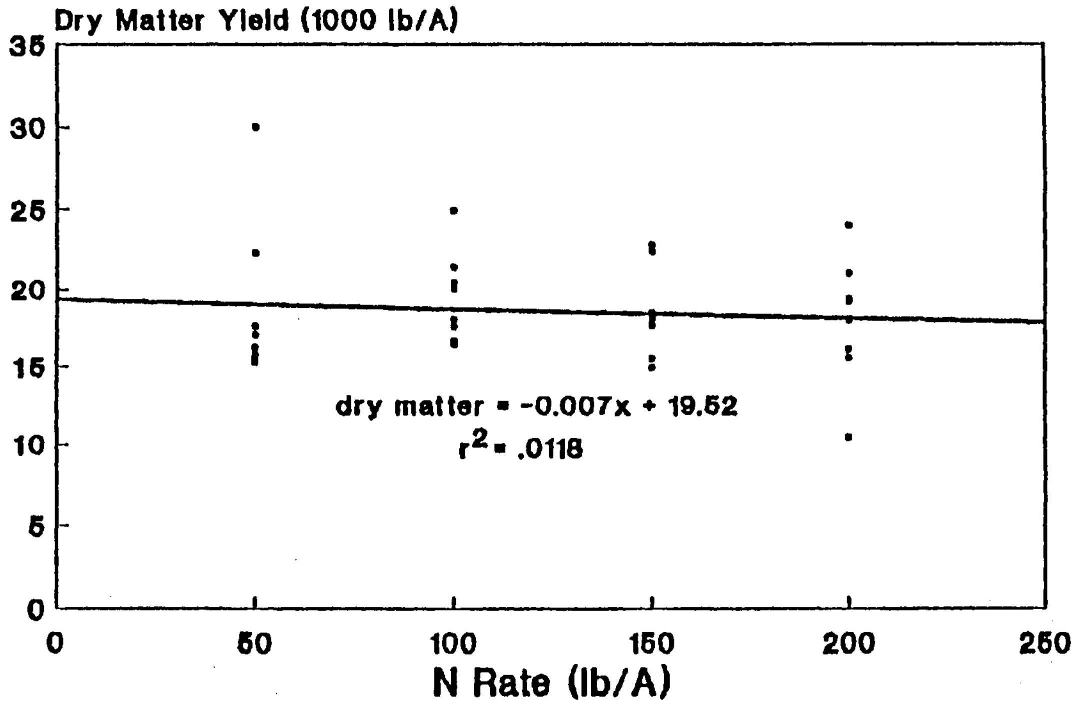
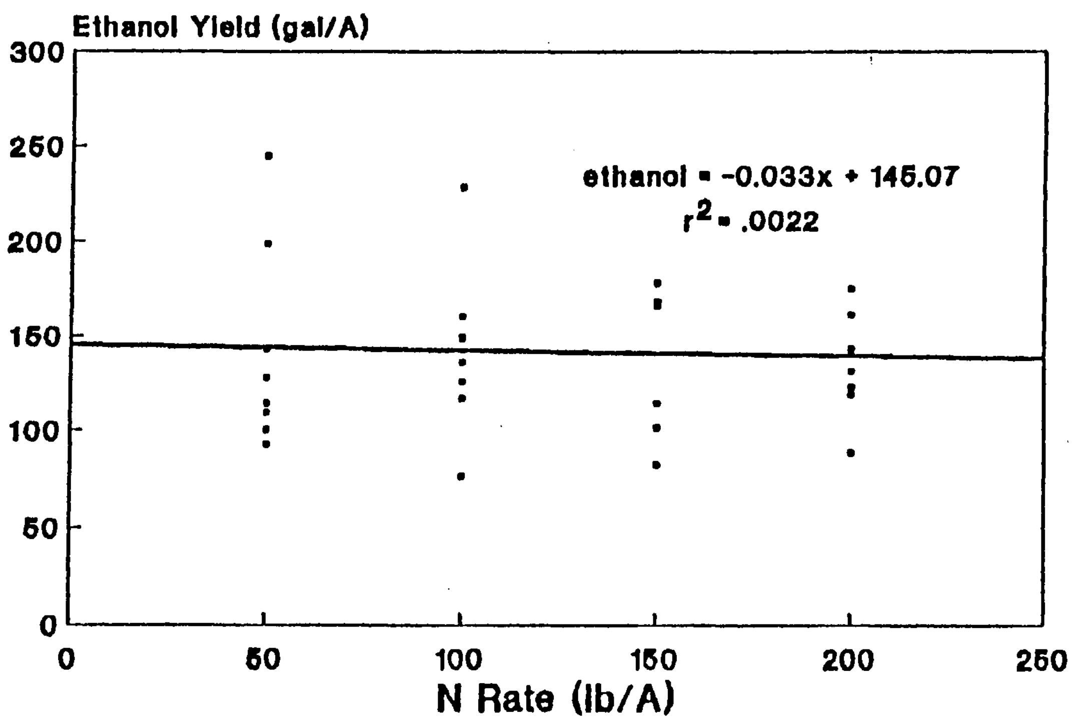


Figure 4. Effect of nitrogen fertilizer rate on ethanol yield of NK 405 sorghum at Waseca in 1987-88.



Effect of Plant Population on Performance of Two Sweet Sorghum Varieties in 1988[1/]

William Lueschen, Brian Kanne and Thomas Hoverstad

Objective: To evaluate the effects of plant population on total sugar yield of sweet sorghum for use in ethanol production.

Procedures: This study was conducted near Waseca, Mn on a Webster clay loam soil with the following chemical properties: pH=6.2, P=59 lb/A, K=273 lb/A. Soybeans were the previous crop and the site was chisel plowed following harvest. Nitrogen was applied in October 1987 as anhydrous ammonia at a rate of 160 lb N/A. Spring tillage consisted of two field cultivations prior to planting.

This study was designed as a randomized complete block experiment with four replications and a plot size of 10 by 26 ft. Two varieties were used: 'Keller', a sweet sorghum developed by Mississippi State University, and 'NK 405', which is a semi-sweet forage sorghum developed by Northrup King. Seed for each plot was counted and packaged prior to planting with seeding rates adjusted to a germination test to obtain planting rates of 20, 40, 60, and 80-thousand viable seeds/A for each variety. All plots were planted one inch deep in 30-inch rows on May 2, 1988 with a John Deere 7100 planter equipped with cone planting attachments. To control weeds, 5 lb/A of propachlor (Ramrod) plus 2 lb/A of atrazine was applied preemergence on May 6. All plots were hand-weeded as necessary to keep weed-free.

Actual population counts were obtained by counting the number of plants in 10 ft of row in June. Plant heights were measured every 10 days beginning on July 1 and ending on August 10. Percent lodging was visually estimated on September 21. Lodging is defined as the percent of stalks in the plot leaning 45° from vertical or greater.

Harvest data was obtained by cutting and weighing all plant material in 5 ft of each of the two center rows of each plot on October 11. This data was used to calculate dry matter yield. Five stalks were randomly selected from this sample to determine moisture and sugar content. The seed heads and leaves were removed from these five stalks before each component was weighed separately. The stalks were then squeezed with a small two-roll mill and the sugar content of the juice was determined on a Brix (°B) scale using a Reichert temperature compensated, hand-held refractometer, (Model 10430). All three plant parts were dried in a forced-air oven at 150° F until dry and then weighed. Sugar production was calculated using total stalk biomass (excluding leaves and heads) X °B/100 X 75% sugar extraction. Recoverable ethanol yields were calculated assuming 14.7 lb of sugar/gallon of ethanol. Theoretical ethanol yields were calculated assuming 100% sugar extraction and 12.5 lb sugar/gal ethanol.

[1/] This project was partially supported by a legislative grant obtained through the Mankato Technical Institute for evaluating sweet sorghum as a feed stock for ethanol production.

Results: Actual populations were much lower than the target populations (Table 1). Keller had much lower field emergence rates than NK 405. Population for Keller ranged from 9,400 to 27,400 plants/A while the population of NK 405 ranged from 13,700 to 42,900 plants/A. The reduced stands may have partially resulted from soil crusting, however, crusting was not severe. Adequate rainfall was obtained after planting to allow for good germination.

Plant height on July 1 and July 11 increased as population increased. However, this difference disappeared by July 21. Plant population had no effect on lodging. There was a significant difference between varieties for plant height and lodging on all sampling dates. NK 405 was taller and had much less lodging than Keller. No significant interactions between population and variety were noted except for the July 1 plant height, but this disappeared by July 11.

Population had no effect on °B, dry matter yield, sugar yield or ethanol yield (Table 2). A small increase in stalk moisture was noted at the lowest population. A significant difference between varieties was observed for each parameter except dry matter yield. Keller produced significantly more sugar than NK 405 at all population densities. No population X variety interactions occurred.

Figures 1 to 4 show data for plant population of NK 405 for two years at Waseca. Plant population had no significant effect on any of the parameters measured (°B, stalk moisture, dry matter yield and ethanol yield).

Summary: Since sweet sorghum tillers profusely, plant population did not influence dry matter production or sugar yield, inspite of the fact that populations were lower than we would have predicted for optimum production. These results would indicate that the sorghum plant can adapt to a wide range of populations without influencing biomass yield or potential ethanol production. It was somewhat surprising that the very low plant populations of 9,000 plants/A did not result in lower yield than the higher populations. Even our highest populations were not as high as we felt should be optimum, 60,000 plants/A. However, since we observed no response to plant population, the ability of sorghum to tiller profusely appears to compensate for low population densities.

Table 1. Plant height and lodging of sweet sorghum as influenced by plant population for two varieties at Waseca in 1988.

ACTUAL POPULATION	VARIETY	PLANT HEIGHT 7/1	7/11	7/21	8/1	8/10	LODGING 9/21
1000 plants/A		inches					%
9.4	KELLER	20	31	52	64	90	88
13.9	KELLER	22	33	53	71	92	88
21.8	KELLER	23	35	56	72	94	85
27.4	KELLER	24	37	57	72	92	95
13.7	NK 405	28	47	70	87	98	38
21.3	NK 405	33	55	78	92	106	35
33.8	NK 405	32	52	76	91	103	28
42.9	NK 405	35	56	77	88	101	35

Population means

	PLANT HEIGHT 7/1	7/11	7/21	8/1	8/10	LODGING 9/21
	inches					%
Actual population (1000 plants/A)						
11.5	24	39	61	76	94	63
17.6	27	44	66	82	99	61
27.8	27	44	66	82	98	56
35.2	29	46	67	80	96	65
LSD (.05)	2	5	ns	ns	ns	ns

Variety means

Variety	7/1	7/11	7/21	8/1	8/10	9/21
KELLER	22	34	54	70	92	89
NK 405	32	52	75	89	102	34
% sign. level	>99	>99	>99	>99	>99	>99
Plant population x variety (% sign. level):	97	51	65	43	19	32

Table 2. Stalk moisture, Brix level, total plant dry matter yield, sugar yield, and ethanol yield of sweet sorghum as influenced by plant population over two varieties at Waseca in 1988.

ACTUAL POPULATION	VARIETY	STALK MOISTURE	BRIX	DRY MATTER YIELD	SUGAR YIELD [1]	ETHANOL [2] THEOR	RECOV
1000 plants/A		----- % -----		-- 1000 lb/A --		-- gal/A --	
9.4	KELLER	76	12.9	18.2	5.27	562	359
13.9	KELLER	73	13.6	17.7	5.16	550	351
21.8	KELLER	73	13.6	19.9	5.65	603	384
27.4	KELLER	74	13.0	19.0	5.26	561	358
13.7	NK 405	73	8.1	18.1	2.26	241	154
21.3	NK 405	70	8.0	18.2	2.12	226	144
33.8	NK 405	71	8.3	18.5	2.37	253	161
42.9	NK 405	70	7.4	19.9	2.06	220	140

Population means

	STALK MOISTURE	BRIX	DRY MATTER YIELD	SUGAR YIELD	ETHANOL THEOR	RECOV
Actual population (1000 plants/A)	----- % -----		-- 1000 lb/A --		-- gal/A --	
11.5	74	10.5	18.2	3.77	402	256
17.6	72	10.8	17.9	3.64	388	248
27.8	72	10.9	19.2	4.01	428	273
35.2	72	10.2	19.4	3.66	390	249
LSD (.05)	2	ns	ns	ns	ns	ns

Variety means

Variety	STALK MOISTURE	BRIX	DRY MATTER YIELD	SUGAR YIELD	ETHANOL THEOR	RECOV
KELLER	74.2	13.3	18.7	5.34	570	363
NK 405	71.0	7.9	18.7	2.20	235	150
% sign. level	>99	>99	2	>99	>99	>99
Plant population x variety (% sign. level):	51	16	10	<1	<1	<1

[1] Sugar yield calculated by the following formula: stalk yield/A (wet basis) x Brix/100 x 75% extraction.

[2] Theoretical ethanol yield calculated assuming 100% sugar extraction and 12.5 lb sugar/gal ethanol. Recoverable ethanol yield calculated using 14.7 lb sugar/gal ethanol @ 75% sugar extraction.

Figure 1. Effect of plant population on Brix level of NK 405 sorghum at Waseca in 1987-88.

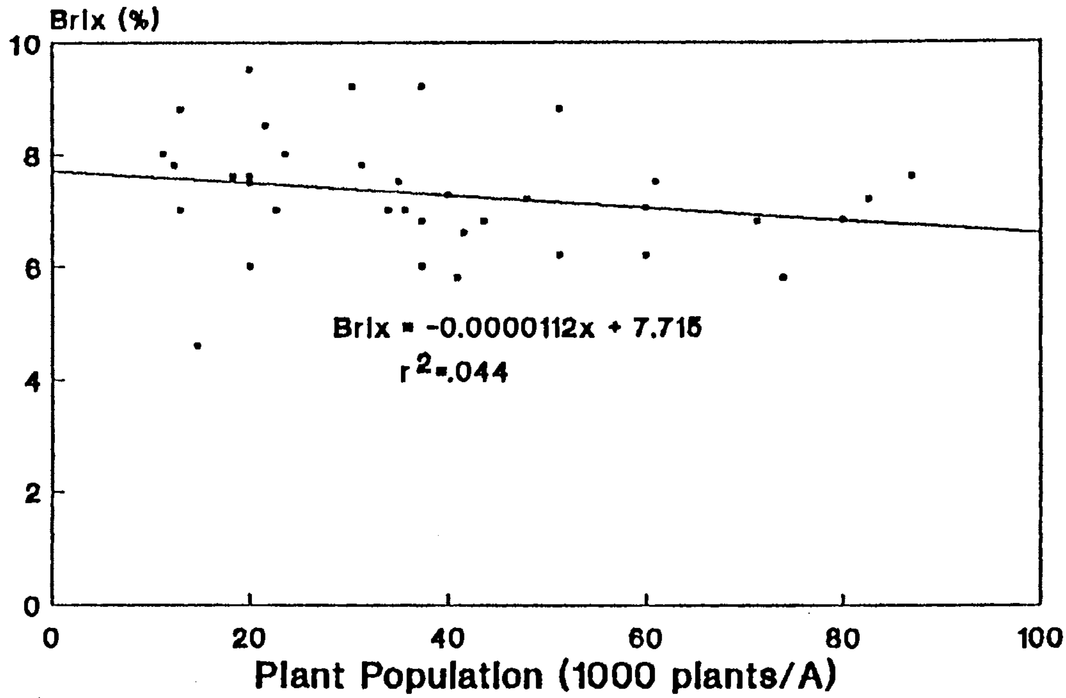


Figure 2. Effect of plant population on stalk moisture of NK 405 sorghum at Waseca in 1987-88.

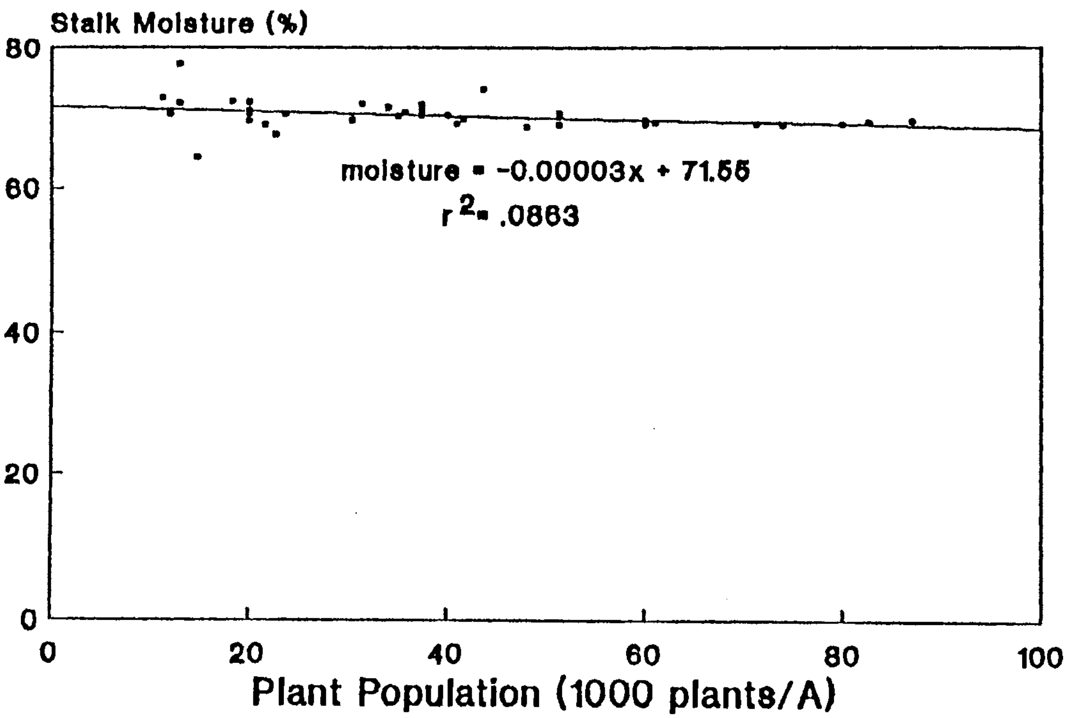


Figure 3. Effect of plant population on total plant dry matter yield of NK 405 sorghum at Waseca in 1987-88.

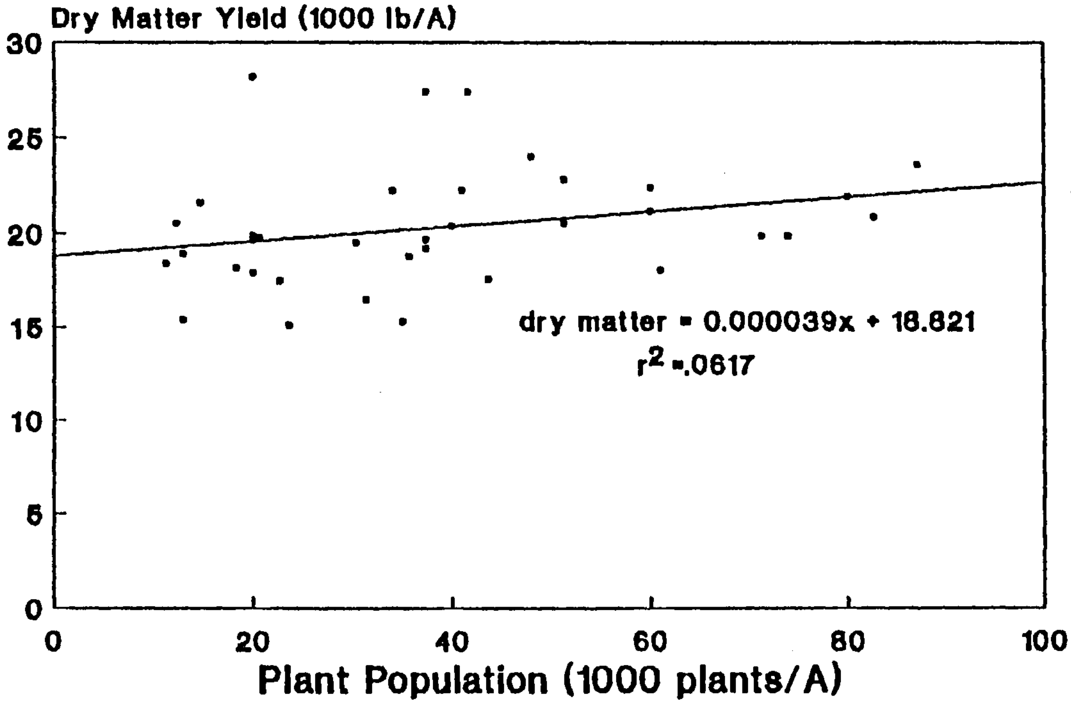
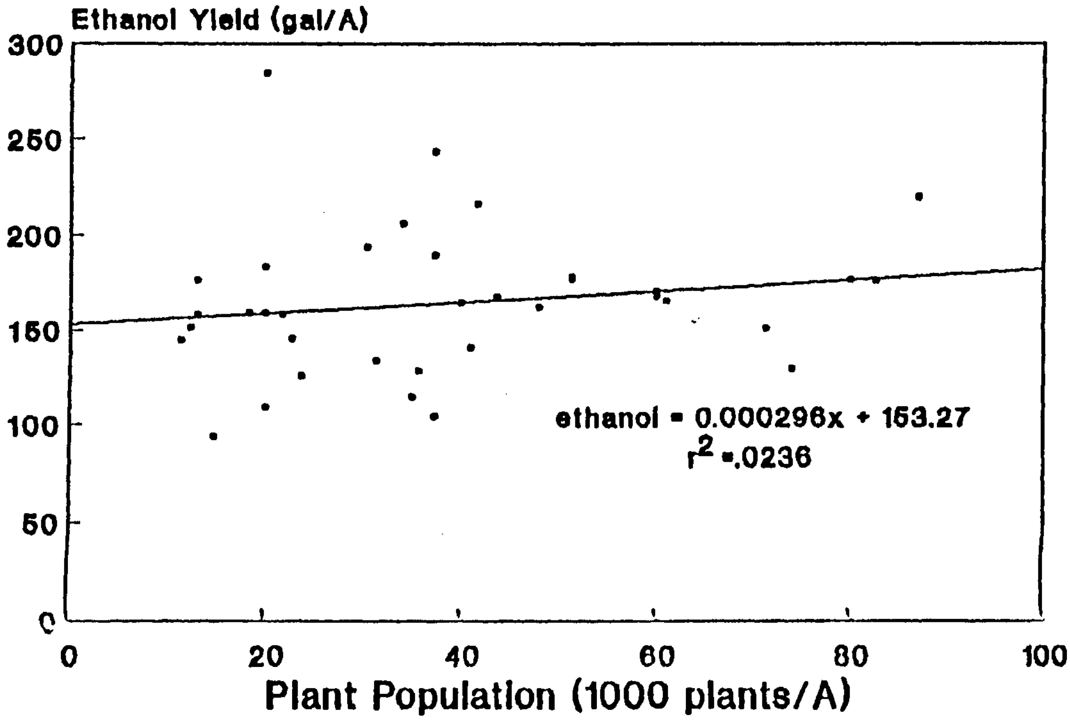


Figure 4. Effect of plant population on calculated ethanol yield of NK 405 sorghum at Waseca in 1987-88.



Effects of Planting Date on Performance of Four Sweet Sorghum Varieties [1/]

William Lueschen, Brian Kanne and Thomas Hoverstad

Objective: To evaluate the influence of planting date on sugar content and biomass yield of four sweet sorghum varieties.

Procedures: This study was conducted near Waseca, MN on a Webster clay loam soil with the following chemical properties: pH=6.2, P=59 lb/A, K=273 lb/A. Soybeans were the previous crop and the site was chisel plowed following harvest. Nitrogen was applied in October 1987 as anhydrous ammonia at a rate of 160 lb N/A. Spring tillage consisted of two field cultivations prior to planting.

This study was designed as a randomized complete block experiment with four replications and a split plot arrangement of treatments. Planting dates were the main plots with varieties as the subplots. Main plots were 10 by 125 ft with corn border strips of an equal size between each main plot, and subplots were 10 by 26 ft. All border strips were planted to corn on May 27 to provide equal competition for all planting dates. Varieties used in this study are listed below:

Table 1. Sweet sorghum varieties tested at four planting dates at Waseca, MN.

Variety	Source	Description
NK 301	Northrup King	sweet sorghum
NK 405	Northrup King	semi-sweet sorghum
NK 8361A	Northrup King	semi-sweet sorghum
Keller	Mississippi State	sweet sorghum

Each variety was planted on four dates: April 29, May 6, May 16, and May 25. Seed for each plot was counted and packaged prior to planting with the seeding rate adjusted according to a germination test to obtain a seeding rate of 60,000 viable seeds/A for each variety. All plots were planted one inch deep in 30-inch rows with a John Deere 7100 planter equipped with cone planting attachments. To control weeds, 5 lb/A of propachlor (Ramrod) plus 2 lb/A of atrazine was applied preemergence immediately after each planting date. All plots were hand-weeded as necessary to keep weed-free.

Population counts were obtained by counting the number of plants in 10 ft of row in June. Plant heights were measured on July 1, July 11, July 21, August 1, and August 10. Percent lodging was visually estimated on September 21. Lodging is defined as the percent of stalks in the plot leaning 45° from vertical or greater. Heading date was determined as the date when 50% of the plants had heads fully extended from the boot.

[1/] This project was partially supported by a legislative grant obtained through the Mankato Technical Institute for evaluating sweet sorghum as a feed stock for ethanol production.

Stalk sugar content and moisture content were determined during the year by sampling on August 4, August 18, September 2, September 16, September 30, October 12, and October 27. Five stalks were cut from each plot, the leaves and seed heads were removed, and the stalks were squeezed with a small two-roll mill to collect a juice sample. Sugar content of this juice was measured on the Brix (°B) scale using a Reichert temperature compensated, hand-held refractometer (Model 10430). On October 12, dry matter yields were taken by cutting and weighing the plants in 5 ft of each of the two center rows. Five stalks were randomly selected from these yield samples, the heads and leaves were removed from the stalks, and all three components were weighed separately. The stalks were squeezed with the two-roll mill to obtain a sample of juice for determining °B. The plant parts were then placed in a forced air oven at 150° F until dry. Sugar yield was calculated using total stalk biomass (excluding leaves and heads) x °B/100 x 75% sugar extraction. Recoverable ethanol yield was calculated by assuming a conversion of 14.7 lb of sugar/gallon of ethanol. Theoretical ethanol yields were calculated assuming 100% sugar extraction and 12.5 lb sugar/gal ethanol.

A killing frost (24° F) occurred on October 5. From October 12 to October 31 there were nine days with minimum temperatures below 25° F. Minimum air temperatures generally remained below 32° F after this day except for October 8 to 10 and 13 to 17. Daily maximum air temperatures ranged between 35° and 70° F until the last sampling date of October 27.

Results: Plant population was well below the target of 60,000 plants/A (Table 2). A significant difference was observed in plant population between the April 29 and May 6 plantings as compared to the May 16 and May 25 plantings. Rainfall of 1.5 inches accumulated on May 7 and 8 so adequate moisture was available for germination of the first two planting dates. Slight crusting of the soil surface occurred after these rains which may have been partially responsible for the reduced population for the first two planting dates. Dry top soil conditions may have contributed to the low populations on the later planting dates.

Significant differences were observed for plant population among the four varieties. Plant populations averaged 36,000; 33,000; 30,400 and 26,500 plants/A for 'NK 8361A', 'NK 405', 'NK 301', and 'Keller', respectively.

Heading date was the same for the first three planting dates, but planting May 25 significantly delayed heading compared to the earlier planting dates (Table 2). Date of heading was earliest with NK 301 which began heading on July 28, nearly 30 days prior to any other variety. Heading of the other varieties occurred on August 25, September 5 and September 12 for NK 405, NK 8361A and Keller, respectively. There was no significant interaction between planting date and varieties for heading date. With the exception of Keller, delaying planting date generally delayed maturity. However, planting date had little effect on heading date of Keller.

Planting date and variety significantly affected plant height (Table 3). The May 16 planting date produced taller plants than the April 29 planting for the July 11 through August 10 period. The May 25 planting was shorter than all other planting dates until July 21. On August 1 no differences were observed between the May 16 and May 25 planting dates. Significant differences between varieties were also observed, with Keller consistantly shorter than all other varieties until August 10 when NK 301 was the shortest variety. NK 301 and NK 405 were the tallest varieties until August 10. Significant interactions between varieties and planting dates occurred on

July 1 and July 11. This significance disappeared by July 21. No plant height measurements were taken after August 10.

The April 29 planting date resulted in significantly less lodging on September 21 than the other planting dates (Table 3). There was a significant difference between each variety with NK 301 exhibiting little or no lodging while Keller was nearly 100% lodged. The other two varieties had 60 to 75% lodging.

Beginning on August 4 and continuing through October 27 the °B levels were monitored approximately every two weeks (Table 4). Planting date did not effect °B until October 12 when a trend started to develop for a higher °B with the earliest planting date (Table 4 and Figure 1.) However, the late season differences in °B were only significant when comparing the earliest to the latest planting date. Significant differences in °B were observed among the varieties for all sampling dates (Table 4 and Figure 2). The highest °B values for the first three sampling dates was observed with NK 301. °B for all varieties except NK 301 increased dramatically from the August 18 to September 2 sampling dates. °B of Keller increased rapidly from 5.7% on August 18 to 10.9% on September 2 and 15.2% on September 16. The °B levels of Keller exceeded those for NK 301 from September 16 through October 27. A significant interaction was observed between planting dates and varieties on all sampling dates except August 4 and September 30. This interaction was primarily the result of lower °B with delayed planting of NK 8361A and NK 405 while the °B of NK 301 and Keller were higher for the later planting dates at most sampling periods. The biggest factor influencing °B was the variety.

Planting date had little effect on stalk moisture content (Table 5). Significant differences were observed among varieties for stalk moisture with NK 301 and NK 405 having consistantly lower stalk moistures than Keller and NK 8361A.

Planting date had no effect on dry matter yield, sugar yield or ethanol yield (Table 6). Significant differences were observed among the four varieties for dry matter, sugar and ethanol yields. NK 301 had significantly lower dry matter yields than the other varieties. Keller had the highest sugar and ethanol yields followed in order of decreasing production by NK 8361A, NK 405 and NK 301.

Tables 7, 8, and 9 give data for two-year averages of this study. Planting date had little effect on °B levels (Table 7 and Figure 3) or on stalk moisture (Table 8). Keller and NK 301 had consistantly higher °B readings than the other varieties for all sampling dates (Figure 4). Keller and NK 8361A had consistantly higher moisture contents than the other varieties for each sampling date (Table 8). Planting date had no effect on dry matter yield over the two years (Table 9). Significantly higher sugar and ethanol yields were observed for the first planting date as compared to the third and fourth planting dates. Keller had significantly higher sugar and ethanol yields than the other three varieties.

Summary: After two years of this study, Keller has the best potential among the varieties tested in this study for ethanol production. Keller produced nearly 50% more sugar and ethanol than any other variety. However, this variety exhibited very poor lodging resistance and was nearly 100% lodged at harvest both years. There was a slight advantage for early planting with the late April planting yielding about 10 to 12% more sugar and ethanol than the mid-May and late-May plantings. However, it should be noted that the number of Growing Degree Days at Waseca for 1987 and 1988 were 262 and 546 above normal, respectively. The greatest portion of this increase occurred in May and June each year, which may account for the response to early planting. Cool, wet conditions in May in more normal years may reduce the response to early planting.

Lodging of sweet sorghum varieties would appear to be a major limiting factor. Severe lodging would make harvest very difficult and result in greater field losses of biomass. If the leaves are to be mechanically stripped from the stalks prior to harvest, lodging would appear to be a serious problem. It would appear to us that before large scale production of sweet sorghum for ethanol production can progress, varieties with high sugar content and low lodging potential need to be developed.

Table 2. Effect of planting date and variety on population and heading date of sweet sorghum at Waseca in 1988.

PLANTING DATE	VARIETY	ACTUAL POPULATION JUNE 10	HEADING[1] DATE
		1000 plants/A	July 1=1
APRIL 29	NK8361A	30.9	64
APRIL 29	NK405	29.2	54
APRIL 29	NK301	20.5	24
APRIL 29	KELLER	11.3	77
MAY 6	NK8361A	30.1	64
MAY 6	NK405	22.2	56
MAY 6	NK301	25.3	26
MAY 6	KELLER	25.7	73
MAY 16	NK8361A	44.0	68
MAY 16	NK405	37.9	54
MAY 16	NK301	38.3	26
MAY 16	KELLER	34.8	72
MAY 25	NK8361A	39.2	74
MAY 25	NK405	42.7	59
MAY 25	NK301	37.5	32
MAY 25	KELLER	34.0	73

Planting date means

	ACTUAL POPULATION JUNE 10	HEADING DATE
	1000 plants/A	July 1=1
Planting Date		
APRIL 29	23.0	55
MAY 6	25.8	55
MAY 16	38.8	55
MAY 25	38.3	59
LSD (.05)	7.2	1

Variety means

Variety		
NK 8361A	36.0	67
NK 405	33.0	56
NK 301	30.4	27
KELLER	26.5	74
LSD (.05)	5.5	1
Planting date x variety (% sign. level):	71	>99

[1] Date when 50% of the sorghum heads were fully extended.

Table 3. Effect of planting date and variety on plant height and lodging of sweet sorghum during 1988.

PLANTING DATE	VARIETY	PLANT HEIGHT 7/1	7/11	7/21	8/1	8/10	LODGING 9/21
		inches					%
APRIL 29	NK8361A	30	41	58	64	83	70
APRIL 29	NK405	29	44	61	72	85	45
APRIL 29	NK301	27	41	62	70	69	0
APRIL 29	KELLER	18	27	45	58	78	80
MAY 6	NK8361A	29	42	58	66	83	78
MAY 6	NK405	27	42	64	74	88	53
MAY 6	NK301	27	42	62	74	73	0
MAY 6	KELLER	20	31	47	60	78	100
MAY 16	NK8361A	28	45	59	69	87	75
MAY 16	NK405	30	46	61	72	87	80
MAY 16	NK301	28	47	65	74	74	0
MAY 16	KELLER	20	33	53	68	83	100
MAY 25	NK8361A	21	33	56	70	88	78
MAY 25	NK405	22	37	60	76	94	68
MAY 25	NK301	20	38	61	78	75	5
MAY 25	KELLER	14	28	46	63	79	100

Planting date means

	PLANT HEIGHT 7/1	7/11	7/21	8/1	8/10	LODGING 9/21
	inches					%
Planting Date						
APRIL 29	26	38	56	66	79	49
MAY 6	25	39	57	68	80	58
MAY 16	26	42	59	71	83	64
MAY 25	19	34	55	72	84	63
LSD (.05)	1	2	3	4	3	6

Variety means

	7/1	7/11	7/21	8/1	8/10	9/21
Variety						
NK 8361A	27	40	57	67	85	75
NK 405	27	42	61	73	88	61
NK 301	26	42	62	74	73	1
KELLER	18	29	48	62	79	95
LSD (.05)	1	2	2	4	3	7
Planting date x variety (% sign. level):	94	91	36	24	45	93

Table 4. Effect of planting date and variety on Brix level of sweet sorghum at seven sampling dates during 1988.

PLANTING DATE	VARIETY	8/4	8/18	9/2	9/16	9/30	10/12	10/27
		BRIX LEVELS						
		%						
APRIL 29	NK8361A	6.1	5.2	7.7	12.3	11.2	10.4	10.3
APRIL 29	NK405	6.8	5.8	9.5	12.2	11.0	10.6	10.8
APRIL 29	NK301	12.6	12.0	11.9	13.6	11.7	11.2	10.9
APRIL 29	KELLER	5.3	5.3	10.3	14.8	15.6	14.5	13.4
MAY 6	NK8361A	5.7	4.8	7.7	11.2	10.8	10.1	9.8
MAY 6	NK405	6.2	5.5	9.4	11.5	11.3	10.1	10.3
MAY 6	NK301	11.0	11.7	11.4	14.6	13.9	10.6	11.6
MAY 6	KELLER	5.7	5.1	10.6	14.6	15.4	13.5	12.7
MAY 16	NK8361A	5.7	4.2	6.9	10.1	9.9	9.6	9.7
MAY 16	NK405	6.8	5.8	8.8	12.0	9.7	9.4	9.5
MAY 16	NK301	12.4	9.9	12.6	13.7	12.6	10.7	10.3
MAY 16	KELLER	5.9	6.7	11.8	15.9	14.9	14.2	13.3
MAY 25	NK8361A	5.7	4.0	6.9	10.4	10.9	9.5	9.0
MAY 25	NK405	5.8	5.4	8.7	12.2	10.4	9.5	10.7
MAY 25	NK301	11.4	13.1	13.4	15.4	14.0	11.8	11.3
MAY 25	KELLER	5.8	5.6	11.0	15.4	14.8	13.1	11.7

Planting date means

	8/4	8/18	9/2	9/16	9/30	10/12	10/27
	BRIX LEVELS						
	%						
Planting Date							
APRIL 29	7.7	7.1	9.8	13.2	12.4	11.6	11.3
MAY 6	7.1	6.8	9.7	13.0	12.8	11.1	11.1
MAY 16	7.7	6.6	10.0	12.9	11.8	11.0	10.7
MAY 25	7.0	7.0	10.0	13.4	12.5	11.0	10.6
LSD (.05)	ns	ns	ns	ns	0.9	0.5	0.7

Variety means

	8/4	8/18	9/2	9/16	9/30	10/12	10/27
Variety							
NK 8361A	5.7	4.6	7.3	11.0	10.7	9.9	9.7
NK 405	6.4	5.6	9.1	12.0	10.6	9.9	10.3
NK 301	11.9	11.7	12.3	14.3	13.1	11.1	11.0
KELLER	5.6	5.7	10.9	15.2	15.2	13.8	12.7
LSD (.05)	0.6	0.4	0.6	0.6	0.9	0.4	0.4
Planting date x variety (% sign. level):	35	>99	98	>99	54	97	>99

Table 5. Effect of planting date and variety on stalk moisture of sweet sorghum at seven sampling dates during 1988.

PLANTING DATE	VARIETY	8/4	8/18	9/2	9/16	9/30	10/12	10/27
		STALK MOISTURE (%)						
APRIL 29	NK8361A	83	83	76	72	72	70	71
APRIL 29	NK405	83	81	75	71	69	69	69
APRIL 29	NK301	74	74	71	69	68	67	70
APRIL 29	KELLER	84	85	80	75	73	73	72
MAY 6	NK8361A	83	84	77	74	71	71	70
MAY 6	NK405	83	81	75	71	69	70	71
MAY 6	NK301	75	75	74	69	69	67	69
MAY 6	KELLER	82	85	80	76	74	73	73
MAY 16	NK8361A	84	83	77	73	73	70	69
MAY 16	NK405	82	80	74	69	68	68	67
MAY 16	NK301	74	74	72	69	68	68	68
MAY 16	KELLER	83	83	78	74	73	72	72
MAY 25	NK8361A	85	84	78	74	71	72	71
MAY 25	NK405	84	81	75	69	68	67	68
MAY 25	NK301	78	74	73	70	69	69	69
MAY 25	KELLER	83	84	79	74	74	74	72

Planting date means

	8/4	8/18	9/2	9/16	9/30	10/12	10/27
	STALK MOISTURE (%)						
Planting Date							
APRIL 29	81	81	76	72	71	70	70
MAY 6	81	81	76	73	71	70	71
MAY 16	81	80	75	71	70	70	69
MAY 25	83	81	76	72	70	70	70
LSD (.05)	1	1	ns	1	ns	1	ns

Variety means

	8/4	8/18	9/2	9/16	9/30	10/12	10/27
Variety							
NK 8361A	84	83	77	73	72	71	70
NK 405	83	81	75	70	69	68	69
NK 301	75	74	72	70	68	68	69
KELLER	83	84	79	75	73	73	72
LSD (.05)	1	1	1	1	1	1	1
Planting date x variety (% sign. level):	84	22	86	71	27	97	56

Table 6. Dry matter, sugar, and ethanol yields of sweet sorghum harvested on October 12, 1988.

PLANTING DATE	VARIETY	DRY MATTER YIELD	SUGAR[1] YIELD	ETHANOL[2] THEOR	RECOV
		-- 1000 lb/A --		-- gal/A --	
APRIL 29	NK8361A	18.0	3.22	343	219
APRIL 29	NK405	16.0	2.55	272	173
APRIL 29	NK301	16.3	1.87	199	127
APRIL 29	KELLER	17.5	5.40	576	367
MAY 6	NK8361A	15.8	2.99	319	203
MAY 6	NK405	17.0	2.84	303	193
MAY 6	NK301	14.5	1.69	180	115
MAY 6	KELLER	19.1	5.27	562	359
MAY 16	NK8361A	18.0	3.04	324	207
MAY 16	NK405	16.1	2.42	258	165
MAY 16	NK301	14.8	1.67	178	114
MAY 16	KELLER	17.5	5.10	544	347
MAY 25	NK8361A	19.3	3.43	366	233
MAY 25	NK405	17.7	2.87	306	195
MAY 25	NK301	14.0	2.25	240	153
MAY 25	KELLER	17.5	4.81	513	327

Planting date means

	DRY MATTER YIELD	SUGAR YIELD	ETHANOL THEOR	RECOV
	---- 1000 A ---		-- gal/A --	
Planting Date				
APRIL 29	16.9	3.26	348	222
MAY 6	16.6	3.20	341	218
MAY 16	16.6	3.06	326	208
MAY 25	17.1	3.34	356	227
LSD (.05)	ns	ns	ns	ns

Variety means

Variety				
NK 8361A	17.8	3.17	338	216
NK 405	16.7	2.67	285	182
NK 301	14.9	1.87	199	127
KELLER	17.9	5.15	549	350
LSD (.05)	1.6	0.33	35	22
Planting date x variety (% sign. level):	66	35	35	35

[1] Sugar yield calculated by the following formula:
stalk yield/A (wet basis) x Brix/100 x 75% extraction.

[2] Theoretical ethanol yield calculated assuming 100% sugar extraction and 12.5 lb sugar/gal ethanol. Recoverable ethanol yield calculated using 14.7 lb sugar/gal ethanol @ 75% sugar extraction

Table 7. Effect of planting date and variety on Brix level of sweet sorghum at six sampling dates. (average of 1987-88)

PLANTING DATE[1]	VARIETY	BRIX LEVELS 8/15	8/30	9/15	9/30	10/15	10/30
		%					
DATE I	NK8361A	4.1	5.7	9.6	8.0	9.4	8.4
DATE I	NK405	5.0	8.1	8.7	6.9	9.8	8.8
DATE I	NK301	11.8	12.3	13.9	13.0	12.4	10.3
DATE I	KELLER	6.1	10.2	13.6	14.9	13.8	12.9
DATE II	NK8361A	3.8	6.2	8.0	7.0	9.3	8.5
DATE II	NK405	4.7	7.2	9.5	6.8	9.5	8.5
DATE II	NK301	11.4	12.1	14.1	13.5	11.4	11.2
DATE II	KELLER	5.8	10.2	12.2	13.7	13.2	11.8
DATE III	NK8361A	3.6	5.5	8.0	7.6	9.1	7.6
DATE III	NK405	4.5	6.9	9.1	5.8	8.9	7.8
DATE III	NK301	9.7	12.0	13.0	11.6	10.6	9.4
DATE III	KELLER	6.4	9.8	14.0	13.9	13.1	12.8
DATE IV	NK8361A	3.1	5.7	8.5	8.3	8.6	7.5
DATE IV	NK405	4.4	6.7	8.2	7.0	8.7	8.3
DATE IV	NK301	10.5	11.2	12.7	13.0	11.3	9.6
DATE IV	KELLER	5.6	10.5	14.2	14.4	13.0	11.6

Planting date means

	BRIX LEVELS 8/15	8/30	9/15	9/30	10/15	10/30
	%					
Planting Date						
DATE I	6.8	9.1	11.4	10.7	11.3	10.0
DATE II	6.4	8.9	10.9	10.3	10.8	10.0
DATE III	6.0	8.5	11.0	9.7	10.4	9.4
DATE IV	5.9	8.5	10.9	10.7	10.4	9.3
LSD (.05)	0.5	ns	ns	ns	0.6	0.8

Variety means

	8/15	8/30	9/15	9/30	10/15	10/30
Variety						
NK 8361A	3.6	5.7	8.5	7.7	9.1	8.0
NK 405	4.7	7.2	8.9	6.6	9.2	8.3
NK 301	10.8	11.9	13.4	12.8	11.4	10.1
KELLER	6.0	10.2	13.5	14.2	13.2	12.3
LSD (.05)	0.4	0.5	0.6	0.9	0.5	0.6
Planting date x variety (% sign. level):	93	57	99	10	15	78

[1] Date I = April 24, 1987 & April 29, 1988
Date II = May 4, 1987 & May 6, 1988
Date III = May 15, 1987 & May 16, 1988
Date IV = May 26, 1987 & May 25, 1988

Table 8. Effect of planting date and variety on stalk moisture of sweet sorghum at five sampling dates. (average of 1987-88)

PLANTING DATE	VARIETY	STALK MOISTURE 8/15	8/30	9/15	9/30	10/15
		%				
DATE I	NK8361A	83	78	72	71	69
DATE I	NK405	80	74	70	69	68
DATE I	NK301	77	73	72	70	67
DATE I	KELLER	83	78	75	71	70
DATE II	NK8361A	84	76	74	70	71
DATE II	NK405	80	75	71	69	68
DATE II	NK301	76	74	72	70	69
DATE II	KELLER	85	79	77	72	72
DATE III	NK8361A	82	77	74	72	69
DATE III	NK405	81	74	70	68	68
DATE III	NK301	77	74	71	71	68
DATE III	KELLER	83	79	74	72	72
DATE IV	NK8361A	85	78	74	70	72
DATE IV	NK405	82	76	71	69	67
DATE IV	NK301	78	75	74	71	70
DATE IV	KELLER	84	78	74	72	72

Planting date means

	STALK MOISTURE 8/15	8/30	9/15	9/30	10/15
	%				
Planting Date					
DATE I	81	76	72	70	69
DATE II	81	76	74	70	69
DATE III	81	76	72	71	69
DATE IV	82	77	73	71	70
LSD (.05)	1	1	1	ns	1

Variety means

	8/15	8/30	9/15	9/30	10/15
Variety					
NK 8361A	83	77	74	71	70
NK 405	81	75	71	69	68
NK 301	77	74	72	70	69
KELLER	84	79	75	72	72
LSD (.05)	1	1	1	1	1
Planting date x variety (% sign. level):	30	97	96	67	>99

Table 9. Dry matter, sugar, and ethanol yields of sweet sorghum harvested in mid-October. (average of 1987-88)

PLANTING DATE	VARIETY	DRY MATTER YIELD	SUGAR[1] YIELD	ETHANOL[2] THEOR	RECOV
		-- 1000 lb/A --		-- gal/A ---	
DATE I	NK8361A	20.8	3.23	345	220
DATE I	NK405	18.2	2.74	292	186
DATE I	NK301	19.0	3.00	320	204
DATE I	KELLER	16.1	4.24	452	288
DATE II	NK8361A	16.3	2.74	292	186
DATE II	NK405	18.4	2.78	297	189
DATE II	NK301	16.5	2.42	258	165
DATE II	KELLER	17.6	4.37	466	297
DATE III	NK8361A	19.0	2.90	309	197
DATE III	NK405	16.5	2.32	247	158
DATE III	NK301	15.4	1.86	198	127
DATE III	KELLER	16.7	4.22	450	287
DATE IV	NK8361A	17.3	2.73	291	186
DATE IV	NK405	16.5	2.37	253	161
DATE IV	NK301	14.4	2.21	236	150
DATE IV	KELLER	17.1	4.24	452	288

Planting date means

	DRY MATTER YIELD	SUGAR YIELD	ETHANOL THEOR	RECOV
	-- 1000 lb/A --		-- gal/A ---	
Planting Date				
DATE I	18.5	3.30	352	224
DATE II	17.2	3.07	327	209
DATE III	16.9	2.82	301	192
DATE IV	16.3	2.89	308	197
LSD (.05)	ns	0.35	37	24

Variety means

	DRY MATTER YIELD	SUGAR YIELD	ETHANOL THEOR	RECOV
Variety				
NK 8361A	18.3	2.90	309	197
NK 405	17.4	2.55	272	173
NK 301	16.3	2.37	253	161
KELLER	16.9	4.27	455	290
LSD (.05)	1.8	0.30	32	20
Planting date x variety (% sign. level):	87	49	49	49

1/ Sugar yield calculated by the following formula: stalk yield/A (wet basis) x Brix/100 x 75% extraction.

2/ Theoretical ethanol yield calculated assuming 100% sugar extraction and 12.5 lb sugar/gal ethanol. Recoverable ethanol yield calculated using 14.7 lb sugar/gal ethanol @ 75% sugar extraction.

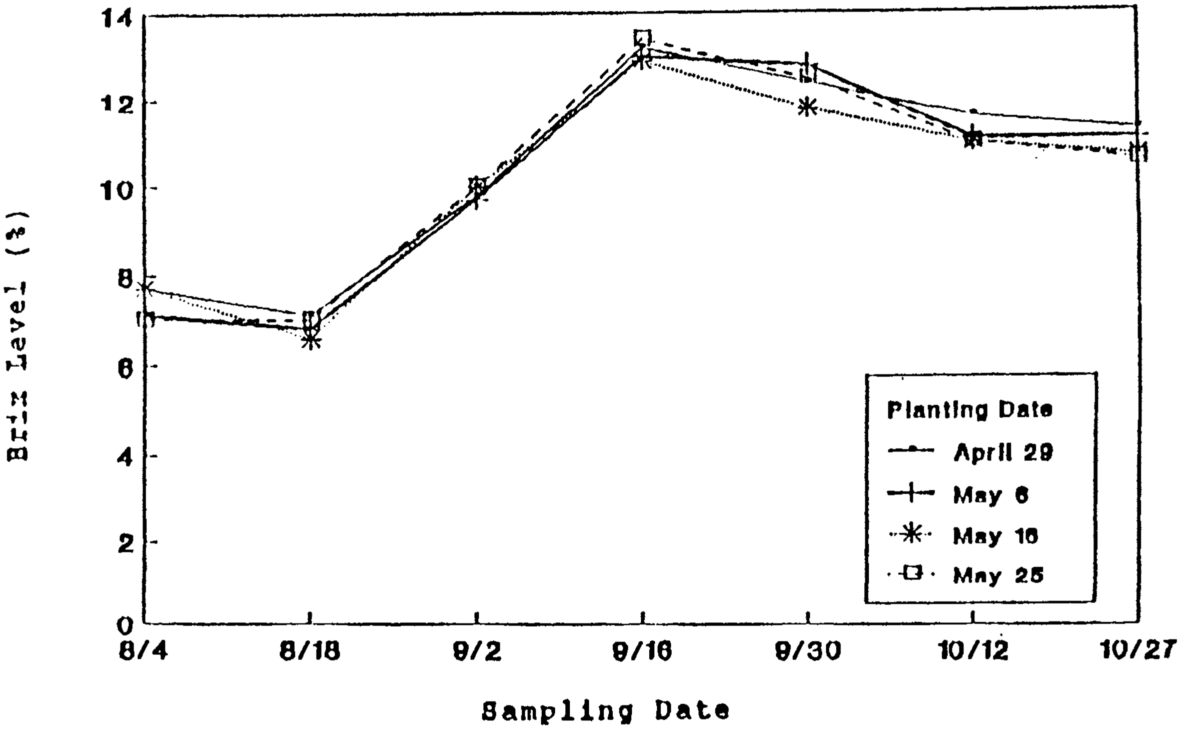


Fig. 1. Effect of planting date on Brix level of sweet sorghum in 1988 (average of four varieties).

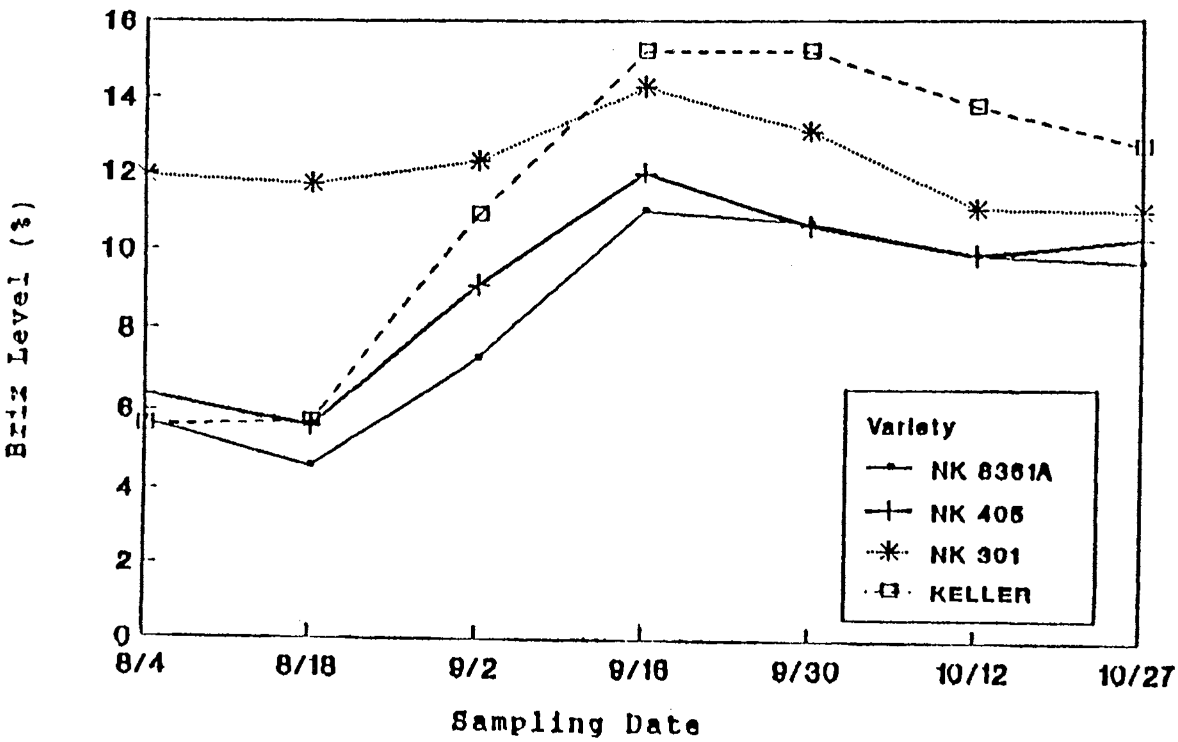


Fig. 2. Brix level of four sweet sorghum varieties averaged across planting date in 1988.

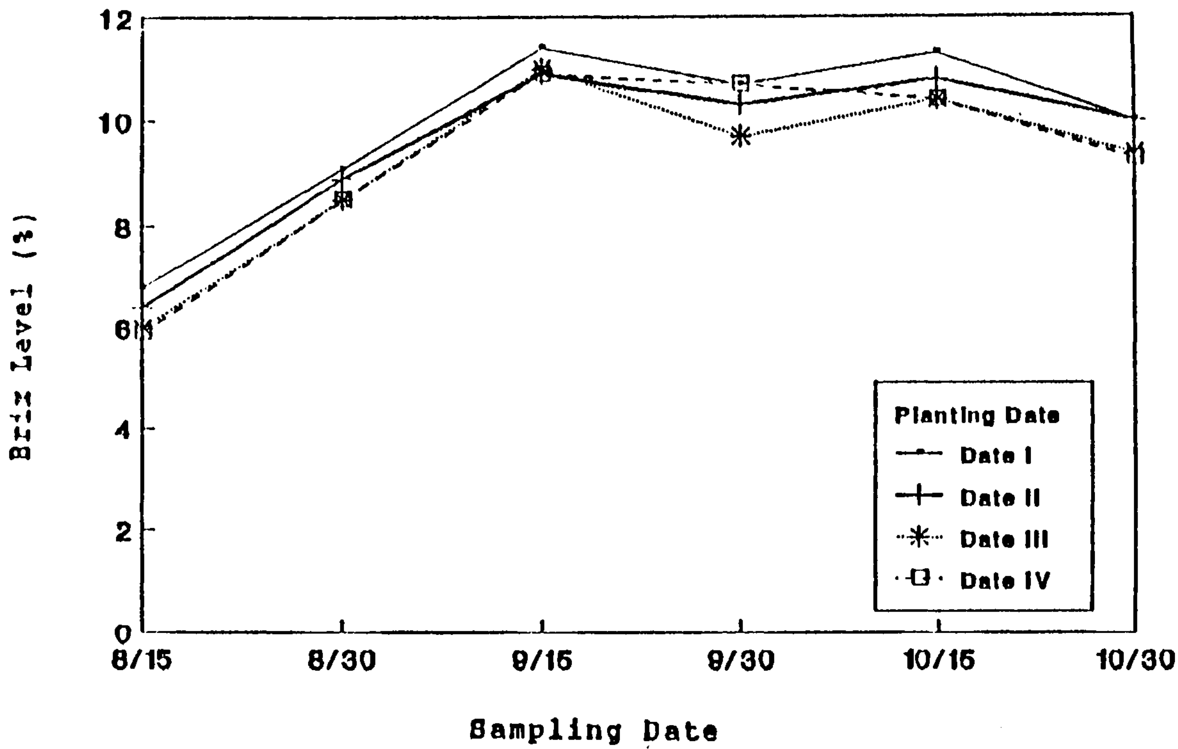


Fig. 3. Effect of planting date on Brix level of sweet sorghum for 1987-88 (average of four varieties).

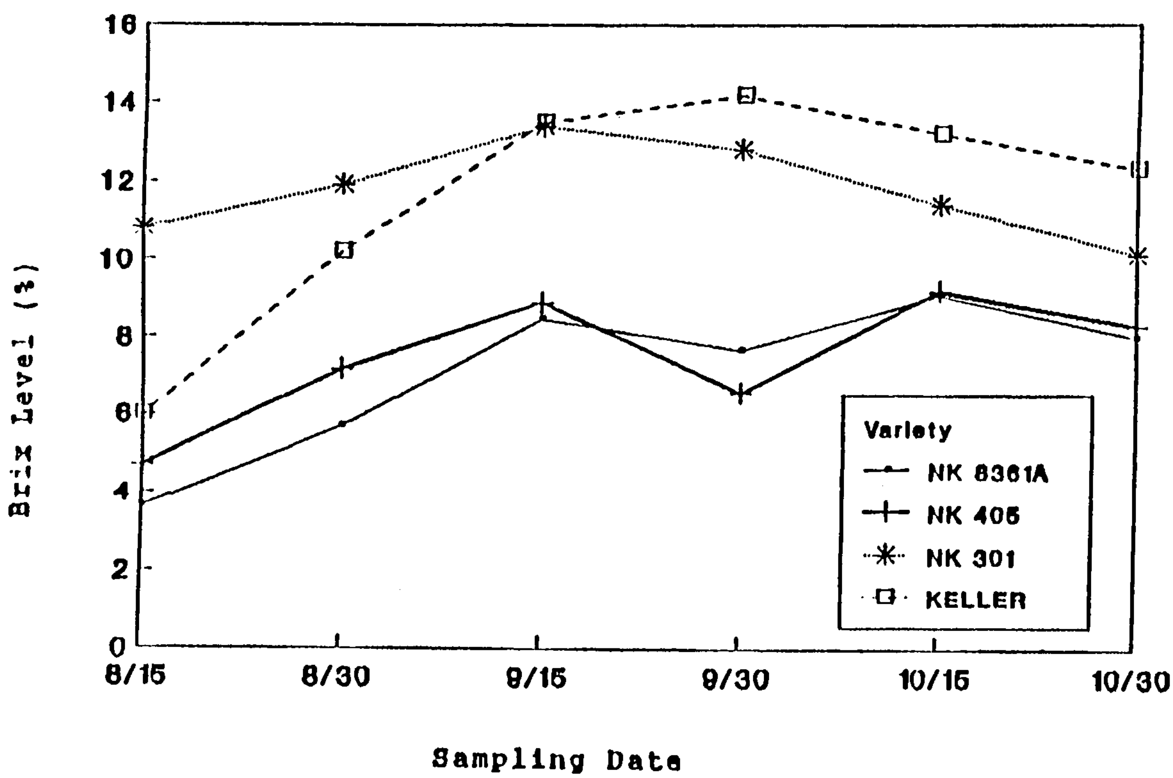


Fig. 4. Brix level of four sweet sorghum varieties averaged across planting date for 1987-88.

A Comparison of Sweet Sorghum Varieties and Corn For Biomass and Ethanol Production[1/]

William E. Lueschen, Brian Kanne, and Thomas Hoverstad

Objective: To evaluate sweet sorghum varieties for sugar yield for use in ethanol production and to compare sorghum with corn as a feed stock for ethanol production.

Procedure: This study was conducted near Waseca, MN on a Webster clay loam soil with the following chemical properties: pH=6.2, P=59 lb/A, K=273 lb/A. Soybeans were the previous crop and the site was chisel plowed following harvest. In October 1987, 160 lb N/A was applied as anhydrous ammonia. Spring tillage consisted of two field cultivations prior to planting. This study was designed as a randomized complete block experiment with four replications with a plot size of 10 by 25 ft. Varieties and the source of seed are listed in Table 1 below:

Table 1. Crop varieties included at Waseca in 1988.

Variety	Seed Source	Type	% Seed Germination[1/]
DK 524	DeKalb Pfizer Genetics	field corn 110 day Minn. maturity rating	95
NK 301	Northrup King	sweet sorghum	96
Mor-Cane	Cargill	sweet sorghum	88
FS5	DeKalb Pfizer Genetics	semi-sweet sorghum	90
Rox Orange	Kansas State University	sweet sorghum	87
940	NC+ Hybrids	semi-sweet sorghum	90
X1415	Paul Menge	sweet sorghum	91
NK 405	Northrup King	semi-sweet sorghum	96
NK 8361A	Northrup King	semi-sweet sorghum	93
X1477	Paul Menge	semi-sweet sorghum	90
Keller	Mississippi State Univ.	sweet sorghum	74
M81E	Mississippi State Univ.	sweet sorghum	96
Dale	Mississippi State Univ.	sweet sorghum	90
NK 8361	Northrup King	semi-sweet sorghum	86

1/ A standard laboratory germination test was run on each variety.

Seed for each plot was counted and packaged prior to planting with seeding rates adjusted for germination test to obtain a seeding rate of 60,000 viable seeds/A for sorghum and 30,000 viable seeds/A for corn. All plots were planted one inch deep in 30-inch rows on May 2, 1988 with a John Deere 7100 planter equipped with cone planting attachments. To control weeds, 5 lb/A of propachlor (Ramrod) plus 2 lb/A of atrazine was applied preemergence on May 6. All plots were hand-weeded as necessary to keep weed-free.

1/ This project was partially supported by a legislative grant obtained through the Mankato Technical Institute for evaluating sweet sorghum as a feed stock for ethanol production.

Percent emergence was calculated by counting the number of plants in 10 ft of row and dividing by the number of viable seeds planted. These counts were taken every four days from the beginning of emergence until no additional plants emerged. Plant heights were measured on July 1, July 11, July 21, August 1, and August 10. Percent lodging was visually estimated on September 21. Lodging is defined as the percent of stalks in the plot leaning 45° from vertical or greater. Heading dates were expressed as number of days after June 30 and determined as follows: for corn - date when 50% of plants had tassels shedding pollen; for sorghum - date when 50% of plants had heads fully extended from the boot.

Harvest data was obtained on October 6, 1988 by cutting and weighing the plants in 5 ft of each of the two center rows. Five stalks from each plot were randomly selected for determination of moisture and sugar content. The five selected stalks, with seed heads and leaves removed, were squeezed with a small two-roll mill to collect a juice sample. Sugar content of this juice was measured on the Brix (°B) scale using a Reichert temperature compensated, hand-held refractometer (Model 10430) with °B = % fermentable sugars. Sugar yield was calculated using stalk biomass (excluding leaves and heads) X °B/100 X 75% sugar extraction. Recoverable ethanol yield was calculated assuming a conversion of 14.7 lb of sugar/gallon of ethanol. Theoretical ethanol yields were calculated assuming 100% sugar extraction and 12.5 lb sugar/gal ethanol. Corn grain yield was determined by harvesting the grain from 15 ft of two center rows. Corn ethanol yield was calculated assuming 2.5 gallons of ethanol/bu corn grain.

Results: Emergence was poor for nearly all sorghum varieties (Table 2). This was partially due to crusting of the soil surface which occurred after rainfall on May 8. 'DK 524' corn had a much higher percentage of seeds that resulted in emerged plants than any sorghum variety, 90% verses 40 to 70%.

There was a wide range in flowering dates among the entries in this study (Table 3). 'NK 301' was the earliest variety with 50% of the heads fully extended from the boot on July 26. 'Mor-Cane', 'DK FS5' and 'Rox Orange' had 50% of the heads fully emerged by mid-August, 'NK 8361A' reached this stage by early September, and 'X1477', 'Keller', 'M81E' and 'Dale' reached this stage in mid-September. 'NK 8361' did not have heads fully extended from the boot until September 21. The earlier sorghum varieties generally had more resistance to lodging than the later varieties. The five latest varieties had 80 to 100% lodging (Table 3).

Stalk moistures of all sorghum varieties, except NK 301, ranged from 71% to 77% (Table 4). NK 301 had significantly less stalk moisture than any other variety. Differences were observed in °B levels among the varieties with the sweet sorghum types generally having higher °B levels than the semi-sweet types. All sorghum varieties, except NK 301, Mor-Cane, and 'X1415' had higher dry matter yields that DK 524 corn. Calculated sugar and ethanol yields were highest from Keller, M81E and Dale. DK 524 corn averaged 110 bu/A of grain, which would yield 276 gallons of ethanol/A compared to 389 gallons/A calculated from Keller.

Table 5 shows data averaged over two years from this study. Keller, Dale, and M81E had the highest calculated ethanol yields of the sorghum varieties with 372, 371, and 353 gallons of ethanol/A, respectively. DK 524 corn averaged 132 bu/A of grain over two years which would yield 332 gallons of ethanol/A. This is not significantly different from either Keller, Dale or M81E.

Summary: Based on this two-year study, it appears that sweet sorghum can compete favorably with corn for ethanol production. However, it should be noted that the number of Growing Degree Days at Waseca for 1987 and 1988 were 262 and 546 above normal, respectively. Precepitation for April through September of 1988 in the Waseca area was 6.21 inches below normal. This hot, dry weather would tend to favor sorghum over corn. It should also be noted that the varieties with the highest calculated ethanol yields also had the most lodging, which would make mechanical harvest extremely difficult and would lead to greater field losses. The development of high sugar, lodging resistant varieties would appear necessary to make sweet sorghum a viable alternative crop for a feed stock for ethanol production.

Table 2. Emergence of corn and sorghum varieties, expressed as percent of target population, at Waseca in 1988.

VARIETY	DAYS AFTER PLANTING 15	18	22	25	29
	---------- % ----------				
DK 524 corn	66	90	91	90	90
NK 301	13	32	35	37	38
MOR-CANE	29	45	54	58	62
DK FS5	13	21	32	35	35
ROX ORANGE	36	64	66	66	70
NC+ 940	26	43	48	52	51
X1415	26	40	43	43	46
NK 405	24	37	43	46	46
NK 8361A	34	43	48	49	49
X1477	25	36	40	44	46
KELLER	10	25	33	35	38
H81E	25	39	41	43	45
DALE	16	31	35	38	42
NK 8361	30	35	39	41	41
LSD (.05)	17	15	16	18	18

Table 3. Plant height, heading dates, and lodging of varieties tested at Waseca in 1988.

VARIETY	PLANT HEIGHT 8/10	HEADING DATE [1]	LODGING 9/21
	inches	July 1=1	%
DK 524 corn	85	15	0
NK 301	69	26	0
MOR-CANE	70	45	13
DK FS5	72	46	8
ROX ORANGE	73	46	5
NC+ 940	74	52	15
X1415	80	54	43
NK 405	89	54	63
NK 8361A	96	64	55
X1477	88	70	80
KELLER	82	74	93
H81E	82	75	98
DALE	71	77	95
NK 8361	91	83	95
LSD (.05)	9	3	15

[1] Date when 50% of the corn tassels were shedding pollen and date when 50% of the sorghum heads were fully extended.

Table 4. Stalk moisture, Brix level, total plant dry matter yield, sugar yield and ethanol yield of corn and sorghum varieties at Waseca on October 6, 1988.

VARIETY	STALK MOISTURE	BRIX	DRY MATTER YIELD	SUGAR[1] YIELD	ETHANOL[2] THEOR	RECOV
	----- % -----		-- 1000 lb/A --		-- gal/A --	
DK 524 corn	51	-	13.2	-	-	276
NK 301	68	13.1	14.8	2.09	223	142
MOR-CANE	77	8.9	17.1	2.26	241	154
DK FS5	74	10.0	18.3	2.43	259	165
ROX ORANGE	76	9.7	18.0	2.56	273	174
NC+ 940	71	13.2	18.3	3.57	381	243
X1415	76	10.4	15.9	2.72	290	185
NK 405	72	8.4	21.7	2.54	271	173
NK 8361A	71	10.8	21.7	3.98	425	271
X1477	73	9.8	19.6	3.73	398	254
KELLER	76	13.0	18.8	5.72	610	389
M81E	76	12.1	18.5	5.09	543	346
DALE	77	12.4	17.8	5.50	587	374
NK 8361	74	8.9	20.5	3.77	402	257
LSD (.05)	2	1.9	4.4	0.99	106	66

Table 5. Heading date, stalk moisture, Brix level, total plant dry matter yield, sugar yield and ethanol yield of corn and sorghum varieties at Waseca (average of 1987-88).

VARIETY	HEADING DATE	STALK MOISTURE	BRIX	DRY MATTER YIELD	SUGAR[1] YIELD	ETHANOL[2] THEOR	RECOV
	July 1=1	---- % -----		-- 1000 lb/A --		-- gal/A --	
DK 524 corn	17	-	-	16.3	-	-	332
NK 301	25	69	13.2	18.8	3.47	370	237
ROX ORANGE	41	77	10.3	21.2	3.37	359	229
X1415	46	75	11.6	17.8	3.89	415	265
NK 405	52	70	7.3	22.9	2.52	269	172
NK 8361A	62	71	8.9	23.5	3.65	389	248
X1477	63	72	8.5	22.6	3.57	381	243
KELLER	64	73	13.4	20.2	5.47	583	372
DALE	67	75	12.3	20.0	5.45	581	371
M81E	71	73	12.7	20.9	5.19	554	353
NK 8361	80	73	7.4	26.3	3.76	401	256
LSD (.05)	2	2	1.6	2.8	0.86	92	59

[1] Sugar yield calculated by the following formula: stalk yield/A (wet basis) x Brix/100 x 75% extraction.

[2] Theoretical ethanol yield calculated assuming 100% sugar extraction and 12.5 lb sugar/gal ethanol. Recoverable ethanol yield calculated using 14.7 lb sugar/gal ethanol @ 75% sugar extraction. Corn ethanol yield calculated using 2.5 gal ethanol/bu.corn grain.

Effect of Planting Depth on Emergence of Two Sweet Sorghum Varieties in 1988[1/]

William E. Lueschen, Brian Kanne and Thomas Hoverstad

Objective: To evaluate the influence of planting depth on rate of emergence and plant population of two sweet sorghum varieties.

Procedure: This study was conducted near Waseca, MN on a Webster clay loam soil with the following chemical properties: pH=6.2, P=59 lb/A, K=273 lb/A. Soybeans were the previous crop and the site was chisel plowed following harvest. In October 1987, nitrogen was applied as anhydrous ammonia at a rate of 160 lb N/A. Spring tillage consisted of two field cultivations prior to planting.

This study was designed as a randomized complete block experiment with four replications and a split plot arrangement of treatments. Planting depths were the main plots with varieties as the subplots. Main plots were 5 by 55 ft with subplots 5 by 26 ft.

Two varieties were used in this study: 'Keller', a sweet sorghum developed by Mississippi State University, and 'NK 405', which is a semi-sweet forage sorghum developed by Northrup King. Seed for each plot was counted and packaged prior to planting with seeding rates adjusted according to germination tests to obtain a seeding rate of 60,000 viable seeds/A for each variety. All plots were planted in 30-inch rows on May 2, 1988 with a John Deere 7100 planter equipped with cone planting attachments. Planting depth was adjusted on the planting units to obtain depths of 0.5, 1.0, 1.5 and 2.5 inches. To control weeds, 5 lb/A of propachlor (Ramrod) plus 2 lb/A of atrazine was applied preemergence on May 6.

Percent emergence was calculated by counting the number of plants in 10 ft of row and dividing by the number of viable seeds planted in this area. These counts were taken every four days from the beginning of emergence until no additional plants emerged. Plant height was measured on July 1.

Results: No significant difference was observed in emergence among planting depths 14 days after planting (Table 1). However, the 2.5 inch planting depth had significantly fewer plants emerged than the other depths for all other sampling dates (Figure 1). There were no significant interactions between the planting depths and the two varieties. Rainfall of 1.6 inches was received 6 to 8 days after planting which enhanced emergence, especially of the shallowest planting depth. NK 405 had a higher percentage of emergence than Keller on all dates (Figure 2).

Planting depth had no effect on plant height (Table 2). NK 405 was significantly taller than Keller on July 1. There was no variety X planting depth interaction.

1/ This project was partially supported by a legislative grant obtained through the Mankato Technical Institute for evaluating sweet sorghum as a feed stock for ethanol production.

Summary: Based on this one year study, it appears that sweet sorghum can be planted from 0.5 to 1.5 inches deep, depending on soil conditions. With the dry topsoil conditions experienced at planting, seeds planted 0.5 inch deep would not have had a good emergence rate without the rainfall received from May 8 to May 10. Planting less than 1 inch deep will increase the odds of the seed germinating zone drying out prior to emergence. Therefore, it is recommended that planting depth for sweet sorghum be 1 to 1.5 inches based on our results from this one-year study.

Table 1. Effect of planting depth on emergence of sweet sorghum at Waseca in 1988 (values expressed as percent of target population).

VARIETY	DEPTH	DAYS AFTER PLANTING 14	18	22	25	29
	inches	%				
NK405	0.5	26	67	72	72	73
NK405	1.0	57	69	79	73	78
NK405	1.5	49	61	62	65	62
NK405	2.5	33	48	53	52	54
KELLER	0.5	7	39	44	42	43
KELLER	1.0	5	31	44	41	48
KELLER	1.5	10	33	40	43	44
KELLER	2.5	0	8	19	22	24

Planting depth means

	DAYS AFTER PLANTING 14	18	22	25	29
	%				
Planting depth					
0.5	16	53	58	57	58
1.0	31	50	61	57	63
1.5	29	47	51	54	53
2.5	16	28	36	37	39
LSD (.05)	ns	18	21	21	21

Variety means

	14	18	22	25	29
Variety					
NK405	41	61	67	66	67
Keller	5	28	36	37	40
% sign. level	>99	>99	>99	>99	>99
Variety x planting depth (% sign. level)	88	36	33	9	18

Table 2. Plant population and plant height of two sweet sorghum varieties planted at four planting depths.

VARIETY	PLANTING DEPTH	POPULATION 5/31/88	PLANT HEIGHT 7/1/88
	inches	1000 plants/A	inches
NK405	0.5	45	33
NK405	1.0	47	33
NK405	1.5	38	32
NK405	2.5	33	32
KELLER	0.5	26	24
KELLER	1.0	30	23
KELLER	1.5	26	22
KELLER	2.5	14	22

Planting depth means

	POPULATION 5/31/88	PLANT HEIGHT 7/1/88
	1000 plants/A	inches
Planting depth		
0.5	35	28
1.0	38	28
1.5	31	27
2.5	24	27
LSD (.05)	12	ns

Variety means

	POPULATION 5/31/88	PLANT HEIGHT 7/1/88
Variety		
NK405	40	32
Keller	24	22
% sign. level	>99	>99

	POPULATION 5/31/88	PLANT HEIGHT 7/1/88
Variety x planting depth (% sign. level)	18	13

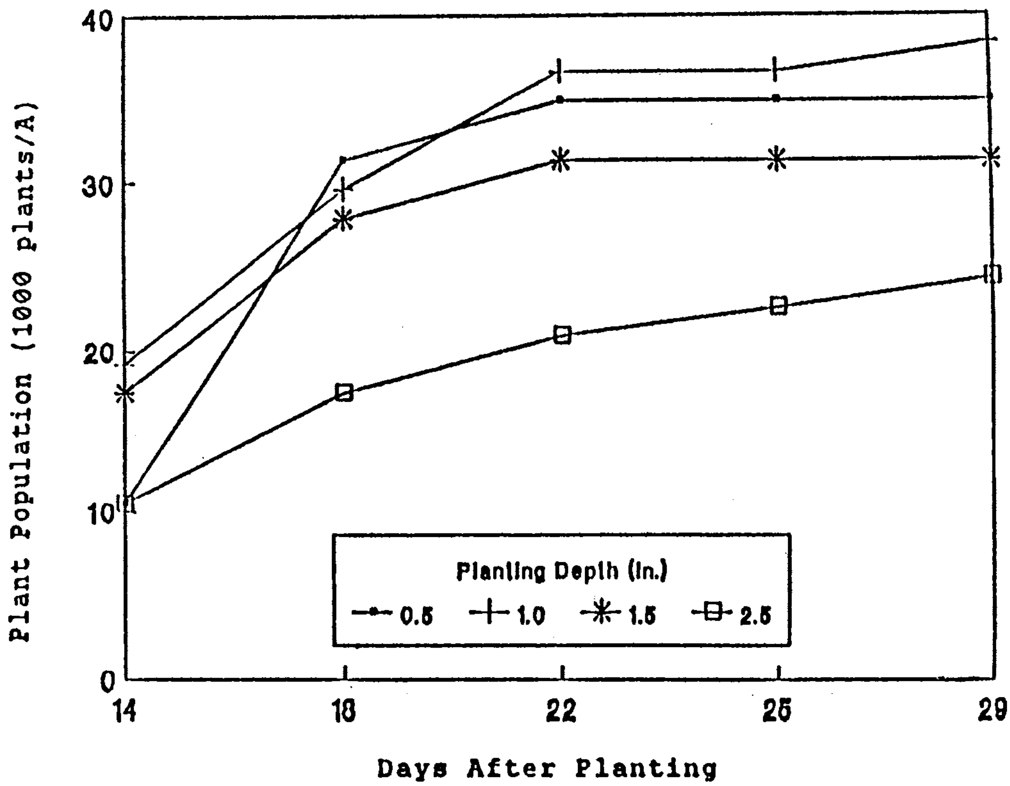


Fig. 1. Effect of planting depth on sweet sorghum emergence (average of two varieties).

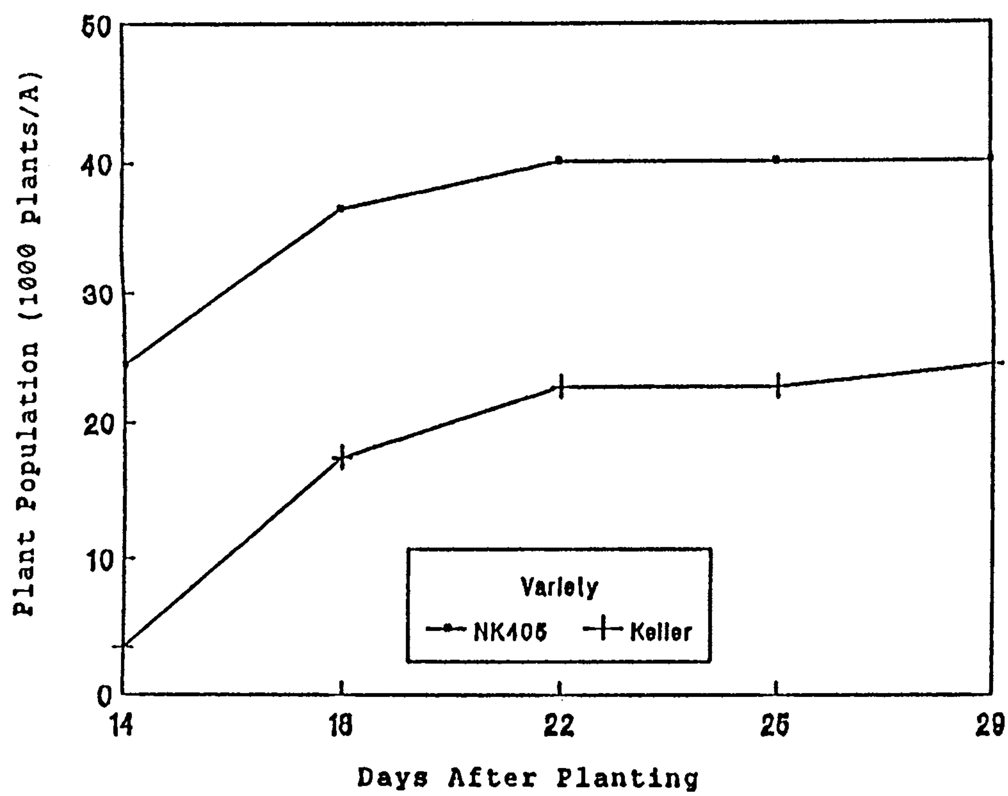


Fig. 2. Emergence of two sweet sorghum varieties averaged across planting depth.

Dairy-Beef

PERFORMANCE OF GROWING HOLSTEIN STEERS FED DIETS CONTAINING SWEET CORN PROCESSING WASTE ENSILED AT DIFFERENT MOISTURE LEVELS

Hugh Chester-Jones, David Ziegler, Jay Meiske, Don Otterby, Marshall Stern and Alfredo DiCostanzo

Summary

Sweet corn processing waste (SCPW) ensiled at 83, 78 or 71% moisture was used in a feeding trial with 36 Holstein steer calves (avg. initial wt. 432 lb). Steers were fed diets (dry basis) consisting of 60% corn silage, 40% corn grain and supplement and either 83, 78 or 71% moisture SCPW replacing the corn silage in the control diet. Steers fed 0% SCPW had higher ($P < .05$) daily gains, dry matter (DM) intake and DM digestibilities than steers fed either of the SCPW diets. Average daily gains were similar ($P > .05$) for steers fed SCPW silage diets but steers fed the 83% moisture SCPW silage had the lowest ($P < .05$) DM intakes. All diets were utilized with similar ($P > .05$) feed efficiencies. Daily gain, daily feed (lb DM) and feed/gain (lb DM/lb gain) were 2.59, 14.69, 5.66; 1.41, 9.26, 6.56; 1.65, 10.60, 6.47 and 1.65, 10.92 and 6.82 lb for steers fed control or SCPW diets that contained 83, 78 or 71% moisture silage, respectively.

Introduction

Processing of sweet corn for human food consumption results in a residue that typically contains 90% husk and leaf, 8% cob and 2% kernel plus washed corn screenings that contain 5% solids. The combined DM of the residue is usually 20% or less. Considerable water is added during the dehusking process. Over 400,000 tons of sweet corn waste (SCPW) are available each year from the 19 processors in southeast Minnesota. Typically the waste material is chopped and squeezed through a pressure chamber and then ensiled in open silage stacks. Producers can purchase the waste material either at the processing plant prior to ensiling or 6 to 8 weeks after the material has been stacked. Analysis of SCPW shows a similar crude protein content, slightly lower ash content but higher acid detergent fiber content when compared to regular corn silage or whole plant sweet corn silage (table 1). The problem of disposal of the SCPW is perennial and increasing each year especially as livestock feeding is the primary outlet for SCPW.

Results of a previous study (1987 Southern Experiment Station Annual Report, pp 199 to 201) indicated that high moisture SCPW silage can replace 50% of the corn silage in a diet for growing Holstein steers (60:40 corn silage:corn, dry basis) without affecting performance. Replacing all of the corn silage with SCPW silage reduced intake by 29% and daily gain by 37% compared to steers fed corn silage diets. The high moisture of SCPW was the major factor limiting intake and performance. A second study was initiated with the following objectives: a) evaluate the performance of Holstein steers fed diets containing SCPW ensiled at different moisture levels, b) evaluate the effect of reducing moisture content of SCPW by mechanical means on nutritional quality and c) to evaluate the optimum moisture content of SCPW that can be achieved practically at the processing plant to maintain production throughput and quality silage available for livestock at an optimum value for the food processor and livestock producer.

Procedure

During the 1987 season, 110 tons of SCPW obtained directly from General Foods in Waseca were ensiled at different moisture contents in horizontal 8-mm plastic storage bags using a silopress. The highest moisture silage (83%) was the SCPW ensiled directly from the plant. The other two moisture levels were obtained by passing the SCPW through a French Screw-Press which mulched the waste material and squeezed out additional effluent. A single pass through the screw press reduced moisture to an average of 78% and a double pass reduced moisture to an average of 71%. Sufficient quantity of SCPW was ensiled at each moisture level to conduct a 120-day growing trial with Holstein steers. All silages were ensiled for 42 days before being fed. Composition analyses of the respective SCPW silages are shown in table 2.

Thirty-six Holstein steers (avg init. wt. 432 lb) were randomly assigned to four treatment groups among six pens (six animals/pen). For one pen each, diets (dry basis) consisted of 1) 60% corn silage and 40% corn grain plus supplement and 2) 60% "high" moisture SCPW silage (83%) and 40% corn grain plus supplement. Two replicate pens were assigned to either 3) 60% "medium" moisture (78%) SCPW silage and 40% corn grain plus supplement or 4) 60% "low" moisture (71%) SCPW silage and 40% corn grain plus supplement. Supplement was fed at 1 lb per head daily (table 3). All steers were fed a similar corn silage-corn grain diet prior to the start of the trial and were changed to their respective treatment diets over a 2-day period. During the trial steers were full fed their respective diets once daily. Feeds were weighed individually and mixed in the feed bunk. Daily feed intake and refusals were recorded. Initial and final weights were obtained after withholding feed and water 16 hours. Steers were vaccinated for IBR, PI_3, BVD and seven strains of clostridia prior to the trial. Steers were implanted with Ralgro every 70 days after weaning. During the final week of the trial fecal grab samples were taken from each steer over a 5-day sampling period. Samples were taken twice daily at different hours each day. The fecal samples were used to estimate apparent dry matter digestibilities of the diets based on acid insoluble ash content of the feed and feces.

Results and Discussion

In contrast to high losses of ensiled feed material in the horizontal plastic bag reported for the previous study, (Minnesota Beef Report B-354) the material was packed more efficiently for this second trial and total losses averaged 5%. Both the single (78% moisture) and double pressed (71% moisture) silages packed more tightly than the highest moisture silage. Towards the end of the trial, the ambient temperature dropped below 0°F and the outside layers of the silages began to freeze. Continuous low temperatures prevented efficient feeding from the bags and the trial was terminated after 98 days.

Steer performance data are given in table 4. Steers fed 0% SCPW diets had higher (P <.05) daily gains and dry matter intakes than steers fed the other three diets. Average daily gains of steers fed the SCPW silages were not different (P> .05) regardless of moisture content although steers fed the highest moisture SCPW silage tended to have the lowest average daily gains. Steers fed the 83% moisture SCPW silage diets had the lowest DM intakes (P <.05). The amount of DM required/100 lb gain was not different (P> .05) among diets although steers fed 0% SCPW diets tended to require lower amounts of feed/100 lb gain.

Replacing corn silage with high moisture SCPW reduced daily gain by 46%, daily DM intake by 37% and feed efficiency 14% compared to steers fed 0% SCPW, respectively. Replacing corn silage with 78% or 71% moisture SCPW resulted in reductions of 36% in average daily gain for both silages. Daily DM intakes were reduced by an average of 27% and feed efficiency by an average of 14% for both silages compared to steers fed 0% SCPW silages. Steers fed the 0% SCPW silage diets had the highest apparent DM digestibilities (P< .05). There were no differences (P >.05) in apparent DM digestibilities of the three SCPW silage diets.

Compared to results from the first study (1987 Soutnern Experiment Station Annual Report, pp 199 to 201), performance of steers fed 0% SCPW silage was similar in feed efficiency to steers fed the same diet in the first study, but daily gains were higher. This was probably due to slightly heavier calves being used for this second study which resulted in higher average daily dry matter intakes. Performance of steers fed the high moisture SCPW silage in the present study were slightly better than those fed similar diets in the first study due perhaps to higher crude protein content of the SCPW.

Conclusions

The data indicate that reduction of SCPW moisture content below 78% prior to ensiling is not justified because quality of the product for livestock feeding is not enhanced. Minimum moisture reduction by a preliminary squeeze at the plant is advantageous environmentally. Chopping the SCPW prior to ensiling does enhance the silage quality.

A major concern not directly addressed in this study is the disposal of the effluent run-off from the silage stacks and that squeezed from the waste prior to ensiling. The effluent taken from the 78% and 71% moisture SCPW silages used in the present study was low in pH (3.9-4.2) and contained high concentrations of crude protein and soluble carbohydrates.

Reducing moisture content in the SCPW below 78% by mechanical means not only increases the nutrient loss from the silage but also poses a problem of effluent disposal. Aeration of lagoons at processing plants has improved the quality of the effluent being used to irrigate land. But unless the sweet corn processing industry adopts a water-sparing process of dehusking corn ears, disposal of the effluent will remain a major problem. Feeding of the SCPW silage to livestock is probably the best use of this waste feedstuff to date. Again, feeding quality of SCPW can be enhanced only if a reduction in water volume can be achieved during processing.

Table 1. Comparative analysis of sweet corn processing waste, whole plant sweet corn and regular dent corn silages.

Analysis	Silages: Sweet corn processing waste	Whole plant sweet corn	Regular dent corn
Dry matter, %	16 - 20	33 - 38	40 - 45
Crude protein; % dry basis	7 - 9	7 - 9	7 - 9
Nitrogen, % wet basis	.18 - .23	.39 - .50	.45 - .58
Acid detergent fiber, %	38 - 44	28 - 32	28 - 32
Typical ash, %	3.4	6.7	4.7
Typical pH after ensiling	4.0	3.9	4.1

Table 2. Composition analysis of sweet corn processing waste silages used in feeding trials.

Item	Dry matter	pH	Crude protein	Acid detergent fiber
	----------- %, dry basis			-------------
Trial 1 (1987 Southern Experiment Station Annual Report):				
High moisture SCPW[a]	19.09	4.00	7.41	39.36
Trial 2:				
High moisture SCPW[a]	17.56	3.92	8.23	42.35
Medium moisture SCPW[b]	22.32	3.99	7.06	44.03
Low moisture SCPW[c]	28.72	3.74	6.62	43.83

[a] Sweet corn processing waste ensiled directly from the processing plant.

[b] Sweet corn processing waste pushed through an additional squeeze process to reduce moisture.

[c] Sweet corn processing waste pushed through an additional squeeze two times to reduce moisture further.

Table 3. Composition of supplement[a]

Ingredient	Amount lb/ton
Soybean meal	260
Urea	340
Ground corn	430
Dicalcium phosphate	240
Limestone	520
Trace mineralized salt	150
Vitamin - monensin premix[b]	60

[a] Fed at 1 lb per head daily.
[b] To supply 25,000 IU vitamin A, 2500 IU vitamin D and 200 mg monensin per lb supplement.

Table 4. Performance of steers fed sweet corn processing waste ensiled at different moisture levels.

Ensiled processing waste, % moisture		83	78	71	
Waste, % of diet DM	0	60	60	60	
Corn silage, % of diet DM	60	0	0	0	
Corn grain, supplement, % of diet DM	40	40	40	40	Sx[a]
Item					
No. of steers	6	6	12	11	
Initial wt., lb[b]	434	423	436	433	
Final wt, lb[b]	688	561	598	595	
Days on feed	98	98	98	98	
Daily gain, lb	2.59[c]	1.41[e]	1.65[de]	1.65[de]	.53
Daily feed, lb of dry matter					
Corn silage	8.69	-	-	-	
Corn silage, fed during transition to waste silage only	-	.09	.10	.11	
Waste silage	-	5.32	6.16	6.26	
Ground corn	5.08	2.96	3.51	3.63	
Supplement	.91	.89	.91	.92	
Total	14.68[c]	9.26[e]	10.68[d]	10.92[d]	.83
Feed/100 lb gain, lb of dry matter					
Corn silage	335	-	-	-	
Corn silage (transition only)	-	6	6	7	
Waste silage	-	377	373	379	
Ground corn	196	210	213	220	
Supplement	35	63	55	56	
Total	566[c]	656[c]	647[c]	662[c]	83.0
Apparent dry matter digestibility, %	74.61[c]	62.61[d]	62.25[d]	61.40[d]	

[a] Standard error.
[b] Obtained after withholding feed and water 16 hours.
[cde] Means in the same row with different superscripts differ ($P < .05$).

Table 5. Analyses of effluent extracted from sweet corn waste silage pressed to 78 and 71% moisture from 83% moisture content, respectively.

Item	Silage effluent	
	78% silage	71% silage
Dry matter, %	6.5	6.7
Crude protein, % dry basis	15.9	16.7
Nitrogen, % wet basis	.16	.18
Organic Acids, % dry basis		
Acetic acid, %	1.90	3.50
Propionic acid, %	.02	.03
Isobutyric acid, %	.40	.80
Butyric acid, %	.40	1.20
Lactic acid, %	5.90	7.90
Water soluble carbohydrates		
% dry basis	61.0	25.0
% wet basis	4.0	1.7
Average pH of effluent	4.2	3.9

Dairy-Beef

EVALUATION OF HYDROLYZED FEATHERMEAL AND UREA AS MAIN NITROGEN SOURCES IN PELLETED PROTEIN SUPPLEMENTS FED IN HIGH ENERGY DIETS TO GROWING HOLSTEIN STEERS

Hugh Chester-Jones, David Ziegler, Jay Meiske and Brian Larson

Summary

A group of 36 Holstein steers (av wt 450 lb) were used for a growing study to evaluate the use of urea, feathermeal, or a combination of urea/feathermeal incorporated into pelleted protein supplements as main nitrogen sources in high energy diets. Steers fed feathermeal supplements had highest ($P < .05$) average final weights after 124 days but there were no other performance differences ($P > .05$) observed. Average daily gain, daily DM intake, and DM/100 lb gain, were 3.18, 17.29, 544; 3.40, 16.46, 484; 3.23, 15.60 and 483 lb for steers fed urea, feathermeal and combined supplements, respectively. Steers fed the feathermeal supplement tended to show higher average daily gains throughout the study. Feed cost/gain was lowest for steers fed the combined supplement. Source of nitrogen fed in growing diets did not affect performance or carcass composition when all steers were fed similar finishing diets.

Introduction

Feeding high energy diets with pelleted protein supplement to Holstein steers has become a regimen adopted by producers to achieve an economic return from marketing these large frame steers at 12 to 13 months of age when weighing 1100 to 1150 lbs. Supplemental nitrogen sources can represent high input costs to these diets and typically urea has been the source of choice after 400 lbs. Plant protein sources are the preferred choice prior to 400 lbs. Past research at the Southern Experiment Station has evaluated a number of rumen by-pass protein sources in starter diets and the only response to date has been to an extruded soybean/urea combination in terms of rate of gain but feed costs of gain were not improved upon in comparison to soybean meal. There has been very little work with feeding by-pass proteins with or without urea to Holstein steers from 400 lb. Hydrolyzed feathermeal is a readily available by-product from the Minnesota turkey industry and research in St. Paul has shown that it has low rumen degradability. Feathermeal typically contains 83 to 85% protein, .2% Ca and .75% P, dry basis, and is an excellent source of sulfur amino acids.

The objectives of this study were to compare urea and hydrolyzed feathermeal as nitrogen sources incorporated in pelleted protein supplements for Holstein steers from 450 lb to heavy feeder weight of over 800 lb using whole corn as the main energy source. The effects of these growing diets on final carcass composition was also evaluated after steers had been fed a common finishing diet to market weight.

Experimental Procedures

Thirty-six Holstein steers (av wt 450 lb), that had been fed whole corn or rolled corn with a pelleted plant protein supplement from weaning, were randomly assigned to two replicate pens (six animals/pen) each of three diets. Diets consisted of a full feed of whole corn, corn silage fed at 12% of the diet DM and 3 lb pelleted protein supplement/head daily. Supplement contained either urea, feathermeal or a 50:50 combination of urea and feathermeal as three main nitrogen sources (Table 1). Steers were full fed their respective treatment diets once daily. Feeds were weighed individually and mixed in the feed bunk. Daily feed intakes were recorded on a per pen basis and feed refusals recorded weekly. Initial and final weights were an average weight taken from two consecutive days prior to feeding.

Steers were fed their respective diets for 124 days, then changed to a common finishing diet of a full feed of rolled corn, corn silage fed at 12% of the diet DM and a urea protein supplement fed at 1 lb/head daily (Table 2). All steers were marketed when pen weights averaged approximately 1150 lb. A final terminal shrunk weight was then taken. Steers were vaccinated IBR, PI_3, BVD and seven strains of clostridia prior to the study. Steers were implanted with Ralgro every 70 days after weaning.

Results and Discussion

Performance data for the growing phase of the study is shown in table 3. Steers fed the feathermeal protein supplement had the highest (P <.05) final weight after 124 days compared to those steers fed the other two supplements. There were no differences (P >.05) in other performance parameters between diets fed. Average daily gain, daily feed intake, DM and feed/100 lb gain, DM were 3.18, 17.29, 544; 3.40, 16.46, 484; 3.23, 15.60 and 483 lb for steers fed urea, feathermeal and urea/feathermeal combination supplements, respectively. Steers fed the feathermeal supplement tended to show highest average daily gains and those fed the urea supplement lowest feed efficiencies throughout the study. Feed cost/100 lb gain favored the combined supplement followed by feathermeal and urea supplemented alone, respectively.

During the finishing phase when all steers were fed the same diet, differences in final weights shown at the end of the growing study were reflected in days on feed to market but these were not significant (P >.05). Other performance data and carcass composition are shown in table 4. There were no differences in steer performance (P >.05) that could be contributed to protein supplement used in the growing phase. All steers performed inconsistently during the finishing phase as extremely hot summer weather at the time depressed daily feed intake, gain and feed efficiencies. The average quality of carcass was not as high as expected for steers fed high corn diets from weaning. Average age at market weight was 397, 379 and 391 days for steers fed urea, feathermeal and combined urea/feathermeal supplements in their growing diets, respectively.

Conclusion and Farmer Recommendations

The study indicated that feathermeal is utilized quite effectively as a nitrogen source for growing Holsteins from 450 lb. Economics will dictate if the price differential between feathermeal and urea permits increased usage of the former by producers. A combination pellet containing both urea and feathermeal could be utilized to reduce feed costs/gain based on performance data shown in this study. Sources of nitrogen supplement did not affect carcass composition of the finished cattle. A further two replicate pens of steers fed protein supplement used in the growing phase is currently being studied to substantiate results of this first trial and a final complete report will be given in next year's annual report.

Table 1. COMPOSITION OF PELLETED SUPPLEMENTS FED IN GROWING DIETS.[a]

Ingredient	Supplement, main nitrogen source[b]		
	U	FM	UFM
	lb/ton		
Ground corn	1534.8	1232.4	1383.4
Urea	126.8	-	61.7
Feathermeal	-	431.7	215.6
Dicalcium phosphate	77.6	73.2	75.6
Limestone	173.4	175.3	176.3
Trace mineralized salt	50	50	50
Calcium sulfate (gypsum)	11.8	11.8	11.8
Betonite	20	20	20
Vitamin A (30,000 IU/g)	1.2	1.2	1.2
Vitamin D (720,000 IU/lb)	2.2	2.2	2.2
Vitamin E (500 IU/g)	.2	.2	.2
Rumensin 60	2	2	2

[a] Fed at 3 lb per head daily.
[b] Nitrogen source; U = Urea; FM = Feathermeal and UFM = 50% protein each supplied by urea and feathermeal.

Table 2. COMPOSITION OF PROTEIN SUPPLEMENT FED IN FINISHING DIETS[a]

Ingredient	Amount lb/ton
Ground corn	900
Urea	310
Limestone	520
Trace mineral salt	200
Vitamin-monensin-sulfur premix[b]	70

[a] Fed at 1 lb per head daily
[b] To supply 25,000 IU vitamin A, 2500 IU vitamin D, 225 mg monensin, and 1.5 g sulfur per lb supplement.

Table 3. PERFORMANCE OF STEERS FED DIFFERENT NITROGEN SOURCES IN PELLETED PROTEIN SUPPLEMENTS FROM 450 LB

Item	Nitrogen source[a]			
	U	FM	UFM	Sx[b]
No. steers	12	12	12	
Initial wt, lb[c]	451	450	450	
Final wt, lb[c]	845[d]	872[e]	850[d]	7.32
Daily gain, lb	3.18[d]	3.40[d]	3.23[d]	.11
Days on feed	124	124	124	
Daily feed, lb of DM:				
Whole corn	12.84	12.11	11.36	
Corn silage	1.75	1.65	1.54	
Supplement	2.70	2.70	2.70	
Total	17.29[d]	16.46[d]	15.60[d]	1.57
Feed/100 lb gain, lb DM	544[d]	484[d]	483[d]	45.66
Feed costs/lb gain	$30.25	$28.79	$27.99	

[a] Nitrogen source; Urea = Urea; FM = Feathermeal; UFM = 50% supplemental protein supplied each by urea combined with feathermeal.

[b] Standard error

[c] Obtained as an average of two consecutive weights taken prior to feeding.

[de] Row means with different superscripts differ ($P < .05$).

[f] Based on corn @ $100/ton, corn silage @ $26/ton, urea @ $240/ton and feathermeal @ $300/ton.

Table 4. PERFORMANCE AND CARCASS COMPOSITION OF STEERS FED FINISHING DIETS FROM 850 TO 1150 LB MARKET WEIGHT

Item	Nitrogen source[a] in growing phase U	FM	UFM	Sx[b]
No. steers	12	12	12	
Initial wt, lb[c]	845[d]	872[e]	850[d]	
Final wt, lb[f]	1056	1043	1046	7.32
Daily gain, lb	2.07	1.94	2.00	
Days on feed	102	88	98	
Daily feed, lb DM	16.35	18.12	17.41	
Feed/100 lb gain, lb DM	790	934	871	
Av age to market from birth, days	397	379	391	
Carcass composition:				
Carcass wt, lb	635	611	621	
Dressing %	60.2	58.6	59.4	
Back fat, in	.26	.28	.26	
Rib eye area, sq in	9.7	9.2	10.2	
Kidney, pelvic, heart fat, %	3.2	3.1	3.1	
Marbling[g]	5.1	4.9	5.0	
Quality grade	Select +	Select +	Select +	

[a] Nitrogen source; U = Urea; FM = Feathermeal; UFM = 50% of supplemental protein supplied each by urea combined with feathermeal.
[b] Standard error
[c] Average of two consecutive weights taken prior to feeding
[de] Row means with different superscripts differ ($P < .05$). No other differences observed.
[f] Obtained after withholding feed and water 16 hours.
[g] Slight = 4.0; small = 5.0, modest = 6.0.

Dairy-Beef

PERFORMANCE OF HOLSTEIN STEERS FED STARTER DIETS CONTAINING EITHER WHOLE OR ROLLED CORN WITH PELLETED SUPPLEMENT

Hugh Chester-Jones, David Ziegler, Jay Meiske and Richard Goodrich

Summary

Two groups of 36 weanling Holstein steer calves (av wt 115 lb) were used in two studies to evaluate steer performance when fed either rolled or whole corn with a pelleted protein supplement in starter/growing diets for 127 days. After 56 days some steers were switched from rolled to whole corn based diets. Feeding regimen did not affect performance ($P > .05$) between day 1 to 56 and 57 to 127. Steers fed rolled corn diets had lowest ($P < .05$) average final weights. Overall average daily gains were higher ($P < .05$) for steers fed whole corn than those fed rolled corn diets. Steers fed rolled/whole corn switch diets had similar ($P < .05$) average daily gains to those of steers fed the other two diets. Average daily DM intakes, daily gains and feed/gain, lb DM, for the entire study were 7.18, 2.28, 315; 7.58, 2.40, 316; 7.50, 2.44 and 307 lb for steers fed rolled, rolled/whole switch and whole corn based diets, respectively. There were no overall performance differences ($P > .05$) in average DM intake and feed efficiencies. Cost of gain tended to be lower for steers fed whole corn throughout the study.

Introduction

There has been a great deal of producer interest recently in raising young male Holstein calves for dairy-beef production to sell as feeders or finish out to market weight. The marketability of these cattle has been enhanced by consumer demand for high quality lean beef and potential profit margins to the producer.

Feeding strategies for these young calves should take advantage of their efficient growth characteristics by feeding high corn diets. One regimen gaining popularity is to feed whole corn and a commercial pelleted supplement throughout the growing and finishing periods. The pelleted protein supplements sold commercially often contain a minimum or no fiber/roughage source. Previous research at the Southern Experiment Station indicates that a minimum of 10% fiber/roughage source is desirable in high corn diets fed to young calves. Another regimen suggested is to feed a coarsely ground or rolled corn starter diet, then switch to a whole corn base, the implications being that young calves initially respond better to the former.

The objectives of this study were, therefore, to: a) compare feeding strategies using whole corn vs rolled corn in high energy starter diets fed to weanling Holstein steers with a pelleted protein supplement to supply a minimum of 10 to 12% fiber/roughage source in the total daily ration; and b) evaluate the effect of switching from a rolled corn base to a whole corn base when steers reach 220 to 230 lb body weight.

Experimental Procedures

Two groups of 36 weanling male Holstein calves (av. wt 115 lb), housed in raised individual crates, were randomly assigned to three diets. Two diets consisted of either rolled (RC) or whole corn (WC) fed at a constant ratio of 3 pts corn with 1 pt pelleted protein supplement, the composition of which is shown in Table 1. The third diet consisted of the protein supplement fed with rolled corn for 56 days then switched to a whole corn base (BW). Each diet was replicated four times. All calves were purchased when 7 to 14 days old, one group in April and the other in September. Calves averaged 38 days old when assigned to treatment diets. All diets were isonitrogenous supplying 16% crude protein, dry matter basis.

Immediately after weaning, initial weights were taken prior to feeding on 2 consecutive days, then calves were assigned to individual crates by treatment group. Diets were full fed daily and individual intakes were recorded for the first 28 days of the study. Routine castration, dehorning and implanting were performed during this initial period. Calves were then moved to previously assigned replicate treatment pens (six animals/pen) in the Southern Experiment Station dairy-beef feedlot. Calves continued to be full fed their respective diets, and daily feed intakes were recorded on a pen basis. Feed refusals were recorded at least once weekly. Diets were fed for 127 days when a final shrunk weight was taken on each animal. An interim weight at the 56 day switch over was taken as an average of two consecutive days prior to feeding. Throughout the trial calves were weighed bi-weekly. Calves were vaccinated routinely for IBR, PI_3, and BVD and re-implanted with Ralgro at 70 days of the study.

Results and Discussion

Performance data is summarized in Table 2. During the first 56 days of the study there were no performance differences ($P > .05$) due to physical form of corn fed. Steers assigned to WC and RW diet treatments tended to have higher average daily gains and DM intakes. Average daily DM intake, daily gains and feed/100 lb gain, lb DM, were 4.80, 1.88, 255; 5.13, 1.95, 263; 5.12, 2.00 and 256 lb for steers fed RC, RW and WC treatment diets, repsectively. From day 57 to 127 performance of all steers increased rapidly. Although no significant differences ($P > .05$) were observed, steers fed RW and WC diets continued to show higher average daily feed intakes and gains than those fed the RC based diet. During this phase of the study daily DM intakes and daily gains increased by an average of 46.2 and 28.4%, respectively, across all groups of steers, compared to the first 56 days. Feed efficiency decreased an average of 24.6% in the same period.

Steers fed RC diets throughout the study had lower ($P < .05$) average final weights than steers fed the other two diets. Average daily gains for the entire study were higher ($P < .05$) for steers fed WC than those fed RC diets. Steers fed the RW switch diet had similar ($P > .05$) average daily gains to the other dietary groups. There were no differences ($P > .05$) in average DM intakes and feed/gain for the overall study. Average daily DM intake, daily gains and feed/100 lb gain, lb DM, were 7.18, 2.28, 315; 7.58, 2.40, 316; 7.50, 2.44 and 307 lb for steers fed RC, RW and WC diets, respectively, for the entire study. Overall feed costs/100 lb gain were \$24.83, \$24.91 and \$24.20 for steers fed RC, RW, and WC diets, respectively.

Conclusions and Farmer Recommendations

Results of this study indicate that young Holstein steers utilize whole corn diets fed with a pelleted supplement slightly more effectively than those fed rolled corn during the starter period. Changing from rolled to whole corn at 220 to 230 lb body weight did not affect overall steer performance. Regardless of diet fed the study emphasized that these young Holstein steers utilize high corn based diets with minimal roughage/fiber source most efficiently. This feeding regimen can be effectively used for a self-feeding feedlot system. It is important to keep feed in front of these steers at all times as any inconsistency in feed intake patterns can lead to digestive problems.

The study did indicate a performance difference between groups of purchased calves although they were bought from the same nucleus of dairy producers. Although similar in age, the April calves were heavier ($P < .05$) than those purchased in September when assigned to diets. This was reflected in higher ($P < .05$) average daily DM intakes and feed/gain ratios for April calves during each phase of the study. The differences in initial weights between each group of calves were negated by the end of the trial and no group differences ($P > .05$) were observed in average daily gains. Differences in feed/gain ratio could have important implications to profit margins in a given season of the year.

Table 1. COMPOSITION OF PELLETED SUPPLEMENT[a]

Ingredient	Amount lb/ton
Alfalfa meal	877.2
Soybean meal (46%)	960.0
Limestone	75.2
Dicalcium phosphate	44.0
Trace mineral salt	40.0
Vitamin premix[b]	3.6

[a] Fed at 1 pt supplement to 3 pt corn to supply 16% crude protein, dry basis, in total diet.

[b] To supply 2000 IU vitamin A, 200 IU vitamin D and 7 IU vitamin E per lb diet.

Table 2. PERFORMANCE OF STEERS FED STARTER DIETS CONTAINING WHOLE OR ROLLED CORN WITH PELLETED PROTEIN SUPPLEMENT FOR 127 DAYS.

	Physical form of corn fed			
Item	Rolled	Rolled/ whole[a]	Whole	Sx[b]
No. steers	24	24	24	
Init. wt. [c]	115	116	115	
---------- First 56 days[d] ----------				
56 day wt, lb[c]	220	225	227	6.85
Daily Feed Intake, lb DM	4.80	5.13	5.12	.27
Daily gain, lb	1.88	1.95	2.00	.09
Feed/100 lb gain, lb DM	255	263	256	12.00
---------- Day 57 to 127[d] ----------				
127 day wt, lb[e]	405[f]	421[g]	425[g]	8.15
Daily Feed Intake, lb DM	9.09	9.51	9.37	.47
Daily gain, lb	2.61	2.75	2.79	.09
Feed/100 lb gain, lb DM	348	345	336	19.00
---------- Overall Performance, 127 days[d] ----------				
Final wt, lb[e]	405[f]	421[g]	425[g]	8.15
Daily Feed Intake, lb DM	7.18	7.58	7.50	.36
Daily gain, lb	2.28[f]	2.40[fg]	2.44[g]	.15
Feed/100 lb, lb DM	315	316	307	.06
Feed cost/100 lb gain, $[h]	24.83	24.91	24.20	

[a] Steers switched from rolled to whole corn after 56 days on the study.
[b] Standard error.
[c] Average of two consecutive weights prior to feeding.
[d] Row means without superscripts do not differ ($P > .05$).
[e] Obtained after withholding feed and water for 16 hours.
[fg] Row means with different superscripts differ ($P < .05$)
[h] Based on corn at $100/ton and pelleted supplement @ $269/ton.

EFFICACY OF A COMMERCIAL MILK REPLACER FOR PIGLETS

Brian Knudson, Ron Moser, Hugh Chester-Jones,
Steve Cornelius and David Ziegler

Summary

A commercial milk replacer was evaluted to artificially rear piglets during a 21-day period. Two hundred eighty piglets were randomly allotted at two days of age to treatment. Nine replicates per treatment were conducted at the Rosemount Experiment Station, and five replicates were used from the Southern Experiment Station. Treatments consisted of natural (suckled) or artificial (milk replacer) rearing. Average daily milk consumption of artificially reared piglets during period 2-9, 10-16 and 17-20 days (d) was 3.04, 4.00 and 1.58 lb/day, respectively. Mortality did not differ between treatments until the final period (17-23 d) when more artificially reared piglets died (.46 vs 11.50%; $P < .01$). Piglet weight was not affected by treatment at day 9 ($P > .66$); however, artifically reared piglets were lighter at day 16 ($P < .02$) and 23 ($P < .001$) than naturally reared piglets. Although differences in mortality and growth rate occurred between treatments, the commercial milk replacer is a viable alternative to rear piglets.

Introduction

The method to successfully rear piglets artificially has traditionally burdened swine producers. Piglets have typically been fostered to other sows or fed bovine milk when a sow: 1) dies, 2) farrows a large litter, or 3) produces little milk. The advent of various commercial milk replacers has attempted to resolve this problem by providing adequate nutrition during this young age. If adequate nutrition can be provided, potential improvement in livability may be obtained since the incidence of crushing and chilling would be lessened. Crushing and chilling comprise the second most common cause of piglet death (18.2%) behind starvation (42.8%).

The product evaluated in this trial was developed to: 1) provide adequate nutrition, 2) maintain piglet livability, and 3) dispense easily. This trial was conducted to determine the efficacy of a commercial milk replacer as a nutrient source for artificially reared piglets.

Experimental Procedure

A total of two hundred eighty piglets were randomly allotted at two days of age to treatment. Treatments consisted of rearing piglets naturally (suckled) or artificially (milk replacer) for a 21-day period. Nine replicates per treatment were conducted at Rosemount Experiment Station and five replicates were used from the Southern Experiment Station. Piglet birth weight and initial weight at day 2 were 3.01 and 3.26 lbs., respectively. Artificially reared piglets were provided supplemental heat (heat lamp), given free access to water and housed in a farrowing crate similar to naturally reared piglets.

Commercial milk replacer used to artifically rear piglets was Littermilk, developed by Land O'Lakes. This product was provided in accordance with the proposed feeding schedule. A modified poultry waterer was used to dispense the milk replacer. Milk replacer was provided for piglets at the suggested daily rate for 20 days of age (Table 1). Quantity of milk consumed by piglets was determined. Creep feed was provided for both treatments at day 13. Total creep feed consumed was determined from day 13 to 23. Piglets were placed on test for 21 days (day 2-23). Mortality and growth data were recorded for period 2-9, 10-16 and 17-23 days.

Table 1. Daily feeding schedule per piglet followed for artificially reared piglets.

Age	Fluid Oz./Piglet
1 - 3	30
4 - 5	50
6 - 7	60
8 - 12	80
13 - 16	50
17 - 20	20
21	Wean

Results and Discussion

Artificially reared piglets made the transition to milk replacer with limited problems. Daily milk consumption of piglets approached the targeted consumptions for all periods (Table 1). Milk consumption per piglet was gradually increased to day 12 and reduced thereafter. Incidence of diarrhea and matted hair was more prevalent for artificially reared piglets. Piglet deaths in period 2-9 d and 10-16 d were attributed histologically to enteric colibacillosis (diarrhea). However, piglet deaths were not similarly diagnosed in period 17-23 days.

Mortality did not differ between treatments until the final period (17-23 d) when more artificially reared piglets died (.46 vs 11.50%; $P < .01$). Based on this data, the nutritional needs of the piglets to day 16 appear to be met by the milk replacer as indicated by the low cumulative mortality of the artificially reared piglets. Increased mortality of artificially reared piglets in period 17-23 may be due to nutritional inadequacies of vitamins necessary for the high plane of growth.

Table 2. Milk consumption of artificially reared piglets

	Mean	SE
Number of replicates	14	
Milk consumption (lb/day)		
a. Period 1 (2-9 d)	213.7	
b. Period 2 (10-16 d)	272.2	
c. Period 3 (17-20 d)	92.4	
Average daily milk consumption (lb/day)		
a. Period 1 (2-9 d)	3.04	0.12
b. Period 2 (10-16 d)	4.00	0.17
c. Period 3 (17-20 d)	1.58	0.08

Table 3. Piglet Performance

	Rearing Method			
	Natural	Artificial	SE	Treatment Difference
Number of replicates	14	14		
Piglet mortality (%)				
a. Period 1 (2-9 d)	4.24	3.90	2.87	
b. Period 2 (10-16 d)	0.56	1.52	1.25	
c. Period 3 (17-23 d)	0.46	11.50	1.83	$P < .01$
Piglet weight (lb)				
a. Birth weight (0 d)	2.85	3.12	0.10	
b. Initial weight (2 d)	3.19	3.27	0.13	
c. Period 1 (9 d)	6.16	6.00	0.25	
d. Period 2 (16 d)	9.11	8.16	0.23	$P < .02$
e. Period 3 (23 d)	11.96	8.84	0.34	$P < .001$
Average daily gain (lb/day)				
a. Period 0 (0-1 d)	0.17	0.07	0.03	
b. Period 1 (2-9 d)	0.42	0.39	0.02	
c. Period 2 (10-16 d)	0.42	0.30	0.15	
d. Period 3 (17-23 d)	0.41	0.06	0.03	$P < .15$
Creep feed consumption (lb)	0.74	18.69	1.28	$P < .20$

Difference in piglet weight was not detected until day 16 ($P < .02$). This difference was further widened at day 23 ($P < .001$) as artificially reared piglets had low average daily gain in period 17-23 d. This disparity in average daily gain was a 6.5 fold difference and can be largely attributed to the reduction in supplied milk replacer. Although milk consumption in period 16-23 d was drastically reuced for artificially reared piglets, the increase in creep feed consumption (.74 vs 18.69 lb) did not provide enough nutrients to compensate for a comparable average daily gain of naturally reared piglets in period 16-23 d. Although numerically different, no difference in creep feed consumption was detected ($P < .20$) because the location x treatment interaction ($P < .01$) was used as the error term.

Conclusions and Farmer Recommendations

Although differences in mortality and growth rate occurred between treatments, the commercial milk replacer provides a viable alternative to rear piglets. The use of this milk replacer when a sow: 1) dies, 2) farrows a large litter, or 3) produces little milk is efficacious. The nutritional needs of the young piglet (0-16 d) appear to be met by the milk replacer. However, further improvements need to be made in the nutritional adequacies and proposed feeding rate of this product from 10-21 days.

FUNGICIDE EVALUATION FOR COMMON RUST CONTROL

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SIGNIFICANCE:

Again in 1988, several fungicides were evaluated for rust control in sweet corn. Many of the fungicides evaluated were systemic. The proposed advantage from the use of these types of fungicides is their residual control qualities after initial application. None of the systemic fungicides are currently registered for use in sweet corn, however, there is an effort by many chemical companies to obtain a label. Rust tolerant varieties continue to be developed but the ability for the rust organism to overcome their resistance is ever present. Future rust management practices are likely to include the use of fungicides.

The objectives of this study were to evaluate several fungicides for rust control potential and to determine if the use of any of these materials had any adverse effects on various yield components.

MATERIALS AND METHODS:

Variety:	Jubilee
Planting Date:	June 3
Plant Density:	24,000/A
Herbicides:	Lasso (alachlor) and Bladex (cyanizine) at 2.5 and 2.0 lb. a.i./A preemergence.
Fertilizer:	Urea applied preplant at 120 lb./A

1988 Fungicide Evaluation for Rust Control

	Treatment	Rate lb a.i./A	Application Interval Days
1.	RH-7592 2 F	.06 + 1 qt. COC/A	10
2.	Propiconazole (TILT 3.6E)	.11	14
3.	Mancozeb (DITHANE F-45)	1.60 + 1 qt. Triton B-1956/100gal.	7
4.	Propiconazole (TILT 3.6E)	.055	7
5.	Triadimefon (BAYLTEON 50 WP)	.25	10
6.	Myclobutanil (SYSTHANE 60 DF)	.12+ 1 pt. Triton B-1956/100 gal.	10
7.	Propiconazole (TILT 3.6E)	.11	7
8.	Diniconazole (SPOTLESS 25WP)	.10 + 6 oz. X-77/100 gal.	10
9.	Mancozeb (MANZATE 80WP)	1.2	7
10.	Untreated	---	--
11.	Chlorothalonil (BRAVO 6F)	.52	7

The experimental plot design was a randomized complete block with four replications. At the four leaf stage, each corn plant was inoculated with rust urediospores suspended in oil. Fungicide treatments were first when the average number of rust pustules/leaf was 4-5. Just prior to harvest, three leaves were sampled from each of five plants in each treatment to determine rust severity levels using a video area meter which contrasts healthy from diseased plant tissue for an objective severity reading. The specific locations of those leaves evaluated were, counting basipetally, the flag, secondary, and opposite/above ear positions. At harvest, various yield components were measured with the aid of a mechanical husker and cutter to simulate industry processing procedures:

Unhusked weight
Husked weight
Useable ears for freezing
Total ears
Ear length
Ear diameter
Cut kernel weight

All treatment plots were harvested when kernel moisture reached 72 -74%.

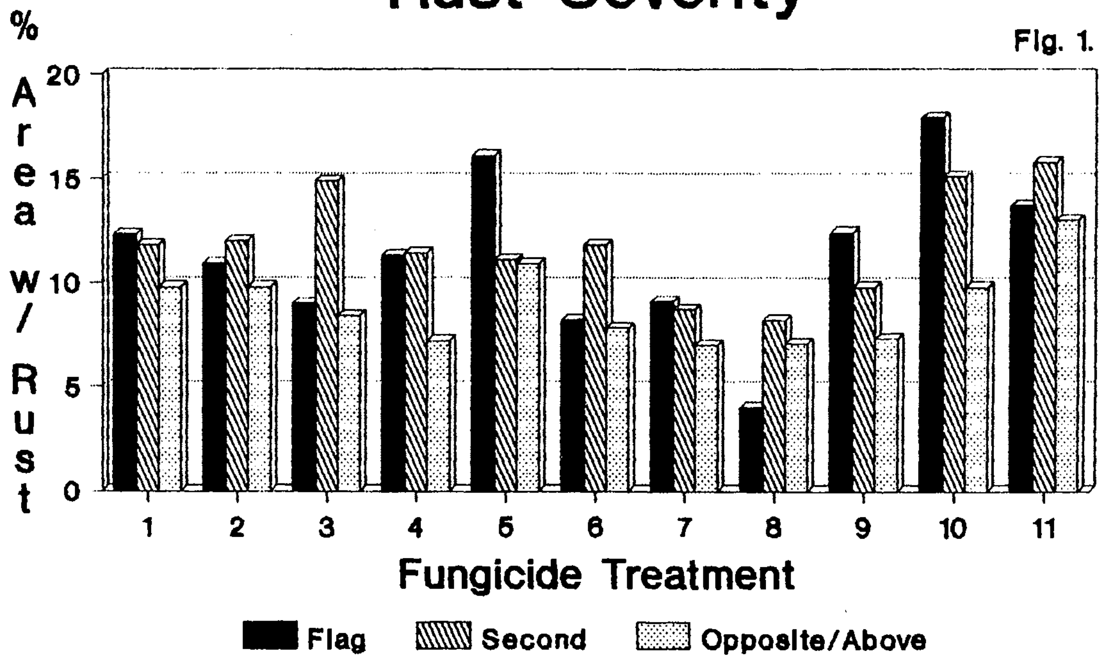
RESULTS AND DISCUSSION:

Rust severity was considered very mild due to the hot, dry environmental conditions all season long. Maximum severity was determined to be 18% of the flag leaf area (fig. 1). Diniconazole fungicide applications resulted in the lowest rust severity (4% infected). Propiconazole gave comparable control when applied at a rate of .11 lb. a.i./A every 7 days (8% infected). The standard mancozeb treatments had an average of 12% of leaf area infected. All applications began at the onset of rust (4-5 pustules/leaf) and stopped at silking.

Yield components (unhusked, husked, and cut corn recovery) from all fungicide treatments were not significantly effected when compared to the control. However, corn treated with either RH-7592 or myclobutanil resulted in a 20% reduction in useable ear recovery for corn on the cob freezing, compared to the standard mancozeb treatment (fig. 2).

Rust Severity**

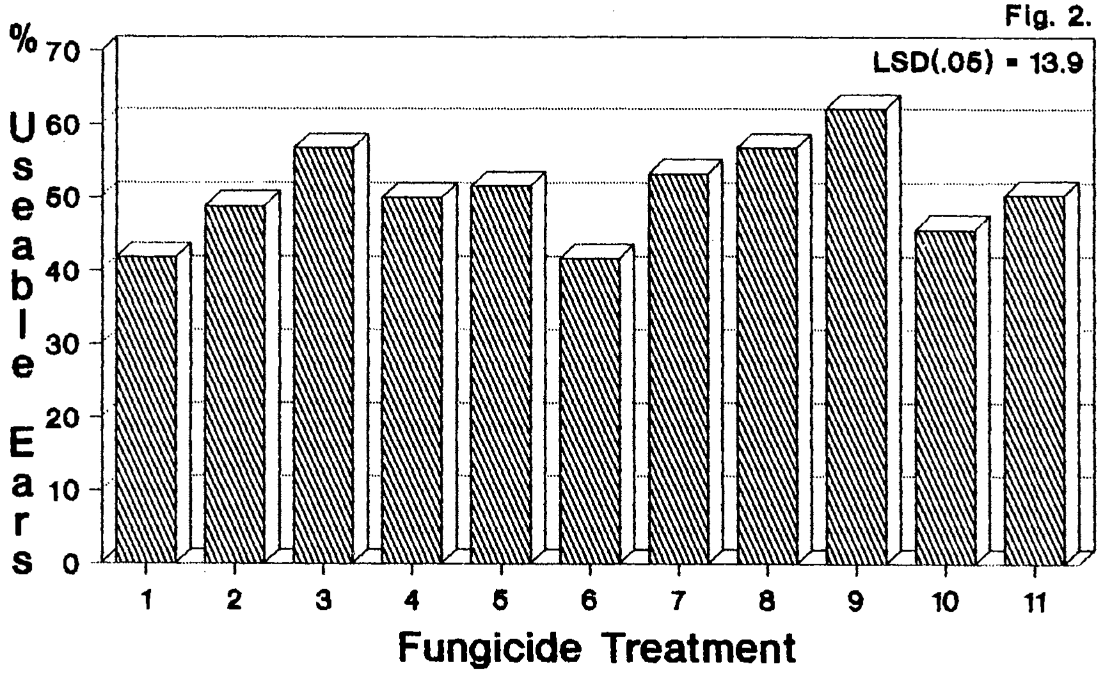
Fig. 1.



** Not Significant

Useable Ear Production

Fig. 2.



The Effect of Ethephon on Plant Height, Lodging, and Various Components of Yield in Three Sweet Corn Genotypes

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Keywords: Sweet Corn, Ethephon, Lodging, Ethylene, Zea mays var. sacharata.

Significance

Sweet corn (Zea mays var. sacharata) production for processing in Minnesota is worth approximately $40 million dollars annually before processing. Traditionally, the industry has produced the sugary genotypes (su) for canning and freezing; however, due to the popularity of the sugary enhancer (se) and super sweet (sh_2) genotypes in the fresh market industry, several processors have begun evaluating these cultivars for production potential because of elevated sugar content. However, the sh_2 cultivars have significant production problems. One of these is a very high susceptibility to root lodging at the soil surface, primarily due to poor brace root development. In addition, cultural management systems used currently promote a rapid growth rate and high productivity per unit area contributing to susceptibility to lodging. Although yields from sh_2 cultivars are comparable or superior to the traditional su cultivars, harvesting costs can be significantly increased primarily due to the slow harvestor speed required in lodged fields.

The objective of this study was to determine the effects of timing of foliarly applied ethephon in three sweet corn genotypes; sugary (su), sugary enhancer (se), and shrunken (sh_2) on lodging and yield.

Materials and Methods

Field experiments were conducted during 1987 and 1988 at the Southern Experiment Station in Waseca, MN on a 'Nicollet' clay loam with a pH of 6.4. The cultivars chosen from each genotype for the study are listed in table 1. The experimental design was a completely randomized block with three replications. Each experimental plot consisted of four rows of corn 20 feet long with 30 inches between rows. Plots were harvested when kernels reached 73-74% moisture. Harvesting was limited to 15 feet of the center 2 rows. Data from all experiments were analyzed statistically using analysis of variance (ANOVA) and least significant difference.

In 1987, urea was broadcast preplant at 120 lb. N/A and incorporated with a spring tooth cultivator. Alachlor and cyanizine were broadcast applied preemergence at rates of 2.5 and 2.0 lb. a.i./A, respectively, for weed control. All cultivars were seeded on May 20 and after emergence, were thinned by hand to a final population of 24,000 plants/A. The experiment was overhead irrigated to insure at least 1 inch water weekly. Carbaryl and mancozeb were sprayed as needed for insect and disease control at rates of 1.2 and 2.0 lb. a.i./A, respectively. Ethephon was foliarly applied at a rate of .25 lb. a.i./A using a high clearance sprayer equipped with flat fan nozzles and calibrated to deliver 20 gal/A at 40 p.s.i. Ethephon was applied at two stages of plant growth; when the length of the embryonic tassel measured 1 - 2 inches or 6 - 8 inches in length. This was determined by manually disecting the main stalk and measuring the developing tassel.

Prior to harvest, a rating scale of 1-5 was used to classify degree of root lodging (1 = upright, 5 = severe lodging) and plant and ear height were measured on 10 plants from each treatment plot. At harvest, the following parameters were measured with the aid of a mechanical husker and cob cutter to simulate processor handling: unhusked and husked ear weights, useable ears for corn on the cob freezing which is defined by 5.25 inches of the ear having superior appearance (straight kernel rows and complete kernel fill), total ear production, ear length and diameter, and cut corn recovery, the primary yield component in the canning industry.

An identical study was conducted in 1988 which was planted on May 16. During the course of the season, excessively high temperatures resulted in abnormal plant growth (lack of synchronization of tasseling with silking) even though the experiment was irrigated to receive 1 inch of water weekly. Table 2 represents the contrast between the two years in heat unit accumulation prior to harvest for each cultivar used in the study. For this reason, the data were analayzed and will be discussed separately. The early ethephon application (1 - 2 inch tassel length) was not applied to the cultivar, 'Reward', in 1988 because the tassel length had exceeded 5 cm when the plots were first evaluated for tassel development.

In 1987, the data suggested that application of ethephon reduced lodging (fig. 1). The late application (6 - 8 inch tassel length) had the least amount of lodging. This increase in resistance to lodging was probably due to shorter internode lengths on the main stalk which is reflected in total plant height (fig. 2). This reduction in plant height was also associated with a slight decrease in ear height but probably does not present any practical problems with mechanical harvesting. Ear length reduction was small and did not reduce cut corn recovery (data not shown). Ear diameter also was not effected. Ethephon application increased total ear production, although the number of useable ears (for corn-on-the-cob freezing) remained unchanged (fig. 3).

Results from the second year of the study (1988) again indicated that the later ethephon application resulted in shorter internodes when compared to both the control and early ethephon application (fig. 4). Height of ear location on the stalk was reduced by 2.75 inches which was similar to 1987 data and does not pose any potential mechanical harvesting problem. Ear length and cut corn recovery were not effected by either application of ethephon. Total ear production was increased (fig. 5) and there was a cultivar x ethephon interaction for useable ear production ($p = .05$) (table 2). The interaction was inconsistent with genotype or heat unit accumulation. It may be that this interaction was manifested by interactions between environment/cultivar/and ethephon treatments. Differences in cultivar response to drought conditions may have effected internal plant ethylene concentrations produced by the plant and in turn, their response to foliar applications of ethephon. However, the intense heat during 1988 may have resulted in varying rates of pollen grain mortality thereby reducing kernel set and fill. Three cultivars in particular, 'Reward' (su), 'Sentry' (se), and 'Sweetie' (sh_2) responded very negatively to foliar applications of ethephon in 1988. It is important to note that ethephon affected the appearance of the ears which qualifies it for corn-on-the-cob freezing and bears great significance to those processors.

When contrasting the effects of foliarly applied ethephon among ten sweet corn cultivars in two extremely different years, it was clear that ethephon reduced lodging in sweet corn by reducing overall plant height. However, its effect on the components of yield can vary greatly. Under a stressful production environment, ethephon also reduced useable ear production for sensitive cultivars.

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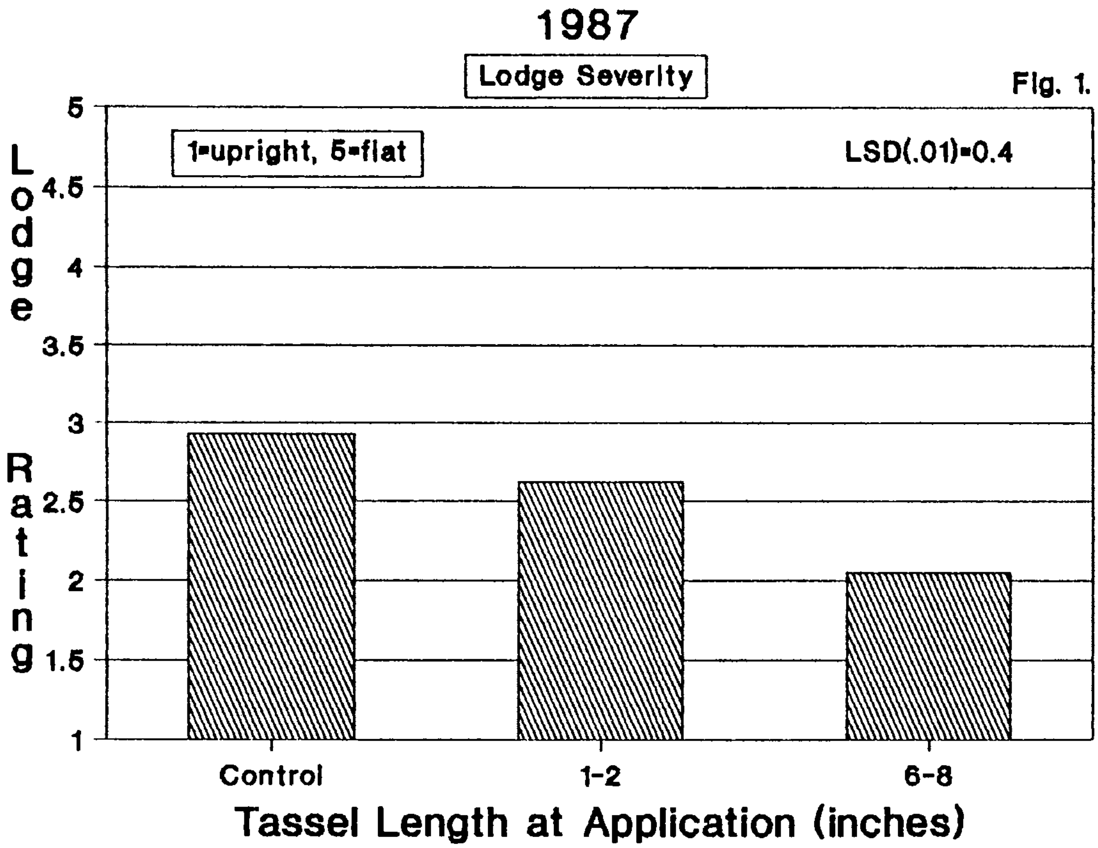
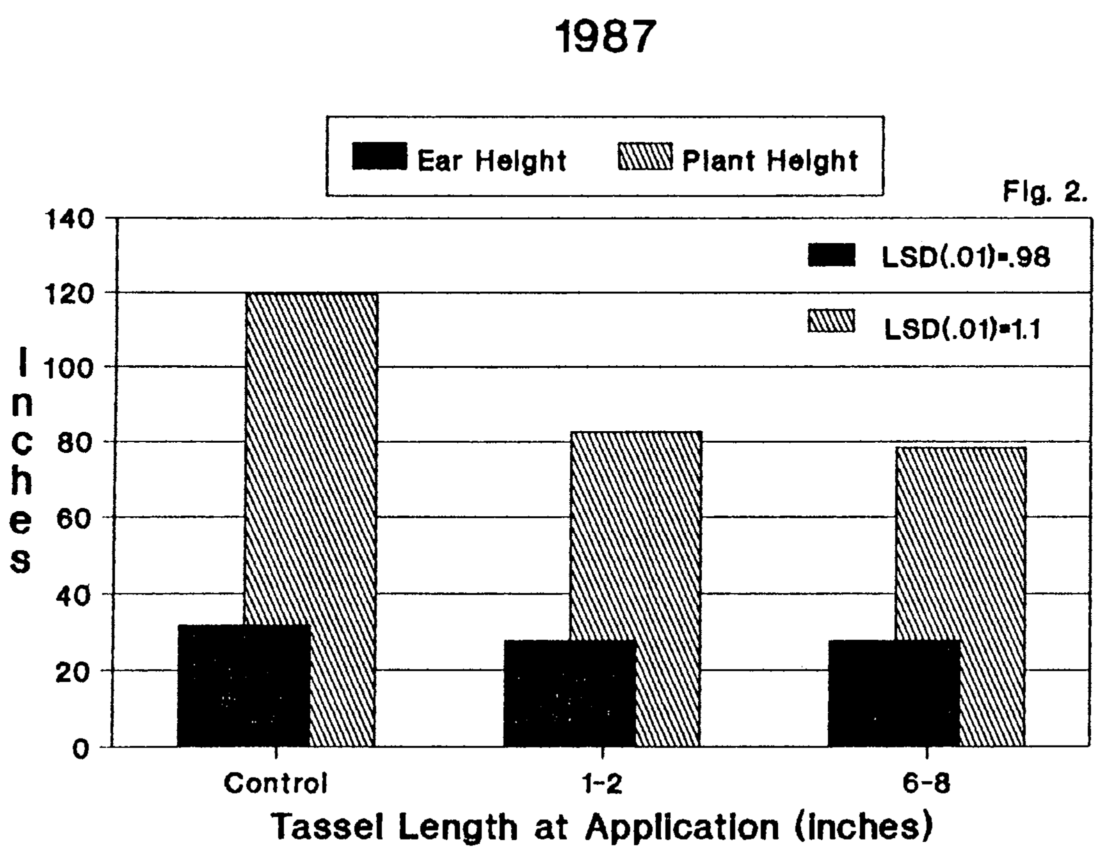
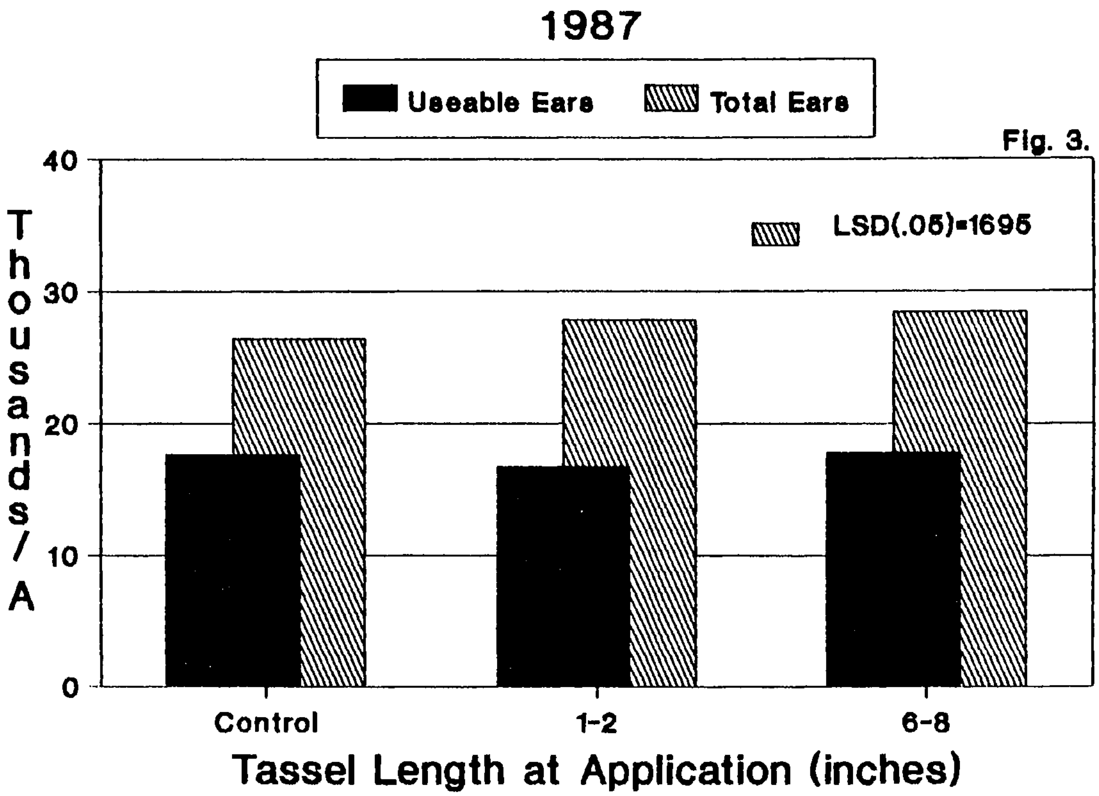
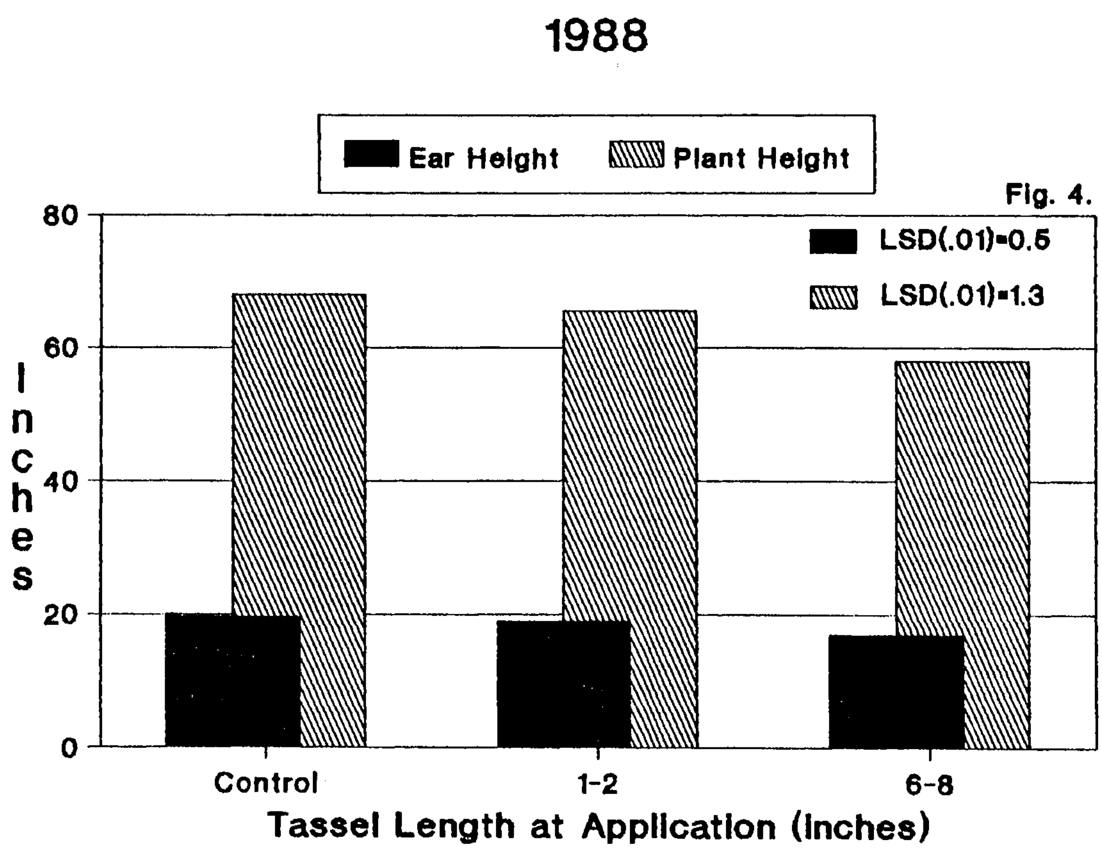
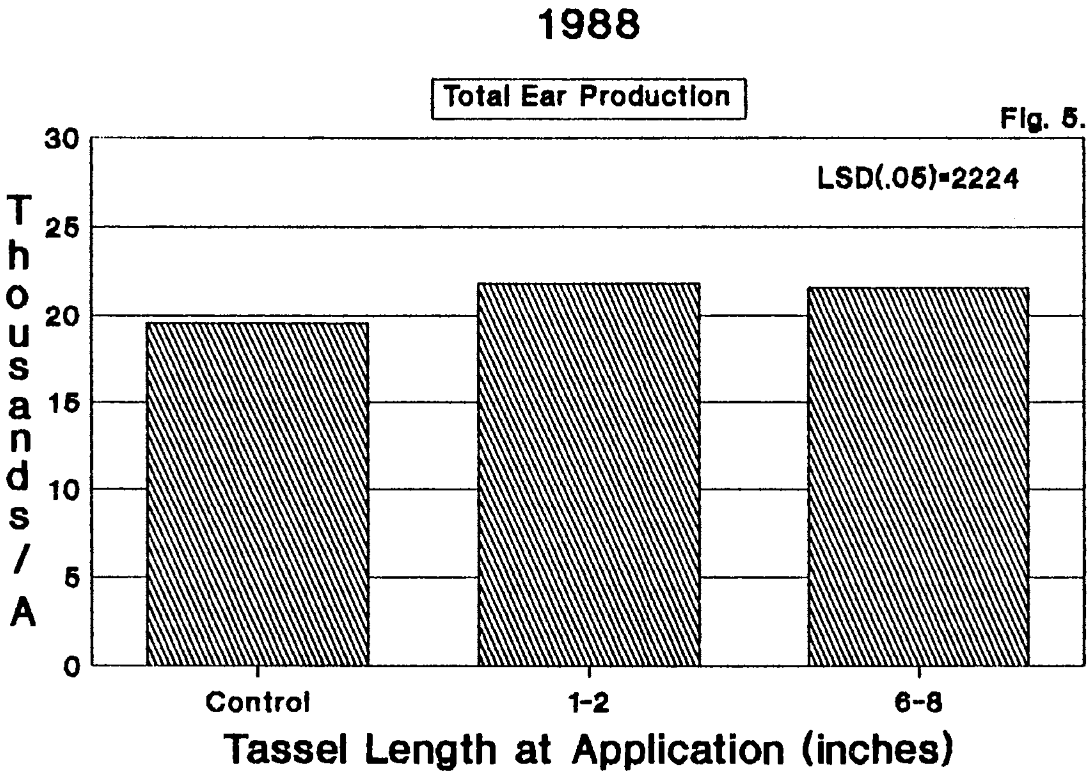

1987
Lodge Severity
Fig. 1.
1=upright, 5=flat
LSD(.01)=0.4
Lodge Rating
5
4.5
4
3.5
3
2.5
2
1.5
1
Control
1-2
6-8
Tassel Length at Application (inches)


1987
Ear Height
Plant Height
Fig. 2.
LSD(.01)=.98
LSD(.01)=1.1
Inches
140
120
100
80
60
40
20
0
Control
1-2
6-8
Tassel Length at Application (inches)


1987
Useable Ears
Total Ears
Fig. 3.
LSD(.05)=1695
Thousands/A
0
10
20
30
40
Control
1-2
6-8
Tassel Length at Application (inches)


1988
Ear Height
Plant Height
Fig. 4.
LSD(.01)=0.5
LSD(.01)=1.3
Inches
0
20
40
60
80
Control
1-2
6-8
Tassel Length at Application (inches)



1988
Total Ear Production
Fig. 5.
LSD(.05)=2224
Thousands/A
30
25
20
15
10
5
0
Control
1-2
6-8
Tassel Length at Application (inches)

Table 1. Heat unit accumulation comparison between two years for ten sweet corn cultivars.

Cultivar	Genotype	Heat unit Accumulation[1] 1987	1988
Commander	su	1818	2149
Jubilee	su	1749	1955
Reward	su	1464	1753
Stylepak	su	1792	2063
Miracle	se	1661	1955
Sentry	se	1818	2242
Tendertreat	se	1911	2242
Crisp 'n' Sweet 710	sh_2	1749	1955
Summersweet 8000	sh_2	1792	2149
Sweetie	sh_2	1613	2149

[1] Calculated using a base temperature of 50°F from time of planting.

Table 2. Cultivar x ethephon effects on useable ear production in ten sweet corn cultivars (P = .05).

Cultivar	Control	Tassel length at application (inches) 1 - 2	6 - 8
	Useable Ears (thousands/ha)		
Commander (su)	3.25 (±1.65)	3.82 (±2.65)	3.82 (±2.88)
Jubilee (su)	7.84 (±2.01)	9.18 (±2.86)	8.80 (±1.19)
Reward (su)	11.47 (±0.57)	-------------	5.92 (±2.01)
Stylepak (su)	4.97 (±2.01)	9.18 (±4.69)	6.69 (±0.87)
Sentry (se)	9.56 (±1.44)	1.53 (±1.65)	8.22 (±2.01)
Miracle (se)	7.46 (±4.13)	5.16 (±1.72)	4.78 (±3.73)
Tendertreat (se)	11.86 (±4.15)	12.81 (±3.68)	12.05 (±8.56)
Crisp 'n' Sweet 710 (sh_2)	11.28 (±2.38)	6.69 (±4.03)	8.22 (±2.88)
Summersweet 8000 (sh_2)	6.88 (±2.06)	9.73 (±4.13)	7.46 (±2.50)
Sweetie (sh_2)	8.22 (±1.44)	7.46 (±3.58)	3.63 (±2.32)

Seed production and handling in supersweet (sh2) sweet corn hybrids

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The use of shrunken-2 sweet corn hybrids by the processing industry has been limited due to poor seed quality. This poor seed quality contributes to erratic emergence and low seedling vigor, especially in cold soils. Seed vigor comprises those seed properties which determine the potential for rapid uniform emergence and development of normal seedlings under a wide range of field conditions (AOSA, 1983). The factors that may affect vigor are numerous and include: genetics, conditions at time of seed formation, date of harvest, maturity at harvest, mechanical damage, drying problems, storage temperature, relative humidity and duration, and insects and diseases (Amaral, 1981).

The following study examined maturity at harvest as a means of improving vigor. The seed industry currently harvests seed at 35-45% moisture. While this moisture level may be optimal for mechanical harvesting, seed may not be at a stage of maximum viability. Seedling vigor has been found to be highly dependent on date of harvest or stage of kernel maturity and poor seed quality could result from an untimely harvest (Knittle and Burris, 1976).

In 1987, hybrid seed of "Florida Staysweet" was hand harvested at 9 different moisture levels ranging from 81 to 23%. In 1988, four harvests of hybrids, "Florida Staysweet" and "Crisp N'Sweet 710, were conducted at moisture levels of 70, 60, 50 and 40%. Ears were artificially dried in a forced air dryer at 32C until they reached 10% moisture. Ears were shelled, and seeds were stored (4C, 45% RH) until used for testing.

Standard germination test results in 1987 for "Florida Staysweet" indicate the highest percent germination was obtained for seed harvested between 31 and 63% moisture (Table 1). Results of the modified seedling growth cold test (SGCT) show seed harvested at 57, 44, and 23% moisture had the highest percent germination. However, the percentage of abnormal seedlings was also high (Table 1).

Seed weight of 100 kernels indicated seed harvested between 31-52% moisture would be most vigorous (data not shown). Kernel dry weight is considered an accurate predictor of seedling vigor because it estimates the amount of stored reserves in the kernel that contribute to the vigor of the developing seedling (Knittle and Burris, 1976).

Table 1. Standard germination test and SGCT results for Florida Staysweet, 1987.

Harvest Moisture	Standard germination (%)	Seedling growth cold test Germination (%)	Normal (%)	Abnormal (%)
81	0.04	0	0	0
76	83.5	36.0	8.0	28.0
72	96.5	64.5	13.5	51.0
63	98.5	65.0	22.5	42.5
57	99.5	95.5	55.0	40.5
52	99.5	72.5	29.0	43.5
44	99.5	97.5	43.0	54.5
31	99.0	88.5	46.0	42.5
23	96.0	97.5	39.0	58.5
Significance at 5% level	*	*	*	*

The 1988 results for "Florida Staysweet" show excellent germination in the standard germination test for all harvests (Table 2). SGCT results show the highest percent germination for seed harvested between 40 and 60% moisture. There were no significant differences found in percent normal and abnormal seedlings in the SGCT, and no differences in seed weight (per 100 kernels). "Crisp N'Sweet 710 seed showed a similar trend in the standard germination test. In the SGCT, seed harvested at 50% moisture had the highest percent germination (Table 2). However, the percentage of abnormal seedlings was very high. This occurrence of abnormal seedlings may be indicative of seeds capable of germination but not of continued growth (Isely, 1957). These abnormal seedlings may not be capable of emerging from the soil and may account for the poor stands and erratic emergence reported for sh2 in the field.

In summary, the data indicate that seed harvested between 30 and 55% moisture provide the highest germination percentages. The seed industry currently harvests seed within this recommended range and yet quality is por. Further investigations are needed to examine the drying, shelling, and handling procedures of these seeds to determine how these factors may be contributing to reduced vigor in shrunken-2 hybrids.

Table 2. Standard germination test and SGCT result for Florida Staysweet and Crisp N'Sweet 710, 1988.

Harvest Moisture	Standard germination (%)	Seedling growth cold test Germination (%)	Normal (%)	Abnormal (%)
70	F 100	96.5	55.0	41.5
	C 98.0	95.5	20.5	75.0
60	F 100	98.5	54.0	44.5
	C 98.0	96.5	26.5	70.0
50	F 99.5	99.0	58.5	40.5
	C 98.5	99.5	27.5	72.0
40	F 100	100	56.0	44.0
	C 97.0	94.0	30.0	64.0
Significance at 5% level	F NS	*	NS	NS
	C NS	*	*	*

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Grass and Broadleaf Weed Control in Sweet Corn

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Waseca, MN - 1988

A study was conducted to evaluate several combinations of herbicides for weed control in sweet corn. 'Jubilee' sweet corn was planted on May 17, in a clay loam soil, pH 6.4 and organic matter 6.5%, at the Southern Experiment Station, Waseca, MN. The plots were 10 by 30 ft with four rows spaced 30 inches apart and arranged in a randomized complete block with four replications. All herbicide applications were made with a CO_2 pressured bicycle sprayer equipped with 8002 nozzles. Weed control and crop injury were rated on June 30. Sweet corn from the two center rows in each plot was harvested by hand on August 19. Weed populations were low and consisted of foxtail spp. (56%), redroot pigweed (9%), velvetleaf (16%), and common lambsquarters (19%). Application dates, sprayer settings, environmental conditions, and plant sizes are listed below:

Date	May 17	June 9	June 13	June 16	June 20
Treatment	PRE	EPO	PO	PDIR	LPO
Sprayer					
gpa	20	20	20	28	20
psi	30	30	30	32	30
Wind (mph)	15E	5-10E	15-18SW	3-5NE	4-5NE
Temperature (F)					
air	70	51	77	51	71
Relative humidity (%)	33	19	54	36	43
Sky	clear	clear	clear	clear	clear
Sweet corn					
leaf no.	--	3-4	4-5	5-6	5-7
Foxtail spp.					
leaf no.	--	1-3	3-4	5-7	5-7
height(inch)	--	--	--	4-6	--
Redroot pigweed					
leaf no.	--	--	--	4-5	--
height(inch)	--	--	--	2-4	--

Weed control, corn injury, and yield are summarized in the accompanying table. All herbicides provided excellent control of broadleaf weeds. Combinations of Basagran and Aatrex plus Lasso, Tough plus Aatrex and Lasso, and EL-177 plus Lasso, and Laddok gave poor control of foxtail spp. Gramoxone Super and Roundup, post/directed applications, and Harmony gave excellent overall weed control, but injured the sweet corn.

Table. Weed control, crop injury and yield of sweet corn (Hertz and Fritz)

Treatment	Rate	Method of appl.	Weed control [x]Grft[y]	Rrpw	Vele	Colq	Corn inj	Corn yield Husk	Cut
		(lb/A)	------ %			------	(%)	(T/A)	(T/A)
Harmony+COC	0.008	PO	83	100	100	100	60	1.1	0.7
+Lasso	2.0	PRE							
Laddok+28%N	0.43+0.4	EPO	73	100	98	100	0	2.1	1.4
+Lasso	2.0	PRE							
Laddok+Dash[z]	0.43+0.4	EPO	85	95	88	100	0	1.7	1.2
+Lasso	2.0	PRE							
Laddok+COC	0.43+0.4	EPO	85	100	100	100	0	2.5	1.8
+Lasso	2.0	PRE							
Laddok+28%N	0.54+0.5	EPO	85	100	100	100	0	2.5	1.7
+Lasso+Dash	2.0	PRE							
Laddok+COC	0.54+0.5	EPO	85	100	100	100	0	2.4	1.8
+Lasso	2.0	PRE							
Laddok	0.54+0.5	EPO	93	100	98	100	0	2.3	1.6
+Lasso	2.0	PRE							
Buctril+Lasso	0.38+2.0	EPO+PRE	80	95	95	100	0	2.1	1.5
Tough+Aatrex	0.45+0.6	PO	83	100	95	100	10	2.4	1.7
+Lasso	2.5	PRE							
Tough+Aatrex	0.45+0.6	LPO	75	98	90	100	5	2.0	1.4
+Lasso	2.5	PRE							
Tough+Aatrex	0.6+0.6	LPO	78	100	100	100	0	2.4	1.7
+Lasso	2.5	PRE							
EL-177+Lasso	0.25+1.0	PRE	80	95	83	93	5	1.1	0.7
+Aatrex	1.0	PRE							
EL-177+Lasso	0.25+2.0	PRE	75	98	100	95	5	2.0	1.4
+Aatrex	1.25	PRE							
EL-177+Aatrex	0.25+1.0	PRE	65	100	93	95	0	1.3	0.9
+Bladex	1.0	PRE							
EL-177+Aatrex	0.3+1.25	PRE	75	93	85	98	5	1.6	1.2
GramoxoneSuper	0.21	PDIR	90	100	95	100	25	1.0	0.7
GramoxoneSuper	0.21	PDIR	95	100	100	100	18	2.1	1.6
+Aatrex	0.25	PDIR							
GramoxoneSuper	0.21	PDIR	95	100	100	100	23	1.6	1.3
+Aatrex	0.5	PDIR							
GramoxoneSuper	0.21	PDIR	98	100	98	100	15	2.1	1.6
+Aatrex	1.0	PDIR							
GramoxoneSuper	0.41	PDIR	98	100	100	100	30	2.5	1.8
Tandem	0.75	LPO	85	100	95	100	5	2.8	2.0
+Aatrex	1.5	LPO							
Tandem	1.5	LPO	90	100	100	100	10	2.6	1.9
+Aatrex	1.5	LPO							
Roundup	0.18	PDIR	80	100	100	100	23	2.6	2.1
Roundup	0.36	PDIR	98	100	100	98	23	2.6	1.8
Roundup+Dacamine	0.18+0.25	PDIR	85	100	100	100	5	2.7	1.8
Weeded	--	--	100	100	100	100	0	2.6	1.8
Untreated	--	--	0	0	0	0	0	2.0	1.4
LSD(0.05)			17	5	5	14	11	--	--

[z]Additives: COC = Crop oil concentrate (BASF); 1 qt/A; Dash = Crop oil concentrate (BASF), 1 qt/A; 28% N = ammonium sulfate solution, 1 gal/A; N =1 gal/A; X-77 = non-ionic surfactant, 0.25%.
[y]Weeds: Grft = green foxtail; Rrpw = redroot pigweed; Vele = velvetleaf; and Colq = common lambsquarters.
[x]Application: PRE = preemergence; PO = postemergence; EPO = early postemergence; PDIR = postemergence directed; and LO = late postemergence.

The Pea Disease Nursery at Waseca, MN

Dave Davis, Frank Pfleger and Vince Fritz

Departments of Horticultural Science and Plant Pathology

Evaluations in 1988

Both replicated (46 entries) and observational (39 entries) trials were evaluated for reaction to common root rot (Aphanomyces euteiches). In the replicated trial three replications (A, B, C) were placed in the disease nursery and 3 (D, E, F) were placed on a clean site about 50 feet away. Results from the diseased site are summarized in the table below. Entries were scored on a 0 to 5 scale for disease, based on appearance of the above ground plant symptoms, on June 15 and on July 2. The points on the scale are defined at the bottom of the table.

Table 1. Pea Root Rot Evaluations, University of Minnesota, Southern Experiment Station
Waseca, 1988

Four-Row Replicated Entries

Field Number	Variety or Line Seed Source	6/15/88			7/2/88		
		A	B	C	A	B	C
1	87 MF 1	1.5	1.5	1.0	2	1	1.5
2	87 MF 2	1.0	1.0	1.0	2.5	1.5	1
3	87 MF 3	1.0	1.0	1.0	1.5	2.0	2.0
4	87 MF 4	1.5	2.5	1.5	3	3	2.5
5	87 MF 5	1.5	3.0	2.5	3	4	3
6	87 MF 6	1.5	1.5	2.0	1.5	1.5	1.5

Field Number	Variety or Line Seed Source	6/15/88			7/2/88		
		A	B	C	A	B	C
7	87 MF 7	1.0	1.5	2.0	2	1.5	2
8	87 MF 10	1.5	2.0	2.5	1.5	2.5	2.5
9	87 MF 12	1.5	2.0	1.5	2.5	2	3
10	87 MF 15	1.0	1.5	2.0	1.5	2	2
11	87 MF 19	2.0	2.0	2.0	3	3.5	2.5
12	87 MF 21	1.5	2.0	4.5	2.5	3.5	3
13	87 MF 24	1.0	2.0	3.0	2	3	3.5
14	87 MF 25	2.5	1.5	2.0	2	2	2.5
15	87 MF 51	2.0	2.5	2.0	3	3	3
16	87 MF 57	1.0	1.0	1.5	1.5	1.5	2
17	87 MF 77	2.5	2.0	2.5	3	2.5	3
18	87 MF 78	1.0	2.5	2.5	3.5	2	2.5
19	87 MF 79	1.5	2.0	2.5	4	3	3
20	87 MF 81	1.0	1.0	1.5	2.5	2.5	2.5
21	87 MF 85	1.0	1.5	1.5	1.5	1.5	1.5
22	87 MF 88	3.0	2.5	2.0	2.5	3	2
23	87 MF 91	3.0	1.5	1.5	1.5	2	2
24	87 MF 93	2.0	2.5	2.0	1.5	2	1.5
25	87 MF 96	1.0	3.0	1.5	1	2	1.5

Field Number	Variety or Line Seed Source	6/15/88			7/2/88		
		A	B	C	A	B	C
26	87 MF 98	2.0	2.5	2.5	2	1.5	1.5
27	87 MF 102	3.5	4.5	3.5			
28	86 MF 16	1.5	2.0	2.0	1.5	2.5	2
29	USDA 792022	1.5	2.0	1.5	1.5	1.5	1.5
30	A 1	2.5	1.5	2.0	3.5	1.5	2
31	A 2	2.5	4.0	3.5	2.5	4.0	3.5
32	A 3	3.0	3.0	2.0	4	4.5	3
33	A 4	3.0	3.0	2.0	4	4	4
34	A 5	3.0	2.0	3.0	3.5	2.5	3.5
35	A 6	4.0	2.0	2.0	4.5	3	4
36	A 7	1.5	2.0	1.5	1.5	3	3.5
37	A 8	2.5	3.0	1.5	4.5	4	3
38	A 9	5.0	4.5	2.5	5	5	4
39	A 10	4.0	2.0	1.5	2.5	1.5	1.5
40	A 11	2.5	3.0	2.0	2.5	3	3
41	Minn. 108	2.0	2.0	1.5	2	2.5	3
42	B 1	5.0	5.0		5	5	--
43	B 2	4.5	3.5	2.0	4.5	4.5	2.5
44	C 1	2.0	1.5	1.5	2.5	1.5	1

Field Number	Variety or Line Seed Source	6/15/88			7/2/88		
		A	B	C	A	B	C
45	C 2	1.0	1.0		1.5	1.5	--
46	8221	3.0	2.5	33.0	3	3.5	3
	Single-Row Entries						
61	87 MF 76	1.5	2.0	1.5*	2.5	23	
62	87 MF 92	1.5	2.0	1.5*	3	3	1.5
63	86 MF 86	3.0	2.5	2.0*	4.5	3	
64	86 MF 93	3.0	1.5*	1.5*	3	2.5	3
65	87 MF 29	2.0	1.0*	1.0*	3	2	2.5
66	87 MF 30	2.0	2.0*		5	3	4
67	97 MF 75	2.0	1.0*	1.0*	2.5	2	1.5
68	86 MF 72 sm	1.5	1.0*		3.5	2	
69	86 MF 72 wr	1.5	1.5*		2	3	
70	D 1	4.0	1.5*		5	3	
71	D 2	3.0	1.5*			2.5	
72	D 3	2.5	2.5*			2.5	
73	D 4	3.0	1.5			3	
74	USDA 87-29	1.0			2.5		
75	USDA 87-31	2.0			3		
76	USDA 87-48	2.0					

Field Number	Variety or Line Seed Source	6/15/88			7/2/88		
		A	B	C	A	B	C
77	USDA 87-196	1.5			1.5		
78	USDA 87-772	2.0			3		
79	USDA 87-2001	1.0			1.5		
80	USDA 87-2009	1.5			1		
81	USDA 87-2276	2.0			3		
82	USDA 87-2380	2.0			2		
83	USDA 87-2384	2.0			2.5		
84	USDA 87-2388	2.0			3.5		
85	USDA 87-2389	1.5			1		
86	USDA 87-2404	2.0			3		
87	USDA 87-2432	2.0			3		
88	USDA 87-2471	1.5			1.5		
89	USDA 87-6021	1.5			2.5		
90	PI 180693	1.0*			1		
91	PI 176721	2.0			1.5		
92	USDA 79-2022	1.0			1.5		
93	Minn. 108	1.5			2		
106	Sunfire	1.5			2		
107	M 163	1.5*			5		

Field Number	Variety or Line Seed Source	6/15/88			7/2/88		
		A	B	C	A	B	C
108	Early Columbia	1.0*			1.5		
109	ES 41	1.5*			4		
110	M 163	4.5			5		
111	8615	1.5			3		
112	Alsweet II	2.5			5		

* border effect (east 3 rows of field--most likely less root rot)

Root Rot Scale:
0 = no damage
1 = 1-25% damage (1-25% of plants dead or showing symptoms)
2 = 26-50%" etc. 4 = 76-100% damage (etc.)
3 = 51-75%" etc. 5 = all dead

History of the Minnesota Root Rot Nursery

A root rot field nursery has been used at the University of Minnesota since the 1940s. The original nursery established on the campus at St. Paul was abandoned when the present nursery was established near Waseca, at the Southern Experiment Station, in 1976.

During the several decades over which it was used, large numbers of commercial pea varieties, breeding lines from various programs, and foreign introductions were screened in the St. Paul nursery by Dr. Tom King and his graduate students. Gradually, a form of recurrent selection took place as the more resistant or tolerant entries were crossed with one another and the subsequent progenies were evaluated in the nursery and the cycle repeated by new crosses of the best with the best. A number of breeding lines were provided to industry and public pea breeders in the 1950s and 1960s. Most of these were relatively viny, "wild" types, although some were white flowered. The most recent releases tracing back to the nursery at St. Paul were Minnesota 108 (in 1976) and Minnesota 494 A11 (in 1981). Both had been further selected via greenhouse and laboratory tests at St. Paul.

The nursery at Waseca, in the pea growing area, was established in 1976 on a clean soil site fairly typical of that used for peas. Aphanomyces euteiches inoculum produced in the laboratory from strains isolated from diseased pea fields in Minnesota and Wisconsin was spread on and disked into the soil at the new site. Thereafter, at least two crops each year of heavily sown peas were grown and plowed down while still lush and green. This continued for several years until a high potential for disease was established. Since that time, this nursery, approximately 150 feet by 160 feet, has been used each year for the screening of pea varieties and breeding material. In some years when the disease severity was extremely high we planted an oats or wheat cover crop on one-half of the nursery the following year.

Until 1988, test entries were planted in single row, 30-inch-row plots replicated 3 to 4 times. Beginning in 1988, the replicated test entries were planted in 4-row beds (not raised) with a 20-inch row spacing. Row length generally has been 18 to 20 feet each year.

Planting generally has been scheduled for the period May 5 to 15, intentionally late as the environmental conditions generally are more favorable for disease development, especially with the warmer weather associated with a later harvest date. Following stand establishment, we have irrigated heavily, keeping the soil wet for a week or so, to encourage root rot infection and disease development. Weed control has been by Randox and Caparol since these do not seem to be active in suppressing root rot and we wanted to get a true response picture from the entries. Those herbicides were supplemented by hand weeding. However, we have had serious weed problems and intend to switch to other herbicides for the 1989 season.

Pea material tested in the nursery at Waseca primarily has been Minnesota breeding material, with a limited number of entries each year from the USDA, Canners Seed Corporation, Green Giant/Pillsbury and Rogers Brothers, plus 2 or 3 from other firms.

Meanwhile, at St. Paul, since the early 1980s, pea disease resistance breeding has been decreased considerably due to shortage of personnel and funding, and also as more effort was diverted to sweet corn research. The main pea breeding effort recently has been the Waseca nursery, a modest undertaking.

Annual Weed Control in Canning Peas

Leonard B. Hertz and V. Fritz
Southern Experiment Station
Waseca, MN 1988

Hertz, Leonard B. and V. Fritz. This study was designed to evaluate several herbicides and herbicide combinations for control of annual weeds in canning peas. Pea seed, 'Canners 9901', was planted May 16, 1988 into a clay loam soil, pH 6.4 and 6.5% organic matter at the Southern Experiment Station, Waseca, MN. The plots were 7 by 30 ft., arranged in a randomized complete block, each with four replications. All herbicides were applied with a bicycle mounted CO_2 pressure sprayer. A visual rating of weed control was made on June 30. Weed populations were moderate and consisted of foxtail spp. (40%), redroot pigweed (55%), and velvetleaf (5%). Application dates, sprayer setting, environmental conditions, and plant sizes are listed below:

Date	May 16	May 16	June 7	June 13
Treatment	PPI	PRE	EPO	PO
Sprayer				
gpa	20	20	20	20
psi	30	30	30	30
Temperature (F)				
air	63	65	72	85
Wind (mph)	5-10 NW	5-10 NW	3-5 SW	15 SW
Sky	cloudy	cloudy	clear	clear
Relative humidity (%)	80	33	24	54
Pea				
leaf no.	--	--	4	7
Redroot pigweed				
leaf no.	--	--	1-3	4-6
Foxtail spp.				
leaf no.	--	--	2-3	3-6

Results of this study are summarized in the accompanying table. Weather conditions were poor for herbicide performance, and also hot, dry weather caused low pea yields and high Tenderometer (TDR) readings. Several herbicides performed well, including Treflan, Command, Pursuit, and Basagran. Basagran and COC plus Cantrol and Basagran plus COC produced excessive crop injury.

Table. Annual weed control in canning peas. (Hertz and Fritz).

Treatment	Rate	Method of appl.[V]	Weed control Grft[W]	Rrpw	Vele	T D R at harvest[X]	Plant stand	Yield
	(lb/A)		- - - -(%) - - -			(%)		(T/A)
Command+	0.5	PPI	95	100	95	137	100	0.65
Treflan	0.5	PPI						
Command+	0.75	PPI	93	100	100	131	98	0.66
Treflan	0.5	PPI						
Command+	0.5	PPI	100	100	93	125	100	0.67
Sonalan	0.5	PPI						
Command+	0.5	PPI	93	100	95	138	93	0.63
Surflan	0.5	PPI						
Command+	0.75	PPI	100	100	100	137	100	0.67
Surflan	0.5	PPI						
Sonalan	1.0	PPI	100	100	85	130	95	0.66
Treflan	0.75	PPI	98	100	85	133	90	0.69
Basagran+28%N[Z]	0.5	EPO	93	100	100	127	100	0.64
+Treflan	0.75	PPI						
Basagran+28%N	0.5	EPO	95	100	100	127	95	0.59
+Treflan	0.75	PPI						
Basagran+Dash[Z]	0.5	EPO	95	100	100	129	95	0.48
+Trefan	0.75	PPI						
Basagran+COC[Z]	0.5	EPO	93	100	100	135	88	0.54
+Treflan	0.75	PPI						
Cinch+	1.5	PRE	100	100	88	128	100	0.68
Treflan+	0.75	PPI						
Assure	0.125	PO						
Pursuit	0.063	EPO	85	100	93	142	100	0.71
Pursuit	0.094	EPO	90	100	98	142	100	0.66
Pursuit+	0.063	PPI	93	100	90	140	100	0.62
Treflan	0.5	PPI						
Pursuit+	0.063	PPI	98	100	90	135	98	0.62
Prowl	0.75	PPI						
Pursuit+	0.063	PRE	80	98	90	128	100	0.61
Dual	2.0	PRE						
Basagran+COC	0.5	EPO	90	100	98	70	93	0.23
+Poast	0.187	EPO						
+Can-trol	0.25	EPO						
Weeded	--	--	100	100	100	134	100	0.56
Untreated	--	--	0	0	0	129	100	0.70
LSD(0.05)	--	--	8.1	1.6	7.4	--	8.5	--

[V]Application: PPI = preplant incorporated; EPO = early postemergence; PO = postemergence
[W]Grft = green foxtail; Rrpw = redroot pigweed; and Vele = velvetleaf
xTDR: Tenderometer
[Z]Additive: 28% nitrogen, 2 qt/A; Dash = BASF adjuvant, 1 qt/A; COC = crop oil concentrate (BASF), 1 qt/A.

Effects of Various Onion Populations on Components of Yield

Vincent Fritz, Alicia Borowski, James Hebel and Patricia Hung
Southern Experiment Station
Waseca, MN 56093

Significance

Plant populations which maximize production efficiency per unit area is a primary goal of any commercially grown crop. Plant populations currently used in commercial onion production in Minnesota vary from farm to farm. Growers in southeast Minnesota are uncertain if production efficiency can be improved in their farm operation. This study was initiated in 1988 to evaluate relative yield performance under different plant populations.

Materials and Methods

Seed of 'Trapps' were band planted in dual rows (2.5" wide) on April 25 on raised beds (35" wide). The necessary fertilizer and pesticide applications for maximum growth were applied prior to planting and throughout the growing season.

The experimental design was a completely randomized block design with 4 replications. Individual plots were comprised of 8 raised beds, 25 feet long. Just prior to harvest, stand counts were taken on 20 feet of row in each plot. At harvest, onions were collected from 10 feet of the inner two beds for yield determination.

Results and Discussion

An increase of seeding rate from 8-9 to 11-12/ft. resulted in almost a doubling of boiler production (table 1). A seeding rate of 14-15/ft. increased U.S. #1 yields although, due to large variation within the experiment, the increase was considered not significant. The study will continue in 1989.

Table 1. The effect of different plant populations on yield components of onions.

1988 ONION POPULATION COMPARISON

Cooperator: Greg Steginga, Hollandale, MN

Seeding Rate seeds/ft.	Stand/A	Yield/A tons	cwt	bags	Boilers lb./A	Culls lb./A
8 - 9	169,524	17.0	340	680	420	620
11 - 12	202,009	17.1	342	684	823	185
14 - 15	252,792	20.0	400	800	1010	463
Significant (95%) Difference:		n.s.	n.s.	n.s.	385	323

Variety: Trapps   Planted: 4/25   Harvested: 9/9

** Double Broadcasted Rows on Raised Beds Using a Nibex 500 Seeder

The Use of Ethephon for Improved Color in Red Potatoes

Vincent Fritz, Alicia Borowski, Patricia Hung and James Hebel
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Waseca, MN 56093

Significance

A deep, red, uniform color in table stock potatoes has been a major marketing concern. Traditionally, growers have foliarly applied 2,4-D in an attempt to improve color; however, results have not been favorable. The production of anthocyanin, the primary pigment responsible for the red color, is mediated by ethylene (a plant growth regulator) and is naturally produced within the plant. A study which began in 1986 to study the effects of foliar applied ethephon (which results in the release of ethylene) on potato color was continued in 1988.

Materials and Methods

Concentrations of ethephon and 2,4-D are represented in fig. 1. All treatments were foliarly applied at the onset of tuberization. The second application of split treatments were applied 10 days after the initial application. All treatments were applied with surfactant (X-77) at .05% using a $CO2$ bicycle sprayer equipped with 8002 flat fan nozzles and calibrated to deliver 40 gal/A at 40 psi. The variety used for the study was "Norland".

The experimental design was a randomized complete block with 4 replications and each plot was comprised of 4 rows, 20 feet long. At harvest, tubers from twenty feet of the inner two rows from each plant were collected for yield and color determinations. Pigment extraction was obtained by soaking 10 periderm (skin) samples (using a #14 cork borer) in 95% ethanol acidified with 1.5 N HCl for 24 hours. Samples were then centrifuged for 10 minutes, the supernatant collected for color intensity using a spectrophotometer at a wavelength of 535. Color determination was repeated with treated tubers from storage 3 months later.

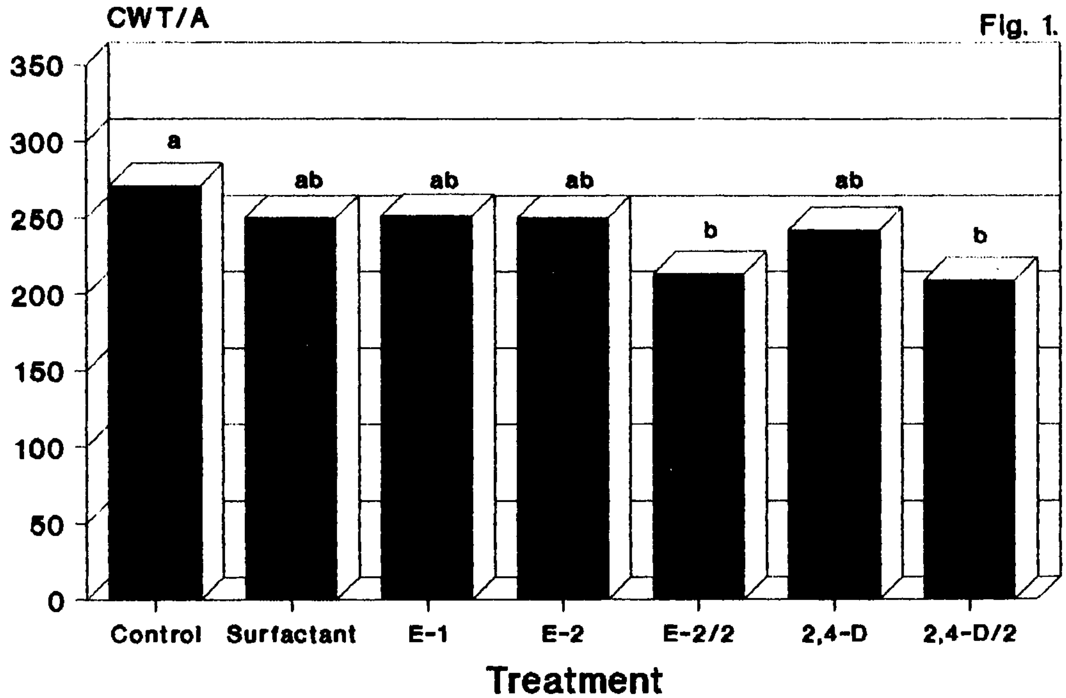
Results and Discussion

The split application of foliar applied ethephon or 2,4-D significantly reduced U.S. #1 yield compared to the control (non-treated) (fig. 1). These results are consistent with 1987 data. Color intensity determinations suggested that 2,4-D, when split applied, resulted in a slight increase in color intensity. However, this was not readily apparent from simple observations (fig. 2). As the % light transmittance increases, the color intensity decreases. Samples taken from tubers on December 20 indicated that during storage, color intensity is gradually lost. An additional sample will be tested for color in March.

Summary

The use of ethephon or 2,4-D for improved color in red potatoes is not recommended. Periderm color intensity was not significantly enhanced from plants treated with ethephon or 2,4-D; however, significant reductions in U.S. #1 yields resulted.

1988 ETHEPHON EVALUATION FOR IMPROVED COLOR IN RED POTATOES



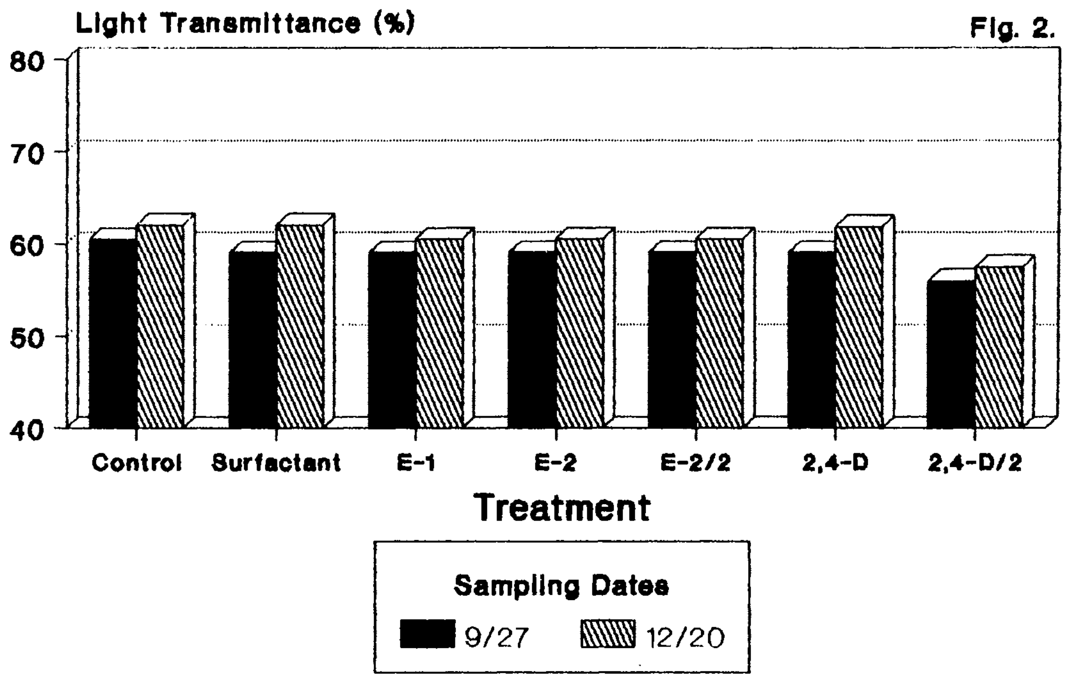
Cooperator: Greg Steginga, Hollandale,MN

Ethrel
- E-1 = .14 oz/gal
- E-2 = .30 oz/gal
- E-2/2 = .30 oz/gal (split)

2,4-D
- 2,4-D = 1 oz/acre
- 2,4-D/2 = 2 oz/acre (split)

1988 ETHEPHON EVALUATION
PIGMENTATION DETERMINATIONS

Fig. 2.



SOUTHERN EXPERIMENT STATION
WASECA, MINNESOTA

WEATHER DATA - 1988

Month	Period	Precipitation 1988	Precipitation Normal[1/]	Avg. Air Temp. 1988	Avg. Air Temp. Normal[1/]	Growing Degree Days 1988	Growing Degree Days Normal[1/]
		---- inches ----		------ °F -----			
January	1-31	2.44	0.84	7.0	10.0		
February	1-29	0.36	0.99	10.9	16.4		
March	1-31	1.34	1.99	33.0	27.6		
April	1-30	2.43	2.64	44.6	44.7		
May	1-10	1.62		62.6		138.0	
	11-20	.10		61.1		130.5	
	21-31	.27		70.9		211.5	
	Total	1.99	3.76	64.8	57.7	480.0	334
June	1-10	0.00		72.2		220.0	
	11-20	0.63		74.3		224.5	
	20-30	0.70		75.1		223.5	
	Total	1.35	4.48	73.9	67.1	668.0	518
July	1-10	0.23		74.8		230.0	
	11-20	0.19		74.3		225.5	
	21-31	0.19		74.5		261.5	
	Total	0.61	4.02	74.5	71.2	717.0	641
August	1-10	3.44		77.2		243.5	
	11-20	0.27		78.2		259.0	
	21-31	0.61		64.0		168.5	
	Total	4.32	3.99	73.1	68.8	671.0	579
September	1-30	5.34	3.36	62.1	59.8	412.5	311
October	1-31	0.32	2.08	43.0	48.9	18.5	38
November	1-30	3.98	1.43	32.4	32.5		
December	1-31	0.74	1.02	18.9	18.0		
Year	Jan-Dec	25.22	30.60	45.0	43.6	2970.0[2/]	2421
Growing Season	May-Sep	13.61	19.61	69.7	64.9	2948.5	2383

1/ 30-year normal from 1951 - 1980.
2/ 50 to 86°F base, May 1 until first fall frost.

Notes:
1) Highest temperature on August 1 -- 103°.
2) Highest 24-hour precipitation on August 3 -- 1.81".
3) Last spring frost -- April 28.
4) First fall frost -- October 3.
5) Warmest growing season in 74 years of records.
6) Driest year since 1976.
7) Driest May-July period in 74 years of records.

NITROGEN APPLICATION METHODS FOR IMPROVED EFFICIENCY IN RIDGE-PLANT TILLAGE SYSTEMS

Gyles W. Randall and Bert Bock

Conservation tillage systems (>30% residue cover) have been shown to effectively reduce erosion and runoff while increasing water storage and maintaining crop yields. Ridge-plant tillage, a strip tillage system for row crop production, is becoming quite popular throughout much of the northern Corn Belt. Nitrogen placement methods for corn grown in this system are somewhat limited because of the absence of primary and secondary tillage -- only the shaving of the ridge at planting or the building of the ridge at cultivation. Consequently, many farmers apply some of their N as UAN solution with a herbicide in a strip over the row at planting. The remainder of the N is either injected preplant as AA or applied sidedress as AA or UAN.

Because of the need for improved N efficiency in a ridge-plant system, the objectives for this study are to:

1. determine the effect of placement and time of N application on yield and N utilization by corn in continuous corn and corn-soybean sequences,

2. evaluate band vs broadcast and split vs single applications of N for improved N efficiency.

3. evaluate the point injector applicator as a feasible technique for precise placement of UAN solutions, and

4. monitor soil NO_3 levels before, during, and after the cropping season as affected by the N treatments.

EXPERIMENTAL PROCEDURES

Twelve N treatments were chosen to provide a N response curve and to compare various times and methods of N application (Table 1). The optimum rate chosen was 150 and 100 lb N/A for continuous corn and corn after soybeans, respectively. Band and broadcast applications of UAN were surface-applied with a motorized bicycle sprayer equipped with CO_2 cylinders. Nozzles (8006) were spaced 15" apart for the broadcast treatment. The band treatments (B-R) were applied in 6 to 7" wide strips with nozzles (8006E) spaced at 30". Anhydrous ammonia was injected about 7" deep. The point-injected treatments were injected 4 to 5" deep and were either placed 2 to 3" to the side of the planted row on the ridge (PINJ-R) or midway between the rows in the valley (PINJ-V). Sidedress applications were made at the 14-leaf stage with the point-injector wheels attached to a Hagie Hi-Boy. None of the sidedress operations damaged the corn plants.

A list of experimental procedures used, dates of application, and dates of specific plant phenology is given in Table 2. Both sites are high in P and K fertility. Consequently, neither broadcast nor starter fertilizers were applied. The Webster soil at the continuous corn site grades towards a Canisteo (high pH variant of the Webster). The site where corn followed soybeans was a Nicollet cl and has a lower pH. Tile lines spaced at 75' intervals run perpendicular to the plots at both sites.

Table 1. Nitrogen treatments applied to continuous corn and corn following soybeans in 1988.

Trt. No.	N Rate: Previous crop Corn[1/]	N Rate: Previous crop Soybeans[2/]	N Source	Application Time[3/]	Application Method[4/]
	----- lb N/A -----				
1	0	0	CHECK	---	
2	150	100	AA	PP	INJ-V
3	100	60	UAN	PE	B-R
4	150	100	UAN	PE	B-R
5	200	140	UAN	PE	B-R
6	150	100	UAN	PE	Bdct
7	150	100	UAN	PE	PINJ-R
8	150	100	UAN	PE	PINJ-V
9	60/90	40/60	UAN/AA	PE/SD 8-lf	B-R/INJ-V
10	60/90	40/60	UAN/UAN	PE/SD 8-lf	B-R/PINJ-V
11	60/90	40/60	UAN/UAN	PE/SD 14-lf	B-R/PINJ-V
12	60/60	40/40	UAN/UAN	PE/SD 14-lf	B-R/PINJ-V

1/ 60/90 = 40% preemergence/60% sidedress
60/60 = 50% preemergence/50% sidedress

2/ 40/60 = 40% preemergence/60% sidedress
40/40 = 50% preemergence/50% sidedress

3/ PE/SD 8-lf = preemergence/sidedress 8-leaf stage
PE/SD 14-lf = preemergence/sidedress 14-leaf stage

4/ INJ-V = anhydrous ammonia injected in valley; B-R = UAN band sprayed on ridge; Bdct = UAN broadcast sprayed; PINJ-R = UAN point injected in ridge; PINJ-V = UAN point injected in valley.

Similar planting date, planting rate, hybrid and N application times were used at both sites. The sidedress treatment at the 14-leaf stage was applied approximately 2 weeks prior to 50% silking and 3 weeks before the blister (BL) stage for the continuous corn study and 1 week and 3 weeks, respectively, for the corn rollowing soybeans. The continuous corn silked later because of additional stress due to a shortage of soil moisture with this crop sequence.

Weather conditions during the 1988 growing season were extremely hot and dry. This stress limited crop yields substantially. Air temperature averaged 4.8°F above normal during the growing season -- the warmest on record (table 3). For the May through July period, temperatures averaged 71.1° (5.8°F above normal) -- the second highest in 74 years of weather records. Temperatures exceeded 86 and 90° in 57 and 42 days, respectively, during the growing season. Rainfall during the May through July period (3.95") was the lowest on record. Fortunately, rainfall during August and September was 2.3" above normal. This assisted late-season crop development greatly. Soil moisture levels dropped from 9.89" of available water in the 5-foot profile in early April (90% of a full profile) to 1.97" in mid-August (18%) -- the lowest on record (Table 4). Leaching did not occur during the growing season. September and November rains recharged the profile up to 7.41" by November 21 and may have also leached some N. Harvest conditions were excellent in October with only .32" of rain. Highest daily temperature and rainfall occurred on August 1 (103°) and August 3 (1.81"), respectively. The long growing season running from the last spring frost (April 28) until the first fall frost (October 3) was also marked by record solar radiation levels and growing degree day accumulation 23% above normal.

Table 2. Experimental procedures used in the point injector study at Waseca in 1988.

	Previous Crop	
Variable	Corn	Soybeans
Soil Type	Webster cl	Nicollet cl
Soil pH	7.4 (7.0 - 7.9)	5.7
Soil B&K P_1 (lb/A)	41 VH	56 VH
Soil Exch. K (lb/A)	283 H	333 VH
Soil OM	H	M
No. of replications	5	5
Planting date	May 5	May 4
Planting rate (plants/A)	30400	30400
Hybrid	Pioneer 3737	Pioneer 3737
Row width	30"	30"
P&K fertilizer used	None	None
Herbicide	Lasso (3½ lb/A) + Bladex (3 lb/A)	Lasso (3½ lb/A) + Bladex (3 lb/A)
Herbicide applc'n date	May 11	May 11
Insecticide	Counter (1 lb ai/A)	None
N Application dates:		
Preemergence - AA	May 3	May 3
Preemergence - UAN	May 12	May 12
8-leaf	June 9	June 9
14-leaf	July 5	July 5
50% silk date	July 18	July 12
Blister stage date	July 28	July 25
Physiological maturity date	Sept 8	Sept 8
Harvest date (grain)	Oct 3	Oct 3

Surface residue accumulation prior to planting was more than 2X as high following the 1987 corn crop compared to soybeans (Table 5). After planting residue accumulation averaged 26% with continuous corn when measurements were made perpendicular to the row. Measurements made in the 8 to 10" wide band centered on the ridge/row showed 11 and 6% residue cover for the continuous corn and corn following soybeans, respectively. This light amount of residue on the ridge would not be expected to interfere significantly with the band sprayed UAN. On the other hand the 11 to 26% residue cover levels could affect the broadcast treatment. Ridge height prior to planting was satisfactory at both sites. Soil NO_3-N levels in the 0 to 5' profile in early April were considered to be low at the continuous corn site and medium at the soybean site.

Table 3. Precipitation and air temperature averages during the 1988 growing season at Waseca.

Month	Period	Precipitation 1988	Precipitation Normal[1/]	Avg. Air Temp. 1988	Avg. Air Temp. Normal[1/]
		---- inches ----		------ °F ------	
April	1-30	2.43	2.64	44.6	44.7
May	1-10	1.62		62.6	
	11-20	.10		61.1	
	21-31	0.27		70.9	
	Total	1.99	3.76	64.8	57.7
June	1-10	0.00		72.2	
	11-20	0.63		74.3	
	21-30	0.72		75.1	
	Total	1.35	4.48	73.9	67.1
July	1-10	0.23		74.8	
	11-20	0.19		74.3	
	21-31	0.19		74.5	
	Total	0.61	4.02	74.5	71.2
Aug	1-10	3.44		77.2	
	11-20	0.27		78.2	
	21-31	0.61		64.0	
	Total	4.32	3.99	73.1	68.8
Sept	1-30	5.34	3.36	62.1	59.8
Oct	1-31	0.32	2.08	43.0	48.9
Growing season May - Sept		13.61	19.61	69.7	64.9

1/ 30-year Normal from 1951-1980.

Table 4. Soil moisture in a 0-5' profile of a Webster soil planted to corn during 1988.

Date	Soil Depth (inches) 0-12	12-24	24-36	36-48	48-60	0-60	Percent of field capacity
	inches available water						%
Apr 13	1.26	1.52	2.26	3.01	1.85	9.89	90
May 2	1.47	1.33	1.72	2.76	2.49	9.76	88
May 17	1.71	1.26	1.45	2.22	1.66	8.30	75
June 1	1.01	.85	1.20	1.72	1.53	6.32	57
June 16	.66	1.04	1.10	2.00	1.63	6.43	58
July 1	-.15	.39	1.42	2.17	1.47	5.31	48
July 18	-.44	-.17	.54	2.10	1.90	3.93	36
Aug 1	-.59	-.28	.22	1.79	1.51	2.65	24
Aug 16	.26	-.16	-.17	.86	1.18	1.97	18
Sept 2	1.09	-.01	.07	1.16	.97	3.29	30
Sept 9	1.02	.03	-.06	1.07	1.20	3.26	29
Sept 17	.71	.16	.34	1.18	1.60	3.98	36
Sept 26	1.38	1.32	.58	1.93	1.28	6.49	59
Oct 3	1.37	1.48	.61	1.85	1.21	6.51	59
Oct 17	1.31	1.34	.99	1.26	1.60	6.50	59
Nov 2	.91	1.07	.50	1.29	1.28	5.06	46
Nov 21	1.97	1.53	1.25	1.34	1.32	7.41	67

Table 5. Surface residue accumulation, ridge height and NO_3-N content of the 0-5' soil profile prior to planting in 1988.

Previous crop	Surface residues[1/] Before planting	Across plot	Within row	Ridge height	Soil NO_3-N[2/]
	%			cm	lb/A 0-5'
Corn[3/]	57	26	11	9	31
Soybeans	10	11	6	12	81

1/ Before planting = April 18; After planting = May 16.
2/ April 19.
3/ Within the 0-lb N plots of the continuous corn study.

RESULTS AND DISCUSSION

Continuous Corn

Earleaf N concentration, final population and grain moisture

Earleaf (opposite and below the ear) N concentration at silking was increased over the check by all of the N treatments (Table 6). Sidedressing the split application of N at the 14-leaf stage (trts 11 and 12) resulted in somewhat lower leaf N concentrations than either the preemergence (PE) or 8-leaf stage split applications. No difference in N concentration was found between the preemergence band and 8-leaf split applications. Slightly less leaf N was found with the 100-lb treatment compared to the 150-lb N rates of banded UAN. Broadcast UAN application significantly reduced leaf N compared to the band applications. No difference was found between the AA treatment (no. 2) and the band-applied UAN treatment (no. 4). There was no difference in final population. Grain moisture at harvest, an indication of maturity, was reduced slightly by some of the N treatments compared to the check.

Table 6. Plant height, earleaf N concentration, final plant population and grain moisture as influenced by the N treatments for continuous corn in 1988.

Trt. No.	Leaf N concentration	Final population	Grain moisture
	%	ppAx10^{-3}	%
1	1.60	28.6	19.6
2	2.26	28.7	18.0
3	2.35	29.0	18.6
4	2.37	29.1	18.5
5	2.40	28.6	18.3
6	2.06	28.0	18.6
7	2.37	27.0	18.9
8	2.34	28.7	18.7
9	2.39	28.7	18.6
10	2.40	28.3	18.5
11	2.07	28.9	19.0
12	2.19	28.9	19.5
Signif. Level (%):	99	78	95
BLSD (.05) :	0.24		1.1
CV (%) :	8.8	3.7	3.7

Corn yields and grain:stover ratio

Corn yields were significantly affected (P = 95% level) by the N treatments (Table 7). Stover yields at the blister stage (BL) were increased significantly over the control by all of the N treatments. Silage yields at physiological maturity (PM) increased significantly over the control by all of the N treatments except the broadcast application of UAN and the 14-leaf applications. However, rates and methods of N application did not statistically affect stover and silage yields. Silage yields were highest with the point-injected PE application into the ridge.

Table 7. Corn yields at the blister stage (BL) and at physiological maturity (PM) and grain:stover ratio as influenced by the N treatments for continuous corn in 1988.

Trt. No.	Yield				Grain:stover[1/] ratio
	Stover (BL)	Fodder (PM)	Silage (PM)	Grain (PM)	
	gDM/plant	---- TDM/A -----		bu/A	
1	61	1.02	2.60	50.8	1.18
2	108	1.22	3.58	76.8	1.53
3	99	1.33	3.65	74.0	1.33
4	102	1.26	3.33	79.4	1.50
5	99	1.26	3.33	72.6	1.38
6	102	1.17	3.28	75.2	1.54
7	109	1.39	3.84	73.9	1.27
8	109	1.31	3.58	78.8	1.46
9	102	1.34	3.72	78.3	1.40
10	104	1.24	3.36	79.7	1.60
11	101	1.18	3.25	69.9	1.44
12	95	1.14	3.25	71.1	1.50
Signif. Level (%):	99	92	98	99	59
BLSD (.05) :	11	-	.72	12.4	-
CV (%) :	9.0	14.	14.	12.	18.

[1/] Grain Yield (TDM/A) ÷ Fodder DM Yield

Grain yields were increased over the control by all of the N rates (Table 7). Yields, however, were not significantly different among the N rates or methods of application in this very dry year. Grain:stover ratios were consistently higher for all of the N rates compared to the control but these differences were not statistically significant due to the high CV.

Nitrogen concentrations

Nitrogen concentrations in the stover at BL were increased over the check by all of the N treatments (Table 8). Plant N concentrations from the broadcast treatment were significantly less than those from the PE surface band or injected treatments. When applied at the 150-lb N rate, stover N concentrations were highest with PE band applications of UAN either on or into the ridge or when AA was banded midway between the rows (PE or PE + 14-leaf). Delaying the second portion of the split application until the 14-leaf stage did not result in significantly less N in the stover at BL.

Fodder N concentrations at PM were increased over the control by all of the 150-lb N treatments except the broadcast and PE point injected (valley) treatments at the 150-lb N rate and the PE + 14-lf 120 lb treatment (Table 8).

Table 8. Nitrogen concentrations in the stover at the blister stage and in the stover and grain at physiological maturity as influenced by the N treatments for continuous corn in 1988.

Trt. No.	N Concentration in Stover (BL)	Fodder (PM)	Grain (PM)
	------------	%	------------
1	.97	.55	1.40
2	1.31	.74	1.56
3	1.25	.71	1.53
4	1.37	.72	1.58
5	1.31	.78	1.59
6	1.15	.64	1.51
7	1.36	.81	1.52
8	1.20	.60	1.49
9	1.39	.78	1.54
10	1.30	.68	1.53
11	1.32	.70	1.52
12	1.26	.59	1.50
Signif. Level (%):	99	99	99
BLSD (.05) :	.07	.13	.05
CV (%) :	4.9	14.	2.6

Grain N concentrations were increased significantly over the control by all of the N treatments (Table 8). Highest N concentrations were obtained with the PE surface band and AA treatments.

Nitrogen yield (uptake)

Nitrogen uptake (the product of DM yield times N concentration) in the stover (BL), grain and silage was increased substantially over the check by all N treatments (Table 9). Fodder N uptake was increased significantly by all of the PE treatments banded either on or into the ridge, by the AA and by the PE + 8-lf treatments. These results closely resemble the yield data. Nitrogen uptake was generally not different between the surface-applied band treatment and the injected treatments at the PE or 8-leaf stage. Split application at PE + 14-leaf stage reduced grain and silage N uptake slightly.

Time of N uptake

Calculations were made to determine both the amount of N taken up by the corn before and after BL and the relative amounts of this assimilated N that was translocated to the grain (Table 10).

Plants growing in the check treatment (0 lb N/A) accumulated 23% of the total N in the grain after the BL stage. This amount (consistently higher than the other N treatments) was due to the very low amounts of assimilated N found in the stover at BL and fodder at PM. Post-blister N uptake (NEW) was negative for all of the other treatments. This was probably due to the severe deterioration of the corn caused by the drought stress following the BL stage.

Table 9. Nitrogen yield (uptake) at the blister stage and at physiological maturity as influenced by the N treatments for continuous corn in 1988.

Trt. No.	Stage: Blister Stover	Physiological mature: Fodder	Grain	Silage[1/]
	------------ Total N (lb/A) ------------			
1	37.4	11.2	33.6	44.8
2	89.1	18.0	56.8	74.8
3	79.2	18.9	53.5	72.4
4	89.5	18.1	59.3	77.4
5	82.1	19.5	54.5	74.1
6	72.8	15.0	53.6	69.7
7	88.1	22.7	53.3	76.0
8	82.4	16.0	55.4	71.4
9	89.4	21.9	57.0	78.1
10	84.5	17.2	57.8	75.0
11	85.3	16.5	50.3	66.8
12	76.4	13.6	50.4	64.0
Signif. Level %):	99	99	99	99
BLSD (.05) :	10.3	5.0	9.2	10.0
CV (%) :	11.	21.	13.	11.

1/ Grain + fodder

Soil Nitrate-N

Soil cores (2 per plot) were taken from 10 to 12" to the side of the rows to a depth of 5 feet in mid-October. All cores were divided into 1-foot increments, composited for each depth within each plot, dried, ground, and analyzed for NO_3-N.

Nitrate-N levels remaining in the 0-5' profile after harvest showed substantially higher NO_3 levels in all treatments where the N was injected midway between the rows regardless of rate, source or time of application (Table 11). Differences among the NO_3 levels of the surface applied or point injected (ridge) treatments were very small. Because of the consistently higher NO_3 values associated with the mid-row applications compared to the ridge applications, there is reason to suspect that these data may have been influenced some by sampling position even though samples were not taken from directly in the application zone. Nonetheless, previous experiences on these soils indicates that much of this residual NO_3 may be lost from the profile before the next crop season.

Table 10. Time of N uptake as influenced by the N treatments for continuous corn in 1988.

Trt. No.	Time of N Uptake OLD[1/]	NEW[2/]	OLD[1/]	NEW[2/]	NEW as a percent of total N
	-- mg/plant --		---- lb N/A ----		%
1	415	120	26.2	7.4	23
2	1127	-223	71.1	-14.3	-26
3	947	-108	60.3	- 6.8	-14
4	1119	-189	71.4	-12.1	-20
5	995	-128	62.5	- 8.0	-16
6	931	- 61	57.7	- 4.1	- 9
7	1091	-195	65.4	-12.2	-26
8	1056	-176	66.5	-11.0	-20
9	1083	-182	68.3	-11.3	-21
10	1079	-146	67.3	- 9.5	-20
11	1078	-282	68.8	-18.4	-41
12	987	-189	62.8	-12.4	-29
Signif. Level (%):	99	88	99	88	95
BLSD (.05) :	17	-	11.2	-	40
CV (%) :	14.	121.	15.	120.	132.

1/ OLD = N in stover at the BL stage - N in fodder at the PM stage; the difference is the N taken up prior to the BL stage and translocated to the grain.

2/ NEW = Total N in grain - OLD; the difference is assumed to be that N absorbed from the soil after BL and/or translocated from the roots.

Table 11. Nitrate-N in the 0-5' soil profile after harvest as influenced by the N treatments for continuous corn in 1988.

Profile depth	Treatment Number 1	2	3	4	5	6	7	8	9	10	11	12
feet	lb NO_3-N/A											
0-1	30	62	28	40	36	40	32	76	65	65	73	52
1-2	24	92	23	28	38	31	39	62	77	72	115	71
2-3	16	36	13	25	29	17	28	26	38	31	52	28
3-4	15	41	10	21	24	15	23	26	29	30	27	25
4-5	14	20	14	24	20	21	29	24	31	28	23	22
Total in 0-5' profile:	98	251	89	137	147	124	151	214	240	226	290	197

Recovery of N

Recovery of N was obtained by adding the total N uptake shown in Table 9 to the residual NO_3-N shown in Table 11, and then subtracting out the uptake plus residual from the check treatment. Highest recoveries were obtained with all of the treatments banded midway between the rows regardless of time or source (Table 12). The high post-harvest recovery with these treatments, due primarily to residual NO_3 in the soil, can be very misleading. If the NO_3 is lost from the soil before the crop in the succeeding year can utilize it, then it cannot be interpreted as true recovery. Soil samples will be taken in May, 1989 to determine the fate of the NO_3 over this 7-month period.

Table 12. Nitrogen recovery as a percent of the applied N.

Trt. No.	Cropping System: Cont. Corn	Cropping System: Corn after Soybeans
	--- % recovery[1/] ----	
2	122	63
3	18	40
4	47	37
5	39	45
6	34	31
7	56	54
8	95	61
9	117	70
10	105	66
11	143	71
12	98	55

1/ [Total N uptake in the plant + residual soil NO_3-N after harvest) - (plant N uptake + soil NO_3-N of the check treatment)] : N application rate.

Corn following Soybeans

Earleaf N concentration, final population and grain moisture

Leaf N concentrations were increased over the check by all of the treatments except the broadcast and PE + 8-lf and 14-lf treatments where UAN was used (Table 13). Highest N concentrations were found with the PE applications of UAN point injected into the ridge. Consistent differences between the surface-band and injected application methods for UAN at the PE stage were not found; however, the broadcast application did give slightly lower N values. Differences in final population were not noted. In contrast to continuous corn, grain moisture at harvest was not affected by the N treatments.

Table 13. Earleaf N concentration, final plant population and grain moisture as influenced by the N treatments applied to corn following soybeans in 1988.

Trt. No.	Leaf N concentration	Final population	Grain moisture
	%	ppAx10^{-3}	%
1	2.16	28.7	16.9
2	2.47	27.8	16.7
3	2.37	27.9	16.7
4	2.53	28.7	16.9
5	2.58	28.6	16.3
6	2.32	29.2	16.7
7	2.67	28.0	16.8
8	2.38	28.1	16.4
9	2.50	27.9	16.8
10	2.29	28.7	16.4
11	2.32	28.2	16.5
12	2.33	28.1	16.8
Signif. Level (%):	99	15	42
BLSD (.05) :	.19	-	-
CV (%) :	6.2	4.6	3.0

Corn Yields and Grain:Stover ratio

Stover yields at BL were not affected by the N treatments (P = 95% level) (Table 14). This was probably due to moderate levels of residual NO_3 and soil mineralization. Although leaf N concentrations were affected significantly by the N treatments, visual N deficiency symptoms and growth differences were not readily apparent at the BL stage.

Fodder, silage and grain yields were not increased significantly over the control by any of the N treatments (Table 14). All yields were very low due to the dry and hot conditions. Grain:stover ratio also was not affected.

Nitrogen Concentrations

Nitrogen concentrations in the stover at BL and in the fodder at PM were increased over the check by all of the N treatments except the broadcast UAN (Table 15). Highest stover N concentrations were generally obtained with the single PE treatments of UAN applied on or into the ridge or AA applied midway between the rows. Compared to these treatments, concentrations were slightly less with split applications at the PE + 14-leaf stage.

Grain N concentrations were increased over the check by all of the N treatments that received $\geq$ 100 lb N/A but not by the 60 or 80-lb treatments (Table 15). However, no differences were found among the placement methods or time of application when applied at the 100-lb N rates.

Table 14. Corn yields at the blister stage (BL) and at physiological maturity (PM) and grain:stover ratio as influenced by the N treatments applied to corn following soybeans in 1988.

Trt. No.	Yield Stover (BL)	Fodder (PM)	Silage (PM)	Grain (PM)	Grain:stover[1/] ratio
	gDM/plant	--- TDM/A ---		bu/A	
1	103	1.35	3.74	81.0	1.43
2	102	1.40	3.74	80.0	1.35
3	101	1.38	3.91	79.5	1.38
4	101	1.38	3.93	78.0	1.35
5	100	1.34	3.90	81.8	1.46
6	102	1.44	3.91	81.6	1.35
7	103	1.49	4.02	77.2	1.27
8	100	1.45	4.09	85.9	1.44
9	99	1.31	3.64	77.3	1.41
10	103	1.46	3.80	79.1	1.30
11	100	1.33	3.68	78.8	1.41
12	95	1.48	4.10	80.2	1.30
Signif. Level (%):	18	35	28	15	27
CV (%) :	6.6	11.	10.	8.9	12.

1/ Grain DM Yield (TDM/A) ÷ Fodder DM Yield

Table 15. Nitrogen concentrations in the stover at the blister stage and in the stover and grain at physiological maturity as influenced by the N treatments applied to corn following soybeans in 1988.

Trt. No.	N Concentration in Stover (BL)	Fodder (PM)	Grain (PM)
	----------- %	-----------	-----------
1	1.15	.56	1.61
2	1.35	.70	1.68
3	1.31	.66	1.65
4	1.36	.73	1.72
5	1.41	.77	1.78
6	1.21	.58	1.68
7	1.34	.77	1.72
8	1.24	.67	1.69
9	1.34	.72	1.73
10	1.24	.66	1.67
11	1.24	.66	1.69
12	1.29	.68	1.66
Signif. Level (%):	99	99	99
BLSD (.05) :	.08	.07	.06
CV (%) :	5.0	8.6	2.8

Nitrogen Yield

Nitrogen yield (uptake) closely paralleled the N concentrations of the stover (BL) and fodder (PM). Stover N yield at BL was increased over the check treatment by only the 140-lb N treatment (Table 16). Fodder N uptake was increased over the check by all of the 100-lb N treatments applied in a band either PE or PE + 8-lf.

Grain N uptake and total N uptake into the corn (silage) were not increased over the check by the N treatments (Table 16).

Table 16. Nitrogen yield (uptake) at the blister stage and at physiological maturity as influenced by the N treatments applied to corn following soybeans in 1988.

	Stage			
Trt.	Blister	Physiological mature		
No.	Stover	Fodder	Grain	Silage[1/]
	Total N (lb/A)			
1	75.3	15.1	61.9	77.0
2	84.6	19.5	63.5	83.0
3	81.0	18.2	62.1	80.2
4	86.0	20.2	63.5	83.7
5	89.3	20.5	68.8	89.3
6	79.8	16.8	64.8	81.6
7	85.4	23.0	62.9	86.0
8	77.1	19.4	68.6	87.9
9	81.6	19.1	63.5	82.6
10	80.3	19.2	63.0	82.2
11	76.9	17.6	63.0	80.6
12	75.4	20.2	63.1	83.3
Signif. Level (%):	95	99	46	76
BLSD (.05) :	11.7	4.0	-	-
CV (%) :	8.8	14.	8.3	7.9

1/ Grain + fodder

Time of N uptake

The percent of the total N in the grain that was absorbed post-BL(NEW N) compared to that N assimilated prior to BL (OLD N) is shown in Table 17. NEW N was not affected significantly by the N treatments and ranged from only -4 to 16% for the PE applications. Even though the split PE + either 8-lf or 14-lf applications tended to show slightly higher late season N uptake, these differences were significant due to the high CV. The reason for these low values is probably due to the stressful growing conditions which resulted in substantially more early-season N uptake than late-season uptake. In general, corn following soybeans absorbed consistently more of its total grain N after BL, however, than did corn following corn (Table 10).

Table 17. Time of N uptake as influenced by the N treatments applied to corn following soybeans in 1988.

Trt. No.	Time of N Uptake: OLD[1/]	NEW[2/]	OLD[1/]	NEW[2/]	NEW as a percent of total N
	--- g/plant --		---- lb N/A ---		%
1	.95	.03	60.2	1.8	3
2	1.06	-.02	65.1	-1.6	-3
3	1.02	-.01	62.8	- .8	-2
4	1.04	-.04	65.8	-2.3	-4
5	1.09	.00	68.8	0.0	-1
6	.98	.03	63.0	1.8	3
7	1.01	.01	62.3	0.6	1
8	.93	.17	57.7	10.8	16
9	1.02	.02	62.5	1.0	2
10	.97	.03	61.0	2.0	2
11	.95	.06	59.3	3.7	6
12	.89	.13	55.2	7.9	11
Signif. Level (%):	89	72	79	73	67
CV (%) :	9.9	350.	11.	367.	429.

1/ OLD = N in stover at the BL stage - N in fodder at the PM stage; the difference is the N taken up prior to the BL stage and translocated to the grain.

2/ NEW = Total N in grain - OLD; the difference is assumed to be that N absorbed from the soil after BL and/or translocated from the roots.

Nitrate-N

Post-harvest levels of residual NO_3 in the 0-5' profile were slightly higher with all N treatments compared to the check (Table 18). Substantially higher amounts of NO_3 remained with the PE application of AA and the split applications (PE + 8-lf or 14-lf), especially in the 0 to 2' zone. Except for the broadcast treatment which had a low level of NO_3, the soil NO_3 levels appeared to be linearly related to rate of N application. Soil samples taken in the spring of 1988 will show whether this NO_3 has remained for the 1988 crop.

Nitrogen recovery

Nitrogen recovery (plant uptake + soil NO_3) ranged from 31 to 71% of the N applied (Table 12). Highest recoveries were associated with the PE application of AA and the band applications of either AA or UAN midway between the rows. These treatments showed very high levels of residual NO_3 in the soil, perhaps due to sampling location, which greatly affected "recovery".

Table 18. Nitrate-N in the 0-5' soil profile after harvest as influenced by the N treatments applied to corn following soybeans in 1988.

Profile depth	Treatment Number											
	1	2	3	4	5	6	7	8	9	10	11	12
feet	lb NO_3-N/A											
0-1	34	59	43	43	50	49	53	58	52	70	50	40
1-2	18	35	22	24	26	21	28	36	42	32	52	36
2-3	10	17	14	15	22	13	18	16	23	15	20	18
3-4	10	15	12	18	20	13	16	12	16	15	14	13
4-5	16	18	18	17	19	17	17	15	18	17	18	18
Total in 0-5' profile:	87	144	108	117	138	113	132	137	151	148	154	125

CONCLUSIONS

Based on these 1988 results we can make the following preliminary statements:

1) The very dry period from May through August affected some of the results dramatically.
2) In the continuous corn system, grain and silage yields were increased over the control by the N treatments. However, differences among N rates (100 to 200 lb/A) and methods of application were not found.
3) Broadcast application of UAN in the continuous corn system often resulted in lower plant N concentrations, fodder yields, and plant N uptake.
4) When corn followed soybeans, none of the N treatments affected yield. However, broadcast applications of UAN resulted in lower concentrations of leaf N, stover N at BL and fodder N at PM than the surface-band or injected applications.
5) Neither N rate nor method of N application had an influence on time of N uptake in either cropping system.
6) High levels of residual soil NO_3 existed especially with the mid-row applications. This may have been due to the extremely dry conditions which limited both crop uptake and diffusion of N away from the fertilizer band.
7) The point injector method of incorporating N into a conservation tillage system shows promise and should continue to be researched and developed. Mechanical problems were not encountered with the exception of breaking some of the spokes when starting to inject with the wheel (swivel) not lined up with the direction of travel.

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NITROGEN LOSS TO TILE LINES AS AFFECTED BY TILLAGE[1/]

Waseca, 1988

G. W. Randall and B. W. Anderson[2/]

ABSTRACT: No tillage (NT) is thought to increase infiltration and, therefore, should increase the amount of water percolating through the soil compared to conventional tillage. This long-term study is being conducted to determine if greater amounts of NO_3-N and pesticides are being lost to tile drainage water with NT compared to moldboard plow (MP) tillage. Rainfall during 1988 was 5.4" below normal and tile flow was limited. Although NO_3-N losses were similar for the two tillage systems, NO_3-N concentrations were markedly higher with MP tillage -- the first time in seven years. Corn yields and N uptake were consistently higher with MP but due to high variability these differences were often not significant at the P = 90% level. Substantially higher amounts of NO_3 remained in the 8-foot soil profile in October with the MP system compared to NT.

Nitrogen losses to tile lines have been documented in a number of research studies including some conducted at Lamberton and Waseca, Minnesota. These studies primarily showed that N losses were a function of the N application rate and amount of precipitation. To some degree the time of application and crop grown have been shown to influence NO_3-N loss to tile lines. The purpose of this long-term study is to determine if tillage has an effect on N utilization, accumulation of NO_3-N in the soil profile, and the subsequent loss of NO_3-N to tile lines.

EXPERIMENTAL PROCEDURES

A study was initiated in 1975 on a Webster clay loam at Waseca to monitor the movement of N into a tile line installed in each of 12 plots measuring 45' by 50'. Each plot is enclosed with plastic sheeting to a 6' depth. Annual N rates of 0, 100, 200, and 300 lb N/A were applied from 1975-1979. No N was applied for the 1980 and 1981 crops. Residual N from N applied over the 5-year period (75-79) was utilized by the 1980 and 1981 corn crops. Soil samples to 10' and tile water samples taken in late 1981 showed little remaining evidence of the previous treatments.

In the fall of 1981, eight plots with the most uniform tile flow rates over the 1975-81 period were selected. Two tillage treatments (fall moldboard plow and no tillage) were replicated four times and randomized over the previous plot histories. Corn was grown on these plots in 1982 through 1987. The stalks were chopped in October, 1987 and moldboard plots plowed.

On April 18, 180 lb N/A as ammonium nitrate was broadcast applied to the surface of all plots. The moldboard treatment was then field cultivated. Corn (Pioneer 3732) was planted on May 6 at a population of 27700 plants/A with a John Deere Max-Emerge planter equipped with ripple coulters. Starter fertilizer was not used because of the high soil tests. Counter was applied at 1 lb (ai)/A to control rootworms. Weeds were controlled with a preemergence application of Lasso (3½ lb/A) and atrazine (3 lb/A) applied May 13. Weed and insect control were excellent. Percent surface residue was measured on April 8 and averaged 6 and 97% for the MP and NT systems, respectively.

The leaf opposite and below the ear was taken from 10 randomly selected plants per plot at silking (MP = July 14 and NT = July 21) and was analyzed for N. Silage and grain yields were taken at physiological maturity by hand harvesting 40' and 80' of row, respectively, from each plot.

Tile lines flowed from only April 27 to May 26. When tile lines were flowing, flow rates were measured daily and samples taken on a daily basis for the first week and then on a M-W-F basis thereafter for NO_3 analysis. All analyses were done by the Research Analytical Lab.

Soil NO_3-N in the 0-8' profile was determined from two cores/plot taken in 1-foot increments on October 14, 1988.

1/ Funding provided by the North Central Regional Research Committee (NC-98) and the Southern Experiment Station.

2/ Professor and Asst. Scientist, Southern Experiment Station, Univ. of Minnesota.

RESULTS

Although yields and N removal tended to be consistently higher with the moldboard plow (MP) system compared to the no tillage (NT) system, differences between the two tillage systems were not significant at the P = 90% level (Table 1). Total N uptake in the silage was significantly increased 93% level) by the MP tillage system. This was due to the high variability caused by the moisture and heat stress conditions during June, July and early August. Leaf N was increased significantly by the MP tillage system, but grain N concentration was not affected by tillage.

Table 1. Influence of tillage system on corn production and N utilization at Waseca in 1988.

Tillage system	Final population	Leaf N	Silage Yield	Silage N uptake	Grain Yield	Grain N	Grain N removal
	$x10^3$	%	T DM/A	lb N/A	bu/A	%	lb N/A
Moldboard Plow	24.8	2.58	3.79	102.1	100.6	1.67	78.9
No Tillage	24.4	2.28	3.26	87.5	83.3	1.64	64.7
Signif. Level (%):[1/]	33	98	79	93	75	45	86
CV (%) :	5.8	4.3	13.	7.8	19.	4.2	14.

[1/] Probability level of significance.

Precipitation during the growing season was 6.0" below normal. Thus, tile flow was confined from late-April into late-May. Tile flow was slightly higher for the NT system; however, NO_3-N concentrations were markedly higher with the MP system. Nitrate losses to the drainage water were similar for the two systems. Soil moisture samples taken July 21 showed 1.76 and 3.26" of available water in the 5-foot profile for the MP and NT systems, respectively. This is probably the reason corn fared better on the NT plots than on the MP plots in late July and August.

Table 2. Influence of tillage system on tile flow, NO_3-N concentration and NO_3-N loss in 1988.

Tillage system	Tile flow	Nitrate-N Concentration[1/]	Nitrate-N Loss
	acre inches	mg/L	lb N/A
Moldboard Plow	1.80	14.8	5.68
No Tillage	2.52	9.4	5.27

[1/] Flow-weighted

Residual NO_3-N in the soil profile at the end of the 1988 growing season showed about 112 lb/A more N remaining with the MP system (Table 3). The largest differences between the two tillage systems occurred in the top 2' where substantially more NO_3 accumulated with MP. These results are similar to 1987.

Table 3. Influence of tillage systems on residual NO_3-N in the soil profile in Oct., 1988.

Profile depth	Tillage System Mb. Plow	Tillage System No Tillage
feet	NO_3-N (lb/A)	
0-1	97.2	54.0
1-2	64.1	24.2
2-3	30.6	27.6
3-4	31.1	22.5
4-5	31.6	24.4
5-6	32.8	28.9
6-7	32.5	28.9
7-8	28.7	26.3
Total (lb NO_3-N/A 0-8')	348.6	236.8

SEVEN-YEAR SUMMARY

The cumulative totals for the 7-year period (1982-1988) are shown in Table 4. Corn yields over this period have averaged 9 bu/A better with moldboard plow tillage. Approximately 11% more N has been removed in the grain with moldboard plow tillage. This has been due to both higher yields and slightly higher grain N concentrations with the moldboard tillage system some years. Even so, very little difference in applied N removed in the grain exists between the two treatments (49% vs 44% for MP vs NT, respectively). Even though total water flow and NO_3-N lost through the tile lines was about 8% higher with no tillage, this small difference is considered to be insignificant when considering tile flow variability among the eight plots over this 7-year period.

Table 4. Cumulative effects of the two tillage systems over the 7-year period.

	Tillage System	
Parameter	Mb. plow	No tillage
Fert. N applied (lb/A)	1260	1260
Corn grain removed (bu/A)	932	869
N removed in grain (lb/A)	623	559
N removed in grain as a percent of applied N (%)	49	44
Tile flow (acre inches)	60.4	65.2
Nitrate-N lost in tile (lb/A)	146.4	157.8
N lost via tile lines as a percent of applied N (%)	12	13

NITRATE LOSSES TO TILE DRAINAGE AS AFFECTED BY NITROGEN FERTILIZATION OF CORN IN A CORN-SOYBEAN ROTATION[1/]

Waseca, 1988

Gyles W. Randall, Gary L. Malzer and Brian W. Anderson[2/]

ABSTRACT: A study to determine the influence of time of N application and N-Serve on the uptake of N by corn and the loss of NO_3 to tile drainage was continued in 1988. Results from this second year were greatly affected by the hot and dry stress conditions. Yields were not consistently affected by N nor its time of application. Nitrogen efficiency was extremely poor. The majority of N uptake occurred prior to silking for all treatments. Tile lines flowed sporadically in late April and early May and averaged less than 1 acre-inch discharge. Even though NO_3-N concentrations averaged about 18 mg/L, NO_3-N losses were very low. Apparently soil mineralization was abundant because residual NO_3 remaining in the soil profile at the end of the season was quite high even when no N had been applied to corn. Accumulation of NO_3 in the top 2' was substantial (200 to 230 lb/A) where N had been applied as a split application.

Nitrogen (N) losses to tile drainage water have been directly linked to N additions, crop grown, and soil organic matter level. Research has been conducted on NO_3 losses to tile water in Minnesota since 1972. This research has focused primarily on the effects of rates and timing of fertilizer N application and tillage in a continuous corn system. The purpose of this study is to determine the influence of time of N application and the use of a nitrification inhibitor on NO_3 movement and accumulation in the soil, NO_3 losses via tile drainage, and yield and N uptake by corn grown in a rotation with soybeans.

EXPERIMENTAL PROCEDURES

Thirty-six individual tile line plots were installed on a poorly drained Webster clay loam at the Southern Experiment Station in 1976. Each 20 x 30' plot is completely surrounded by plastic sheeting to a depth of 6' to prevent lateral flow and contains a tile line (4' deep) 5 feet from one end. All tiles drain to collection pits where flow rates can be measured and water samples collected for analyses. After completing a research project in 1983 using this tile facility, the plots were cropped to corn with a blanket N rate in 1984 and 1985 to establish uniformity.

Beginning in 1986 corn was planted on one-half of the experimental site while soybeans were planted on the other half. Thirty two plots (16 with corn and 16 with soybeans) with the most uniform drainage were selected from the 36 for the primary study. The experimental design consists of a 4 x 4 Latin square where the rows and columns were based on the previous (1977-83) tile flow rates from each plot. The four basic N treatments (see Table 1) are applied to the corn phase each year with the residual effects measured in the soybean phase. Three additional N treatments were replicated four times around the edge of the core 16-tile-plot area and were planted to corn. These three treatments were analyzed along with the other four as a completely randomized design.

Anhydrous ammonia was applied at a rate of 135 lb/A for all N treatments while N-Serve was applied at 0.5 lb/A. Fall treatments were applied on October 21. Average soil temperature at the 4" depth on that date was 43°F with an average of 43°F over the following 10-day period. Spring preplant treatments were applied on April 18. The sidedress portion (60%) of the split treatments was applied at the V-7 stage on June 15.

No primary or secondary tillage was done on the soybean area that was planted to corn in 1988. The corn area, however, was fall chiseled and spring disked once prior to planting soybeans. Surface residue accumulation estimated by the line-transect method on June 2 showed an average of 18 and 30% for the areas that were planted to corn and soybeans, respectively, in 1987. Because of high soil P and K tests, no broadcast nor starter fertilizer was used.

1/ Partial funding provided by Dow Chemical U.S.A., Center for Agricultural Impacts on Water Quality, and Minnesota Agric. Exp. Stn.

2/ Professor, So. Exp. Stn.; Assoc. Prof. Dept. of Soil Science; Assistant Scientist, So. Exp. Stn., Waseca.

Corn (Pioneer 3737) was planted at 30,800 plants/acre on May 6 with a JD Max-Emerge planter equipped with waffle coulters. A corn rootworm insecticide was not used. Weeds were chemically controlled with a preemergence application of Lasso (3.5 lb/A) plus Bladex (3 lb/A).

Soybeans (Hardin) were planted in 13" rows at 3-4 beans per foot of row on May 19. Weeds were chemically controlled with a preemergence application of Lasso (3½ lb/A) plus Amiben (3 lb/A). Pursuit (imazethapyr) was applied on June 7 at 0.06 lb/A plus 0.25% v/v X-77 to plots 1, 5, 6, 11, 12, 13, 15 & 16 to determine if it could be found in tile drainage water.

Two plots within each of the corn and soybean areas were not planted and were fallowed all summer. These four fallow plot areas were located on those tile plots that showed greatest water flow variability (1977-83). The purposes of these plots were to simply check the NO_3-N concentrations in the tile water in a fallow system and to utilize all 36 of the tiled plots, even though these four historically showed the highest flow variability.

Stand counts were taken at the V-7 stage and plots were thinned to a uniform population. Eight randomly selected plants were removed from the center rows at silk initiation (July 19) and were chopped, dried, weighed and ground for total dry matter accumulation and analyzed for total N concentration. Stover and grain samples were taken at physiological maturity by hand harvesting 30' of row for stover yields and 60' of row for grain yields and moisture. Chemical analyses of whole plant, stover and grain samples were performed by the Research Analytical Laboratory, University of Minnesota.

Tile line flow rates were determined daily and were recorded when flow exceeded 10 ml/minute (0.01"/day). Samples were collected for NO_3-N analysis on an every-other-day basis. Periodic samples were collected for alachlor (Lasso) and cyanazine (Bladex) analyses.

Soil samples for NO_3-N analysis were taken in 1-foot increments to a depth of 8 feet from the fallow plots and selected corn and soybean plots on April 19. The same technique was used to sample all fallow and corn plots and selected soybean plots after harvest on October 14.

RESULTS AND DISCUSSION

Plant

Whole plant N concentration at the silking stage was greatly increased over the check by all of the N treatments with little difference among the six N treatments (Table 1). Dry matter accumulation at this stage was unaffected by N treatment. Stover N concentration at physiological maturity (PM) was increased consistently over the check by all N treatments. Stover yield at PM was somewhat higher for the three additional N treatments than for the four primary N treatments. This unexpected result was noticed for all yield parameters at PM. It was probably due to "over" drainage in the small plots with the 25' tile spacing compared to the border plots without the close spacing in this very dry year. This phenomenon had never been encountered in 11 previous years of experiments at this tile drainage site. Final population was not significantly different among the N treatments.

Table 1. Influence of time of N application and N-Serve on whole plant N, stover yield, and final population of corn following soybeans.

N application		Whole Plant Silk Stage		Stover		
Time	N-Serve	N	DM	N	Yield	Final Population
		%	g/plt	%	TDM/A	ppA x 10[3]
Primary trts						
Fall (Oct.)	No	1.44	102	.69	1.74	29.1
Fall (Oct.)	Yes	1.48	102	.67	1.65	29.2
Spr. (April)	No	1.47	96	.72	1.63	29.7
Split[1/]	No	1.41	96	.67	1.52	28.8
Additional trts						
Check	-	1.20	92	.53	1.74	29.2
Spr. (April)	Yes	1.54	103	.71	2.07	29.7
Split[1/]	Yes	1.43	97	.68	1.93	30.0
		Statistical Analysis				
Latin square (Primary Trts)						
Signif. Level (%):		50	58	18	58	23
CV (%) :		4.8	7.6	11.	10.	4.1
Completely randomized (7 trts)						
Signif. Level (%):		99	80	89	99	31
BLSD (.05) :		.08	-	-	.31	-
CV (%) :		4.3	6.9	14.	11.	3.5

1/ 40% preplant + 60% sidedress.

Grain yields in general were low but were also lower for some of the primary N treatments located in the Latin square design compared to the additional N treatments along the border (Table 2). Significant differences in yield were not found among the four primary N treatments due to the high CV (8.9%). Although grain moisture tended to be higher in the additional N treatments, differences were not significant due to the high variability. Grain N concentration was improved significantly over the 0-lb N control by all N treatments. In the primary study, grain N was significantly higher for the fall treatment without N-Serve than the split treatment. Grain N removal (product of grain yield times N concentration), silage DM yield, and total N uptake in the silage were not different among the four primary N treatments but were generally lower for these four treatments than for the border plots when N was applied.

Total N removal in the grain ranged from 66.9 to 92.6 lb/A for the six N treatments (Table 2). Based on these removal amounts, N efficiency (N removed by a treatment - N removed in the check ÷ 135 lb N/A) ranged from 1 to 16% for the four primary treatments up to a maximum of 39% with the spring preplant application with N-Serve. Nitrogen efficiency based on the total plant uptake ranged from 6 to 16% for the four primary treatments up to a high of 43% with the spring preplant application with N-Serve. These efficiency values are very low and reflect the stress conditions during the 1988 growing season.

Total N uptake by the plants prior to silking (Fodder N yield at silking) divided by total N uptake at PM shows that from 79 to 102% of the N was accumulated by the plants prior to silking (Table 3). The lowest amounts of pre-silk N accumulation were found on the additional border plots. In general, split application of N reduced pre-silk N uptake slightly. NEW N in the grain (assumed to be taken up by the plant after silking and translocated to the grain) ranged from -3 to 23%. Under these conditions fall applications of N with or without N-Serve and spring application without N-Serve resulted in almost no post-silk N uptake into the grain. However, post silk N uptake into the grain ranged from 11 to 23% with the split applications.

Table 2. Corn grain and silage production as influenced by time of N application and N-Serve.

N application		Grain					Total N
Time	N-Serve	Yield	H_2O	N	N removal	Silage	uptake
		bu/A	%	%	lb/A	TDM/A	lb/A
Primary trts							
Fall (Oct.)	No	90.9	15.4	1.66	71.4	4.42	95.4
Fall (Oct.)	Yes	101.4	15.8	1.60	76.8	4.65	98.8
Spr. (April)	No	87.6	15.6	1.62	66.9	4.26	90.2
Split[1/]	No	99.6	15.7	1.55	73.2	4.53	93.8
Additional trts							
Check	-	102.4	17.7	1.37	66.4	4.76	85.2
Spr. (April)	Yes	121.4	17.2	1.62	92.6	5.74	122.1
Split[1/]	Yes	123.4	18.5	1.52	89.0	5.57	115.5
		Statistical Analysis					
Latin square (Primary trts)							
Signif. Level (%):		84	1	99	59	72	23
BLSD (.05) :		-	-	0.03	-	-	-
CV (%) :		8.9	12.	1.2	11.	5.8	12.
Completely randomized (7 trts)							
Signif. Level (%):		97	64	99	96	99	97
BLSD (.05) :		27.0	-	0.08	21.1	0.65	26.9
CV (%) :		15.	14.	3.5	16.	9.2	16.

1/ 40% preplant + 60% sidedress.

Table 3. Influence of time of N application and N-Serve on time of N uptake.

N application		Fodder N Yield at[1/]		Grain N Yield at PM			
Time	N-Serve	Silk	PM	Total	OLD[2/]	NEW[3/]	NEW[3/]
		---------- lb N/A				----------	%
Primary trts							
Fall (Oct)	No	94.8	24.1	71.3	70.7	.6	1
Fall (Oct)	Yes	97.9	21.9	76.8	76.0	.8	1
Spr (April)	No	92.3	23.3	67.0	69.0	-2.0	-3
Split[4/]	No	85.6	20.6	73.2	65.0	8.2	11
Additional trts							
Check	-	71.3	18.7	66.5	52.6	13.9	19
Spr (April)	Yes	103.5	29.4	92.6	74.0	18.6	17
Split[4/]	Yes	91.7	26.4	89.0	65.3	23.7	23
		Statistical Analysis					
Latin square (Primary trts)							
Signif. Level (%):		46	36	59	56	76	77
CV (%) :		13.	18.	11.	13.	318.	332.
Completely randomized (7 trts)							
Signif. Level (%):		99	95	96	99	94	93
BLSD (.05) :		13.4	7.9	21.1	9.9	-	-
CV (%) :		9.8	19.	16.	9.8	141.	137.

1/ Silk = silk stage, PM = physiological maturity.

2/ OLD N = N in stover at silk - N in stover at PM; the difference is assumed to be translocated to the grain.

3/ NEW N = Total N in grain - Old N; the difference is assumed to be absorbed from the soil and/or translocated from the roots after silking.

4/ 40% preplant + 60% sidedress.

Water

April through July conditions were extremely hot and dry and resulted in rapid early season growth with subsequent stunting due to low soil water levels. Because precipitation for April through May totaled only 4.42" (69% of the normal 6.40"), tile lines flowed only sporadically from April 28 thru May 20. Drainage ranged from 0.38 to 1.10 acre inches in the plots planted to corn (Table 4).

Table 4. Influence of N application time and N-Serve on NO_3-N concentration and N loss to tile lines in 1988.

N Application: Time	N Application: N-Serve	Tile Flow 1/	NO_3-N: Concentration	NO_3-N: Loss
		acre-inches	mg/L	lb N/A
Fall	No	0.62	18.0	2.54
Fall	Yes	1.10	16.1	4.01
Preplant	No	0.87	22.3	4.40
Split	No	0.38	15.5	1.33
None (Fallow) 2/	-	0.62	19.4	2.71

1/ Tile flow occurred August 28 to May 20.
2/ Average of 4 replications.

Flow-weighted NO_3-N concentrations averaged from 15.5 to 22.3 mg/L. Perhaps these high values were partially due to the soybeans in 1987 and the high rate of N (260 lb N/A) applied for the 1986 corn crop. Nitrate-N losses via the drainage water ranged from 1.3 to 4.4 lb/A in 1988 and were highly dependent on volume of drainage water.

Soil

Nitrate-N remaining in the 0-8' soil profile in mid-April was very high in the fallow plots (207 lb/A) compared to those where either soybeans or corn were grown in 1987 (Table 5). Soybeans that had not received fall-applied N averaged 109 lb/A with 76 lb/A remaining in the top 5'. Little residual NO_3-N remained in the 0-8' profile when corn was the previous crop, especially when no N was applied (49 lb/A). Differences among the fall, preplant and split applications were small. Distribution of NO_3 within the profile was consistently high to 6' with the fallow system, high in the surface 1-foot and uniformly medium to high to 7' with soybeans, and generally high in the surface 1-foot, medium to high in the 1 to 2' zone, and low below 2' for corn.

Table 5. Nitrate-N in the soil profile in April, 1988 as influenced by previous crop and N treatment for corn in 1987.

Profile depth	1987 Crop: Fallow	Soybean	Corn: 0 lb N	Corn: Fall	Corn: Preplant	Corn: Split
feet	lb/A 1/					
0-1	36.4	23.0	20.4	22.0	27.8	23.8
1-2	34.2	13.4	4.8	13.0	16.3	12.2
2-3	35.6	10.5	1.4	5.6	13.4	7.0
3-4	34.3	10.7	1.8	4.7	7.1	6.0
4-5	23.4	18.1	3.6	4.4	5.6	5.1
5-6	19.3	14.7	5.0	4.8	5.0	5.1
6-7	12.0	10.0	6.1	4.9	4.8	5.1
7-8	11.7	8.4	5.6	5.4	4.6	5.1
Total in						
0-5' profile	163.9	75.7	32.0	49.7	70.2	54.1
0-8' profile	206.9	108.8	48.7	64.8	84.6	69.4

1/ Average of 4 replications

Residual NO_3-N remaining in the 0-8' profile after the 1988 crop was considerably higher in the fallow plots (447 lb/A) and the soybean area planted to corn without N (224 lb N/A) than in April (Table 6). This was due to high mineralization activity during the 1988 growing season. Residual NO_3 remaining in the fertilized corn plots was also quite high and reflects the low crop demand. Differences among the N treatments were not substantial; however, consistently higher levels were found with the N-Serve treatments.

Table 6. Residual NO_3-N remaining in the 0-8' soil profile after harvest as influenced by time of N application and N-Serve.

Profile			Application Time					
			N-Serve			No N-Serve		
depth	Fallow	Check	Fall	Preplant	Split	Fall	Preplant	Split
ft.	lbs NO_3-N/A[1/]							
0-1	85.3	45.1	75.8	67.9	138.7	56.9	69.4	93.9
1-2	84.7	26.0	59.1	60.7	95.0	57.1	93.3	108.9
2-3	63.9	20.0	40.9	34.5	29.3	42.7	37.9	40.9
3-4	57.9	24.0	28.1	24.6	23.1	36.4	31.7	29.2
4-5	56.4	24.3	37.7	25.6	27.4	38.1	33.4	28.4
5-6	43.0	29.4	33.9	25.7	25.2	30.9	30.0	30.3
6-7	29.5	28.7	26.5	23.0	25.6	33.9	27.4	26.7
7-8	26.6	26.7	24.2	19.7	20.6	32.6	28.4	24.9
Total in								
0-5' profile	348	139	242	301	314	231	266	213
0-8' profile	447	224	326	282	385	329	352	383

1/ Avg. of 4 replications

CONCLUSIONS

The hot and dry conditions resulted in low and highly variable corn yields, poor N efficiency, and low drainage volume and accompanying NO_3-N losses. Nitrate N concentrations in the tile water averaged about 18 mg/L. Mineralization of soil organic matter is thought to have caused substantial increases in soil NO_3-N in the 0-8' profile between April and October even when corn received no N fertilizer. As of mid-October high levels of residual NO_3 remained in the upper two feet of the profile in all corn plots except the 0-lb N rate.

IMPACT OF NITROGEN AND TILLAGE MANAGEMENT PRACTICES ON CORN YIELD AND POTENTIAL GROUNDWATER CONTAMINATION IN SOUTHEASTERN MINNESOTA[1/]

Center for Agricultural Impacts on Water Quality
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ABSTRACT: Studies are being conducted on the silt loam soils of southeastern Minnesota to evaluate specific N and tillage practices for their role in providing profitability (BENEFIT) while minimizing NO_3 occurrences in the water below the root zone (RISK). The dry conditions seriously impacted corn yields and NO_3 leaching at two of the three sites. In general, continuous corn yields were optimized at N rates from 100 to 150 lb N/A except when alfalfa and manure were in the system (1983-85). Corn yields were not improved with split or sidedress N applications. Tillage did not appear to effect either corn yield or NO_3-N concentrations in the soil water. Manure applications resulted in slightly higher yields but greatly increased NO_3-N concentrations in the water. When profitability was highest, NO_3-N concentrations at 5' ranged between 10 and 14 mg/L. Fall applications of N doubled the NO_3-N concentration in the soil water at 5'. In an effort to more clearly define BMP's for these soils, additional years will be needed to more closely ascertain benefit vs risk relationships of these various N and tillage practices.

Current agricultural production systems are being linked closely to the occurrence of agricultural chemicals in the groundwater. This concern is especially prevalent in southeastern Minnesota where agriculture is quite intensive and the soils are rather shallow over a fractured limestone and sandstone bedrock geology (karst). The purposes of these studies are to: (1) determine the cause and effect relationship of specific N and tillage management practices on corn production and NO_3 and pesticide accumulation/movement through the soil and (2) identify best management practices that minimize groundwater contamination while maintaining economic profitability.

EXPERIMENTAL PROCEDURES

Three sites were continued for the 1988 studies. The primary site with the most intensive investigation is being conducted in Olmsted Co. on the Lawler Farm. The other sites are in Goodhue Co. on the Foss Farm and in Winona Co. on the Kalmes Farm.

Olmsted County - Lawler Farm

In April of 1986 a 6½ acre site of Port Byron soil was identified on the Richard Lawler and Sons Farm approximately 6 miles east of Rochester. A very comprehensive field history for the last 7 years was provided. Corn was grown in 1986. No herbicides and no nitrogen (N) fertilizer were applied to the corn which was cultivated three times.

Nitrogen Study

A randomized, complete-block with 4 replications was established in the fall of 1986 and was continued in 1988. Ten N treatments including both anhydrous ammonia and manure were established for a total of 40 plots (Table 1). Each plot was 30' wide and 65' long. The fall N treatments were applied on October 30, 1987. Spring N fertilizer treatments were applied on April 21 and again on June 16, 1988. Liquid hog manure was obtained from a neighbor, James Stellplug, on April 15 and applied to the soil surface using his equipment. The manure was incorporated with a disk within 3 hours. The rates of application were 6600 and 9500 gal/A. Six manure samples were taken and sent to Minnesota Valley Testing for analyses. Nitrogen, P_2O_5 and K_2O concentrations averaged 40.3, 27.4 and 8.1 lb/1000 gallons, respectively. All plots except the no-till treatment were disked again on April 25.

Corn (Pioneer 3737) was planted on May 4 at 30,600 plants/A. Lasso (3 lb/A) and atrazine (2½ lb/A) were applied preemergence. Counter was applied in the furrow at a rate of 8 oz/1000' of row to control rootworms. Cultivation was not performed during the season.

1/ Funding provided by the Legislative Commission on Minnesota Resources, Center for Agricultural Impacts on Water Quality, and the Minnesota Agricultural Experiment Station.

Whole plants were harvested from selected rows at silking, were weighed, dried, ground and analyzed for total N to determine pre-silk N uptake. Stover and grain yields were taken from 20' and 80' of row, respectively, at physiological maturity (Sept. 24). All samples were weighed, dried, ground and analyzed for total N.

Soil samples were obtained from each plot on April 12 and Oct. 24 by taking two 2-inch cores in 1-foot increments to the bedrock and then compositing the cores from each increment. The samples were forced-air, oven-dried at 120°F, ground, and analyzed for inorganic N (NH_4-N and NO_3-N).

Suction lysimeters installed in 1987 at the 5 and 7.5-foot depths in each plot were used to extract soil water from these depths to measure NO_3 concentrations in the soil water. Samples were collected on April 18, May 13, Aug. 12, Oct. 5 and Nov. 14.

Pesticide Study

An area adjacent to the N study was established in the fall of 1986 to accommodate a study to evaluate the movement of Lasso, atrazine, Banvel and Counter through the soil profile as influenced by four tillage systems. The four tillage treatments (moldboard plow, chisel plow, ridge tillage, and no tillage) were initiated in November, 1986. Nitrogen was applied on April 21 at a rate of 180 lb N/A as anhydrous ammonia. All other planting operations were the same as in the N study. The herbicides were applied using specialized plot equipment. Potassium bromide was broadcast-applied to a 15-foot section of each plot. The Br serves as a tracer to which pesticide movement can be compared. The corn was cultivated two times. The ridge plots were ridged in mid-June.

Each plot was intensively soil sampled throughout the season to monitor herbicide movement. Stainless steel suction lysimeters installed at 5' and 7½' depths were used to extract soil water. Grain and stover yields were taken at physiological maturity (PM) from the non-Br treated areas.

Goodhue County - Foss Farm

In May of 1986 an area of 5.1 acres of Port Byron soil was identified on the Selmer Foss and Sons (James Foss) farm in Goodhue County. A good field history was provided for the past 6 years. Corn was grown in 1986 and received a minimal amount of N (75 lb N/A) because it was in continuous corn. Weeds were controlled with 4 lb atrazine/A. Due to wet conditions no primary tillage was performed in the fall of 1986.

A randomized, complete-block design with 4 replications was established at this site in April, 1987 and was continued in 1988. Sixteen N treatments all consisting of anhydrous ammonia applied to chiseled and no-till plots were established. Each of the 64 plots measures 30' wide and 65' long. Chisel plowing was done with a John Deere Mulch Tiller on November 4, 1987. Anhydrous ammonia was applied preplant on April 20. All chisel plots were disked on May 5.

Corn (Pioneer 3790) was planted at 30,200 plants/A on May 6. Lasso (3 lb/A) and Bladex (2½ lb/A) was applied preemergence. Counter was applied at 1 lb a.i./A to control corn rootworms. The chisel plowed plots were cultivated to remove weeds and volunteer corn. Sidedress applications of N as anhydrous ammonia were applied at the 6-leaf stage (June 6) and 8 to 9-leaf stage (June 16).

Plant sampling procedures at silking and at PM were essentially the same as at the Olmsted Co. site. Soil sampling to the 10-foot depth on April 15 and October 31 was accomplished using the same procedures as in Olmsted Co. Suction lysimeters installed in six treatments (24 plots) to a 5' depth in 1987 were sampled on Apr. 15, May 12, Sept. 30 and Nov. 17 to determine the NO_3 and pesticide concentrations in the extracted soil water.

Winona County - Kalmes Farm

A 3.0 acre contour strip of Seaton soil was identified in early April, 1987. This farm is owned by Eugene Kalmes and son, Robert Kalmes. A field history was provided for the last 4 years. Corn was grown in 1986 and received 70 lb N/A and 2 lb atrazine/A. Alfalfa was grown in 1983-85 and received 6 T manure/A in the fall of 1985.

A randomized, complete-block design with 4 replications was established at this site in mid-April, 1987 and was continued in 1988. Twelve N treatments were established for a total of 48 plots. Each plot measures 20' wide by 65' long.

Spring chiseling was conducted on October 28, 1987. The preplant anhydrous ammonia treatments were applied immediately afterward. A field cultivator was used as secondary tillage just prior to planting.

Corn (Pioneer 3790) was planted at 30,200 plants/A on May 2. Lasso (3 lb/A) and Bladex (2½ lb/A) was applied preemergence. Counter (8 oz/1000') was used to control corn rootworms. The chisel plowed plots were cultivated to remove weeds. Sidedress applications of N as anhydrous ammonia were applied at the 6 to 7-leaf stage (June 8) and the 8 to 9-leaf stage (June 17).

Plant and soil sampling procedures were identical to those used in Olmsted Co. Stainless steel and PVC suction lysimeters installed in 1987 at the 5' depth in six treatments (24 plots) were sampled on April 18, May 13, Aug. 17, Oct. 5, and Nov. 18 to determine NO_3 and pesticide concentrations in the extracted soil water.

RESULTS AND DISCUSSION

Olmsted Co.

Corn grain yields in 1988 were increased significantly by both the fertilizer and manure N treatments (Table 1). The addition of 75 lb N/A increased yield by 60 bu/A resulting in very high fertilizer N efficiency. The 150-lb N rate applied preplant (PP) gave the optimum yield among the fertilizer treatments. Yields were about 8 bu/A higher with the two hog manure treatments, but this difference was not significantly (P = 95% level) above the 150-lb N/A PP treatments. Corn yields with the fall and split 150-lb treatments were not significantly different from the 150-lb PP treatment. There was no significant yield difference between the chisel and no tillage systems. Average 2-year yields showed greatest economic return to the 150-lb PP application with no advantage to higher rates, fall application or split treatments.

Table 1. Effect of N treatments on the 1988 corn grain yields and NO_3-N concentrations in the water at 5' in Olmsted Co.

	Treatment			Grain Yield		Nitrate-N[3/] Conc. in Water	
No.	Tillage	N Rate	Time/Method	1988	1987-88	5'	7.5'
		lb N/A		---- bu/A	-----	--- mg/L	---
1	Chisel	0	-----	79.9	94.6	1	4
2	Chisel	75	Spr., preplant	139.7	161.0	6	7
3	Chisel	150	Spr., preplant	153.5	176.9	12	9
4	Chisel	225	Spr., preplant	153.4	168.7	18	8
5	Chisel	150	Fall, post tillage	153.9	174.8	24	-
6	Chisel	150 + NI[1/]	Fall, post tillage	156.8	174.0	22	-
7	Chisel	150 split	50% Spr., preplant 50% SD, 8-leaf	152.6	172.8	10	-
8	No tillage	150	Spr., preplant	155.0	176.7	14	-
9	Chisel	175[2/]	Spr., disked in	161.7	184.5	41	10
10	Chisel	230[2/]	Spr., disked in	161.0	185.2	63	5
	Significance Level (%):			99			
	BLSD (.05) :			15.2			
	CV (%) :			7.7			

[1/] N-Serve

[2/] Applied liquid swine manure at rates of 6600 and 9500 gal/A, respectively. Total N rates were 280 and 360 lb N/A or approximately 175 and 230 lb "available" N/A.

[3/] Oct. 5, 1988

Nitrate-N concentrations in the soil water extracted from the 5-foot depth were correlated linearly with the spring-N rate (Table 1). Concentrations below 10 mg/L were found only with the 0 and 75-lb N rates, but economical return was also considerably less with the treatments. The split N application resulted in a similar NO_3-N concentration as the spring preplant application. Fall application, regardless of the inclusion of N-Serve, resulted in NO_3-N concentrations almost twice as high as with the spring applications. There appeared to be no difference between tillage systems. Highest NO_3-N concentrations occurred with realistic application rates of liquid hog manure. Nitrate leaching from the treatments had not reached the 7.5-foot depth at the end of the two growing seasons probably because of the dry conditions in 1988. It should be cautioned that these 5-foot NO_3-N concentrations may not represent the concentrations entering the aquifer because of dilution; however, they do provide an indication as to the environmental sensitivity of the treatments.

Corn yields in the pesticide study were not influenced statistically at the P = 90% level by tillage system because of the high variability (CV = 13%) (Table 2). The apparent 10 to 18 bu/A reduction with the ridge-till and no tillage (NT) systems could have been due to the ridging operation which may have pruned some roots and to some weeds in the NT system.

Table 2. Effect of tillage treatments on the 1988 corn yields in Olmsted Co.

Tillage	Grain Yield 1988	Grain Yield 1987-88 Avg.
	bu/A	
Moldboard plow	158.0	171.0
Chisel plow	158.0	170.6
"Ridge till"1/	147.8	162.8
No tillage	140.4	156.7
Significance Level (%):	47	
BLSD (.05) :	-	
CV (%) :	13.	

1/ First ridged in June, 1987.

Corn was planted on a 1½ acre area which is being saved for "future" investigations. Neither fertilizer N nor pesticides were applied. The corn was cultivated twice to control weeds as best possible. Corn yields averaged only 8 bu/A primarily due to weed pressure (early season moisture stress) and insufficient N. It is interesting to note the 72 bu/A difference between this site and the 0-lb N plots that were kept weed-free by herbicides.

Goodhue Co.

Grain yields were increased significantly over the control (both chisel and no tillage) by all of the N treatments (Table 3). Yields were optimized with the 100-lb spring PP treatment. The highest yield, although not statistically speaking, was obtained with the 150-lb PP treatment containing N-Serve. There was no difference between the two tillage systems. None of the split and sidedress treatments enhanced yields over the spring PP anhydrous applications.

Two-year average grain yields also show: (1) optimum N rate to be 100 lb/A, (2) no improvement in yield with either split or sidedress N application, and no difference between the two tillage systems except at the 0-lb N rate where there was a slight advantage for chisel plowing.

Nitrate-N concentrations in the soil water extracted from the 5-foot depth on Sept. 30 varied considerably and did not appear to relate well to N treatment (Table 3). This was probably due to the dry conditions and the incomplete number of samples obtained.

Table 3. Corn yield and NO_3-N concentation in the soil water at 5' as affected by N treatments in Goodhue Co. in 1988.

No.	N rate	Application time	Tillage[1/]	Grain Yield 1988	Grain Yield 1987-88 Avg.	Nitrate-N[3/] Conc. in water at 5'
	lb/A			----- (bu/A) -----		mg/L
1	0	-----	Chisel	68.3	103.0	8
2	50	Spr. preplant (PP)	"	106.8	138.6	-
3	100	"	"	113.8	149.9	12*
4	150	"	"	114.5	149.4	12
5	200	"	"	118.6	154.0	-
6	0	-----	No Tillage	67.5	91.6	-
7	100	Spr. preplant (PP)	" "	112.4	150.0	7
8	150	"	" "	115.5	152.8	15
9	200	"	" "	115.2	153.4	-
10	50 + 50	Spr. PP + SD 9-1f	Chisel	111.4	145.6	-
11	50 + 100	" "	"	116.5	149.4	-
12	100 + 50	" "	"	117.3	151.6	-
13	100	SD 6-1f	"	106.4	143.4	-
14	150	"	"	116.6	152.1	38*
15	150 + NI[2/]	Spr. PP	"	123.7	159.1	-
16	150 + NI	SD 6-1f	"	120.1	150.0	-
	Significance Level (%):			99		
	BLSD (.05) :			14.0		
	CV (%) :			9.6		

1/ Chiseling was done in April, 1987.
2/ NI = N-Serve
3/ Sept. 30, 1988
* Avg. of only 2 samples

Winona County

Corn grain yields were very poor at this site due to the dry and hot weather (Table 4). Yield responses to the applied N were inconsistent and highly variable. There did not appear to be an advantage for the split or sidedress N treatments over the spring preplant treatment. No difference was observed between tillage systems.

Two-year average yields show: (1) no difference between the two tillage systems, (2) no advantage for the split and sidedress applications, and (3) a very slight but inconsistent response to fertilizer N at this site which was in alfalfa from 1983-85. Nitrate-N concentrations in the soil water at 5' after two years of experimentation still are at 14 mg/L where no N has been used. Concentrations ranged between 26 and 46 mg NO_3-N/L for the treatments that received fertilizer N, but there was no relationship to N rate. These high values must be a result of the previous alfalfa crop which received manure in 1985.

Table 4. Effect of N treatments on the corn grain yield and NO_3-N concentrations in the soil water at 5' in Winona County in 1988.

No.	Treatment: N Rate	Treatment: Time	Tillage[1/]	Grain Yield: 1988	Grain Yield: 1987-88 Avg.	Nitrate-N[2/] Conc. in water at 5'
	lb N/A			------- bu/A	------	mg/L
1	0	-----	Chisel	72.1	128.9	14
2	50	Spr. preplant (PP)	"	73.9	131.8	-
3	100	" "	"	81.8	135.2	36
4	150	" "	"	84.9	137.8	37
5	200	" "	"	97.7	144.6	27
6	0	-----	No Tillage	68.0	129.0	-
7	100	Spr. preplant (PP)	" "	80.3	135.0	46
8	150	" "	" "	69.9	126.9	-
9	200	" "	" "	86.8	135.5	26
10	50 + 50	Spr. PP + SD 9-1f	Chisel	86.8	138.4	-
11	50 + 100	" " "	"	85.4	139.4	36
12	150	SD 6-1f	"	76.4	132.6	42
	Significance Level (%):			95		
	BLSD (.05) :			21.5		
	CV (%) :			15.		

1/ Chiseling was done in October, 1987.
2/ Oct. 5, 1988

SUMMARY

The following summarizes the yield results from the second year of these studies:

1) N rate was optimized at 150 lb/A for third year corn while at a second site 100 lb N/A was optimum.
2) Yields were slightly but not significantly higher with the manure treatments.
3) No apparent yield advantages were found with split or sidedress applications of N at any of the three sites.
4) There was no yield difference between the no tillage and chisel tillage systems at any of the three sites.
5) Previous crop and manure history apparently impacts corn yield and N management at the Winona Co. site.
6) The role of alfalfa and manure contributions to available N for succeeding corn crops needs to be carefully examined and understood before improved N management is a reality on these soils.
7) Nitrate-N concentrations in the soil water at 5' (below the root zone) provide a good basis upon which to compare the environmental risks associated with various N management systems.

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RESIDUAL SOIL NITRATE FOLLOWING ALFALFA AS INFLUENCED BY TILLAGE AND CORN HYBRID[1/]

C. G. Zadak, G. W. Randall, and M. P. Russelle[2/]

ABSTRACT: Experiments were initiated at three locations in 1988 to determine the influence of tillage, N rate, and corn hybrid on the residual NO_3-N remaining after harvest in a first year corn after alfalfa cropping system. Soil NO_3 in the 0-5' profile was low prior to tillage and planting in the spring. Thirty to 50% of the profile NO_3 was found in the top foot. The applied N resulted in higher residual NO_3 in the fall at all three locations with the majority accumulated in the top foot. Corn hybrid affected residual NO_3 in one location while tillage significantly affected fall NO_3 levels at another location. Substantially more NO_3-N remained with moldboard plow tillage compared to no tillage especially when 62 lb N/A was applied. These data indicate that soil NO_3-N levels following alfalfa change dramatically between the spring and fall and that N rate, tillage and hybrid can affect NO_3 levels.

Recent evidence has shown that residual soil nitrate (NO_3) in the upper part of the root zone may be helpful in more accurately predicting fertilizer N needs of corn. The purpose of this study was to determine: (1) the amount of NO_3-N in the 0 to 5' profile in the spring following alfalfa, (2) the amount of residual NO_3-N remaining after 1st year corn following alfalfa was harvested, and (3) the effect of tillage, corn hybrid, and fertilizer N rate in this alfalfa-corn sequence on residual NO_3-N.

EXPERIMENTAL PROCEDURES

Studies were initiated into growing alfalfa stands at the Rosemount Agricultural Experiment Station, Southern Experiment Station at Waseca, and on the Gary Luehmann farm in Winona Co. in April, 1988. The primary soil type at each location was Port Byron sil, Nicollet cl, and Seaton sil, respectively. A randomized, complete-block experiment in a split-plot arrangement with four replications was used. Main plots consisted of two primary tillage variables (moldboard plow vs no tillage) while subplots consisted of six genetically dissimilar 105-day RM corn hybrids.

Random soil cores were taken in 1-foot increments to a depth of 7', 6' and 5' at the Rosemount, Winona, and Waseca locations in mid-April prior to spring tillage. Specific treatments were sampled in mid-October after corn harvest by taking two cores per plot and compositing the cores according to the depth increments. The soil was forced-air, oven-dried at 120°F, crushed to pass a 2 mm sieve, and analyzed for NO_3-N concentration.

RESULTS AND DISCUSSION

Spring sampling

Samples taken prior to tillage of the alfalfa showed low levels of NO_3-N in the 0-5' profile at each site (Table 1). Lowest values were obtained at Winona and Waseca. From 30 to 50% of the NO_3 in the 5-foot profile was found in the top foot.

Fall sampling

Rosemount

Fall soil NO_3-N data for Rosemount are given in Tables 2 and 4. In contrast to the spring data, this site showed the lowest amount of total NO_3-N in the profile of the three sites -- as much as 100-150 lbs N/A less. These differences might be due to differences in the 1987 alfalfa stand. There were no differences in total residual NO_3-N at Rosemount due to tillage when averaged over hybrid and N rate, but differences due to N rate and hybrid were present. The magnitude of the difference between the 0 and 62 lb N/A rates was nearly equal to the 62 lb N/A application. Most of this N remained in the top foot of soil, however. In fact, very little

1/ Funding provided by the Minnesota Agric. Exp. Stn. and the So. Exp. Stn. at Waseca.
2/ Graduate research assistant, Dept. of Soil Science; Professor, So. Exp. Stn., Waseca; and Assoc. Professor, Dept. of Soil Science and USDA-ARS-USDFRC.

NO_3-N was detected below 2 feet. Approximately 20 lbs less N/A was present under P3569 than under P3732 (no difference in total N uptake between these hybrids was detected, however).

Winona Co.

Fall results for the Winona Co. site are given in Tables 3 and 4. Again, a significant increase in total profile NO_3-N occurred due to N application, with most of the NO_3-N concentrated in the top foot. There were 80 lbs N/A more in the profile under moldboard tillage than under no-tillage when averaged over N rates and hybrids. This is likely the result of greater mineralization of the alfalfa residues caused by the tillage. The presence of a significant tillage X N rate interaction is a bit puzzling. Perhaps this was due to greater uptake of the fertilizer N under no-tillage (a good response to fertilizer N addition was observed for no-tillage) or greater immobilization of the surface-applied N occurred under no-tillage. No differences in residual NO_3-N between the two hybrids (P3732 and DK547) were detected.

Waseca

Fall total profile NO_3-N values were similar to those at Winona Co. (Tables 5 and 6). Again, addition of N resulted in higher residual NO_3-N levels, with most of the NO_3-N in the top foot. Little to no differences in the residual NO_3-N are apparent under the 30, 62, and 90 lb N/A rates, however. No difference in residual N due to tillage is apparent. Clearly, the low yields that occurred at this site minimized the potential for differences in soil NO_3-N to show up.

Table 1. Soil nitrate-N following alfalfa in April, 1988.

Profile depth	Location: Rosemount	Winona Co.	Waseca
feet	lb NO_3-N/A		
0 - 1	32.4	13.2	16.0
1 - 2	13.6	7.1	9.7
2 - 3	6.7	4.3	6.6
3 - 4	4.2	2.9	3.1
4 - 5	2.2	2.0	3.5
Total in profile	59	30	39

Table 2. Residual soil nitrate-N after harvest in October, 1988 at Rosemount as influenced by tillage, hybrid, and N rate.

Profile		Moldboard				No-tillage			
		P3732		P3569		P3732		P3569	
depth	lb N/A:	0	62	0	62	0	62	0	62
feet		lb NO_3-N/A							
0 - 1		51.4	103.3	52.4	88.9	38.8	122.5	36.2	53.2
1 - 2		10.5	17.9	6.7	23.1	4.8	15.4	4.4	8.1
2 - 3		3.1	3.3	1.7	4.7	1.7	3.0	1.4	2.3
3 - 4		1.4	2.3	1.2	2.8	1.3	1.9	1.0	1.4
4 - 5		0.8	1.2	0.9	2.2	1.6	1.4	1.0	1.1
Total in 0-5' profile		67	128	63	122	48	144	44	66

Table 3. Residual soil nitrate-N after harvesting in October, 1988 at Winona Co. as influenced by tillage, hybrid, and N rate.

Profile depth		Moldboard				No-tillage			
		P3732		DK547		P3732		DK547	
	lb N/A:	0	62	0	62	0	62	0	62
feet		lb NO_3-N/A							
0 - 1		71.4	160.2	75.0	148.4	53.8	83.9	36.7	89.3
1 - 2		51.4	86.8	43.3	56.6	32.9	47.2	24.0	46.9
2 - 3		16.6	18.0	16.2	17.5	15.8	18.2	15.1	16.4
3 - 4		20.4	17.7	13.1	17.2	13.9	16.1	12.8	13.5
4 - 5		18.5	19.1	15.8	19.6	20.0	16.3	15.4	16.0
Total in 0-5' profile		178	302	163	259	136	182	104	182

Table 4. Means for main effects and interactions for total residual soil nitrate-N (0-5') after harvest at Rosemount and Winona Co. in October, 1988.

Treatment			Location	
			Rosemount	Winona Co.
			lb NO_3-N/A	
Tillage				
	Moldboard		95	231
	No-tillage		76	151
	P > F		0.44	0.05
N Rate (lb/A)				
	0		56	139
	62		115	231
	P > F		0.01	0.01
Hybrid				
	P3732		97	200
	P3569/DK547		74	177
	P > F		0.04	0.15
Tillage X N Rate Interaction				
	Moldboard	0	65	164
		62	125	281
	No-tillage	0	46	120
		62	105	182
	P > F		0.97	0.03
Tillage X Hybrid Interaction				
	Moldboard	P3732	98	247
		P3569/DK547	92	215
	No-tillage	P3732	96	159
		P3569/DK547	55	143
	P > F		0.10	0.65
N Rate X Hybrid Interaction				
	0	P3732	58	152
		P3569/DK547	53	126
	62	P3732	136	242
		P 3569/DK547	94	221
	P > F		0.08	0.90
Tillage X N Rate X Hybrid Interaction				
	P > F		0.10	0.34

Table 5. Residual soil nitrate-N after harvest in October, 1988 at Waseca for P3732 as influenced by tillage and N rate.

Profile depth	lb N/A: Moldboard 0	Moldboard 30	Moldboard 60	Moldboard 90	No-tillage 0	No-tillage 30	No-tillage 60	No-tillage 90
feet	lb NO_3-N/A							
0 - 1	64.5	90.0	103.2	112.1	66.4	96.4	105.0	116.6
1 - 2	38.1	56.4	57.5	57.4	44.5	51.5	42.6	45.0
2 - 3	20.1	17.5	24.1	20.7	27.1	26.8	23.2	23.7
3 - 4	24.0	21.2	22.4	21.2	22.7	21.6	27.8	24.5
4 - 5	23.5	24.7	24.8	23.2	23.3	26.0	24.2	25.6
Total in 0-5' profile	170	210	232	235	184	222	223	236

Table 6. Means for total residual soil nitrate-N after harvest for tillage and N rate at Waseca.

Treatment	Residual N
	lb NO_3-N/A
Tillage	
Moldboard	212
No-tillage	216
N Rate (lb/A)	
0	177
30	216
60	227
90	235

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DECLINE RATES OF SOIL TEST P AND K IN A CORN-SOYBEAN ROTATION[1/]

1988

G. W. Randall and S. D. Evans[2/]

ABSTRACT: Decline rates of soil test P and K are being measured following 12 years of various application rates of P and K at two locations. Soil test P and K did not decline in 1988, probably because of low crop demand due to the hot and dry conditions. Soybean yields were increased about 10% by increasing P up to a soil test of 40 lb P/A at Waseca but did not increase with higher P levels. Soil test K, ranging from 235 to 325 lb K/A at Waseca, did not influence yield. Soybean yields were very low at Morris and were not affected by soil test P level.

With good fertilization practices over the last 20 to 30 years, many farmers throughout the Cornbelt have built their P and K soil tests to high and very high levels. Studies conducted over the last 12 years have not shown corn and soybean yield increases from additional broadcast P and K at these high to very high test levels. Consequently, a number of farmers have curtailed P and K fertilization on these high testing soils. Two commonly asked questions in this scenario are: (1) How fast will my soil test drop if I don't continue to add fertilizer P and K? and (2) At what test level should I begin to add P and K to maintain fertility at an optimum level for efficient and economical production? The purposes of this study are to determine (1) the decline rates of soil test P and K and (2) the optimum soil test level which should be maintained for economical corn and soybean production.

EXPERIMENTAL PROCEDURES

High rates of P and K were applied over a 12-year period (1973-84) in studies at the Southern Experiment Station at Waseca (Table 2) and the West Central Experiment Station at Morris (Table 3). These rates created a wide range of soil test values upon which we can evaluate the decline rates of soil test P and K when no additional fertilizer is added. Treatments 2, 3, and 4 have not received additional P since 1984 while treatments 6 and 7 at Waseca have not received K. The K treatments were not included at Morris because of very high native soil test K levels. Treatment 5, which had a moderately high level of fertilization prior to 1985, continues to receive P and K, and thus, serves as the high fertility control.

The P and K materials (0-46-0 and 0-0-60) were broadcast on the soil surface and incorporated by moldboard plowing the corn residue in the fall of 1987. Specific experimental procedures used for soybean at the two locations are presented in Table 1. Management practices providing for optimum yields were employed at each location. Starter fertilizer was not used.

Table 1. Experimental procedures for soybean on the high P and K rate study at the two branch stations in 1988.

Variable	Location: Morris	Location: Waseca
Planting date	5/3	5/19
Row spacing	30"	13"
Planting rate (plants/A)	10 beans/ft	3-4 beans/ft
Variety	Evans	Hardin
Herbicide	3# Lasso + 2.5# Amiben/A (Bdct)	3.5# Lasso + 3# Amiben/A (Bdct)
Harvest date	9/9	10/5
Soil type	Aastad clay loam	Webster clay loam

1/ Funding provided by the TVA - National Fertilizer Development Center.
2/ Soil scientists and professors at the Southern Experiment Station, (Waseca) and West Central Experiment Station (Morris), respectively.

RESULTS AND DISCUSSION

Total phosphate (P_2O_5) and potash (K_2O) applied over the 12-yr period ranged from 0 to 1200 lb/A (Tables 2 and 3). These application rates plus the 1985-86 rates resulted in highly significant differences in soil test P at both locations and in soil test K at Waseca. At Waseca soil test P ranged from 17 to 121 lb P/A (Table 2). Soil test P did not change compared to 1987, but soil test K was generally 10 to 20% higher. This may have been due to the very dry conditions or to the fact that soybeans were grown in 1988 compared to corn in 1987. Soybean yields were increased significantly by P but plateaued at soil P levels higher than 40 lb/A. No reason can be given for the slightly lower yield of treatment 7.

At Morris, Bray P_1 ranged from 17 to 66 lb/A while Olsen's $NaHCO_3$ test ranged from 8 to 45 lb P/A (Table 3). Due to the extremely dry conditions, yields were very low and soil test P and K levels remained similar to those found in 1987.

Table 2. Soil test values, soybean moisture, and soybean yield as influenced by 15 years' application of P and K at Waseca.

No.	P and K Treatments: Total 1973-84	1985-87[1/]	Soil Test[2/]: pH	P	K	Soybean: Moisture	Yield
	----- lb P_2O_5 + K_2O/A -----			--- lb/A ---		%	bu/A
2	0 + 1200	0 + 100	6.7	17	316	11.8	35.8
3	600 + 1200	0 + 100	6.4	45	309	11.3	40.1
4	1200 + 1200	0 + 100	6.7	82	278	11.2	39.7
5	600 + 1200	100 + 100	6.7	85	327	11.4	41.4
6	1200 + 0	100 + 0	6.7	121	235	11.3	40.5
7	1200 + 600	100 + 0	6.6	120	237	10.7	37.1
	Signif. Level (%):		53	99	99	93	96
	BLSD (.05) :		-	11	32	-	4.0
	CV (%) :		3.1	8.3	6.4	3.3	5.1

1/ Treatments applied each Fall.
2/ Samples were taken in October before 1988 treatments were applied.

Table 3. Soil test values, soybean moisture, and soybean yield as influenced by 15' years' application of P and K at Morris.

No.	P and K Treatments: Total 1973-84	1985-87[1/]	Soil Test[2/]: pH	P_1	P_{Ol}	K	Soybean: Moisture	Yield
	---- lb P_2O_5 + K_2O/A -----			------ lb/A	-------		%	bu/A
2	0 + 1200	0 + 100	7.7	17	8	406	11.1	8.0
3	600 + 1200	0 + 100	7.6	38	24	380	10.3	8.3
4	1200 + 1200	0 + 100	7.7	66	45	369	10.4	9.3
5	600 + 1200	100 + 100	7.7	58	41	363	10.8	9.0
	Signif. Level (%):		94	99	99	41	8	19
	BLSD (.05) :			16.	14.			
	CV (%) :		22.	22.	30.	12.	16.	79.

1/ Treatments applied each Fall.
2/ Samples were taken in October before 1988 treatments were applied.

CONCLUSIONS

Long-term (12-yr) P additions to these two soils created a wide range in soil test P levels. Soybean yields were optimized over the no P treatments at soil test P levels of 40 lb/A at Waseca. Yields were not affected by K at Waseca or by P at Morris, primarily because of the very dry conditions. Soil test P levels at both locations were similar to 1987; however, soil test K was 10 to 20% higher at Waseca in 1988. Additional years will be needed to more accurately determine the decline rates.

CONSERVATION TILLAGE FOR CORN AND SOYBEAN PRODUCTION[1/]

Waseca, 1988

G. W. Randall and J. B. Swan[2/]

ABSTRACT: This was the 14th year in a study to evaluate five primary tillage systems for corn and soybean production on a Nicollet-Webster soil complex. Corn grain yields were significantly higher with moldboard plow tillage compared to chisel plow, spring disk, or no tillage. Although yields from ridge tillage were 16.7 bu/A less than from moldboard plowing, they were not statistically different. No tillage yields were considerably less than the other tillage treatments primarily because of high grass pressure. Yields from the no tillage, chisel plow and spring disk systems were improved markedly where Poast herbicide had been applied previously to soybeans. Weed pressure was very low with the ridge plant and moldboard plow systems. Under the hot and dry conditions the lesser yields obtained with the conservation tillage (CT) systems were partially due to poor weed control (especially with no tillage) but may also have been due to poor, early season root development in the CT systems in this 14-year study.

With increasing emphasis on controlling erosion and minimizing energy requirements (time, labor, and fuel), tillage practices have changed markedly over the last decade. Many of tillage practices have come to be known as "conservation tillage". To fit this definition, a tillage practice must leave 30% of the soil surface covered with residue after planting. The primary purpose of this study is to evaluate five conservation tillage (CT) systems in a long-term corn-soybean sequence. A secondary objective is to determine the value of starter fertilizers in CT systems.

EXPERIMENTAL PROCEDURES

To evaluate some of these conservation tillage practices an experiment was started in 1975 with continuous corn grown on a Webster clay loam at the Southern Experiment Station. Five tillage treatments (no tillage, fall moldboard plow, fall chisel plow, ridge-plant and till-plant [flat]) were replicated four times. Each plot was 20' wide by 125' long. Tile lines spaced 75' apart run perpendicular to the rows in all plots. Beginning in 1979 all plots were split into two, 4-row plots -- one with starter fertilizer and the other without.

After 8 years of continuous corn, soybeans were planted in 1983 to begin a long-term corn-soybean rotation. Tillage and starter fertilizer treatments remained the same except the till-plant (flat) treatment was changed to a spring-disk (20" disk blade) treatment (Table 1). Because of increased pressure of the grass weeds in the no tillage treatment, all plots were split so that either the front or rear half received a postemergence application of Poast at a rate of ¼ lb/A with 1 qt of oil concentrate in the years that soybeans were grown.

Ridges for the ridge plant treatment in 1988 were built in June, 1987. After the 1987 soybean harvest, the moldboard and chisel plow treatments were performed. On April 21 the moldboard and chisel plow treatments were field cultivated once and the spring disk treatment was disked twice. Ammonium nitrate was broadcast-applied at a rate of 150 lb N/A immediately before the secondary tillage. Ridges for 1989 soybeans were prepared on June 20.

Corn (Pioneer 3732) was planted in 30" rows at a rate of 29,900 plants/A on May 4. All treatments were planted with a John Deere 7100 planter equipped with 2" fluted coulters. B&H ridge cleaners were attached to the planter for the ridge-plant treatment. Ten gallons/A of 7-21-7 was used as the starter treatment.

Broadcast P and K were not applied for the 1988 soybean crop because of very high soil tests. Soil tests on this site in 1984 averaged: pH = 6.7, Bray[1] extractable P = 60 lb/A and exchangeable K = 424 lb/A. Chemical weed control consisted of 3 lb Bladex and 3½ lb Lasso/A applied preemergence (May 14). In order to evaluate the effectiveness of the preemergence herbicide application on weed control, a plastic sheet 18" wide and 6' long was placed between the 4th and 5th rows of each plot during herbicide spraying to prevent the application of herbicide onto the soil surface. Weed counts (grass and broadleaf) were taken on May 23 from sprayed and unsprayed areas and poast and non-poast

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1/ Funding provided by the Southern Experiment Station, Waseca.
2/ Professors, Southern Experiment Station and Department of Soil Science, respectively.

areas. Treatments 2, 3, 4, and 5 were cultivated on June 1. Weed control was quite good on all cultivated plots.

Surface residue coverage was measured by the line-transect method on April 18 prior to spring tillage and on May 16 after planting. Planting depth was determined by cutting off the coleoptile at the soil surface from all the plants in a 10-foot length of row in each tillage plot 27 days after planting. The seeds were then excavated and the length of the coleoptile to the seed was measured. Early plant growth (EPG) was determined by harvesting the above ground portion of 10 random plants per starter and non-starter plot 41 days after planting.

Corn leaf samples were taken on July 14 from all treatments except NT, which was sampled on July 21, by randomly sampling the leaf opposite and below the ear from the starter treatment within each tillage treatment. Yields were taken by combine harvesting the center two rows from each plot with a modified JD 3300 combine. Grain moisture and N concentrations were determined on each of these samples.

RESULTS

Grain yield and moisture differences among the tillage treatments were highly significant when averaged over starter fertilizer and previous Poast treatments (Table 1). Moldboard plow (MP) tillage resulted in significantly higher yields than the chisel plow (CP), spring disk (SD), and no tillage (NT) systems. Grain yield was significantly lower and grain moisture higher for NT compared to all other tillage systems. The highly significant interaction between tillage and Poast treatment for yield indicated that yields from the NT, CP and SD systems were increased significantly by the Poast treatments applied to soybeans in previous years (1983, 1985 and 1987). Yields with the MP and ridge-plant (RP) systems were not affected by the Poast treatments primarily because of excellent weed control with these tillage systems regardless of Poast application.

Starter fertilizer increased yields by 16% when averaged across all tillage and Poast treatments (Table 1). Even though a statistically significant interaction between tillage system and starter fertilizer did not exist (23% level), the 15% yield response for the MP system was considerably higher than the 2% for the RP system. This was in contrast to previous years when greatest response to starter fertilizer was with the RP, CP and NT systems. Grain moisture was decreased significantly (0.6 points) by the starter fertilizer but was unaffected by the previous Poast treatments.

Early plant growth was affected significantly by the tillage systems (Table 2). Plants were largest with the MP and RP systems, were intermediate in size with the CP and SD systems and were significantly smaller with NT. Starter fertilizer increased early plant weight when averaged across tillage systems. The interaction between tillage and starter fertilizer was not significant (33% level). Final population was not affected by tillage or starter fertilizer.

Grain N was not influenced by tillage or starter fertilizer (Table 2). However, N removal in the grain (product of grain N concentration and grain yield) was affected significantly by both tillage and starter fertilizer. This effect was due largely to the yield differences among the treatments, which resulted in lowest N removal with the NT system and the plots without starter fertilizer.

Residue measurements taken prior to planting showed significant differences among the treatments for percent of the soil surface covered with residue from the previous crops (Table 3). The treatments ranked NT > SD > RP = CP > MP. After planting, surface residue measurements were taken both within the row and randomly across the plot area. All tillage treatments showed significantly more residue than the MP treatment. However, only the NT system exceeded 30% and therefore met the definition of "conservation tillage". Within the row measurements showed similar residue amounts compared to random across-the-plot measurements for all tillage systems.

Planting depth was affected significantly by the tillage systems (Table 3). This was consistent with most previous years. The variability in the seeding depth as measured by standard deviation and range in depths indicates least variability with the CP and SD systems and greatest variability with the NT system. Seed placement average between 2.2" and 2.5" for the MP, CP, RP and SD tillage systems compared to 1.6" for the NT system. These differences point out the need for careful adjustments of the planter even when following soybeans.

Table 1. Influence of tillage methods, starter fertilizer and previous Poast herbicide treatment on corn production at Waseca in 1988.

Tillage	Starter fertilizer[1/]	Poast herbicide[2/]	Grain Moisture	Grain Yield
			%	bu/A
No tillage	S	P	22.9	50.1
"	S	NP	22.7	36.5
"	NS	P	24.5	31.9
"	NS	NP	24.2	27.4
Fall plow, f. cult.	S	P	19.5	119.5
" "	S	NP	18.6	117.0
" "	NS	P	19.7	95.8
" "	NS	NP	19.4	109.2
Fall chisel, d., f. cult.	S	P	19.5	109.2
" "	S	NP	20.0	82.0
" "	NS	P	20.2	88.5
" "	NS	NP	21.1	65.4
Ridge plant	S	P	19.4	93.0
" "	S	NP	19.2	96.8
" "	NS	P	19.2	95.2
" "	NS	NP	19.3	89.9
Spring disk (2x)	S	P	19.9	109.3
" "	S	NP	21.0	76.0
" "	NS	P	20.2	105.2
" "	NS	NP	21.3	55.6
Individual Factors				
Tillage				
No tillage			23.6	36.5
Fall plow			19.4	110.4
Fall chisel			20.2	86.3
Ridge plant			19.2	93.7
Spring disk (2x)			20.6	86.5
Significance Level (%):[3/]			99	99
BLSD (.05) :			1.0	22.2
Starter Fertilizer				
Starter			20.3	89.0
No starter			20.9	76.4
Significance Level (%):[3/]			99	99
Poast Herbicide				
Poast			20.5	89.8
No Poast			20.7	75.6
Significance Level (%):[3/]			62	99
Interactions			Significance Levels (%)	
Tillage x SF			82	23
Tillage x Poast			93	99
SF x Poast			41	7
Tillage x SF x Poast			2	27
CV (%)			4.6	22.

1/ S = starter fertilizer used and NS = no starter fertilizer used.
2/ P = Poast herbicide used and NP = no Poast herbicide used in 1987.
3/ Probability level of significant difference between means.

Table 2. Influence of tillage methods and starter fertilizer on corn production at Waseca in 1988.

Treatment: Tillage	Treatment: Starter fert.[1/]	Early plant growth	Final population	Grain: N	Grain: N Removal
		g/plant	x10³	%	lb/A
No tillage	S	6.1	26.1	1.66	38.8
No tillage	NS	4.7	28.0	1.67	25.4
Fall plow, f. cult.	S	16.2	29.0	1.62	91.1
Fall plow, f. cult.	NS	14.7	28.6	1.70	77.1
Fall chisel, f. cult.	S	11.5	28.8	1.66	84.8
Fall chisel, f. cult.	NS	9.2	29.5	1.70	70.1
Ridge plant	S	12.2	28.5	1.67	72.1
Ridge plant	NS	11.8	28.9	1.67	74.2
Spr. disk	S	9.3	28.8	1.65	85.2
Spr. disk	NS	8.1	28.9	1.60	79.2
INDIVIDUAL FACTORS					
Tillage					
No tillage		5.4	27.0	1.66	32.1
Fall plow		15.5	28.8	1.66	84.1
Fall chisel		10.4	29.2	1.68	77.5
Ridge plant		12.0	28.7	1.67	73.2
Spr. disk		8.7	28.9	1.63	82.2
Signif. Level (%):		99	59	15	99
BLSD (.05)		2.0			18.8
Starter fertilizer					
Starter		11.1	28.3	1.62	74.4
No starter		9.7	28.8	1.68	65.2
Signif. Level (%):		99	79	67	99
Till x SF IA					
Signif. Level (%):		33	47	87	69
CV (%) :		12.	4.4	2.8	13.

1/ S = starter fertilizer used and NS = no starter fertilizer

Table 3. Influence of tillage methods for corn following soybeans on surface residue, seeding depth and leaf N at Waseca in 1988.

Treatment	Surface Residue: Before planting	Surface Residue After Planting: Across plot	Surface Residue After Planting: Within row	Planting Depth: Average	Planting Depth: S	Planting Depth: Range	Leaf nitrogen
	%	%	%	mm	mm	mm	%
No tillage	90	88	90	42	7.6	28-54	2.32
Fall plow	4	1	1	62	7.2	51-76	2.49
Fall chisel	18	7	7	64	5.8	55-78	2.44
Ridge plant	22	14	10	55	7.1	43-67	2.55
Spr. disk	60	14	9	59	5.9	47-69	2.38
Signif. Level (%):	99	99	99	99			48
BLSD (.05) :	9	6	4	12			-
CV (%) :	17.	18.	14.	13.			7.8

Nitrogen concentration of the earleaf at silking was not influenced significantly by tillage (Table 3).

The rate of seedling emergence was determined by counting the number of plants that had spiked thru in 100-feet of row/plot from the 10th to the 19th day after planting. Emergence, as a percent of final stand, shown in Table 4 indicates most rapid emergence with the RP system. Emergence was delayed about 1 to 2 days with the MP, CP and SD systems and about 3 days with the NT systems. These differences continued through about the 6 to 8-leaf stage, but by silking phenological differences among the RP, MP, CP and SD were not evident. The NT system, however, continued to be about 7 days behind at silking and reached physiological maturity a few days after the other tillage systems.

Table 4. Influence of tillage methods on the emergence progress of corn following soybeans at Waseca in 1988.

	Days Post Planting								
Treatment	10	11	12	13	14	15	16	17	19
	% emerged								
No tillage	0	0	8	22	44	74	89	97	100
Fall plow	0	15	55	76	86	90	94	96	100
Fall chisel	0	6	46	73	89	94	98	99	100
Ridge plant	2	38	82	90	96	99	100	100	100
Spring disk	0	8	44	69	84	94	96	98	100

Weed counts (broadleaf and grass) were taken between the 4th and 5th rows from 1 ft^2 sections/plot from both the previous (1987) Poast and non-Poast sections 12 days after preemergence herbicide application (Table 5). Weed pressure from broadleaf weeds was not great, as broadleaf weed counts were low from both herbicide treated and untreated areas. Grasses were controlled extremely well in the MP and RP systems and to a lesser degree with CP tillage. Grass weed control was least adequate with the NT tillage system. Under these dry conditions, the Lasso + Bladex combination had little overall effect on grass weed control at this time.

Table 5. Weed populations on May 23 as affected by tillage and herbicide for corn following soybeans at Waseca in 1988.

	Herbicide[1/]		No Herbicide	
Treatment	Grasses	Broadleaves	Grasses	Broadleaves
	plants/10 sq. ft.[2/]			
No tillage	1400	0	1427	10
Fall plow	20	10	30	0
Fall chisel	250	0	81	10
Ridge plant	50	0	40	0
Spring disk	620	0	719	0

1/ 3½ lb Lasso and 3 lb Bladex/A, preemergence
2/ Average over 4 replications and 2 counts/rep.

Grass counts from these 1 ft^2 areas were also taken for both the Poast and non-Poast areas that had been treated in 1983, 1985 and 1987. The purpose of these measurements was to evaluate the effect of these previous Poast applications on the grass pressure. Data shown in Table 6 indicate: (1) a tremendous affect of tillage on grass density, (2) some improvement in weed control with the preemergence herbicide, and (3) a marked decrease in weed pressure resulting from the previous applications of Poast. This resulted in the highly significant tillage x Poast interaction for corn yield shown in Table 1. Even though most farmers would use a herbicide program for general weed control somewhat similar to the Lasso + Bladex program, it is quite apparent that post emergence applications of materials such as Poast in the soybean phase of this crop sequence would be especially helpful for long-term grass management in the NT and SD tillage systems.

Table 6. Grass populations on May 23 as affected by previous Poast applications and tillage.

Treatment	Poast[1/] Preemerg	Poast[1/] No Preemerg	No Poast Preemerg	No Poast No Preemerg
	Grasses/10 sq. ft.[2/]			
No Tillage	670	800	1130	2060
Fall Plow	10	20	30	40
Fall Chisel	30	80	460	1540
Ridge Plant	0	10	100	70
Spr. Disk (2 X)	130	140	1110	1290

1/ Applied in 1983, 1985 and 1987.
2/ Avg. of 4 replications and 2 counts/rep.

SUMMARY - 1987

This was the third crop of corn grown after soybeans in this long-term study with continuous corn from 1975 through 1982, soybeans in 1983, 1985 and 1987 and corn in 1984 and 1986. Surface residues prior to planting were greater than 50% with the NT and SD systems and remained above 30% after planting with the NT system. Plant emergence was fastest with RP, delayed by about 1 to 2 days with the MP, CP and SD systems, and by about 3 days with NT. Weed pressure was reduced some with the Lasso + Bladex preemergence application. Lowest weed pressure was noted with the RP and MP systems. Highest weed counts, primarily grasses, were found with the NT and SD systems. Previous applications of Poast to soybeans greatly reduced grass pressure in the CP, SD and NT systems. Early plant growth was greatest for the MP system and least for NT. Phenological plant development throughout the season continued to be a couple of days behind for the NT plants compared to plants grown on the other tillage systems. Leaf N was not affected by tillage or starter fertilizer. Yields were highest for MP, intermediate for RP, CP and SD, and lowest for the NT system. Soil profile investigations in mid-July indicated very limited soil water throughout the top 36" with all tillage systems and particularly poor rooting systems for the RP and NT tillage systems. Starter fertilizer increased yields by 16% when averaged over tillage systems. However, yield increases due to starter were greatest with the NT, CP and MP systems.

FOURTEEN-YEAR YIELD SUMMARY

Grain yields from the five tillage systems where starter fertilizer was used from 1975-1982 are shown in Table 7. The 8-year average yield shows a 5.3 bu/A yield advantage for the moldboard plow over the ridge-plant system. Some of this difference can be attributed to the 17 bushel advantage in 1980 for moldboard plowing. The chisel plow and till-plant (flat) systems showed intermediate yields while lowest yields were obtained with no tillage. Weed control was excellent in all treatments except no tillage. Postemergence herbicides were applied to no tillage in 1979 and 1980 and did provide better weed control.

Four-year data (1979-82) indicate some advantage for the use of starter fertilizer with the chisel plow (6 bu/A), ridge-plant (5 bu/A) and no tillage systems (5 bu/A). No reason can be given for the obvious difference in response to starter fertilizer between the no tillage and till-plant (flat) systems when both treatments represent the most severely reduced tillage systems.

Yields with no tillage continue to be significantly below the other tillage systems since converting to a corn/soybean sequence (Table 7). Corn yields in this sequence have not been different among the MP, CP, RP and SD systems when starter fertilizer has been used. Without starter fertilizer, yields from the CP, RP and SD systems have averaged about 9% less than from the MP system. Soybean yields in this sequence averaged about 6% higher with the moldboard plow system compared to the CP, RP, or SD systems with virtually no difference among the latter three systems.

Table 7. Influence of tillage methods and starter fertilizer on long-term corn and soybean yields at Waseca.

Treatment		Cont. Corn Yield		Soybeans	Corn
Tillage	Starter	1975-82	1979-82	1983,85 & 87	1984,86 & 88
		bu/A			
No tillage	Yes	129.2	140.6	34.5	111.5
"	No		136.0	34.3	98.8
Fall plow	Yes	154.5	170.9	51.0	145.6
"	No		170.8	50.2	141.2
Fall chisel	Yes	144.4	161.8	47.7	136.0
"	No		155.5	45.5	124.5
Ridge plant	Yes	149.2	161.5	46.9	137.4
"	No		156.4	47.2	129.4
Till plant (flat) 1/	Yes	144.9	154.8	46.8	139.7
"	No		157.4	47.1	132.1

1/ This treatment was converted to a spring disk (2x) beginning with the 1983 crop.

TILLAGE SYSTEMS FOR CORN AND SOYBEAN CROP SEQUENCES

Waseca, 1988

G. W. Randall, B. W. Anderson and R. R. Allmaras[1/]

ABSTRACT: A study was started in 1986 to determine the effect of tillage on corn and soybean production when grown in rotation compared to a continuous monoculture. Yield results in 1988 were highly variable due to the heat and moisture stress. Although both corn and soybean yields were substantially higher with NT compared to MP and CP tillage, these differences were not statistically significant at the 90% level. Corn and soybeans in rotation yielded 16 and 20% higher, respectively, than did the continuous monoculture systems. Tillage x crop sequence interactions were not significant for either crop.

Corn-soybean rotations have often been compared to continuous corn and soybean monocultures using a particular tillage system. Seldomly, however, have these comparisons been made over a range of primary tillage systems. The purpose of this study is to determine the effect of tillage on corn and soybean production when grown in a monoculture compared to a rotation.

Experimental Procedures

A study had been established on this Webster clay loam site in the fall of 1980 to determine the relationship between primary tillage and the incidence of corn and soybean diseases in continuous corn, continuous soybeans and a corn-soybean rotation. The tillage systems were fall moldboard plow (MP), fall chisel plow (CP), and no tillage (NT). After this 5-yr study was completed in 1985, the initial tillage plots and some of the monoculture plots were kept intact to take advantage of the past tillage and cropping history. Some of the monoculture plots were changed to a corn-soybean sequence so that there are now four cropping systems over each tillage system. The cropping systems are continuous corn (C-C), corn-soybean (C-Sb), soybean-corn (Sb-C), and continuous soybeans (Sb-Sb). Each treatment is replicated four times in a split-plot design with tillage as the main plot and crop system as the subplot.

Fall tillage was performed in October, 1987 after stalk chopping all corn plots. Spring secondary tillage consisted of disking the CP plots and field cultivating the MP and CP plots on April 21.

Nitrogen was broadcast applied as ammonium nitrate prior to secondary tillage to all 1988 corn plots at a rate of 200 lb N/A regardless of previous crop. Broadcast P and K were not applied because of high soil test P and K levels. Starter fertilizer was not used.

Corn (Pioneer 3737) was planted on May 4 at a rate of 28,400 ppA with a John Deere Max-Emerge II 4-row planter equipped with bubble coulters. Counter (1 lb ai/A) was applied to all corn plots at the time of planting. Weeds were chemically controlled with a combination of 3½ qts. Lasso and 3 qts Bladex/A applied preemergence on May 11. Row cultivation was performed on May 31 in the MP and CP corn plots.

Soybeans (Hardin) were planted in 30" rows with the aforementioned planter at a rate of 9 beans/foot on May 16. Weeds were controlled with a preemergence application of Lasso (3½ qts/A) + Amiben (6 qts/A) on May 20. The MP and CP soybean plots were cultivated on June 10.

A modified JD 3300 plot combine was used to harvest both the corn and soybeans. Corn and soybean yields are expressed at 15.5 and 13.5% moisture, respectively.

All wheel traffic during the season was confined to the same inter-row areas that were trafficked at the time of planting. This resulted in wheel traffic on one side of each row with the other side non-compacted by machinery operations.

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Results and Discussion

Corn yields were quite poor and highly variable due to the extreme heat and dry conditions throughout most of the growing season (Table 1). When averaged over crop sequence, NT yields were 38% and 17% higher than with CP or MP tillage, respectively. These yield differences, however, were not statistically significant at the 90% level due to the high CV (16%) and the highly significant tillage x rep interaction. This interaction is demonstrated by CP yields ranging from 38 bu/A in rep 1 to 107 bu/A in rep 2 while NT yields ranged from 78 bu/A in rep 3 to 136 bu/A in rep 4. Yield variation with MP tillage was much smaller, ranging from 75 bu/A in rep 1 to 108 bu/A in rep 3. These extreme differences were largely due to small changes in microrelief which affected stored soil moisture within the experimental site and because the CP tillage blocks in reps 1 and 3 were on the south edge of the study. Since there was no crop for over 1/2 mile to the south, the hot and dry south winds appeared to have influenced these plots to a greater degree than the rest of the study. Crop sequence significantly influenced corn yield. Corn following soybeans yielded 16% higher than continuous corn. The tillage x sequence interaction was not significant.

Grain moisture was significantly higher with NT compared to the MP and CP systems and for continuous corn (Table 1). Final population was not influenced by either tillage or crop sequence.

Table 1. Corn grain yield and moisture content and final population as affected by tillage and crop sequence.

Tillage	Crop Sequence	Grain Yield	Grain Moisture	Final population
		bu/A	%	$\times 10^{3}$
MP	C-C	77.0	17.6	28.4
"	C-Sb	96.9	16.6	28.7
CP	C-C	71.4	18.4	28.3
"	C-Sb	75.8	16.9	27.9
NT	C-C	94.4	20.2	28.2
"	C-Sb	109.2	18.0	29.2
FACTORIAL COMPARISONS				
Tillage				
MP		86.9	17.1	28.6
CP		73.6	17.7	28.1
NT		101.8	19.1	28.7
Signif. Level (%):1/		72	98	90
BLSD (.05) :			1.4	
Crop Sequence				
C-C		80.9	18.8	28.3
C-Sb		93.9	17.2	28.6
Signif. Level (%):1/		95	99	82
Tillage x Replication Interaction				
Signif. Level (%):1/		98	99	96
Tillage x Sequence Interaction				
Signif. Level (%):1/		43	92	51
CV (%) :		16.	2.5	1.8

1/ Probability level of significance.

Soybean yields were relatively better than corn but were also highly variable (Table 2). When averaged over crop sequence, the NT yields were 20% and 14% higher than CP and MP tillage, respectively. Similar to corn, these yield differences were not statistically significant due to the high CV (10%) and the significant tillage x rep interaction. Soybeans following corn yielded 20% more than did continuous soybeans. There was no significant tillage x sequence interaction. Soybean seed moisture at harvest was unaffected by tillage and crop sequence.

Table 2. Soybean seed yield and moisture content as affected by tillage and crop sequence.

Tillage	Crop Sequence	Yield	Moisture
		bu/A	%
MP	Sb-Sb	29.8	11.2
"	Sb-C	36.5	11.5
CP	Sb-Sb	27.8	11.4
"	Sb-C	35.0	11.3
NT	Sb-Sb	35.6	11.5
"	Sb-C	40.0	10.9
FACTORIAL COMPARISONS			
Tillage			
MP		33.1	11.4
CP		31.4	11.4
NT		37.8	11.2
Signif. Level (%):		72	86
Crop Sequence			
Sb-Sb		31.0	11.4
Sb-C		37.2	11.2
Signif. Level (%):		99	74
Tillage x Replication Interaction			
Signif. Level (%):		96	13
Tillage x Sequence Interaction			
Signif. Level (%):		29	97
CV (%) :		10.	2.6

THREE-YEAR SUMMARY

Corn yields from this completely weed-free site were approximately 15 bu/A higher for NT compared to either MP or CP regardless of crop sequence (Table 3). Corn yields following soybeans averaged approximately 10% higher than continuous corn regardless of tillage system. Soybean yields were not affected by tillage system. Soybeans following corn yielded approximately 16% higher than continuous soybeans when averaged over tillage systems.

Table 3. Three-year corn and soybean yield averages as influenced by tillage and crop sequence.

Tillage	Crop Sequence	Yield Corn	Yield Soybean
		bu/A	bu/A
MP	Cont. Corn	131.0	-
"	Corn-Soybean	146.5	48.9
"	Cont. Soybean	-	44.2
CP	Cont. Corn	132.5	-
"	Corn-Soybean	142.5	50.8
"	Cont. Soybean	-	42.5
NT	Cont. Corn	147.4	-
"	Corn-Soybean	161.5	51.7
"	Cont. Soybean	-	44.1

CORN PRODUCTION AS AFFECTED BY TILLAGE IN A SOYBEAN-CORN MANAGEMENT SYSTEM

Waseca, 1988

G. W. Randall, B. W. Anderson, and W. E. Lueschen

Abstract: A three-year study was conducted to determine if the optimum N rate and hybrid are affected by tillage when corn follows soybeans. Corn yields in this study were generally not influenced by tillage system. Three-year averages suggest a maximum difference of 5% among tillage systems. Corn yields were increased about 45 bu/A with the first 80 lb N/A. Profitable increases in yield were generally not obtained at N rates greater than 80 pounds. Considerable yield differences existed among hybrids, but these differences were not influenced by tillage system. The highest and lowest yielding hybrids performed consistently across all tillage systems.

The objectives of this study initiated in the fall of 1985 were to evaluate the effect of tillage following soybeans on (1) corn production, (2) the optimum N rate for corn production, (3) corn hybrid performance and the interaction of hybrid with tillage, and (4) N uptake patterns of five corn hybrids.

Experimental procedures

Five tillage systems (continuous no tillage (NT), continuous paraplow (PP), continuous ridge-plant (RP), NT after soybeans and chisel plow (CP) after corn, and CP after soybeans and moldboard plow (MP) after corn) were established in the fall of 1985 on a Webster soil that had soybean stubble. A split plot design with tillage as main plots and N rate as subplots was used with 4 replications. Only the CP/MP treatment received spring secondary tillage -- one field cultivation. Five corn hybrids (Pioneer 3737, Pioneer 3732, DeKalb 524, Supercrost 2410, and Funks G-4327) were planted on May 5 at a population of 29900 plants/acre. Pioneer 3737 was used in the "N rate" portion of the study while all hybrids were used in the "hybrid" part of the study. No starter fertilizer or rootworm insecticides were used. Weed control was excellent with a preemergence application of Lasso + Bladex.

Nitrogen rates of 0, 40, 80, 120, 160 and 200 lb N/A were applied midway between the rows as anhydrous ammonia at the 5-leaf stage (June 7). Surface residue measurements were taken from the 40- and 120-lb plots via the line-transect method on May 11. Plant populations were taken on May 31. Ridges were built for 1989 on June 21. Silking stage whole plant dry matter accumulation and N concentration were measured on 6 random plants per plot on July 15-19; the onset of silk initiation varied with N rate and tillage. Total DM at physiological maturity (PM) was obtained by harvesting 8 consecutive plants from 5 feet of row, weighing, chopping, subsampling, drying and weighing. Grain yields were obtained by harvesting with a modified JD 3300 plot combine on October 10. Nitrogen concentrations of the stover at silking and fodder and grain at PM were determined by the Research Analytical Lab.

Results

Surface residue coverage after planting but before ammonia injection was greatly affected by the tillage system and by the planter (Table 1). Residue accumulation was lowest with the CP and RP systems, intermediate for the PP system and highest with NT. Scalping of the ridge-top resulted in the least amount of residue along the row.

Table 1. Effect of tillage on residue cover after planting.

Tillage System	Residue accumulation[1/] In row	Between row
	%	
No Till	22	58
Paraplow	22	41
Ridge-plant	2	14
No Till/CP	18	49
Chisel/MP	4	8

1/ Each number is an average of 16 observations.

Grain yields were significantly affected (P = 90% level) by the rate of N application but not by tillage (Table 2). Grain yields were optimized at the 80-lb rate of N application. Although not statistically significant (due to high variability, CV = 11.4%), yields were consistently lower with the PP tillage system and highest for the RP and NT/CP systems. There was no interaction between tillage system and N rate.

Table 2. Corn yield following soybeans as influenced by tillage system and N rate.

N Rate	Tillage System[1/] CP/MP	NT	NT/CP	PP	RP	Avg.
lb N/A			bu/A			
0	87.6	80.0	80.9	75.6	80.7	81.0
40	91.3	101.4	92.6	92.0	98.8	95.2
80	99.3	96.9	104.2	93.7	100.1	98.8
120	98.3	104.4	115.6	91.4	101.3	102.2
160	94.1	99.9	106.9	99.2	117.1	103.4
200	100.8	95.3	102.0	90.8	110.9	100.0
Average:	95.2	96.3	100.4	90.4	101.4	96.8

Statistical Analysis

Variable	Signif. Level (%)	BLSD (.05)
Tillage	54	-
N rate	99	17.4
Tillage x N rate	54	-

CV (%) = 11.4

1/ Pioneer 3737 only.

In the hybrid portion of the study, grain yields were again not affected by tillage (Tables 3 and 7). A highly significant difference existed among hybrids. Highest yields were obtained with Pioneer 3737 followed by Pioneer 3732 and DeKalb 524. Yields were lowest with the Supercrost 2410 and Funks G-4327 hybrids. There was no interaction between tillage system and hybrid.

Table 3. Corn yield following soybeans as influenced by tillage system and hybrid.

	Tillage System[1/]					
Hybrid	CP/MP	NT	NT/CP	PP	RP	Avg.
	bu/A					
P3737	94.1	99.9	107.0	99.2	117.1	103.4
P3732	101.2	88.0	107.5	82.4	101.5	96.1
DK524	89.4	101.0	98.4	96.7	87.4	94.6
SC2410	93.2	89.1	90.6	88.6	88.1	89.9
G-4327	82.6	81.0	94.8	80.6	94.0	86.6
Average:	92.1	91.8	99.7	89.5	97.6	94.1

1/ 160 lb N/A

Plant populations shown in Table 4 were significantly lower for the RP system compared to the others. Even though the settings were the same for both JD planters the 7300 dropped more seeds than did the 7100 ridge planter. This also occurred in the hybrid portion of the study (Table 5). In addition, plant populations were slightly lower for the P3732 and SC2410 hybrids. Grain moisture at harvest, an indication of maturity, was significantly higher for the NT and NT/CP tillage treatments and for the 0-lb N treatment. Consistent grain moisture differences did not exist among the 40 to 200-lb N rates.

The plant properties shown in Tables 5-8 are expressed on both an area and per plant basis because of the population differences. At the silking stage stover DM yields were significantly higher for the CP and PP systems when averaged over hybrids (Table 5). When averaged over tillage, significant DM differences among hybrids were also found. The P3732, DK524, and G-4327 hybrids produced markedly higher DM yields than the other two hybrids. There was no significant tillage x hybrid interaction.

Stover N concentrations at silking were influenced significantly by tillage and hybrid (Table 5). Highest concentrations were obtained with RP tillage and P3737. No difference existed among the other hybrids.

Nitrogen uptake at silking was significantly lower with NT compared to the other tillage systems when averaged over hybrids, primarily due to lower DM accumulation (Table 5). Uptake differences among hybrids were not significant.

At physiological maturity (PM) fodder DM yields were not affected by tillage but were affected greatly by hybrid (Table 6). Yields were highest with DK524 and G-4327, intermediate with P3732 and SC2410, and lowest with P3737.

Fodder N concentration was not affected by tillage but was affected by hybrid (Table 6). Highest concentrations occurred with DK524 and G-4327 while P3737 had the lowest N concentration.

Fodder N uptake at PM was not affected by tillage when averaged over hybrids but was significantly affected by hybrid when averaged over tillage (Table 6). This was primarily due to the lower DM accumulation and N concentration with P3737 compared to the other hybrids.

The N assimilated by the plants prior to the silk stage that was subsequently translocated to the grain (Stover N uptake at silking - Fodder N uptake at PM) was not influenced significantly (P = 95% level) by tillage but was significantly different among hybrids (Table 6). This "pre-silk grain N" (OLD N) was markedly higher with the two Pioneer hybrids compared to the others.

Grain N concentration was not significantly different (P = 95% level) among tillage systems when averaged over hybrids (Table 7). When averaged over tillage hybrid ranking for grain N concentration was SC2410 >DK524 = G-4327 > P3737 = P3732 with the Pioneer hybrids being substantially lower than the rest. This ranking was almost identical to 1987.

Grain N uptake was not affected by tillage system when averaged over hybrids (Table 7). When averaged over tillage systems hybrid ranking for grain N uptake was SC2410 > P3737 = DK524 ≥P3732 ≥G-4327. This ranking was also identical to 1987. A significant tillage x hybrid interaction was not found.

Total plant N uptake at PM was influenced by hybrid but not tillage (Table 8). Similar to the other N parameters, total plant N uptake was highest with DK524, intermediate for SC2410 and G-4327, and lowest for P3737 and P3732 when averaged over tillage systems. Interactions between tillage and hybrid were not significant.

One of the objectives of this study was to determine if either tillage or hybrid affected the amount of N taken up by the plant after silking (late season uptake) and then accumulated in the grain. The POST-silk uptake data shown in Table 8 are quite variable but do indicate rather large differences among the hybrids when averaged over tillage systems. Post-silk N uptake was highest for SC2410 and DK524, intermediate for G-4327, and lowest for P3737 and P3732 when averaged over tillage systems. There was no significant tillage x hybrid interaction.

Since POST-SILK values are obtained by subtraction (Total Grain N Uptake - PRE-SILK grain N uptake) and PRE-SILK grain N uptake is obtained by subtracting fodder N uptake at PM from SILK N uptake, the negative values and high variability may be due simply to cumulative experimental sampling error.

Conclusions

Based on these 1-year results in a dry year:

1) Corn yields in a corn-soybean sequence were not affected by tillage system but were influenced by hybrid. Yields were highest for the P3737 hybrid and lowest for G-4327.

2) Corn yields were optimized with 80 lb N/A.

3) The optimum N rate was not affected by the tillage system.

4) Substantial differences occurred among the five hybrids evaluated, but there was no interaction between the hybrids and tillage systems.

THREE-YEAR SUMMARY

Tillage x N Rate Study

Average corn yields over the 3-yr period (1986-88) indicated that tillage did not have a large effect on corn production following soybeans (Table 9). Yields from the NT/CP, RP, and CP/MP systems averaged only about 5% higher than from the NT and PP systems when averaged over N rates. When averaged over tillage systems, yields were optimized at a N rate of 80 lb/A. It appears that applying N at the 120-lb rate would have optimized yields with the NT and PP systems. However, because of year to year variation and plot variability, it does not appear that a tillage x N rate tillage interaction exists. In other words, the optimum N rate will generally not be affected by the tillage system used when corn follows soybeans.

Tillage x Hybrid Study

Similar to the previous study, tillage did not have a large effect on corn yields when averaged over hybrid for the 3-yr period. Again, slightly higher yields were obtained with the NT/CP, CP/MP and RP systems. Hybrid selection substantially affected yields regardless of tillage system. Yields were highest for P3737 and lowest for G-4327 in all tillage systems. These data indicate that interpretations from hybrid performance trials should not be affected by tillage. Farmers should select a consistent, high-yielding hybrid regardless of the tillage system they use.

Table 4. Final population and grain moisture as influenced by tillage and N rate.

Tillage	N rate lb/A	Final population ppA x 10^3	Grain Moisture %
CP/MP	0	31.0	17.3
	40	31.1	17.1
	80	30.7	16.9
	120	30.5	17.1
	160	31.7	16.6
	200	30.8	17.6
NT	0	29.9	18.4
	40	31.2	18.5
	80	31.2	18.6
	120	31.6	18.2
	160	30.0	18.1
	200	31.0	18.8
NT/CP	0	30.2	18.6
	40	32.2	17.3
	80	31.0	17.6
	120	31.0	17.6
	160	31.7	17.4
	200	30.8	17.3
PP	0	30.9	17.8
	40	30.9	17.1
	80	30.3	16.8
	120	30.0	16.6
	160	30.7	16.1
	200	30.4	16.8
RP	0	27.2	18.1
	40	27.6	17.2
	80	28.2	16.7
	120	27.8	17.0
	160	27.4	16.0
	200	27.2	17.8
Main Factors			
Tillage			
CP/MP		31.0	17.1
NT		30.8	18.4
NT/CP		31.2	17.7
PP		30.5	16.8
RP		27.6	17.1
Signif. Level (%):		99	99
BLSD (.05) :		0.8	0.5
N Rate (lb/A)			
0		29.8	18.0
40		30.6	17.4
80		30.3	17.3
120		30.2	17.3
160		30.3	16.7
200		30.3	17.6
Signif. Level (%):		65	99
BLSD (.05) :		–	0.7
Interaction		Signif. Level(%)	
Tillage x N		49	41
CV(%) :		3.6	4.4

Table 5. Final population and plant properties at silking as influenced by tillage and hybrid.

Tillage	Hybrid	Final popl'n	Stover DM Yield		Stover N Conc.	N Uptake	
		$x10^3$	g/plt	TDM/A	%	g/plt	lb/A
CP/MP	P3737	31.7	88	3.08	1.49	1.31	91
"	P3732	30.2	99	3.30	1.29	1.28	85
"	DK524	29.7	105	3.46	1.46	1.54	101
"	SC2410	27.8	94	2.88	1.42	1.33	82
"	G-4327	30.6	99	3.33	1.39	1.38	93
NT	P3737	31.4	83	2.88	1.45	1.21	84
"	P3732	27.6	98	2.98	1.44	1.42	86
"	DK524	29.0	93	2.96	1.40	1.30	83
"	SC2410	28.6	86	2.71	1.45	1.24	79
"	G-4327	30.6	100	3.38	1.35	1.35	91
PP	P3737	30.7	92	3.10	1.56	1.44	97
"	P3732	29.7	101	3.31	1.48	1.50	98
"	DK524	29.0	103	3.29	1.42	1.45	93
"	SC2410	28.0	98	3.09	1.45	1.42	89
"	G-4327	30.7	98	3.32	1.42	1.39	94
RP	P3737	27.4	91	2.71	1.60	1.45	87
"	P3732	27.0	102	3.02	1.45	1.49	88
"	DK524	28.6	94	2.97	1.45	1.37	87
"	SC2410	26.9	95	2.82	1.45	1.38	82
"	G-4327	27.1	100	2.98	1.41	1.41	84
Main Factors							
Tillage							
	CP	30.0	97	3.21	1.41	1.37	90
	NT	29.4	92	2.98	1.42	1.31	84
	PP	28.8	98	3.22	1.46	1.44	94
	RP	27.4	96	2.90	1.48	1.42	86
Signif. Level (%)	:	99	95	99	97	99	98
BLSD (.05)	:	1.2	5	.16	.05	.08	7
Hybrid							
	P3737	30.3	88	2.94	1.52	1.35	90
	P3732	28.6	100	3.15	1.42	1.42	89
	DK524	29.1	99	3.17	1.43	1.42	91
	SC2410	28.0	93	2.88	1.44	1.34	83
	G-4327	29.8	99	3.25	1.39	1.38	91
Signif. Level (%)	:	99	99	99	98	48	74
BLSD (.05)	:	0.9	6	.22	.08	-	-
Interaction							
Tillage x Hybrid				Signif. Level (%)			
		92	29	15	29	38	12
CV (%)	:	4.6	8.3	9.9	7.6	12.	13.

Table 6. Dry matter yield and N concentration in the fodder at physiological maturity and pre-silk N uptake that was translocated to the grain as influenced by tillage and hybrid.

Tillage	Hybrid	Fodder DM Yield		Fodder N Conc.	Fodder N Uptake		Grain N from PRE-SILK uptake	
		g/plt	TDM/A	%	g/plt	lb/A	g/plt	lb/A
CP/MP	P3737	63	2.19	.65	.41	28.6	.90	62.8
"	P3732	71	2.35	.72	.51	34.0	.77	51.0
"	DK524	76	2.50	.85	.64	42.3	.90	58.8
"	SC2410	73	2.25	.73	.54	32.9	.80	49.0
"	G-4327	74	2.51	.78	.58	39.3	.79	53.6
NT	P3737	57	1.98	.76	.44	30.1	.77	53.5
"	P3732	67	2.02	.66	.45	26.9	.98	59.4
"	DK524	72	2.30	.73	.53	33.6	.77	49.4
"	SC2410	69	2.19	.74	.52	32.6	.73	46.1
"	G-4327	75	2.51	.79	.59	39.7	.76	51.3
PP	P3737	56	1.90	.65	.38	24.9	1.07	71.9
"	P3732	69	2.26	.73	.51	33.3	.99	64.7
"	DK524	84	2.71	.85	.72	46.4	.73	46.7
"	SC2410	64	2.01	.82	.53	33.5	.89	55.9
"	G-4327	75	2.53	.88	.66	45.0	.73	49.2
RP	P3737	52	1.55	.69	.36	21.4	1.09	65.2
"	P3732	67	1.98	.78	.52	31.0	.97	57.6
"	DK524	74	2.31	.86	.63	39.6	.75	47.1
"	SC2410	66	1.97	.73	.48	28.5	.90	53.4
"	G-4327	70	2.10	.70	.50	29.6	.91	54.8
Main Factors								
Tillage								
	CP	72	2.36	.75	.54	35.4	.83	55.1
	NT	68	2.20	.74	.50	32.6	.80	51.9
	PP	70	2.28	.79	.56	36.6	.88	57.7
	RP	66	1.98	.75	.50	30.0	.92	55.6
Signif. Level (%):		45	92	43	41	82	73	35
Hybrid								
	P3737	57	1.91	.69	.39	26.2	.96	63.4
	P3732	68	2.15	.72	.50	31.3	.93	58.2
	DK524	77	2.45	.83	.63	40.4	.79	50.5
	SC2410	68	2.11	.76	.52	31.9	.83	51.1
	G-4327	74	2.41	.79	.58	38.4	.80	52.2
Signif. Level (%):		99	99	99	99	99	99	99
BLSD (.05) :		5	.19	.06	.06	4.1	.12	8.1
Interaction								
Tillage x Hybrid				Signif. Level (%)				
		35	41	90	67	83	80	53
CV (%) :		11.	13.	12.	18.	18.	19.	20.

Table 7. Grain yield, N concentration and N uptake as influenced by tillage and hybrid.

Tillage	Hybrid	Grain Yield		Grain N Conc.	Grain N Uptake	
		g/plt	bu/A	%	g/plt	lb/A
CP/MP	P3737	101	94.1	1.58	1.60	70.6
"	P3732	84	101.2	1.64	1.37	77.8
"	DK524	74	89.4	1.94	1.44	82.1
"	SC2410	90	93.2	2.01	1.82	88.3
"	G-4327	79	82.6	1.85	1.46	72.4
NT	P3737	97	99.9	1.56	1.51	74.0
"	P3732	96	88.0	1.55	1.48	64.3
"	DK524	92	100.9	1.78	1.64	84.8
"	SC2410	92	89.1	1.98	1.82	83.8
"	G-4327	84	81.0	1.83	1.54	70.1
PP	P3737	96	99.2	1.62	1.54	75.4
"	P3732	85	83.6	1.61	1.36	63.3
"	DK524	83	96.7	1.87	1.56	85.3
"	SC2410	81	87.4	2.06	1.67	85.3
"	G-4327	72	80.6	1.86	1.33	70.8
RP	P3737	97	117.0	1.67	1.61	92.0
"	P3732	93	101.4	1.65	1.51	78.2
"	DK524	87	87.4	1.84	1.58	75.5
"	SC2410	93	88.1	2.02	1.87	84.0
"	G-4327	88	94.0	1.80	1.59	80.1
Main Factors						
Tillage						
	CP	86	92.1	1.80	1.54	78.2
	NT	92	91.8	1.74	1.60	75.4
	PP	84	89.5	1.80	1.49	76.0
	RP	92	97.6	1.79	1.63	82.0
Signif. Level (%):		84	47	92	82	61
Hybrid						
	P3737	98	102.6	1.61	1.57	78.0
	P3732	90	93.6	1.61	1.43	70.9
	DK524	84	93.6	1.86	1.55	81.9
	SC2410	89	89.4	2.02	1.80	85.4
	G-4327	81	84.5	1.84	1.48	73.4
Signif. Level (%):		99	99	99	99	99
BLSD (.05) :		8	8.5	.04	.13	6.6
Interaction						
Tillage x Hybrid			Signif. Level (%)			
		21	84	76	5	92
CV (%) :		13.	13.	3.8	12.	12.

Table 8. Total plant N uptake and post-silk absorbed N (NEW) in the grain as influenced by tillage and hybrid.

Tillage	Hybrid	Total Plant N at PM g/plt	Total Plant N at PM lb/A	Grain N from POST-SILK Uptake g/plt	Grain N from POST-SILK Uptake lb/A	Grain N from POST-SILK Uptake %[1/]
CP/MP	P3737	2.00	99.3	.70	7.8	42
"	P3732	1.88	111.8	.60	26.8	43
"	DK524	2.08	124.4	.54	23.3	38
"	SC2410	2.36	121.2	1.02	39.3	55
"	G-4327	2.04	111.6	.66	18.8	45
NT	P3737	1.95	104.1	.74	20.5	48
"	P3732	1.93	91.1	.51	4.9	34
"	DK524	2.16	118.4	.86	35.4	53
"	SC2410	2.34	116.4	1.09	37.8	60
"	G-4327	2.14	109.9	.78	18.8	50
PP	P3737	1.91	100.3	.47	3.6	31
"	P3732	1.86	96.6	.36	-1.4	24
"	DK524	2.28	131.7	.83	38.6	53
"	SC2410	2.20	118.8	.78	29.4	46
"	G-4327	2.00	115.8	.61	21.6	45
RP	P3737	1.97	113.4	.52	26.7	32
"	P3732	2.04	109.2	.55	20.7	35
"	DK524	2.21	115.1	.83	28.4	53
"	SC2410	2.35	112.5	.97	30.6	51
"	G-4327	2.09	109.7	.67	25.4	38
Main Factors						
Tillage						
	CP	2.07	113.7	.70	23.2	44
	NT	2.10	108.0	.80	23.4	49
	PP	2.05	112.6	.61	18.5	40
	RP	2.13	112.0	.71	26.3	42
Signif. Level (%):		15	29	62	53	62
Hybrid						
	P3737	1.96	104.3	.61	14.6	38
	P3732	1.93	102.2	.50	12.7	34
	DK524	2.18	122.4	.77	31.4	49
	SC2410	2.31	117.2	.97	34.2	53
	G-4327	2.06	111.7	.68	21.1	44
Signif. Level (%):		99	99	99	99	99
BLSD (.05) :		.16	8.3	.19	10.7	10
Interaction						
Tillage x Hybrid			Signif. Level (%)			
		2	71	14	77	39
CV (%) :		11.	11.	39.	68.	32

1/ On a per plant basis

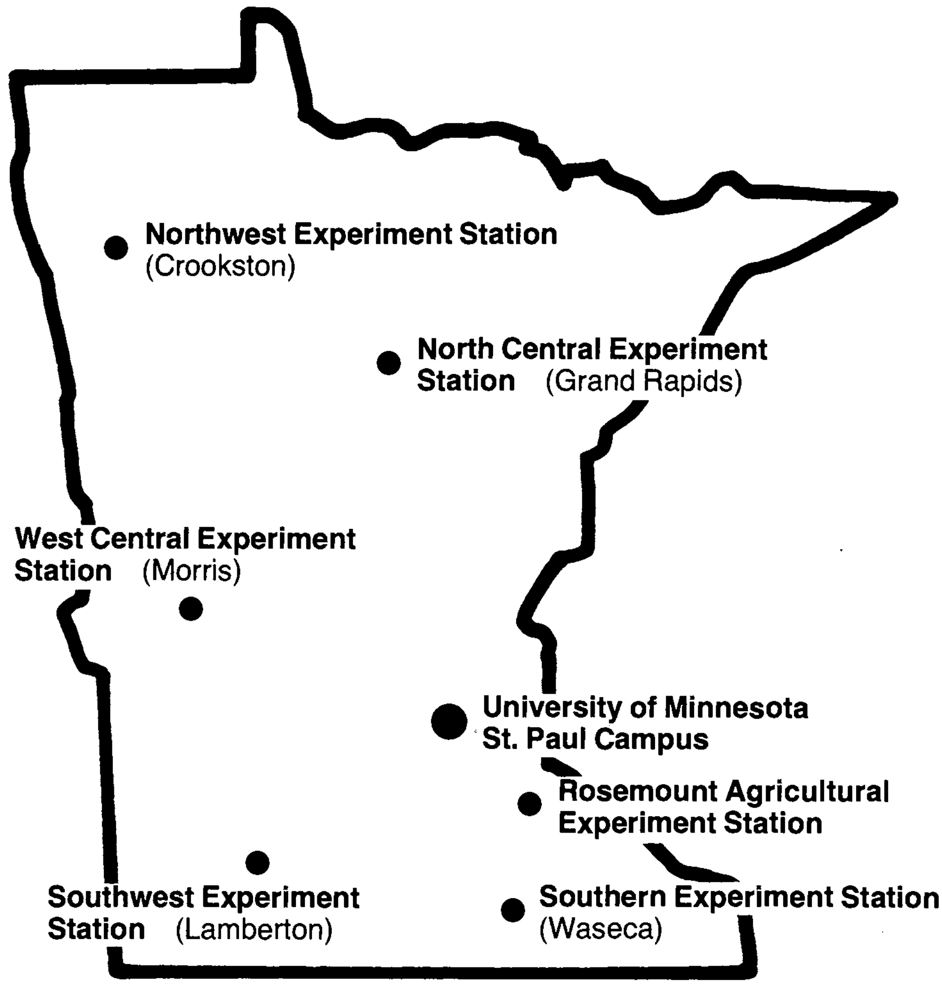
Table 9. Three-year average corn yields following soybeans as influenced by tillage system and N rate.

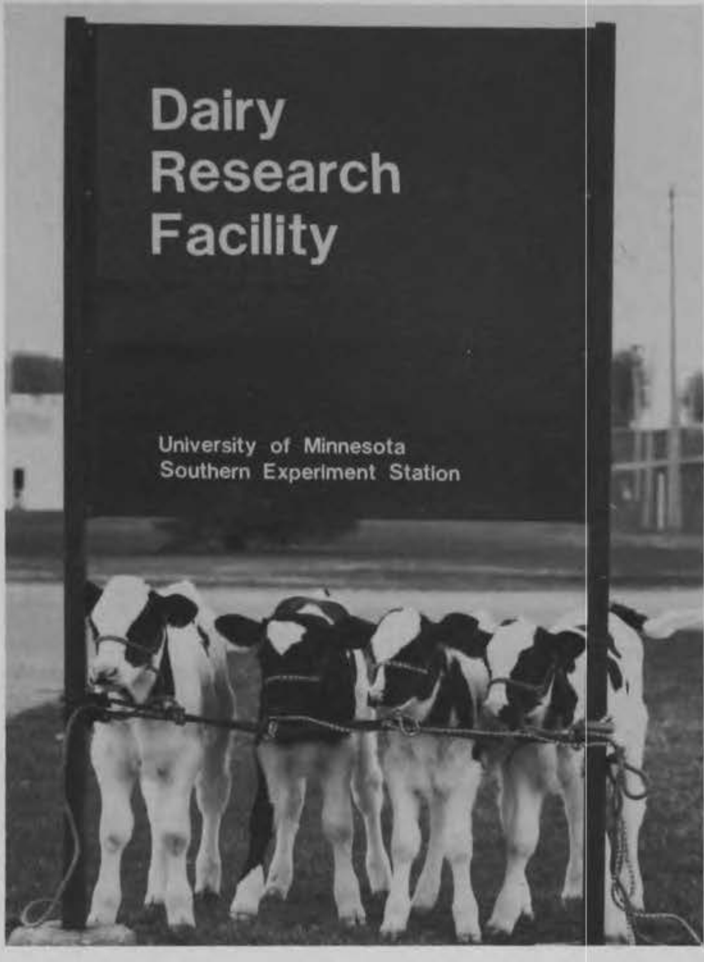
N rate	Tillage System					
	CP/MP	NT	NT/CP	PP	RP	AVG.
lb/A	bu/A					
0	93.6	82.2	93.6	85.3	85.6	88.1
40	117.4	111.4	119.7	115.3	121.6	117.0
80	137.0	130.5	137.0	127.8	133.0	133.1
120	138.1	137.4	136.7	133.8	132.7	135.7
160	138.5	138.0	141.8	135.5	146.2	140.0
200	135.2	130.4	140.9	129.4	141.8	135.5
Avg.:	126.6	121.6	128.3	121.2	126.8	

Table 10. Three-year average corn yields following soybeans as influenced by tillage system and hybrid.

Hybrid	Tillage System					
	CP/MP	NT	NT/CP	PP	RP	AVG.
	bu/A					
P3737	138.5	138.0	141.9	135.5	146.2	140.0
P3732	131.4	125.6	137.0	126.8	131.6	130.5
DK524	135.8	125.6	131.4	126.7	126.3	129.6
SC2410	133.0	124.7	123.2	128.1	128.8	127.6
G-4327	107.3	111.5	119.6	115.4	120.8	114.9
Avg.:	129.2	125.1	130.6	126.5	128.5	

Minnesota Agricultural Experiment Station Locations





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