1995 Research Project Abstract
For the period ending June 30, 1995
This project was supported by the MN Future Resources Fund

Title:	Cover Crops in a Corn and Soybean Rotation
Program Manager:	Dennis D. Warnes
Organization	West Central Experiment Station, University of Minnesota Highway 329, Morris, MN, 56267
Legal Citation	M.L. 93 Chpt. 172, Sect. 14, Subd. 3(b)

Approp. Amount $150,000.

STATEMENT OF OBJECTIVES

A. Development of management strategies of cover crops for corn and soybean for most effective use in Minnesota.

B. Summarize the data and make visual aids for presentation to farmers explaining the management needed to reduce environmental and economic risk.

RESULTS

It is impossible to plant a cover crop in Minnesota after corn and soybean are harvested and still obtain adequate stand of cover crop. We found that cover crops could be established in corn and soybeans before they are harvested by use of airplanes or by use of an endgate seeder mounted on a tractor or highboy to broadcast the seed. "Topping" of corn did enhance establishment of cover crops. Establishment is dependent on precipitation for one month after seeding, but of 26 planting occurrences, 22 times resulted in good to excellent stands of cover crops. The earlier broadcast seeding is done in the previous crop, the better the chance of getting adequate precipitation to produce a good to excellent stand of cover crop. Depending on planting date, the cover crop will use soil moisture and management will be needed to minimize water use in dry conditions and maximize water use in wet conditions. Farmers were quoted as saying there are many benefits of using cover crops such as preventing wind and water erosion, providing additional N if the cover crop is a legume, scavenging for excess water and N, providing grazing for livestock, and helping in weed control by providing allelopathy and competition to reduce the need for preplant or preemergence herbicides.

We helped improve communication between the University and the Sustainable Agriculture Community. When we interviewed farmer cooperators of the Sustainable Agriculture Community, we received many good comments from farmers who were so happy to have the University do research with cover crops. We made many good research relationships in the Sustainable Agriculture Community who previously had thought that the University was doing nothing for them.

PROJECT RESULTS USE AND DISSEMINATION

1. We presented results from this cover crop research to diverse audiences. We provided presentations at Fall Field Days at WCES, SWES and 2 farmer cooperator field days, and Wilmar Area ELCA Church Synod pastoral meeting. We demonstrated establishment of cover crops at WCES Ag Awareness Day; we wrote 2 Extension new releases and were interviewed by 2 radio stations about topping of corn. We presented posters at Minnesota Sustainable Farming Association, Stress Management Symposium, Brookings, North Central Weed Science Society, and American Society of Agronomy. Oral papers were presented at Minnesota Academy of Science, and we are planning to present a poster at American Society of Agronomy 1995.

2. The suggested video was prepared and it was decided to make a video to both supply needs of the final report and possibly be used by the Sustainable Agriculture community telling about this cover crop research. Copies will be made available to all research cooperators on this project.

3. Drafts of 3 possible articles were written and are included in the appendix of the detailed report and may result in scientific publications.

Date of Report: June 30, 1995 WORK PROGRAM AMENDMENT
LCMR RESEARCH WORK PROGRAM 1993 - Summary

I. Project Title: Cover Crops in a Corn and Soybean Rotation

Program Manager:	Dennis D. Warnes
Agency Affiliation:	West Experiment Station University of Minnesota
Address:	Highway 329, Morris, Minnesota, 56267
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A. Legal Citation: M.L. 93 Chpt.172, Sect. 14, Subd. 3(b)

Total Biennial LCMR Budget:	$150,000.00
Balance:	$236.88 as of June 26, 1995

Appropriation Language 7/27/92: Subd. 3(b). This appropriation is from the future resources fund to the commissioner of agriculture for a contract with the University of Minnesota for the development of economic management strategies of cover crops for corn and soybean rotations to reduce soil erosion, nitrate leaching, and pesticide use.

B. LMIC Compatible Data Language: Not Applicable

C. Status of Match Requirement: Not Applicable

II. Project Summary:

The ultimate goal of this project is to develop management strategies of using cover crops in a corn and soybean rotation. Cover crops wisely used reduce wind and water erosion of soil, improve water quality, and reduce the use of persistent synthetic herbicides. The principal cooperators of this project have done preliminary research on various aspects of the use of cover crops and the best treatments needed in a corn and soybean rotation. It is the intent of this research to develop economic management strategies of cover crops for corn and soybean rotations to: 1) scavenge residual soil nitrogen to reduce potential nitrate leaching, 2) reduce use of persistent herbicides by taking advantage of cover crop competition, allelopathy, and use of postemergence herbicides which have little soil residue, and 3) reduce wind and water erosion of soil.

As of July 1, 1992 Harlan Ford has assumed responsibilities as Acting Superintendent of SWES, Lamberton, MN so David R. Huggins, Soil Scientist at SWES, Lamberton, MN will share leadership of the project at SWES, Lamberton, MN. Because of incomplete funding the following changes have been made to the project: 1) 1 junior scientist position at Morris will be funded 2) This project will rent a corn detasseler instead of purchasing and modifying one. 3) selective data will be collected from some treatments, but the highest priority data will be collected from all treatments.

The University of Minnesota, in cooperation with Sustainable Farming Association of Western Minnesota, Chippewa County Soil Conservation District, Chippewa County Soil Conservation Service, and the Chippewa County Extension Service will host an On-Farm Research Workshop on cover crops and soil saving weed control on January 28, 1993 with Dick and Sharon Thompson, Boone, Iowa and Dennis Warnes, WCES, Morris as featured speakers. After this workshop 6-8 interested farm producers will be asked to put out farmer demonstrations in the fall of 1993. Dennis Warnes would act as the consultant for these farmers and he would arrange for aerial application of the cover crop seed and would partially compensate each producer for the cost of cover crop seed.

Contributions of time for project manager and other cooperators:
1. Dennis Warnes will spend 5% as project manager and 10% supervising Experiments 1 and 3 at Morris and 5% as consultant to the farmer demonstrations in cooperation with the Sustainable Farming Association of Western Minnesota
2. J. Harlan Ford will spend 2% supervising Experiment 2 at Lamberton
3. David R. Huggins will spend 6% supervising Experiment 2 at Lamberton
4. Alan Olness will spend 5% supervising the data collection related to topping of the corn
5. Donald C. Reicosky will spend 10% supervising the data collection relating to evapotranspiration, photosynthesis, and nitrogen scavenging
6. Richard Alderfer will spend 6% supervising the data summarization and preparing visuals for presentation to farmers.
7. Audrey Arner will spend 5% coordinating the farmer demonstrations in cooperation with the Sustainable Farming Association of Western Minn. and Western Minn. Office of Land Stewardship Project.

III. Statement of Objectives:

A. Development of management strategies of cover crops for corn and soybean for most effective use in Minnesota.

B. Summarize the data and make visual aids for presentation to farmers explaining the management needed to reduce environmental and economic risk.

PROJECT ACTIVITY FLOW CHART

A. Experiments

Experiments planted at Morris and Lamberton involving management strategies of a corn and soybean rotation

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Crop yield, soil moisture, photosynthesis, N scavenging, and evapotranspiration data will be collected to explain relative competition of crops and cover crops.

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Experiments planted at Morris involving cover crop establishment in large plots in a corn and soybean rotation

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A. Data Collected

Cover crop establishment and relative light penetration will be collected to explain factors affecting cover crop establishment

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Farmer demonstrations will be planned with farmers in western Minnesota

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Farmer participation will be planned after a cover crop workshop January 28, 1993 by Sustainable Farming Assoc. of Western Minnesota coordinated by Land Stewardship Project, Soil Conservation Service, and Minnesota Extension Service

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B. Data Summarization

Economic analysis of cover crop systems will be compared to conventional systems. Cover crop establishment methods will be compared for relative effectiveness of establishment. Farm demonstrations will be observed and farmers will be interviewed about their experiences.

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B. Presentation to Farmers

Management needed to reduce environmental and economic risk will be presented at Summer and/or Fall Crops and Soils Field Days WCES, Morris and SWES, Lamberton. Data will be summarized and presented to Minnesota Extension Service for presentation at county and regional extension meetings. Farmers in the farm demonstrations will be asked to discuss their results with cover crops at future meetings of the Sustainable Farming Association of Western Minnesota.

IV. Research Objectives:

A. Title of Objective: Development of management strategies of cover crops for corn and soybeans for most effective use in Minnesota.

A.1. Activity: The hypothesis for this project is that cover crops in a corn and soybean rotation can be used for short term weed control and as a temporary sink for excess soil NO_3-N. Using cover crops is relatively new to Minnesota and therefore a number of crops and management strategies need to be researched. Winter rye is winter hardy and will be compared in a number of management strategies, Brassica will be used as a "smother crop" and will be planted with the agronomic crop, and hairy vetch is only marginally winter hardy but will be compared. Corn and soybean rotation experiments will be conducted in 1993 and 1994 at the West Central Experiment Station (WCES) at Morris and the South West Experiment Station (SWES) at Lamberton. Two years and two locations will be needed to see if results change under different environments. Experiment #1 will evaluate management strategies of cover crops for corn and soybeans at Morris in 1993 and 1994. Experiment #2 will be located at Lamberton and will have similar treatments to Experiment #1 at Morris. These plots in Experiment #1 and Experiment #2 will be only 3 m. x 10.6 m. so it was decided to also have another experiment. Experiment #3 with much larger plots to minimize the border effect will be only at Morris and with only 4 treatments will compare methods of establishing winter rye before the previous crop is harvested and the plot size will be 9.1 m. x 18.2 m. Experiment #4 will study the effect of topping the corn at various corn maturities and the effect topping the corn and cover crop planting date have on the establishment of the winter rye and hairy vetch cover crops.
Full season corn and soybean cultivars are used in Minnesota, therefore, to utilize different cover crop planting dates in the fall, will require planting dates before the previous crop is harvested. Light penetration and precipitation will be major factors in the success of the establishment of the cover crop. In order to provide more light penetration, it was decided to mechanically remove the corn plant above the ear by "Topping" at physiological maturity with a detasseler. The production of hybrid seed corn utilizes detasseling to speed up corn drying for earlier harvest. The harvested forage would help cover the cover crop seed for better establishment, or it could be harvested for forage. The "Topped" corn grain would also be expected to dry faster.

Because the fall planted cover crops for a 1993 crop season must be planted in the fall of 1992, and the corn and soybeans must be planted before funding begins on July 1, 1993; therefore the experimental sites have already been located, some 1992 fall treatments were established, and spring planting will be done before funding begins from this allocation on July 1, 1993. **No funding will be charged for activities conducted prior to July 1, 1993.**

A.1.a. Context within the project: Conducting the three experiments each year (1993-1994) in A.l. is the major part of the project. Two years at each of the two locations will enable 4 location years to be used to evaluate various treatments. These experiments must be conducted in a manner which provides data that can be scientifically analyzed and summarized for presentation to farmers.

A.1.b. Methods: Field experiments for corn and soybean rotations will be conducted in 1993 and 1994 crop seasons at two locations, WCES, Morris, Minnesota and SWES, Lamberton, Minnesota. Four experiments will be conducted each year:

Treatments in each experiment will include Brassica used as a "smother crop", hairy vetch will be compared even if it is only marginal for winter hardiness, and various strategies for planting and establishing winter rye as a cover crop after the previous crop is harvested and before the previous crop is harvested.

Data collected to characterize both the cover crop and agronomic crop will include biomass, leaf area, light intercept, and tissue analysis to include NO_3 and total N. Soil water content in selected treatments will be measured at 7 to 10 day intervals using the Century AT 200 soil moisture probe. The short term effect of the cover crop on evapotranspiration (ET) and photosynthesis (CER) will be determined using a portable chamber. Other treatments and measurement times will be determined by the research team as field conditions warrant. Official Weather records at WCES, Morris and SWES, Lamberton will be used to relate results of cover crop research to weather. Long time weather records will be used to establish probabilities of certain weather events.

Experiment #1 will be at Morris on a Doland silt loam and will include 14 treatments in corn and comparable 14 treatments in soybeans in a corn and soybean rotation. Methods and timing of establishment of cover crops will be compared such as "topping corn", harvesting corn as silage, planting in standing corn. In addition to winter rye as a cover crop, Brassica as a smother crop and hairy vetch will be compared. All plots will be cultivated.
Experiment #2 will be identical to Experiment #1 except that it will be at Lamberton on a Normanie silty clay loam.
Experiment #3 will be conducted at Morris and will include 4 treatments to determine the effect of topping the corn at physiological maturity, taking the corn off at silage, or harvesting the corn at maturity will have on the establishment of the winter rye cover crop. It is important to have large plots in order to minimize the border effect of "topped corn" plots on light penetration to neighboring plots which are not "topped."
Experiment #4 will be conducted by Dr. Al Olness and Dr. Don Reicosky, ARS, Morris, at their Swan Lake farm near Morris. Experiment #4 will study the effect of topping the corn at various corn maturities and the effect topping the corn and cover crop planting date on the establishment of the winter rye and hairy vetch cover crops.
Farmer participation in demonstrating results from this research was initiated when Dennis Warnes met with the Sustainable Farming Association of Western Minnesota. Chippewa County Soil Conservation District, Chippewa County Soil Conservation Service, and the Chippewa County Extension Service on December 9, 1992 to plan an On Farm Research Workshop on cover crops and soil saving weed control. The workshop will be held on January 28, 1993 with Dick and Sharon Thompson and Dennis Warnes as the main speakers. After this workshop, 6-8 interested farm producers would be solicited to put out farmer demonstrations in the fall of 1993. Dennis Warnes would act as one of the consultants and he would arrange for aerial application of the cover crop seed and would partially compensate each producer for cover crop seed cost.

A.1.c. Materials: Fields for these experiments have been designated at both Morris and Lamberton. Since fall planted cover crops for the 1993 crop season must be planted in the fall of 1992, the experiments have been located and some treatments established this fall. Most equipment for planting and harvesting of corn and soybean is available at Morris and Lamberton. Seed, fertilizer, and herbicides will have to be purchased each year. Most of the data collection equipment is available at WCES, SWES, or ARS-USDA, Morris. Laboratory analysis for soil and plant $N0_3$ and N will be funded from this project.

Soil tests will be taken prior to the experiment and values will be used to apply nutrients according to university recommendations. Since the soil pH is high there will be no need to lime. Crop residue, ground cover and biomass data will be taken and will be related to potential for erosion control. Weed control ratings will be taken 2-3 times during the growing season and related to weed counts taken from the weedy check. To identify the cover crop ability to accumulate soil nitrogen, total N and nitrates will be evaluated in the cover crop and the economic crop.

Equipment Funds will be spent to :
1. Purchase 2 Century AT 200 Soil Moisture Probes (one for Morris and one for Lamberton),
   (See A Status, January 1, 1994 for explanation)
2. Modify planters at Morris and Lamberton to plant Brassica in a band with incorporation at time of planting the corn and soybeans,
3. Rent a corn detassler to mechanically top the corn at physiological maturity.

A.1.d. Budget: $130,000.
Balance: $37.98 as of June 26, 1995

A.1.e. Timeline:

	7/93	1/94	7/94	1/95	6/95
Planting Fall Cover Crops	**				
Planting Spring Smother Crop			**		
Harvesting Crop		**		**	
Planting Corn /Soybeans			**		
Soil Moisture Data	*******		********		
Collecting Research Data	*******		********		
Collecting Weather Data	**********				

A. Status:

January 1, 1994
Experiments established in the fall of 1992 and described in Summary Work Program: A.l.b. Methods were continued and data was collected from them during the 1993 crop season. The experimental designs and computer generated summaries of data collected are included in the List of Deliverables included for Minnesota Department of Agriculture. Experimental design and computer generated summary of a research

experiment conducted by Dr. Don Reicosky and Dr. Al Olness at Swan Lake, Minnesota is also included. At the Swan Lake location an experiment was established in 1993 to determine effect of topping corn on cover crop establishment. To determine the effect of topping at various corn maturities, corn stalks were removed by hand above the ear, a portion of the plot was harvested for forage, and final crop yields were measured.

Seven farmer cooperators were contacted and they agreed to put out demonstrations on interseeding cover crops into the previous crop. Two farmers had an aerial operator fly the cover crop into the standing corn and soybean crops. WCES purchased an endgate seeder and mounted it on a corn highboy detassel and WCES interseeded the cover crops for three farmers. One farmer utilized his own endgate seeder to interseed cover crops into the standing previous crop. One farmer did not get his cover crop planted. A corn detasseler was rented from Quality Seeds of Olivia, Minnesota and this machine was used to detassel corn at maturity for the experiments at Morris and Lamberton and for 2 farmer cooperators.

July 1, 1994

Rather than have all the cooperators tour all the cooperation farmers, we decided to take video of each farmers cover crop and then show the video to all cooperators at one time. On April 4, we took video of the cover crop plots at VanDerPol, Roske, Lamberton, and Handeen, and on April 5 we took video at Olson, Fernholz, and Murphy. On April 6, we showed the video of cover crop establishment to all the cooperating farmers. In addition to cooperating farmers, Audrey Arner and Roger Larson were also present at this video showing. In addition, Barbour visited the one or more cooperating farmers May 2, May 12, May 26, June 10, June 21, to take notes, take more video, take biomass samples, and take soil samples, and on June 29 annual medics were planted at Craig Murphy's sunflower field with the endgate seeder mounted on a highboy detasseler.

The cover crop experiments at WCES, Morris, and SWES, Lamberton were continued. Warnes, Barbour met with Ford and Quiring to plan procedures for the 1994 season on March 16 at Montevideo. Residue and cover crop percents were taken on corn and soybean plots. The winter rye was killed with Roundup, corn and soybeans were planted, and herbicides were applied in selected treatments. Soil moisture probe tubes were inserted in selected corn and soybean treatments, and moisture readings were recorded with Century AT 200 Soil Moisture Probes. Plots were evaluated for weed control, cultivated, and we took photos and video of the experiments.

In 1993, good stands of hairy vetch were established at Fernholz and Handeen farms because of adequate precipitation after planting. Only fair stands of the hairy vetch and sweet clover mixture were established at Bert Olson farm in 1993, where the soil was wet at planting but received only sparse precipitation for 3 weeks after planting. A good stand of rye was established at the VanDerPol farm in 1993 because of adequate precipitation in the week after planting. Winter rye planted at Roske farm with and without topping the corn produced fair stands of rye with only sparse precipitation after planting. Annual medics planted at Murphy farm were very poor stands because not adequate precipitation occurred after planting date and annual medics do not establish easily with only broadcast seeding.

Low precipitation is a major risk in establishment of a cover crop by broadcast planting by aerial seeding or by endgate seeder prior to the harvest of the previous crop. The earlier the date of seeding gives a greater chance of more precipitation to help establish the cover crop. Drilling of the cover crop after harvesting the corn and soybean for silage provided the best stands of cover crops, but this would not be economically satisfactory if the farmer could not make use of the silage. Drilling of the cover crop after harvesting the previous corn and soybean crops provided a late planting, and produced germination but did not allow enough growth of the winter rye to protect against erosion over the winter, or provide for early spring grazing

Analyses of the N content of the rye and vetch planted as cover crops shows that amounts and patterns of N accumulated were quite different. Vetch accumulated up to three to five times as much N in the biomass as rye grass when seeded in June (Appendix F of the deliverables). The differences in accumulated N were generally proportional to the differences in biomass dry matter. The general patterns of accumulated N with respect to planting date were very distinctive. For vetch and rye grass planted as 'pure' control stands, accumulated N decreased exponentially with planting date. For interseeded vetch, accumulated N also decreased exponentially with planting date. However for interseeded winter rye, accumulated N reached a maximal amount with seeding in August; this contrasted with the biomass accumulation which decreased almost linearly with planting date.

Biomass accumulation for vetch decreased sharply when planted after June (nearly 6 Mg verses <0.5 Mg) without competition from the corn crop. In contrast, biomass of rye decreased from only about 1.8 Mg for June plantings to about 1.2 Mg for August plantings. Topping had only a small effect on relative N accumulation by the cover crop. Clearly, planting date seemed to have the greatest affect on N accumulation by cover crops interplanted with corn. Competition with the corn crop diminished N accumulation of both rye grass and vetch by 3.5 to 10 fold. Accumulations of N by interseeded rye grass and vetch were similar in August plantings even though N accumulation by 'pure' stands of rye grass were much greater than accumulation by 'pure' stands of vetch.

Canopy gas exchange measurements were made this spring on selected treatments to evaluate the effect of cover crops on total canopy photosynthesis (CER) and evapotranspiration (ET) in the corn and soybean plots. Before spraying, differences in CER were related to rye biomass and leaf area. Four days after spraying to kill the rye in soybean plots, CER as respiration was essentially the same. Corn plots show slightly more respiration (negative CER) on treatments 7 and 8, 13 days after killing the rye, possibly due to residue decomposition. Evaporation was essentially the same on all treatments on day 143. Evaporation rates were the same on all treatments on day 144, but higher than day 143 due to 0.42 inches of precipitation the previous night.

January 1, 1995

Original plans were to finish field work with the end of the 1994 cropping season on Experiments #1, #2, and #3 at Morris and Lamberton and to have only 1993 fall demonstrations at cooperating farmers. Since this experiment focuses on establishment of cover crops, it was decided to plant the cover crops in fall 1994 and make observations on establishment in the spring of 1995 to obtain more observations on

establishment. Spring evaluations of the stands will be made in time to complete the final report for July 1, 1995. Contacts were made with farmers and again 6 farmers decided to cooperate for fall 1994.

Experiments #1, #2, and #3 at Morris and Lamberton were managed and cared for as planned. Crop biomass samples were taken in late August. The crop was removed as silage in treatment 8. Cover crops were broadcast and drilled as prescribed. Corn was topped at physiological maturity. After harvest, soil samples were taken in selected plots (treatments 7, 8, 9, 12) for nitrogen analysis. Crop residue and cover from cover crop readings were taken in late October. Soil moisture was monitored throughout the season. Evapotranspiration measurements were made. At both Lamberton and Morris, grain yield of soybean and corn was higher in plots which received postemergence herbicides (10, 13, 14) in addition to the rye cover crop than in the rye plots without herbicide. The moisture of corn grain was not affected by topping in the plots in Morris or Lamberton. Late June weed control in rye plots showed a positive relationship with percent cover from rye in the spring, and the effect of rye declined in Morris as the season progressed. Increased evapotranspiration was observed in plots where soybean had been removed as silage, indicating the winter rye cover crop was growing and using water. A slight increase in evapotranspiration was observed in plots where corn had been removed as silage.

Experiment #4 at Swan Lake was managed and cared for as planned. Grain yields and moisture contents were recorded from Experiment 4 at Swan Lake on October 17. Winter rye and hairy vetch forage samples were collected for biomass determinations and chemical characterization including nitrogen accumulation. Soil samples were collected and are being processed for mineral N content. Soil moisture data were collected throughout the growing season. Light penetration and carbon exchange rate measurements were taken in topped plots and in untreated plots both with and without interplanted cover crops. Topping was conducted at three different times: at late milk soft dough stage (late August), at late dough early dent (early September), and at the hard dent (R5) stage of development. Cover crops were interseeded at flowering (mid July) and with each topping treatment. In treatments where topping occurred before mid-September, crop yield was sharply reduced (treat 1). This may have been caused partly by a severe hail storm which stripped lower leaves from the plants in early July (before flowering). Grain yield was unaffected by topping in mid-September (treat 3) when plants and grain were near physiological maturity. Grain moisture content was decreased by topping; the size of this effect increased with time after killing frost. Light penetration at the soil surface increased by about 100% with early topping, and biomass development of the interseeded cover crop was nearly doubled as a consequence.

Six farmers cooperated with this project this year. Returning cooperators were Carmen Fernholz, Richard Handeen, Craig Murphy, Leon Roske, and Jim VanDerPol. Vince Meyer participated in 1994 for the first time. At the Fernholz farm, hairy vetch was planted into corn, corn was topped, and grain was harvested for yield and moisture comparisons. The hairy vetch did not decrease the yield of corn, and topped corn was slightly drier than the grain where the corn had not been topped. A good stand of vetch was obtained. Handeen planted rye and vetch into corn, and rye into soybean. Meyer planted a mixture of rye and hairy vetch into sunflowers, and planted hairy vetch into soybean. Handeen and Meyer both attached the endgate seeder from this project to their own equipment for seeding. Annual medics at two seeding rates and barrel medic were planted into sunflower at the Murphy farm. Seeding was earlier this year than last and frost was later so a good stand was obtained. Roske contracted with an aerial applicator to have rye flown into standing corn and achieved a good rye stand which should aid in preventing water and wind erosion. Rye was seeded into soybean stubble at the VanDerPol farm. Because the seeding was late (September 30), there was little rye growth but there was a good population of small plants which will vernalize and will provide good grazing free of parasites for new lambs in the spring of 1995.

June 30, 1995

Cooperation with Farmers.

On April 20 we interviewed Leon Roske on video, the last of the farmers we needed to interview in anticipation for a video with the final report. Where ever it was appropriate we evaluated cover crop stands by biomass and residue. Craig Murphy had planted annual medics which did not survive the winter and there was no spring evaluation possible. Because of the cold spring , the hairy vetch at Carmen Fernholz was very small and growing very slow. Because the winter rye was planted so late at VanDerPol, stands were slow to develop and grazing by sheep was also delayed. Biomass and crop residue measurements were made at Leon Roske and Richard Handeen. Biomass and crop evaluations were also made at Experiments #1, #2, and #3 at Morris and Lamberton.

Summarization of Data

We expect a number of publications to result from this research. Since we just finished this research, we have not had time to finalize scientific or popular articles from it. There has been some summarization of data which can be used in the writing of future publications.

With the suggestion that a video accompany the final report, tapes of operations and interviews were edited and a video was prepared to accompany the final report.

Summarization of topping of corn to enhance cover crop establishment research at Swan Lake was continued and a draft article was written "Working Report for Cover Crop Studies" by D. C. Reicosky, D. D. Warnes, and A. E. Olness.

Summarization of the evapotranspiration (ET) and photosynthesis (CER) evaluation of the cover crop research was continued. A draft article was written "Cover Crops in Maize and Soybean, Topping of Maize to Enhance Interseeded Cover Crop Growth" by Alan Olness, Dennis Warnes, D. C. Reicosky, J. H. Ford, D. R. Huggins, R. Alderfer, and A. Arner.

Summarization of the research with *Brassica* as a smother crop was continued. Kevin Betts and Don Wyse have summarized some of the other *Brassica* research and have written a summary that has 3 objectives, "1. Continue to develop through classical plant breeding dwarf Brassica smother plants for weed control in soybean and corn, 2. Evaluate the effectiveness of dwarf Brassica smother plants for controlling weeds and reducing soil erosion, and 3 Identify the factors that could impede the adaptation of the dwarf Brassica smother plant system by corn and soybean producers."

Conclusions:

Introduction: Concerns about soil erosion, water quality, and synthetic agricultural chemicals have increased interest in development of more sustainable systems for corn and soybeans. Cover crops could help reduce erosion, improve physical condition of the soil, and increase water penetration. The ultimate goal of this project was to develop management strategies of using cover crops in a corn and soybean rotation. It is impossible to plant a cover crop after corn and soybean are harvested and get adequate stand to prevent erosion. After corn or soybean harvest, temperatures are too low for fast growth and development of the cover crop. Therefore it was necessary to determine if cover crops could be established before the previous crop is harvested, if the cover crop would develop under the canopy of the previous crop, and if the cover crop would be adequately developed to prevent wind and water erosion, provide additional N, scavenge excess water and N, help in weed control by providing allelopathy and competition, and provide grazing for livestock.

Establishment Factors: We found that cover crops could be established in corn and soybeans before they are harvested by use of airplanes or by use of an endgate seeder mounted on a tractor or highboy to broadcast the seed. "Topping" of corn did enhance establishment of cover crops. Establishment is dependent on precipitation for one month after seeding, but of 26 planting occurrences, 22 times resulted in good to excellent stands of cover crops. The earlier broadcast seeding is done in the previous crop, the better the chance of getting adequate precipitation to produce a good to excellent stand of cover crop. Depending on planting date, the cover crop will use soil moisture and management will be needed to minimize water use in dry conditions and maximize water use in wet conditions.

Benefits: Farmers were quoted as saying there are many benefits of using cover crops such as preventing wind and water erosion, providing additional N if the cover crop is a legume, scavenging for excess water and N, providing grazing for livestock, and helping in weed control by providing allelopathy and competition to reduce the need for preplant or preemergence herbicides. Each benefit will be discussed individually.

Erosion: Crops such as soybean and sunflower have little crop or weed residue after harvest, which make them vulnerable to wind and water erosion especially on sloping land. Cover crops growing at crop harvest would help control wind and water erosion, by providing vegetative cover to trap moving soil particles. We did not take specific evaluations of erosion control, but we did take various ground cover measurements which relate to potential erosion control. More ground cover generally leads to reduced erosion. In the spring the cover crop can be killed and an economic crop planted. Corn and soybean can be no-till planted in the spring into the killed rye residue. This would help farmers comply with residue requirements after planting on highly erodible land (H.E.L.). The farm program is getting very specific on highly erodible land and farmers are required to leave 30% cover after planting..

Grazing: An efficient pasture system program for grazing animals should achieve a uniform distribution of forage for production throughout the grazing season. In an ideal full season pasture program, cool season grasses and legumes are utilized in the spring and fall, warm season grasses are utilized in the summer, and winter annuals such as winter rye could be utilized in the very early spring and the very late fall. Providing forage for grazing is a very important benefit of cover crops. It is difficult to establish a cover crop after a corn or soybean crop is harvested, but if the cover crop to be used for forage was established before the corn or soybean crops were harvested, than the cover crop like winter rye could be used for forage in the very late fall and the very early spring

Water Use: In dry years in west central Minnesota, water use by the cover crop would cause a serious loss of soil moisture, but in wet years this is a benefit of cover crops. Therefore it will require a management plan to deal with the variation in the annual precipitation. We prepared a winter rye management guide to help deal with this variation in annual precipitation and this can be used whenever the winter rye cover crop is used to help in weed control.

Fall Soil Profile Moisture:
- If Dry, Plant Rye Late in Fall
- If Wet, Plant Rye Early in Fall

Spring Soil Profile Moisture
- If Dry, Kill Rye 2 Weeks before Planting
- If Wet, Kill Rye 2 Days before Planting

Risk: Low precipitation and high weed pressure are the major risks to using a rye cover crop system with corn and soybeans in Minnesota. More research is needed to find ways to minimize the competition of the winter rye cover crop, such as delaying fall seeding date, killing the rye earlier in the spring and then seeding soybeans earlier, or finding other cover crops that do not compete as seriously as winter rye. There has been little or no breeding for cover crops specifically for special uses. Any change in management of the rye cover crop to reduce competition for soil water will require more postemergence herbicides to adequately control weeds.

Weed Control: Herbicides used to kill the winter rye plus adequate followup postemergence herbicides will provide adequate weed control. This herbicide combination do not involve preplant incorporated herbicides which have residual soil activity. Switching to a winter rye cover crop system to help in weed control in Minnesota will require an understanding of the complex system and will need to follow a management guide similar to this:

Winter Rye Cover Crop Management Guide
Weed population after crop emergence
- If few weeds - no herbicides needed
- If many weeds- apply post emergence herbicides as needed

Scavenge Soil Nitrogen. For soybeans we found that broadcasting the winter rye at last cultivation and drilling after soybean silage both reduced the soil nitrate the next spring to about 5 lbs/A for each of the soil depths (0-6, 6-12, 12-18") for a total of about 15 lbs/A, whereas the available soil nitrate with the other two treatments where winter rye was drilled after soybean harvest or broadcast seeding at leaf yellowing had soil nitrate levels at 10 to 20 lbs/A (0-6, 6-12, 12-18") for a total of about 45 lbs/A.

Reducing the soil nitrate by 30 lbs/A is an important consideration of preventing pollution by nitrogen fertilizer.

For corn we found that broadcasting the winter rye at corn tasseling produced the most winter rye growth and reduced the soil nitrate to about 4 lbs/A at each of the soil depths (0-6, 6-12, 12-18") for a total of about 12 lbs/A, whereas the available soil nitrate with the other three treatments where winter rye was drilled after corn silage, broadcast after topping at physiological maturity and broadcast at physiological maturity had soil nitrate levels at 6 to 10 lbs/A (0-6, 6-12, 12-18") for a total of about 25 lbs/A. Reducing the soil nitrate by 13 lbs/A is an important consideration of preventing pollution by nitrogen fertilizer.

Cost of establishing cover crops into the previous crop: Seeding cover crops by airplane is one practical way of establishing cover crops while the previous crop is still standing. However, many airplane applicators are not equipped with airplane seeding attachments. Other airplane applicators change the airplane from herbicide application to airplane seeding only when there is an immediate request. Therefore the cost of seeding cover crops from the air varies greatly. We paid $7 per acre plus the cost of seed because of a small acreage and the operator had to pay for the changeover time from herbicide to seeding mechanism. One farmer (VanDerPol in 1993) paid $175 for 10 acres which included the changeover cost. Another farmer (Murphy in 1993) paid $200 for 5 acres which included the changeover cost. With a large demand for airplane seeding, the cost of airplane seeding would probably drop to $4-5 per acre plus the cost of seed. Seed size and seeding rate per acre would determine load size and the number of acres seeded per load, and ultimately the cost per acre.

Establishing cover crops into the previous crop by ground equipment was more difficult because, there is no conventional equipment available. We purchased an endgate seeder (Thompson Electric Spreader with Rheostat) for $416.36. We mounted the endgate seeder on a corn detasseler hi-boy borrowed from Quality Seeds of Olivia, Minn. and we seeded winter rye, hairy vetch, and annual medic cover crops into standing crops. Cooperating farmers borrowed endgate seeder to mount on their tractors to establish cover crops into the standing crop. The cost of operating a Hi-boy or tractor for herbicide application would be about $3.00-3.70 per acre. So the cost for seeding cover crops with a Hi-boy should be about the same, plus the investment in an endgate seeder.

Comparing Conventional and Cover Crop Systems: For this report, equipment cost per acre, hours of labor per acre, and gallons of fuel per acre were taken from the 1994 Minnesota Farm Machinery Economic Cost Estimates by Minnesota Extension Service. The cost of the rye cover crop systems would be similar (only $5-7 less) according to these tables ($112.28 vs $119.74 for corn and $108.10 vs $114.89 for soybeans). However the cover crop system would use different machinery than is generally owned by farmers in this region, since they would have to no-till plant the corn and soybeans into the winter rye residue.

We have not figured in the reduced herbicide cost due to the competition and allelopathic effect of the winter rye. Management would be needed to scout the fields each spring to use the most effective post emergence herbicides for efficient weed control. Since the seedbed is prepared before seeding the rye, no further weed seeds would be brought to the surface when no-till seeding into the winter rye residue. The cover crop system would reduce the need for preplant incorporated and preemergence herbicides which have residual soil activity.

We have not used any economic values for control of soil erosion. If we could add a cost for erosion control to the conventional system then the cover crop system would be the most economical system.

Energy Savings: Dr. John Nalewaja, North Dakota State University has written extensively about energy use by various weed control practices. We referred to his articles and used his assumptions in our calculations.
Conventional corn and soybean production requires almost twice the total energy kcal as the cover crop system (571,248 vs 324,575). The major difference is the equipment energy needs for the conventional (284,140 vs 100,147 kcal). Another important consideration is the change from using only preemergence herbicides (pounds/acre) for conventional to largely postemergence herbicides (ounces/acre) for the cover crop system.

In addition to the above energy comparisons, the cover crop system would greatly reduce the energy and cost of cleaning of ditches and drainageways caused by erosion of soil from conventional fields into ditches and drainageways.

Further Research with Cover Crops Needed: Winter rye is the only potential cover crop for our northern corn belt area that is winter hardy and has sufficient allelopathy and competitiveness to help control weeds. This research points out the serious need for plant breeders to develop varieties of cover crops that are less competitive for moisture and nutrients, will adequately control weeds by allelopathy and competition, are easy to establish, and are winter hardy for our area. At present there is very little research on improving cover crops, and crops and varieties that were developed for other purposes must be used. Emily Hoover of Horticulture and Don Wyse of Agronomy are in the process of surveying about 100 current varieties of plants as potential cover crops.

Problems:
<u>January 1, 1994</u>
1993 was a very wet and cold growing season. Total precipitation for the April-August growing season was 24.25 in. which was 8.54 in. above the average of 15.71 in. Average temperature for the growing season was 59.7° which was about 2 degrees colder than the average of 61.8°. Corn growing Degree days accumulated only 1800 units which was 155 below the average 1955 Corn Growing Degree units for the growing season. Corn and soybeans did not mature normally. Many corn hybrids that would have matured in most years, did not mature and dry below 30% - 40% grain moisture. The first killing frost of 28° occurred on September 29 with several light frosts on the 15th, 18th, 22nd, and 23rd of September. Many farmers in our area plowed under their corn to comply with 0-92 farm program requirements.

Corn in Experiment #1 at Morris did not mature normally and when the grain yields were harvested the grain moistures were above 40% so the yield data is questionable for reliable information. Also it was apparent that there was some stress effect from some treatments from a previous experiment conducted from 1975 to 1987, "Decline of wild mustard seeds in soil under various cultural and chemical practices". The computer generated summaries of the corn yield and grain moisture are included in the List of Deliverables for the Department of Agriculture however, we do not think that we will do any more summarization of the corn yield and grain moisture. We will use only the cover crop establishment information and weed control information from this experiment this year.

July 1, 1994 No Problems

January 1, 1995 No Problems

June 30, 1995
The spring of 1995 was very cold and wet. We had planned to evaluate cover crop stands this spring and to evaluate cover crop use of soil moisture. With the cold and wet spring we only evaluated cover crop stands because there would be no differences in soil water under various cover managements this spring because of excessive wet conditions.

We purchased 2 Century AT 200 Soil Moisture Probes (one for Morris and one for Lamberton), to evaluate soil moistures, instead of using the neutron probes for soil moisture evaluation. We used the same procedure for installing soil moisture tubes as we used with the old neutron probes, but these Century AT 200 Soil moisture probes require a specific method of installing moisture tubes to get better soil-tube contact. This is very labor intensive if tubes are not installed for a number of years, but for us it would have been labor intensive when we had to install tubes every spring. The soil moisture data we obtained with the Century AT 200 Soil moisture probes is not as accurate as we would have liked.

I am retiring from the University of Minnesota on June 30, 1995. If there is any peer review of this project after June 30, 1995, I will have to be contacted early enough so that I can schedule time to be available.

B. Title of Objective: Summarize the data and make visual aids for presentation to farmers explaining the management needed to reduce environmental and economic risk.

B.1. Activity: Summarize the data and make visual aids for presentation to farmers explaining the management needed to reduce environmental and economic risk.

B.1.a. Context within the project: Many of the scientific measurements collected in Activity A are important to scientific research but are not available or easily understood by the producer for application to his or her farm. Soil moisture at various depths, comparative moisture use by the cover crop and by the economic crop, and light intensities needed to establish a cover, are examples. This part of the project will find ways to simulate or approximate these measurements and prepare them for application at the farm level. Educational materials for producers and extension educators will be prepared from this portion of the project.

B.1.b. Methods: An economic analysis comparing grain yields of the cover crop system will be compared to the conventional system. In addition an analysis will be made of the production costs per unit harvested or per unit area harvested. Non-linear regression and simulation are powerful tools for identifying alternative measures in the crop-soil ecosystem. One example is estimating fall soil moisture for effective management of the cover crop system. If soil moisture can be represented by some function of daily, weekly, or monthly precipitation and/or temperature, then historical weather records can be used to approximate values needed by the producer for management decisions on his or her farm.

Presentations will be made to farmers at Summer and/or Fall Crops and Soils Field Days at West Central Experiment Station, Morris and South West Experiment Station, Lamberton. Data will be summarized and presented to Minnesota Extension Service for presentation to county and regional extension meetings. Farmers in the farm demonstrations will be asked to discuss their results with cover crops at future meetings of the Sustainable Farming Association of Western Minnesota.

B.1.c. Materials: Computer network, computer software, and data transfer, will be supported with West Central Experiment Station and USDA, ARS funds. Support for a graduate student, travel cost, and a limited number of reference materials will be funded from project.

B.1.d. Budget: $20,000
Balance: $198.90 as of June 26, 1995

B.1.e. Timeline:

	7/93	1/94	7/94	1/95	6/95
Work with farm demonstrations	**********	**********			
Gather data	**********	**********			
Statistical analysis		**********	**********		
Prepare Extension material			**********	**********	
Final report and publication				**********	******

B. Status:
January 1, 1994
Talks about previous cover crop research and these cover crop experiments were given at the Fall Field Days at Morris, September 14 and Lamberton September 15, and at Carmen Fernholz's Field Day September 16 who is one of the farmer cooperators.

Two posters and followup abstracts and articles were presented at Stress Management Symposium, Brookings, South Dakota: "Effects of a winter rye cover crop system on grain yield, weed control, available soil water, and net return per acre in corn and soybeans" authored by R. Alderfer, D. D. Warnes,

J. H. Ford, and G. A. Nelson, and "Accelerated field desiccation of maize (*Zea mays* L) grain through stress induction and forage recovery by 'topping'" authored by A. Olness, D. D. Warnes, D. C. Reicosky, and J. H. Ford. A poster with an abstract was presented at the annual meetings of the North Central Weed Science Society, December 6-9, Kansas City, Missouri: "Effects of management of winter rye cover crop on weed control and grain yield in soybeans and corn" authored by D.D. Warnes, J. H. Ford, and N. W. Barbour.

A news release about the effect of topping corn on drying was put out by the Minnesota Extension Service "'Topping' corn plants can save drying costs this fall", and also a news release was put in the Fall Issue of the West Central Crop Pest Management Newsletter, "Cut drying costs by topping corn". Because of the critical drying conditions for corn in 1993 when these new releases came out September 6, there was a lot of interest about the potential increased drying from topping of the corn and 2 phone calls were received: Herman Wilts, County Extension Agent, Wilmar and Clyde Tiffany, Agronomist of Pioneer Hi-Bred International, and 2 recorded telephone interviews were taken: Worthington Radio Station and Yankton Radio Station.

The winter rye cover crop is primarily dependent on moisture. A formula was developed to relate soybean yields to fall soil moisture 0-5 feet plus the April, May and June precipitation. Since it would be difficult for farmers to determine soil moisture 0-5 feet, it was decided to try to develop a formula for determining soil moisture from previous precipitation. Step 1. Fall soil moisture (inches of water in the top 60 inches of the soil about mid October) plus spring rain in April, May and June were fitted in quadratic equation to the dependent variable of relative yield of soybeans. The principal measure for goodness of fit was an R^2 = 0.83. Step 2. Soil moisture data near Lamberton has been recorded semi-weekly for more than 17 years. In a simple linear regression of August, September, and October precipitation at SWES, on the dependent variable of soil moisture (in inches of soil water in the top 60 inches of the soil) regression results were promising with R^2 = 0.62. Step 3. Using the soil moisture from step 2, Morris rainfall for August September and November were inserted to compute a variable used in place of observed fall soil moistures. Step 1 was redone using this new variable and the results were a minimal change in coefficients and virtually no change in the quadratic equation on relative yields. Step 4. With the success of steps 1-3, it is possible to estimate the effectiveness of the rye cover crop systems for 103 years worth of Morris weather data. This has been done and will be presented at a later date.

A literature review on cover crops was conducted and the title, authors, and an abstract was collected and printed for future reference. This review will be helpful when writing scientific publications that require literature review of previous research.

July 1, 1994

Warnes attended the Minnesota Sustainable Agriculture Conference, February 14 at Earle Brown Center on the St. Paul Campus of the University of Minnesota. Warnes and Barbour also attended the Third Annual Meeting of Sustainable Farming Association, March 12, in Mankato. We presented a poster at this conference where we shared the poster with Dennis Johnson, Dairy Scientist. We presented some results of the cover crop cooperation with farmer cooperators of the Sustainable Farming Association and Dennis Johnson presented some information on his proposed intensive grazing research.

Plans were made to present two posters at both the 1994 Annual Meetings of American Society of Agronomy in Seattle, Washington, November 14-18, 1994 and also two papers at the Minnesota Academy of Science meetings, at UMM, Morris in April 27-28 1995. The Title-Summaries have been sent in and are included in the deliverables. "Establishment of cover crops into previous corn and soybean crops before harvest at 6 farms and 2 experiment stations of West Central Minnesota" by D. Warnes, N. Barbour, A. Olness, Don Reicosky, D. Huggins, R. Alderfer and "Benefits of cover crops established at 6 farms and 2 experiment stations in west central Minnesota" by D. Warnes, N. Barbour, A. Olness, Don Reicosky, D. Huggins, R. Alderfer

West Central Experiment Station sponsored an Ag Awareness Day on May 22 where we geared our material for elementary aged children. We had 316 registered school age children with their parents attending Ag Awareness Day. Warnes was assigned to do a "mock experiment". Since the objective of this LCMR project is to compare methods of establishing cover crops, we designed a cover crop experiment in the greenhouse comparing broadcast seeding and drilling of winter rye and hairy vetch under high and low water conditions. This gave the opportunity to discuss the procedures to conduct a research experiment. 1. Treatments (what you want to compare), 2. Vary only treatments (all else done the same), 3. Randomization (mixing the order), 4. Replication (do more than once), 5. Keep records (Planting plan and data), and 6. Evaluate data (What worked the best). A copy of the experimental design, data summary, chart on research procedures, and newspaper article are in Appendices H-K of the deliverables.

The formula developed in the last report to relate soybean yields to fall soil moisture 0-5 feet plus the April, May and June precipitation, was used to predict an estimate of the effectiveness of the rye cover crop systems for 103 years worth of Morris weather data. This formula was used to develop a proxy variable for soil moisture which primarily relies on rainfall data which for most locations is readily available. This data was then incorporated into a draft paper written by a graduate student, Arif Hussain, which currently is titled "The Economics of a Winter Rye Cover Crop System in Soybeans". A copy of this paper is in the deliverables.

January 1, 1995

Warnes spoke about cover crop establishment research at the Craig Murphy Field Day July 16, 1994. Murphy is one of the farmer cooperators. Warnes spoke about cover crops at the Carmen Fernholz Field Day on September 16, 1994. Fernholz is one of the farmer cooperators.

Warnes spoke about Sustainable Agriculture at the Wilmar Area Evangelical Lutheran Church of America Synod. A major component of Sustainable Agriculture is "Cover Crops" and so Warnes referred many times to his cover crop research.

Warnes and Barbour presented two posters at the American Society of Agronomy meetings at Seattle, Washington on November 13-17. One poster was "Cover Crop Establishment Before Corn and Soybean

Harvest in the Northern Corn Belt" by Warnes, Barbour, Olness, Reicosky, and Ford. The other poster was "Benefits of Cover Crop Establishment Before Corn and Soybean Harvest in the Northern Corn Belt" by Barbour, Warnes, Reicosky, Olness, and Ford. Many of the graphs in the deliverables were from the two posters. Copies of the abstracts submitted in the previous report were available for attendees. There was a good response to the posters with many comments and questions from researchers in the Upper Midwestern United States and Canada. Also at these meetings, Richard Thompson, Thompson On-Farm Research of Boone, Iowa gave a talk and he stopped to see our two posters. He was very impressed and complimented us on our posters, which he wished more people from Northern Plains could see. Helene Murray, Coordinator of Minnesota Institute of Sustainable Agriculture, was there and she wanted copies of the posters. Upon return to Morris, a copy of the charts and tables from the posters was sent to her. She wants to write an article about this research for the MISA Newsletter.

June 30, 1995

Warnes presented a seminar to review all his cover crop research at a Cover Crop Task Force on January 13, 1995 in Agronomy 408 where all those interested in cover crops at University of Minnesota met and discussed various aspects of cover crops. From this task force, Emily Hoover of Horticulture and Don Wyse of Agronomy have planned to conduct 2 large experiments in 1995 where they will survey the potential of over a 100 different kinds of cover crops.

Two papers were presented at the Minnesota Academy of Science meetings, at UMM, Morris in April 27-28 1995. The titles were "Establishment of cover crops into previous corn and soybean crops before harvest at 6 farms and 2 experiment stations of West Central Minnesota" by D. Warnes, N. Barbour, A. Olness, Don Reicosky, D. Huggins, R. Alderfer and "Benefits of cover crops established at 6 farms and 2 experiment stations in west central Minnesota" by D. Warnes, N. Barbour, A. Olness, Don Reicosky, D. Huggins, R. Alderfer.

Data from the article "Effects of a Winter Rye Cover Crop System on Grain Yield, Weed Control, Available Soil Water and Net Return per Acre in Corn and Soybeans" by R. Alderfer, D. D. Warnes, J. H. Ford, and G. A. Nelson was summarized and included in "Weed Control, The Environment and the Bottom Line, A Special Report Summarizing Findings of Research Funded by the Agricultural Utilization Research Institute, Edited by David Hest, December 1994.

Summarization of Data

We expect a number of publications from this research. Since we just finished this research, we have not had time to finalize scientific or popular articles from it. There has been some summarization of data which can be used in the writing of future publications.

With the suggestion that a video accompany the final report, tapes of operations and interviews were edited and a video was prepared to accompany the final report. It was decided to make a video to both supply needs of the final report and possibly be used by the Sustainable Agriculture community telling about this cover crop research. Copies will be given to all cooperators on this project, and to all farmer cooperators on this cover crop project.

Summarization of topping of corn to enhance cover crop establishment research at Swan Lake was continued and a draft article was written "Working Report for Cover Crop Studies" by D. C. Reicosky, D. D. Warnes, and A. E. Olness.

Summarization of the evapotranspiration (ET) and photosynthesis (CER) evaluation of the cover crop research was continued. A draft article was written "Cover Crops in Maize and Soybean, Topping of Maize to Enhance Interseeded Cover Crop Growth" by Alan Olness, Dennis Warnes, D. C. Reicosky, J. H. Ford, D. R. Huggins, R. Alderfer, and A. Arner.

Summarization of the research with *Brassica* as a smother crop was continued. Kevin Betts and Don Wyse have summarized some of the other *Brassica* research and have written a summary that has 3 objectives, "1. Continue to develop through classical plant breeding dwarf Brassica smother plants for weed control in soybean and corn, 2. Evaluate the effectiveness of dwarf Brassica smother plants for controlling weeds and reducing soil erosion, and 3 Identify the factors that could impede the adaptation of the dwarf Brassica smother plant system by corn and soybean producers."

Project Conclusions

1. We presented results from this cover crop research to diverse audiences and we provided presentations at places such as:

Talked at Fall Field Days at WCES, Morris and SWES, Lamberton;
Talked at Craig Murphy and Carmen Fernholz farmer field days;
Talked at Wilmar Area ELCA Church Synod pastoral meeting;
Demonstrated establishment of cover crops at WCES Ag Awareness Day;
Interviewed by radio stations of Worthington, Minn. and Yankton, South Dakota
Wrote 2 Extension new releases about topping of corn;
Presented poster at Minnesota Sustainable Farming Association, Mankato;
Presented 2 posters at Stress Management Symposium, Brookings;
Presented poster at North Central Weed Science Society,
Presented 2 posters at American Society of Agronomy, Seattle;
Presented 2 oral papers at Minnesota Academy of Science, Morris;
Planning to present poster at American Society of Agronomy, St. Louis

We Helped Build Good Relations with Sustainable Agriculture Community!

We helped improve communication between the University and the Sustainable Agriculture Community, but I am concerned. When we interviewed the farmer cooperators of the Sustainable Agriculture Community, we received many good comments from farmers who were so happy to have the University do research with cover crops. For example when interviewing Carmen Fernholz, he was quoted as saying;

"I see things happening out in the field, I try things out in the field, and I can observe, but when I can work in cooperation with the University and people like yourself,... I can get these answers and that's exciting to me".

We made many good research relationships in the Sustainable Agriculture Community who previously had thought that the University was doing nothing for them. Since this is the end of this funding with cover crop research, I'm concerned what is going to happen to these new research relationships.

Problems:
January 1, 1994 No Problems

July 1, 1994 No Problems

January 1, 1995 No Problems

June 30, 1995 No Problems

V. Evaluation: The most direct and tangible measurement of the success of this program will be to identify factors that may limit successful use of cover crop management in Minnesota. Farmers will have to use the management strategies from this research to minimize the risk involved to use cover crops in their farming program in Minnesota. Other farmers must observe success by these farm producer demonstrations to consider using cover crops themselves. Management needed to reduce environmental and economic risk will be presented at WCES and SWES Field Days. Data will be summarized and presented to Minnesota Extension Service for presentation at county and regional extension meetings. Farmers in the farm demonstrations will be asked to discuss their results with cover crops at future meetings of the Sustainable Farming Association of Western Minnesota. Farmers who use cover crops wisely could improve water quality, reduce the use of persistent synthetic herbicides and help control wind and water erosion of soil.

VI. Context Within Field: Public concerns have increased regarding water quality, the use of persistent synthetic herbicides, and wind and water erosion of soil. Cover crops are used extensively in the Southern Corn Belt and Southern Great Plains but cover crops are not used extensively in Minnesota primarily because of moisture competition between the agronomic crop and the cover crop. It is the intent of this research to develop economic management strategies to reduce risk of using cover crops for corn and soybean rotations. Proper use of cover crops will reduce wind and water erosion of soil, scavenge soil nitrogen to reduce nitrate leaching, and reduce use of persistent herbicides by taking advantage of cover crop competition, allelopathy, and increased reliance on the use of postemergence herbicides which have little soil residue.

Each of primary cooperators have done previous research relating to cover crops in Minn.

1. **D. D. Warnes**, et al, research has been summarized in "Effects of a winter rye cover crop system and available soil water on weed control and yield in soybeans" by D. D. Warnes, J. H. Ford, C. V. Eberlein, and W. E. Lueschen, presented at the "Cover Crops for Clean Water" symposium held at Jackson, Tennessee, April 9-11, 1991. The figure in that article demonstrated that available soil water and precipitation have a direct effect on the relative yield of soybeans in a cover crop system. Preliminary data showed that winter rye cover crop system about one month after planting the soybeans had 5.5 centimeters less soil moisture than the handweeded check in 1989 and 8.3 centimeters less soil moisture in 1990 (0-1.5 meter).

2. **D. C. Reicosky and D. D. Warnes** research has been summarized in "Evapotranspiration and nitrogen accumulation in a winter rye cover crop in the Northern corn belt" by D. C. Reicosky and D. D. Warnes, which was presented at the "Cover Crops for Clean Water" symposium held at Jackson, Tennessee, April 9-11, 1991. Results showed the largest amount of fall rye growth was in the irrigated soybeans resulting in a dry rye biomass of 829 kg/ha and the total N content in the above ground biomass was 30 kg N/ha in the fall and 37 kg N/ha in the spring regrowth.

3. **A. E. Olness** research has showed that removing the corn stalk and leaves above the corn ear at physiological maturity increased light penetration to increase growth of cover crops without major effect on corn yield. "Topping" the corn provided 1000 kg/ha of high quality forage that partially would offset the operational cost and resulted in improved interseeding a winter cover crop.

4. **R. D. Alderfer**, a production economist, and D. D. Warnes have used fall soil water values and precipitation records from Lamberton, MN data over a 30-year period. A formula is being developed to improve the estimation of fall soil water from precipitation records for future cover crop management. Alderfer will contribute economic analysis for the various management strategies of a cover crop system to assure they will be accepted by farmers.

VII. Benefits: It is the intent of this research to develop economic management strategies to reduce risk of using cover crops for corn and soybean rotations. Proper use of cover crops will reduce wind and water erosion of soil, scavenge soil nitrogen to reduce nitrate leaching, and reduce use of persistent herbicides by taking advantage of cover crop competition and allelopathy. It will also increase reliance on the use of postemergence herbicides which have little soil residue. Farm Program changes will require 30% residue after planting a crop for highly erodible soils. It is very difficult to do fall tillage, prepare a seedbed in the spring, and have 30% residue after planting. Only no-till planting and ridgetill planting of row crops would comply for highly erodible soils. Proper use of winter hardy cover crops would be another tool for farmers to use, to comply with the farm program changes.

VIII. Dissemination: Results from this project will be presented at Field Days at WCES, Morris and SWES, Lamberton. Some results will be presented by primary cooperators at regional and national professional meetings. Publications will be written and submitted to scientific and professional journals. After completion of this project we hope to write an extension publication on "Cover Crops" to be made available to farmers through the Minnesota Extension Service.

IX. Time: The proposed project is to be completed in the two year funding period July 1, 1993 to June 30, 1995. Research with cover crops will continue after this project is completed and it is possible that a future request to LCMR could be requested for more promising aspects of cover crop management.

X. Cooperation: Dennis Warnes, Agronomist, West Central Experiment Station, Morris, MN is Program Manager and he will be in charge of the conduct of the experiments at Morris.

Cooperators on this project are:

J. Harlan Ford, Agronomist, South West Experiment Station, Lamberton, MN will share responsibilities of the conduct of the experiments at Lamberton with David R. Huggins.

David R. Huggins, Soil Scientist, South West Experiment Station, Lamberton, MN will share responsibilities of the conduct of the experiments at Lamberton with J. Harlan Ford.

Donald C. Reicosky, Soil Scientist, ARS, USDA, Morris, MN will be in charge of collection of evapotranspiration data, leaf analysis data, biomass data, and nitrate accumulation data.

Alan E. Olness, Soil Scientist, ARS, USDA, Morris, MN will be in charge of "topping corn", collection of light penetration data, quality and quantity of topped forage data.

Richard D. Alderfer, Production Economist, WCES, Morris, MN will be in charge of objective B to summarize data and make visual aids for presentation to farmers explaining the management needed to reduce environmental and economic risk.

Audrey Arner, Western Minnesota Office of the Land Stewardship Project, 103 W. Nichols, Montevideo, Minn. will help coordinate the farmer demonstrations selected after the Cover Crop Workshop January 28, 1993 by the Sustainable Farming Association of Western Minnesota.

XI. Reporting Requirements: Semi-annual status reports will be submitted not later than Jan. 1, 1994, July 1, 1994, Jan. 1, 1995, and a final status report by June 30, 1995.

REQUIRED ATTACHMENT: Qualifications:

Name: Dennis D. Warnes, Agronomist, Program Manager
West Central Experiment Station,
Morris, MN 56267
Education: B.S. North Dakota State University, Fargo, ND 1955-Agronomy
University of Minnesota, Minneapolis, MN 1960-Agronomy
Ph.D. University of Nebraska, Lincoln, NE 1969-Plant Breeding

Name: J. Harlan Ford, Agronomist, Acting Superintendent, SWES
South West Experiment Station
Lamberton, MN 56152
Education: B.S. North Dakota State University, Fargo, ND, 1950-Agronomy
M.S. University of Minnesota, Minneapolis, MN. 1959-Plant Breeding

Name: David R. Huggins, Soil Scientist
South West Experiment Station
Lamberton, MN 56152
Education: B.S. College of Environmental Science & Forestry, Syracuse, NY, 1976, Forest Resources
M.S. College of Environmental Science & Forestry, Syracuse, NY, 1982, Forest Soils
Ph.D. Washington State University, Pullman, WA, 1991, Soil Fertility/Conservation Systems

Name: Donald C. Reicosky, Soil Scientist
ARS-USDA, NC Soil and Water Conservation Research Laboratory
Morris, MN 56267
Education: B.S. Ohio State University, Columbus, OH 1963-Agronomy
M.S. Ohio State University, Columbus, OH 1965-Agronomy
Ph.D. University of Illinois, Urbana, IL 1969-Soil Physics

Name: Alan E. Olness, Soil Scientist
ARS, USDA, NC Soil and Water Conservation Research Laboratory
Morris, MN 56267
Education: B.S. University of Minnesota, Minneapolis, MN 1963-Soil Science
M.S. University of Minnesota, Minneapolis, MN 1967-Soil Science
Ph.D. University of Minnesota, Minneapolis, MN 1973-Soil Science

Name: Richard D. Alderfer, Production Economist
West Central Experiment Station
Morris, MN 56267
Education: B.S. Purdue University, Lafayette, IN 1979-Agriculture
M.S. Purdue University, Lafayette, IN 1985-Extension Ed.
Ph.D. Michigan State University, East Lansing, MI 1991 - Ag. Economics

Name: Audrey Arner, Director
Western Minnesota Office, The Land Stewardship Project
103 W. Nichols, Montevideo, Minnesota, 56265
Education: B.S. Macalester College, St. Paul, MN

LITERATURE REVIEW:

Public concerns have increased regarding soil erosion, water quality, and the use of persistent synthetic herbicides. Cover crops managed effectively in corn and soybean production will reduce wind and water erosion, control weeds without persistent herbicides, and reduce nitrate leaching and ground water contamination. The "Cover Crops for Clean Water" Symposium held April 9-11, 1991 at Jackson, Tennessee, edited by W. L. Hargrove is a good literature review on the need, benefits and the best management practices needed to reduce environmental and economic risk but there is little information on use of cover crops in colder and drier parts of the northern great plains.

Warnes et al. (1989, 1991) have shown that variable precipitation is a major risk associated with using a winter rye cover crop system for soybean production in Minnesota. Minimizing moisture stress in soybean will require additional research on managing the winter rye cover crop to conserve moisture. As dates of planting and killing of the rye are changed to reduce moisture stress on the soybeans, there will be a greater reliance on postemergence herbicides and cultivation for weed control.

Reicosky and Warnes (1991, 1990a, 1990b), have researched the evapotranspiration and nitrate accumulation in a winter rye cover crop in the Northern Corn Belt and found that there was a difference in evapotranspiration between early fall-planted and late-fall planted winter rye. The midday evapotranspiration of the early fall-planted rye crop was consistently larger than the late-fall-planted rye through the early part of the season. Results showed the largest amount of fall rye growth was in the irrigated soybean resulting in a dry biomass of 740 pounds/acre and the total N content in the above ground biomass was 27 pounds N/acre in the fall and 33 pounds N/acre in the spring regrowth.

Olness et al. (1993) have shown that maize grain yields were unaffected by topping after plants had reached the R5 growth stage. At harvest, grain moisture contents of topped plants averaged 0.3 % less in 1991 and 6.0% less in 1992. About 2 to 2.2 kg ha $^{-1}$ (dry wt) of high quality forage or potential residue cover were harvested by topping.

Alderfer in his Ph.D. thesis developed decision support systems for firm level risk management through commodity marketing Alderfer, a production economist and Warnes have used fall soil water values and precipitation records from Lamberton, MN data over a 30-year period. A formula is being developed to improve the estimation of fall soil water from precipitation records for future cover crop management.

PUBLICATIONS:

Alderfer, R. D. 1991. Decision Support Systems for Firm Level Risk Management through Commodity Marketing, Ph.D. Thesis. Michigan State University, East Lansing, MI.

Olness, Alan, D. D. Warnes, and D. C. Reicosky. 1993. Accelerated field desiccation of maize (*Zea mays* L.) grain through defoliation and cover crop induced stress management. Abstract submitted to Northern Plains Biostress Symposia, South Dakota State University, College of Agriculture and Biological Sciences, April 1993.

Reicosky, D. C. and D. D. Warnes. 1991. Evapotranspiration and nitrogen accumulation in a winter rye cover crop in the Northern Corn Belt presented at the "Cover Crops for Clean Water" symposium held at Jackson, TN, April 9-11, 1991.

Warnes, D. D., J. H. Ford, C. V. Eberlein, and W. E. Lueschen. 1991. Effects of a winter rye cover crop system and available soil water on weed control and yield in soybeans presented at the "Cover Crops for Clean Water" symposium held at Jackson, TN, April 9-11, 1991.

Warnes, D. D., C. V. Eberlein, J. H. Ford, W. E. Lueschen, and M. W. Seeley. 1989. Effect of precipitation and management on weed control and crop yields with a winter rye cover crop system. In Agronomy Abstracts. Am. Soc. Agron. Madison, WI. PP 296.