Sustainable Agriculture Program of Minnesota

GREENBOOK 91

Minnesota Department of Agriculture
Energy and Sustainable Agriculture Program

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Minnesota Department of Agriculture
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Energy and Sustainable Agriculture Program Overview

To promote and encourage the adoption of farming practices which conserve natural resources, the state of Minnesota initiated the Energy & Sustainable Agriculture Program (ESAP) through its Department of Agriculture.

Energy and Sustainable Agriculture Program was initiated in 1987 with EXXON oil overcharge funds. In 1988, the Minnesota legislature provided ESAP with additional funding for a Sustainable Agriculture Grant and Loan program. In 1989, the Minnesota legislature continued its support of ESAP by providing funding for two additional positions within ESAP. The Energy and Sustainable Agriculture Program now consists of five full-time employees.

The agricultural development we are witnessing is moving towards a more sustainable agriculture by developing alternatives to conventional farming methods. The Minnesota Department of Agriculture, ESAP, has established the following goals to direct the development of sustainable farming systems:

- Maintain and improve soil productivity and tilth
- Conserve soil; reduce wind and water erosion
- Avoid the entrance of agri-chemicals into groundwater
- Minimize the use of agri-chemicals, where possible
- Produce safe and wholesome food, free of residues
- Reduce the use of and reliance on non-renewable resources
- Reduce farmers' economic and health risks
- Increase both short- and long-term farm profitability
- Maintain or increase farm numbers

The management of natural resources and farming practices for sustainability revolves around three critical areas: environmental protection, farm profitability, and social acceptance. In order for sustainable agriculture practices to make a significant difference they must be *at least* environmentally benign, and preferably environmentally positive or enhancing, and at the same time profitable for the farmer and acceptable to the general public.

Farmers will not adopt any practice that does not provide them with a profitable return (unless it is subsidized by the government). The public is increasingly concerned with health risks associated with residues in foods, and with the protection of its soil and water resources. The goal of ESAP and other organizations to formulate practices that are both profitable and environmentally sound is challenging, but is possible given local, state and federal support.

Methods for Achieving Project Goals

To achieve the adoption of farming practices which encourage the incorporation of the above goals, ESAP uses a multi-programmatic approach. This approach is designed to:

1. Evaluate current farm sustainability;
2. Recommend alternatives for future farm sustainability;
3. Demonstrate and research practical farming alternatives;
4. Inform farmers about sustainable techniques from both experiment station and on-farm research/demonstrations;

5. Grant funds to farmers and researchers capable of performing on-farm research and demonstrations; and
6. Loan funds to farmers for purchase of equipment that will speed the adoption of sustainable practices;
7. Listen to farmers; work with, and learn from them.

To these ends, the following programs have been developed.

On-Farm Research/Demonstration Program: Energy and Sustainable Agriculture Program has set up research and demonstration projects to investigate alternative farming practices. Farmers want to see alternative practices demonstrated on their farms or nearby farms before they will adopt them. Demonstrations are established on farm, at farm scale, and within the farmer's management system. Plots are randomized, replicated in side-by-side design with a minimum of 4 replications.

Sustainable Agriculture Grant Program: Farmers, researchers, extension agents, and crop consultants can obtain grant funds to conduct on-farm experimentation of sustainable techniques. Grant funding is competitive and contingent upon meeting sustainable agriculture criteria, and cooperation with county agents, conservation districts, extension specialists, private consultants, and non-profit groups. In 1989, 17 grants were awarded averaging $16,500; and in 1990, 14 grants were awarded averaging $13,500 for 2 to 3 year projects. Grant recipients present details of their projects to the public during field days. In so doing, the information collected from the grant projects is shared with interested parties.

Sustainable Agriculture Loan Program: Loans up to $15,000 per farmer, at a fixed 6% interest rate, are made to assist the adoption of management practices that are environmentally sound, conserve soil, and reduce energy consumption. Over $946,000 in loans have been made to a total of 95 farmers to date.

Sustainable Agriculture Information Program: ESAP has compiled materials from both land grant university research, and successful farmer implementation of sustainable techniques, and made this material available to the public. Publications being produced include conference proceedings, communication meeting findings, results from a survey of farmers using alternative management techniques, a manual for the transition from high input to low input farming, and management guidelines for sustainable techniques. In addition, a database of a wide range of sustainable agriculture related topics is being developed by ESAP to assist people who want information.

Sustainable Agriculture Farmer Communication: Discussion groups, workshops, and informal meetings are held to provide an exchange of ideas on sustainable agriculture for researchers, extension agents, regulators, agri-professionals, and farmers. Some topics previously discussed include: how farmers can economically implement new farming techniques, and what kinds of additional research farmers feel they need. ESAP coordinators have fulfilled requests to speak at 72 farmers meetings the past two years to about 1720 attending farmers. Several workshops were held to update agri-professionals on new developments in sustainable agriculture, including a two-day workshop with about 220 extension agents and adult farm management instructors attending. ESAP has also conducted meetings with Soil and Water Conservation District personnel, crop consultants, farm groups, and sales people.

Energy Audit Program: This program assists farmers in calculating farm energy use. Farmers can evaluate their use of non-renewable inputs - both direct (fuel and electricity) and indirect (fertilizers and pesticides) - to analyze the associated costs of production. Farmers are

encouraged to consider input reduction in areas where energy use and/or production costs exceed the norm for a sustainable farm.

Organization Partnerships and Cooperation

ESAP has established partnerships with the Minnesota Extension Service and Experiment Station - organizations traditionally known for providing information to farmers. On-farm research/demonstration plots are coordinated with local county extension agents, state extension specialists, and non-profit group agronomists. Information generated from these plots is shared and disseminated by the various organizations at conferences, meetings, and in publications. The partnership with the University of Minnesota is successful because of concerted efforts to coordinate all ESAP programs with local and state agents. This relationship includes equal access to all research activities, information and reports.

ESAP has also established partnerships with organizations that are advocating changes for Minnesota's agriculture such as the Land Stewardship Project, Organic Growers and Buyers Association, Minnesota Food Association, Minnesota Project, and International Alliance for a Sustainable Agriculture. These relationships keep ESAP on the cutting edge of changes that will move Minnesota agriculture toward sustainability over the next decade.

On-Farm Research and Demonstration Program

In the early days of the Energy and Sustainable Agriculture Program (ESAP), a series of focus group meetings were held with farmers and agri-professionals around the state to determine what direction ESAP should take in order to best meet the needs of farmers wanting information on energy and sustainable agriculture. From these meetings, it was apparent that farmers wanted to know how to reduce fertilizer and pesticide applications without reducing their profits. As a result of this process, the ESAP has embarked on some on-farm studies designed to address a few of the concerns brought up in the focus group discussions. Information collected from these on-farm studies are presented in this report.

On-Farm Research and Demonstration An Explanation

Most agricultural research studies are conducted on experiment stations, university research plots, or some other site specifically designated for research purposes. These plots are situated on relatively small areas in which the researcher attempts to control environmental conditions as much as possible. While such an approach is excellent for the researcher to assess the exact effect of a treatment under very specific conditions, it is less useful in evaluating a treatment in a cropping system.

On-Farm Research, agricultural experiments performed on commercially-operated farms on plots that are farm scale, offer an additional tool for examining sustainable agriculture methods.

Advantages of On-Farm Research

1. Because environmental factors on farm-scale research cannot be manipulated to the degree that smaller plots allow, the yields and results obtained by these studies are more realistic to what a grower can expect to see on a commercial farm, which adds credibility to the study from the perspective of the grower.
2. Farmers play a critical role in managing on-farm research by: planning the treatments, applying the treatments, maintaining the experimental field, and harvesting and collecting data.
3. Neighboring farmers are more willing to adopt the techniques demonstrated by this research when they have seen a successful execution on a commercial farm.
4. Researchers can use on-farm studies to evaluate the feasibility of an agricultural system using prototypical farm equipment. This is not possible on standard-sized plots, which are too small to accommodate the operation of normal farm equipment.[7]
5. Researchers, farmers, and extension personnel are interacting in a "give and take" basis avoiding the "top down" syndrome.
6. Research information is usually published and useful for years following.

Disadvantages of On-Farm Research

1. Since there is more field and environmental variation in large plots, the resulting data from on-farm research studies generally can be expected to contain higher variability than that of typical agricultural studies. However, studies by Fleming et al.[8] and Shapiro et al.[9] suggest that "long narrow strips, when replicated, increase statistical precision as a result of representing the population of inference better."
2. The management decisions made by the farmer participating in the study may contribute a source of experimental error (variability) to the research.
3. For these reasons, researchers are skeptical of the scientific merit of on-farm studies. They have been reluctant to embrace the findings of these experiments, and rarely use these methods on their own research projects.

Despite the logistical difficulties present in on-farm studies, many agri-professionals believe that these investigations play an important role in agricultural research and may provide valuable information to the benefit of farm growers and producers.

How is On-Farm Research done?

Some guidelines for setting up statistically reliable on-farm research designs were presented by Rzewnicki et. al.[10]:

1. Long, narrow plots from 125 to 1320 feet, wide enough to accommodate one to two passes of farm equipment.
2. Few treatments (2 to 3 treatments) per experiment.
3. Randomized, replicated treatments with six to eight replicates per treatment - using several different farms and cooperators if necessary.
4. Farmer participation in planning, planting, maintaining, and harvesting plots, and collecting data, using standard farm equipment.

Effectiveness of On-Farm Research

Evaluating the effectiveness of on-farm research is similar to evaluating standard research, in many respects. It is important to conduct appropriate statistical analyses on soil, agronomic, and yield data.

Other relevant parameters of evaluating on-farm research include: analyzing the economics of the system - whether it compares favorably to the corresponding conventional system; assessing the magnitude of input

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[7]Lockeretz, W. 1987. Establishing the proper role of on-farm research. Am. J. of Alternative Agriculture 3:132-136.

[8]Fleming, A.A., T. Hayden Rogers, and T.A. Bancroft. 1957. Field plot technique with hybrid corn under Alabama conditions. Agron. J. 49:1-4.

[9]Shapiro, C.A., W. L. Kranz, A.M. Parkhurst. 1989. Comparison of harvest techniques for corn field demonstrations. Am. J. of Alternative Agriculture 4:59-64.

[10]Rzewnicki, P.E., R. Thompson, G.W. Lesoing, R.W. Elmore, C.A. Francis, A.M. Parkhurst, and R.S. Moomaw. 1988. On-farm experiment designs and implications for locating research sites. Am. J. of Alternative Agriculture 3:168-173.

reduction; and determining the amount of labor and time necessary to implement the system.

On-Farm Demonstration

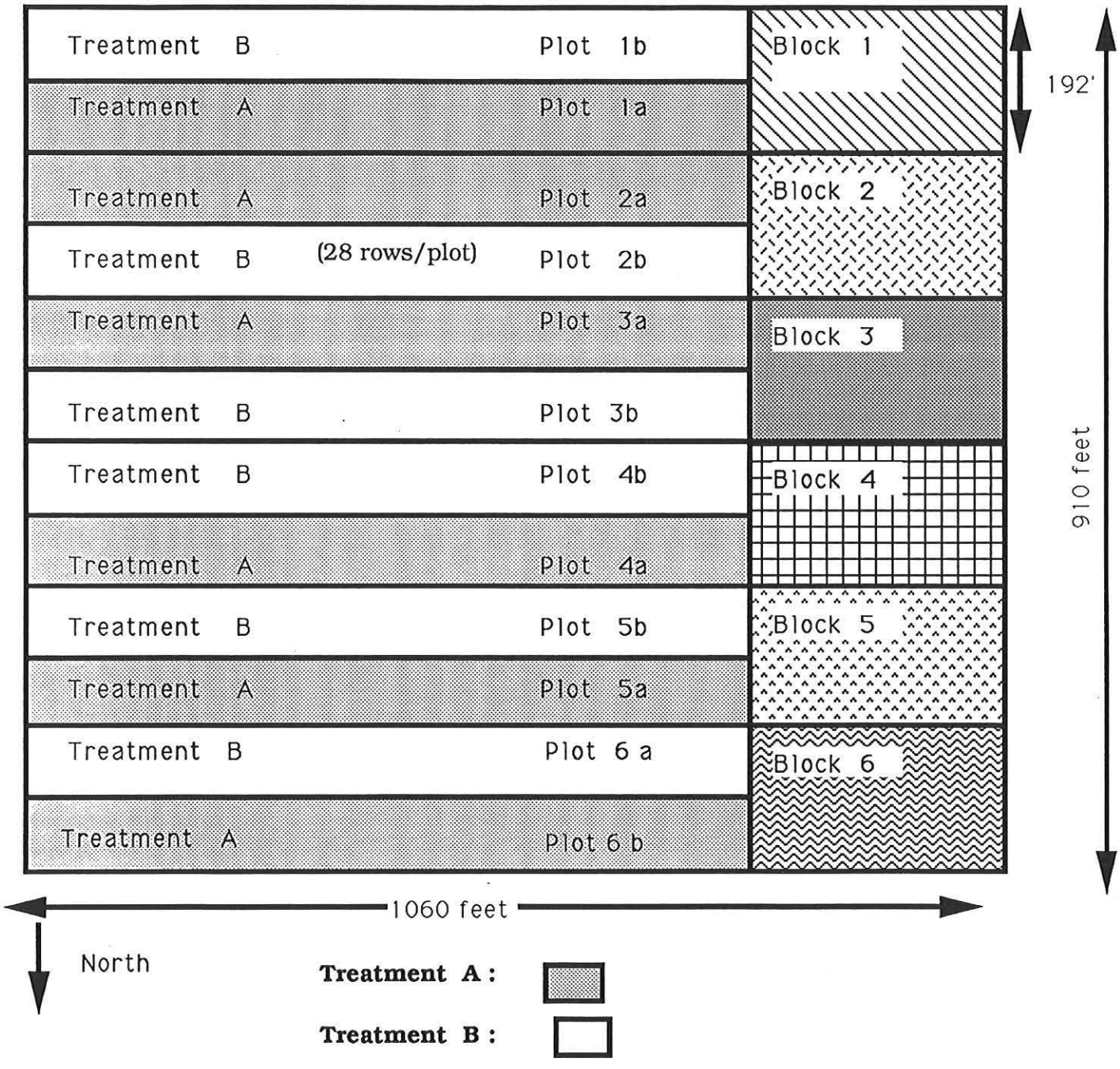
On-farm demonstrations are similar to on-farm research in many ways, and are also useful for presenting new farming techniques to growers. On-farm demonstration, like on-farm research, are studies conducted on a farm, on a large-scale field, using standard farm equipment. Farmer participation, again, is crucial in conducting a demonstration.

Unlike on-farm research, however, demonstrations do not meet the requirements for statistical design. The "treatments" are not randomized and the replication is incomplete. Usually, on-farm demonstrations present contrasting farming systems in side by side comparisons.

Effectiveness of On-Farm Demonstration

Since statistical analyses are inappropriate for on-farm demonstrations, the effectiveness of a demonstration is evaluated based on its ability to draw public interest as measured by the number of persons attending farm tours and/or field days, by the amount of media coverage generated, and by the number of people who adopt or consider adopting the techniques demonstrated.

Example of
On-Farm Research Plot Design



Weed Management Study

Farming profitably without herbicides is a challenge for farmers who are concerned about the environmental impact, health risks, and added costs of using herbicides. Some alternatives to herbicides include mechanical and manual cultivations, and crop rotations to keep weeds under control. Whether these methods are practical for farmers today is uncertain because developments in cropping systems and crop varieties have been geared towards intensive, high-input environments, and not towards sustainable systems. ESAP has been conducting an on-farm research study of weed management now with three years of data.

In this study, the effectiveness of mechanical weed management using the rotary hoe was explored. The rotary hoe is one option for weed control in row crops and works by uprooting weed seedlings before emergence. The objectives of this study were:
1) To examine the effectiveness of pre-emergence and post-emergence mechanical weed management on working farms; and
2) To compare the economic and agronomic effectiveness of managing weeds under mechanical and chemical systems.

MATERIAL AND METHODS

The study takes place in south central Minnesota on four participating farms. The farmers planted corn and/or soybeans and managed the weeds either by rotary hoeing (mechanical treatment) or by spraying herbicides (chemical treatment). The treatments (mechanical vs. chemical) were randomized, replicated (4 to 6 replicates per farm) and applied side-by-side on large plots (0.33 acre to 2.34 acres per treatment).

The following measurements were taken:

1. Stand counts (4 sites/treatment) 0.001 Acre; 8 weeks after emergence following last hoeing.
2. Weed counts (4 sites/treatment) 1 x 4 ft; 15-20 days after planting, 60-65 days after planting.
3. Yield: weigh wagon length of field.
4. Economic return to labor and management was calculated by subtracting actual direct expenses from the gross return for each treatment. Land cost per acre was based on average rent for the area. Machinery overhead costs was taken from the suggested custom rates by the University of Minnesota . These figures were then used to compare the treatments for their economic advantage.

RESULTS IN SOYBEAN

SOYBEAN YIELDS

There were a total of nine trials run over a period of 3 years (1988-90) on 4 different farms. Five out of the 9 trials resulted in higher soybean yields under mechanical compared to chemical control, although only two of those five were statistically significant. Overall soybean yields show no difference between mechanical vs. chemical weed management.

Soybean Yields of Weed Management Study

Cooperator	Year	Mechanical Treatment	Chemical Treatment
		---Bu/Acre---	
Jutz	1990	48.45	46.64*
	1989	49.06	47.16**
	1988	34.05	33.51
Grisham	1990	51.84	54.41*
	1989	45.46	47.46
	1988	34.46	38.01**
Monsen	1990	44.66	43.71
	1989	33.00	33.90
Mosel	1990	51.36	50.75
Overall	1988-90	43.43	43.85

*,** Significant at 0.05 and 0.01, respectively

SOYBEAN ECONOMIC RETURNS

Economic analysis of soybean returns under chemical and mechanical weed management shows that the net profit under mechanical weed management exceeded that of chemical weed management in seven out of nine trials, with an average increased return of $10.83 per acre.

Cost Analysis of Weed Management in Soybean

Farm	Year	Mechanical Treatment	Chemical Treatment
		---Return Per Acre ($)[a]---	
Jutz	1990	126.88	83.75
	1989	128.35	110.01
	1988	125.09	98.54
Grisham	1990	146.63	146.24
	1989	83.97	78.29
	1988	110.07	117.55
Monsen	1990	117.66	106.27
	1989	42.57	50.01
Mosel	1990	148.88	141.89
Average	1989-90	114.45	103.62

[a]Return per acre calculated as return to capital, labor, and management

SOYBEAN WEED AND STAND COUNTS

Weeds were counted twice during the growing seasons: early - during vegetative growth of soybean plants; and late - at flowering. The data from the late-season count generally support those of the early-season count. The data suggests that rotary hoeing provides comparable weed control to herbicides.

The stand counts were consistently lower under mechanical weeding compared to chemical weeding in every case. Soybean yields do not appear to be affected by lower stand counts. Most of the mechanically-weeded soybeans showed higher yields despite the lower plant populations. Soybeans are able to compensate in yield after being thinned by the rotary hoe.

Weed and Stand Counts - Soybean

	Mechanical Treatment	Chemical Treatment
Broadleaf Weeds		
1990	0.21	0.31
1989	0.52	1.43
Grass Weeds		
1990	9.06	3.95
1989	4.88	6.13
Stands Counts		
1990	144.38	154.55
1989	124.50	137.43

RESULTS IN CORN

CORN YIELDS

Corn yields are lower under mechanical treatment of weeds compared to chemical treatment of weeds. A total of six (6) trials were run over a period of two years on four different farms for the study of weed management in corn. Five (5) out of the 6 trials resulted in lower mean corn yields under mechanical treatment compared to chemical treatment (although of those 5 trials, only 3 were statistically significant). Only one of the six trials resulted in significantly higher mean corn yield under the mechanical treatment. Overall, there was less than a 5 bushel difference in corn yield between mechanical and chemical treatment.

Corn Yields of Weed Management Study

Cooperator	Year	Mechanical Treatment	Chemical Treatment
		----------*Bu/A*----------	
Jutz	1990	133.35	128.73**
	1989	136.43	148.27**
Grisham	1990	139.29	142.76
	1989	145.50	148.99
Monsen	1990	101.53	113.21**
Mosel	1989	137.77	140.73
Overall	89-90	132.19	136.80**

**Statistically significant at 0.01

CORN ECONOMIC RETURNS

The economic analysis of the plots suggests that higher yields do not guarantee highest financial returns. Of the six trials run, 2 resulted in $5.00-$15.00 greater returns per acre under mechanical weed treatment compared to herbicide treatment. The differences in returns of another 2 of the 6 trials were less than $1.00 per acre between the two treatments. The remaining two trials showed that the herbicide-treated plots netted almost $20.00 more compared to the mechanically-weeded plots. The overall average of the six trials showed that the return per acre under mechanical treatment was $3.22 less than under chemical treatment.

Cost Analysis of Weed Management in Corn

Farm	Year	Mechanical Treatment	Chemical Treatment
		–Return Per Acre($)–	
Jutz	1990	90.94	75.86
	1989	147.63	166.62
Grisham	1990	62.51	56.83
	1989	118.42	119.11
Monsen	1990	18.01	37.61
Mosel	1989	124.45	125.23
Average	1989-90	93.66	96.88

*Return per acre calculated as return to capital, labor, and management

CORN WEED AND STAND COUNTS

The mechanical weed control was generally not as effective in reducing weed pressure as the herbicides were, although a few of the plots showed better weed control with mechanical control. Overall, the weed count data was consistent with the corn yield data in that the plots with mechanical weed treatment had lower yields and more weeds than the chemically treated plots.

The stand count showed that the plant populations were consistently lower in the mechanically-weeded plots

compared to the chemically-weeded plots in every case. As the rotary hoe is driven through a crop, some of the crop plants are inadvertently uprooted along with the grass and broadleaf weeds. Presumably, this is what accounts for the lower stands. The stand counts in the mechanically-weeded plots ranged from 1% to 17% less than the chemically-weeded plots. Despite the stand loss, however, there was still one trial (out of 6) which resulted in higher yields under the mechanical compared to chemical weed treatment.

Weed and Stand Counts - Corn

	Mechanical Treatment	Chemical Treatment
Broadleaf Weeds		
1990	0.40	0.23
1989	0.75	0.41
Grass Weeds		
1990	10.13	2.08
1989	2.77	1.18
Stand Counts		
1990	23.28	25.35
1989	22.13	24.99

WHAT WE LEARNED

Based on three years of research, we have found that the rotary hoe is a practical, and effective tool for managing weeds. In many cases, it can replace herbicide usage without reducing the farmer's profits and even enhancing his profits - especially in soybeans. One common perception about the rotary hoe is that it is not effective in managing weeds during wet, rainy years. The difficulty of using the rotary hoes under especially rainy seasons is that there is greater risk of compacting the soil if the soil has not been given a chance to dry out. At the same time, hoeing or cultivating must be performed while the weeds are manageable and the crop is resistant to damage by the machinery. So in wet years, the window of opportunity for managing weeds with the rotary hoe may be quite narrow. On the other hand, dry conditions are much more ideal for mechanical weed control compared to chemical control because many herbicides are water-activated and are not effective in dry conditions.

As luck would have it, the three years during which this study has been conducted have offered vastly different rainfall levels - from the drought of 1988, to the excess rains of 1990. Furthermore, the results of the system tested on four different farms, with different management histories, by different farmers on two crops gives an idea of how adaptable and flexible the alternative system can be. Our conclusion is that the rotary hoe for weed management can successfully fit into a sustainable system.

MANAGEMENT TIPS

Some points to consider when using the rotary hoe for weed control:

1. See Fact Sheet on page 15 for tips on how to use the rotary hoe.

2. Start by using the rotary hoe for weeding soybeans, which respond well to this tool.

3. Since corn population is thinned by the rotary hoe, corn should be planted at a greater density.

4. Weeds should be rotary hoed when they are most vulnerable, at the white root stage before emergence.

ROTARY HOE & WEED MANAGEMENT FACT SHEET

Richard E. Gauger

Farmers are becoming increasingly aware of the need for alternatives to herbicides for weed control. One tool that is frequently discussed as an alternative to pre-plant incorporated and pre-emergence herbicides is the rotary hoe. As with all methods of controlling pests a number of considerations need to be taken into account **before** deciding to using a rotary hoe.

Major Objective

The main purpose for using the rotary hoe is to control weeds within the crop row. Row crop cultivators are not always able to control weeds within the row. This is why the rotary hoe is so important in farming systems where little or no herbicides are used.

Climatic Conditions

Prolonged periods of rain or excessive soil moisture will render the rotary hoe useless, until the soil moisture level is acceptable for tillage. Weeds that have emerged from the soil during this high moisture period will not be controlled with the rotary hoe. Therefore it is important to plan ahead for inclement weather when depending on the rotary hoe for weed control in the row. Strategies must include rotary hoeing early to avoid impending rain storms. It is better to rotary hoe early, than to wait till after a rain.

Timing & Stage of Growth

Timing is the single most important aspect of weed control with the rotary hoe. Once weeds have emerged from the soil, the percentage of weeds controlled by the rotary hoe goes down drastically. Therefore, when in doubt and weeds are detected in the white stage, rotary hoeing should be initiated immediately.

Strategies must include rotary hoeing early to avoid impending rain storms. It is better to rotary hoe early, than to wait till after a rain.

The best method for determining when to rotary hoe will be based on the following factors:

• *Pre-plant tillage.* When determining the expected date for weed germination and emergence, the first factor to look at is the date of last tillage. Weeds will begin to germinate immediately following the last tillage, not the date of planting. A common mistake for misjudging weed growth, is the assumption that weeds will emerge so many days after planting, when actually it is after the last tillage.

•*Think like a Weed.* Inorder to get a jump on the crop, weeds will try to germinate and emerge prior to crop emergence. Therefore, it is important to remember, that rotary hoeing will usually need to begin prior to crop emergence.

• *Stage of Weeds.* The rotary hoe is most effective when the weeds are in the white root stage, prior to emergence from the soil. At this stage, weeds are detected as white shoots (almost like skinny white worms) when the soil is scraped back .

Timing is the single most important aspect of weed control with the rotary hoe.

• *Stage of Crop.* Corn and soybeans are most susceptible to damage at emergence from the soil. The stage of crop growth is generally not as important of a consideration as weed stage and numbers. If weeds are detected in the white stage it is better to rotary hoe than to wait for the crop to get to a less susceptible stage. Weeds will be ready to emerge a few days prior to crop emergence in most cases, therefore rotary hoeing should be initiated then.

Stand loss will range from 1 to 4 percent per pass with the rotary hoe, depending on soil and weather conditions. Soybeans are much more tolerant to stand losses than corn.

• *What crop stages prohibit the rotary hoe.* Crop stage, such as emergence, should not prohibit the use of the rotary hoe. The stage of the weed, and weed pressure will determine timing and effectiveness of the rotary hoe.

If weeds are detected in the white stage it is better to rotary hoe than to wait for the crop to get to a less susceptible stage.

• *Time of Day.* Late morning to afternoon is the best time of the day to rotary hoe. The hot dry conditions are best for desiccation of weed seedlings that are uprooted and deposited on top of the soil. Corn and soybean seedlings are more flexible and less likely to be damaged by the hoe in warmer daytime temperatures.

• *Soil Moisture.* The moisture condition of the top 3 inches of soil will dramatically effect the ability to use the rotary hoe, and its effectiveness for controlling weed seedlings. The soil should be dry enough for shallow

tillage. Soil that is to wet will throw out clods behind the hoe and compact. Another indication of poor soil conditions is the appearance of pock marks or pockets after rotary hoeing, indicating that either the surface is wet or compacted.

• *Number of times across field.* Once again, the primary consideration for number of rotary hoeing depends upon the weed pressure. Plan on rotary hoeing at least 2 times for optimum control. Most farmers range from 2 to 5 trips with the rotary hoe.

Equipment Specifications

A poorly designed and maintained rotary hoe, is like forgetting to mix the herbicide in your sprayer. Water will not control weeds, neither will a defective rotary hoe.

• *Spacing between hoes.* Optimum spacing seems to be 3 to 3.5 inches. *Principle:* Every inch of ground covered by a hoe spoon.

• *Independent Spring loaded arms.* Independent arms will insure even penetration of the spoons over low spots or rolling terrain. Independent arms will have less tendency to jam with crop residues.

inches. Soil structure and tilth will have a great impact on the depth of penetration by the hoe. Compacted wheel tracks will only allow penetration to .5 inches, and "pock marks" will be very apparent.

Total Weed Management

Planting Date. Manipulating planting dates can allow for early and late season tillage which can significantly reduce weed pressure (Table 1). One way to help a corn and soybean rotation reduce herbicide use is to plant soybeans 1-2 weeks later than normal and to use pre-plant tillage to suppress weed growth. Furthermore, including a small grain in this rotation every third year allows for late season tillage to suppress weeds further.

• *Late emerging weeds.* Any time moisture and light are able to penetrate a crop canopy weeds will germinate and grow unless they are inhibited chemically (allelopathy or herbicides). Therefore, late emerging weeds can be a problem for farming systems which depend solely on non-herbicide controls. Weeds germinating and emerging 4 weeks after emergence of the crop will not significantly reduce crop yields in most cases, but they could contribute to the seed reservoir if allowed to mature.

Table 1. Windows of Opportunity for Significant Mechanical Weed Control

Crop	Date	Relative Planting Problems	Weed Early Season → Late Season	Windows for Control	
Soybeans	Late	Warm Season	Pre-Plant Tillage	Rotary Hoe	Cultivation
Corn	Mid	Cool/Warm		Rotary Hoe	Cultivation
Small Grain	Early	Cool Season			Post-harvest tillage

• *Offset hoes.* The main function of offset hoe wheels is the reduction of trash build-up. It is more difficult to collect large amounts of trash between the wheels. Proper arm extension length will allow the wheels to un-jam themselves.

• *Spoon condition.* The tips of the rotary hoe wheel (flared end) or spoons should be kept in good condition. Worn down tips and edges will significantly reduce the effectiveness of the rotary hoe.

Depth and Speed

• *Relationship between speed and depth.* The higher the tractor speed, the deeper the hoe will penetrate. Tractor speeds of between 8 -12 mph are the most effective. Older model rotary hoes penetrate to a depth of 1 to 2 inches, while the newer models will penetrate to 3

• *Row crop cultivation.* Cultivation is normally necessary to control weed which have escaped the rotary hoe. If weeds have emerged the rotary hoe will have a very limited effect on them, and this is the time to begin row cultivation.
Adjustment and setting of shanks and shields is critical for effective cultivation. In a non-chemical system, it is important to be more aggressive with the cultivator than when relying on herbicides.

• *Post-emergence herbicides.* New developments in post-emergence herbicides in corn and soybeans will provide a back-up or rescue treatment if weeds are not adequately controlled by mechanical means. Plan and prepare for these rescue treatments prior to planting the crop, because timing and stage of weed growth is very critical with post-emergence herbicides.

Compost Management Study

Many farmers have been wondering about the potential for using compost in a sustainable agriculture system. The benefits of composting are numerous:

1. Composting provides a stable nitrogen source which becomes available to the plant when it is most needed.
2. The composting process kills weed seeds that may be present in raw materials.
3. Composting reduces the volume of material, which allows farmers to transport materials to their fields more easily.
4. Materials from today's waste stream can be recycled as compost and utilized as a fertilizer or soil amendment.
5. Applying compost to soils can increase levels of organic matter and active humus.

In response to requests for composting information, we started an on-farm research study in 1990 comparing compost to no-compost controls. (No additional fertilizers were applied because soil tests on the research plot indicated high levels of N, P, and K). In the first year of the study, we applied 1 ton of compost on replicated strips for soybeans, and in 1991 we will follow with corn. Results are presented in the following table.

Results of Soybean Yield and Returns with Compost vs. No-Compost Treatments

	Compost	No-Compost
Yields (bu/A)	52.4	50.8
Broadleaf Weeds*	0.42	0.58
Grass Weeds*	10.9	26.0
Protein	39.71%	38.45%
Return/Acre	$124.23	$120.45

*Average of 4 counts; 1' x 4' area

After the first year of this compost experiment, we have not gathered enough information to make any recommendations. However, this study will be continued next season.

Grant Program

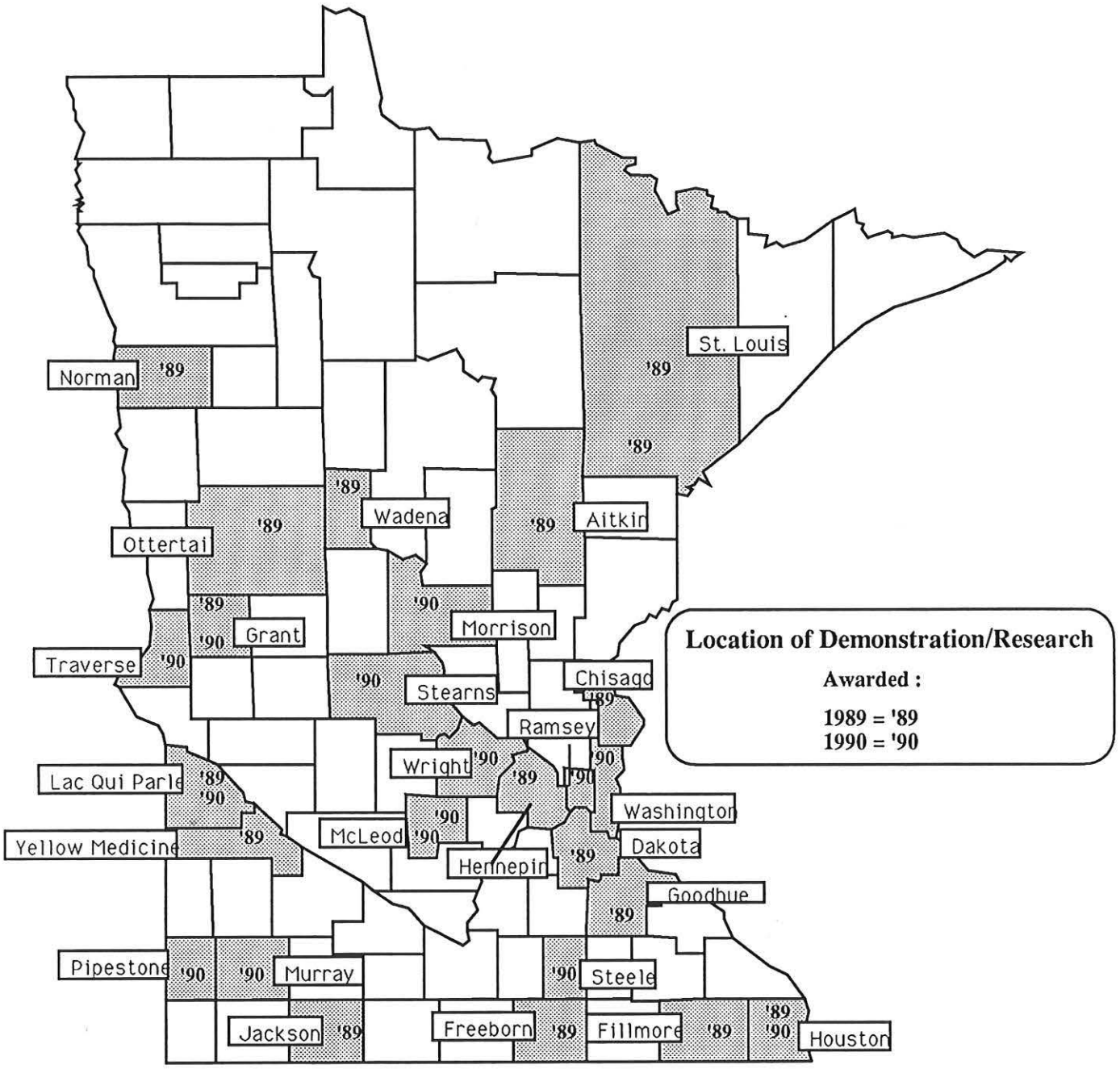
Current, up-to-date information on sustainable agriculture practices is in great demand. Farmers seeking alternatives to conventional practices have encountered a shortage of farm-based information. Before commiting themselves to changing to more sustainable practices, farmers like to see these concepts actually demonstrated on working farms, and preferably on equipment and conditions similar to what they might find on their own farms. By observing sustainable practices demonstrated on a farm, farmers learn how to use these concepts, and they develop greater confidence that these alternatives are indeed practical.

In response to farmers' request for ideas of sustainable farming techniques, the Energy and Sustainable Agriculture Program of the Minnesota Department of Agriculture has implemented the Grant Program. The Grant Program has provided a unique opportunity to individual farmers and agricultural researchers across the state to explore innovative and creative solutions to enhancing the sustainability of a wide range of farming practices. The response to the program has been extremely positive. The department received over 300 grant applications, and approved 31 projects for funding. A panel composed of 14 farmers, university agricultural researchers, extension agents and agricultural specialists were involved in the selection process. The projects chosen for funding were diverse, ranging from livestock systems to integrated pest management to cropping systems. All projects have the potential to meet several of the following criteria: reduce chemical inputs; reduce ground and surface water pollution; conserve soil; and increase net profits.

Many individuals cooperated in carrying out the research of the grant projects, bringing with them a wealth of technical expertise and practical knowledge. Among the individuals involved in the projects were 25 farmers, 44 University of Minnesota research and extension scientists, 5 instructors from other colleges and technical colleges, and 16 farm management instructors and consultants.

These projects have generated tremendous interest throughout the state. Farmers and researchers involved in the program held field days open to the public to provide details about their projects. Over 4000 people attended field days held in the 1989 and 1990 seasons. These research and demonstration projects were also the focus of over 170 newspaper and magazine articles, radio and television reports. In addition, the Sustainable Agriculture Program of Minnesota report of 1990, which included summaries of the grant projects, was distributed to over 1200 individuals throughout Minnesota and across the nation.

The project summaries which follow are based on one or two years of data and show that sustainable practices have excellent potential in solving environmental problems of conventional agriculture practices while at the same time maintaining profitability.



Sustainable Agriculture Program of Minnesota
Minnesota Department of Agriculture

Project Title:	**Benefits of Crop Rotation in Reducing Chemical Inputs and Increasing Profits in Wild Rice Production**	*Time Span:*	August 89 to August 92
Principal Investigator:	George Shetka	*Tel:*	218-927-6617
Address	Fleming Route, Box 6402 Aitkin, MN 56431	*County:*	Aitkin
Cooperators:	Ervin Oelke - Dept. of Agronomy, U of M	*Enterprise*	wild rice, small grains

Project Description

Continuous cropping of wild rice with the use of fungicides and herbicides to control disease and broadleaf weeds is practiced by most wild rice growers. Since wild rice grows in flooded soils and some of the water is released into rivers before harvest, the possibility of contaminating the water supply with agri-chemicals is evident. Reducing the use of these chemicals would lower production costs and lower the risk to the environment. Rotating wild rice with other crops has the potential to lessen the demand for chemicals compared to the continuous cropping system.

The objective of this study is to compare growing wild rice continuously with growing wild rice in rotation with alfalfa, canola, or fallow every other year. The economics and environmental impact (water quality) of these two systems will be evaluated.

Project Results

The experiment was established in August of 1989. Six 2-acre paddies previously planted to wild rice were rotovated after wild rice harvest. Three of the six paddies were fall fertilized and flooded the next spring for growing a crop of wild rice. Each of the other three were divided into three strips in the spring of 1990. One strip was fallowed, one was planted to two varieties (Parkland and Legend) of canola, and the third planted to 'Nitro' alfalfa.

We were successful in establishing canola and alfalfa on fallow wild rice fields in 1990.

Crop Yields on Wild Rice Fields - 1990

Rotational Cropping		Continuous Cropping	
Crop	Yield (lb/A)	Crop	Yield (lb/A)
Alfalfa	1264 (6.5%*m**)	Wild Rice	
Canola		w/Tilt**	594 (40%*m*)
Parkland	303 (7%*m*)	no Tilt	546 (40%*m*)
Legend	792 (7%*m*)		

**m*=moisture ***Tilt - fungicide

Parkland is an early variety from Canada and flowered very early resulting in few seed pods. Legend, a late variety, had greater yields; however, the yields were lower than the 2000 lb/A that a good crop of canola should produce. The low yields were partly due to a wet spring resulting in poor growth in some areas of the plot and the presence of weeds, especially smartweed. Alfalfa feed analysis showed 14.3% crude protein, 42% acid detergent fiber, and 54% neutral detergent fiber. The alfalfa was not harvested except for small subplots for yield sampling. The alfalfa was incorporated into the soil in early fall to allow for decomposition as a source of nitrogen for wild rice the following year.

One of the three continuous wild rice paddies was lost due to crayfish damage. Brown spot disease was prevalent in the other two continuous wild rice paddies especially in the center of each paddy that was not treated with the fungicide Tilt.

In the summer of 1991 wild rice will be planted in all six paddies. The three paddies that contained wild rice in 1990 will be fertilized with nitrogen and treated with a fungicide while the other three will not be treated with a fungicide; the strip planted with alfalfa will not be fertilized with nitrogen. Yield comparisons will be made, and water samples taken during the growing season to determine water quality differences between typically treated wild rice paddies and those with reduced nitrogen and fungicide inputs.

Management Tips

Weed problems can be limiting in establishing alfalfa or other crops in fallow wild rice fields.

Growers need to plant rotational crops as early as possible.

Location of Project

10 miles north of Aitkin on Hwy 169. 1 1/2 miles east on 210th. North side of road.

Project Title:	**Hairy Vetch and Winter Rye as Cover Crops**	*Time Span:*	April 89 to October 90
Principal Investigator:	Mark Ackland	*Tel:*	507-826-3358
Address	Route 2 Albert Lea, MN 56007	*County:*	Freeborn
Cooperators:	Jim Tjepkema, Rodale Institute	*Enterprise*	corn, soybeans

Project Description

Finding a suitable cover crop that fits into a rotation with corn is a challenging but important step in nutrient cycling and soil conservation. The standard practice in raising corn is to leave the ground essentially bare after the corn is harvested. This leaves the soil vulnerable to erosive elements, such as winds and rains. Weeds also become a problem in the spring as they take advantage of the uncovered grounds and rapidly move in to establish before the next crop is sown.

Raising hairy vetch and winter rye as cover crops offer a potential solution to some of the problems in a simple corn cropping system. Such a system may improve weed control and reduce need for herbicides and the environmental and health risks from handling herbicides; reduce need for nitrogen fertilizer where hairy vetch is used; maintain or increase corn yield; protect the soil from erosion; add organic matter and improve soil structure.

This study evaluates the feasibility of using hairy vetch, hairy vetch plus winter rye, or winter rye alone as cover crops after oats and preceding corn. A randomized, replicated experiment includes the cover crops and a no cover crop control. Effects on weed control, soil moisture, and yield in corn following the cover crops are measured. Nitrogen fertilizer rates for corn are reduced where hairy vetch grew. Either herbicide with light tillage, or tillage alone are used to kill the cover crops. Cultivation alone is used to control weeds in the corn.

Project Results

The cover crop was seeded in the Fall '89, and incorporated prior to spring planting. The hairy vetch, the seeds of which are raised on the Ackland farm, survived the cold weather and did not experience any winterkill. This is particularly noteworthy since hairy vetch does not normally survive harsh winters. Ackland believes that the hairy vetch he raised is hardier than normal because it has been adapted to this region and climate.

Yields of Cover Crop Biomass for 1990

Crop	Dry Matter (lbs/A)
Hairy Vetch	920
Rye	1040
Vetch/Rye	385 - vetch tops 960 - rye tops

The recommended seeding rates for hairy vetch is 20 lbs/A, for rye is 1 bu/A, and for vetch/rye mixture at 50/50 is 40 lbs/A.

The hairy vetch was given a nitrogen credit of 30 lbs/A; 100 lbs/A nitrogen fertilizer was applied to corn for plots where hairy vetch was used as a cover. All other treatments, including vetch/rye, received 130 lbs/A nitrogen.

Results of 1990 Hairy Vetch & Winter Rye Cover Cropping in Oats and Corn

	Soil Nitrate (ppm)[a]	Weeds[b]	Corn Yields (bu/A)
Control	22.3[c]	53	145
Hairy vetch	18.3	54	141
Rye	17.8	51	139
Vetch/Rye	20.0	58	138

[a]Soil tested in April 1990.
[b]Percent of area in corn rows filled with foxtail weed (visual rating)
[c]Figures represent averages - not statistically analyzed

Weed control was poor because wet conditions prevented timely mechanical weed control. However, the weeds probably had little effect on corn yield because moisture was not a limiting factor this year.

Hairy vetch seemed to survive the winter well in the plots where it was planted alone as well as in plots where it was planted with rye.

Management Tips

Hairy vetch should be planted no later than the end of August in order for it to survive the winter in Minnesota. Winter Rye can be planted as late as mid-October. If either of these cover crops are incorporated or killed before planting corn, a later corn planting date would allow more time for cover crop growth, however some yield loss may occur if planting is delayed too long.

Location of Project

First farm north of Manchester on Hwy 13 on east side.

Project Title:	**Chemical Free Double-Cropping**	*Time Span:*	April 90 to December 92
Principal Investigator:	Jeff Mueller	*Tel:*	612-547-2288
Address	Route 1, Box 85 Swanville, MN 56382	*County:*	Morrison
Cooperators:	David Stish - FBM Instructor Jim Carlson - Morrison County Agent	*Enterprise*	corn, dairy, alfalfa

Project Description

Replacing a chemical-intensive corn silage production system with a non-chemical double-cropping system on a dairy farm would result in a number of benefits. A double-cropping system would: 1) reduce row crop acreages and the number of trips over a field/crop; 2) reduce or eliminate herbicide usage through increased rotation and solid seeding; 3) reduce purchased nitrogen needed (improve efficiency of manure applications, since manure applied in the fall would be immediately available to fall-seeded crop); 4) reduce protein purchases by improving protein quantity in forages for livestock; 5) reduce soil erosion and ground/surface water pollution by herbicides and chemical fertilizers.

The timeline for the project in the 1990 growing season was as follows:
Fall '89 - plant winter forage type triticale. Harsh open winter kills triticale and 95% of the alfalfa in Morrison and surrounding counties.
Spring '90 - No-till plant spring forage triticale and forage peas.
July '90 - Harvest triticale/peas; mulch, till and disc; press drill popcorn/forage, soybeans.
Sept '90 - Harvest popcorn/forage soybeans; plant winter forage type triticale - 10% mulch tilled, planted/press drill; remainder no-till planted/press drill.

Project Results

1. There was no need for commercial fertilizer. Nitrogen management in these systems are ideal with N-fixing legumes in both crops and the winter grass forage taking advantage of the stabilized available nitrogen.
2. Thick ground cover of both forage crops provided complete weed control. No new weed seed was produced in 1990.
3. The soil was always protected by a growing crop, stubble, or both.
4. Triticale/peas forage quality is high whereas popcorn/beans quality is marginal for dairy cow rations.
5. Seed costs are high, but are justified by eliminating pesticide costs.
6. Timing the seeding, tillage, harvest operations and manure applications with weather and other farm activities to obtain maximum yields and reduce all inputs - especially tillage - requires extra attention.
7. Triticale/peas are difficult to harvest due to lush growth and moist condition clogging cutter bar.

Yields from Chemical-Free Double Cropping 1990

Forage	Harvest Date	Yield (tons dry matter/acre)
Spring seeded Triticale and Canadian Field Peas	6/3	1.45
July seeded Forage Soybeans and Popcorn	9/12	1.42

Feed Analyses of Forage Crops 1990

	Triticale/ Peas	Soybeans/ Popcorn
Dry Matter	17.6%	22%
Crude Protein	16.6%*	17.9%
ADF	31.9%	39.5%
NDF	55.4%	
TDN	58%	49%
NEL	0.60	0.57
RFV	108	

ADF=insoluble protein; TDN-total digestible nutrients; NEL-net energy for lactation; RFV-relative feed value
*Protein content may actually be higher, based on previous years' analyses.

Management Tips

Timing is critical to obtaining quality forage.
No-till plant whenever possible.

Location of Project

12 miles west of Little Falls on Highway 27 and intersection of Morrison Ct. #28 southwest Corner.

Project Title:	**Using Nitro Alfalfa in a No-Till Corn and Soybean Rotation**	*Time Span:*	Spring 90 to Fall 94
Principal Investigator:	Jeff Johnson	*Tel:*	507-451-1409
Address	Route 2, Box 148 Owatonna, MN 55060	*County:*	Steele
Cooperators:	Tim Arlt - County Extension Agent	*Enterprise*	corn, soybeans, alfalfa

Project Description

This demonstration is designed to investigate the use of non-dormant alfalfa as a source of nitrogen in a no-till corn/soybean rotation. We will attempt to reduce spring and fall labor demands in a corn/soybean rotation; diversify the cropping sequence for a cash grain farm; reduce chemical nitrogen applied; evaluate the profitability of using a non-dormant alfalfa to supply the nitrogen needs in a corn/soybean rotation.

The treatments (rotations) will include a standard corn/soybean rotation, a barley-alfalfa/corn/soybean rotation and an alfalfa/corn/soybean rotation. Each treatment will be replicated four times in a randomized complete block design. All plots will be 60 ft. x 425 ft. to accommodate planting equipment. All crops will be harvested, weights and yields recorded, and economics of production calculated. At the end of the three years, we will be able to calculate economics for the rotations.

Project Results

In this initial year of the study, each rotation was started on land that grew soybeans last year. Three rotations - corn/soybean; barley alfalfa/corn/soybean; alfalfa/corn/soybean - were planted in April & May. The alfalfa and barley/alfalfa rotations were planted April 26th with a Haybuster No-till drill directly into the soybean stubble. They were seeded at 12 lbs/A alfalfa and 1 bu/A barley. No herbicide was used on these plots. Corn was planted May 5th with an IH Early Riser planter, directly into soybean stubble. Planting rate was about 28,000 seeds/A. This was fertilized with 30 gal/A of 28% liquid N, 5 gal/A 9-18-9, and 4 lbs/A DCD - a nitrification inhibitor. For weed control, we used 1 1/2 pts/A Tandem and 2.2 lbs/A Extrazine. All plots were planted on a Webster clay soil.

The weather conditions this year proved challenging. Rain and insects delayed the harvest of our alfalfa until July 15th. First cut yields averaged about 2552 lbs/A over all the plots. The barley-alfalfa plots yielded about 1 1/4 times the alfalfa plots. However, leafhoppers caused a lot of damage and yield loss. Yields were one-third to one-half less than expected due to the insects. Malathion was sprayed at 1 1/2 pts/A after the first cutting to control the leafhoppers.

First Year of Multi-Crop Rotation
Corn and Alfalfa (2nd Cutting) 1990
Returns per Acre

Rotation (1st Crop)	Yield	Gross Return	Cash Expense	Net Returns
Corn ($2/bu)	125.2 bu/A	$250.40	$118.50	$131.90
Barley/ Alfalfa ($80/ton)	2.46 ton/A	$196.80	$40.00	$156.80
Alfalfa ($80/ton)	2.43 ton/A	$194.40	$36.00	$158.40

With low corn prices, gross returns for corn were about equal to the one cutting of alfalfa. The first cutting of alfalfa was not considered in the analysis because of poor quality and low yields due to a leafhopper problem. The harvesting costs were about equal to the value of the hay. If two cuts would have been made, with total yields being one ton/A higher, the alfalfa would have been more profitable than corn, in terms of gross returns. Net returns would likely follow the same course. Returns minus costs expenses for one cut indicated that the NITRO alfalfa was as good if not better than corn.

Location of Project

From Owatonna, take 35W south to Hope exit. Go west on County Road 14. (Between 35W and Hope on north side of road.)

Project Title:	**Early Tall Oat and Soybean Double Crop**	*Time Span:*	March 90 to October 92
Principal Investigator:	Charles D. Weber	*Tel:*	612-485-2566
Address	Route 2, Box 175 Howard Lake, MN 55349	*County:*	Wright
Cooperators:		*Enterprise*	oat, soybeans

Project Description

This project will demonstrate the feasibility of interplanting soybeans with oats. Double cropping reduces soil erosion and herbicide use. Oats competing with weeds benefit later-emerging soybeans. Through nitrogen-fixation, soybeans would provide nitrogen for the oats. Double cropping of spring oats and fall beans would increase income compared to raising just one crop. Oats could also prevent erosion and loss of topsoil.

Oats will be planted with a drill and interseeded with soybeans in 30" rows. Oats will be planted first, and the soybeans planted 10 and 20 days later.

Project Results

For the 1990 season, this system could not be evaluated to its fullest potential due to poor weather conditions. Because of excessive rains and winds, the oat crop was damaged. Lodging problems created difficuties in harvesting oats and beans. Costs of combining are somewhat higher in processing two crops in a double cropping system.

The late-soybean variety (Hardin) resulted in greater yields regardless of when it was planted compared to other varieties.

Results of Double Cropping Oats and Soybeans in 1990

	Double Crop with Oats	Ridge-till Two (2) Cultivations
Soybean Yield		
---Variety---		
Evens	16.2 bu/A	
Dassel	18.5 bu/A	
Hardin	21.3 bu/A	29 bu/A
Oat Yield	---none due to lodging---	--- 0 ---

The oats provided plenty of coverage for the soybeans and protected the soybeans from frost damage. (The soybeans were planted on April 24th; frost occurred on May 11th). There was also enough cover to minimize soil erosion from wind and water runoff.

No herbicides were applied, which led to a savings of $18-20/acre. However, weed control was inadequate late in the season because the oat stands were too thin. Next year, the oats will be planted in greater density (2 to 3 bu/A) to provide a thicker stand.

Location of Project

From Highway 12 to Howard Lake, take #6 south 4-1/2 miles. Turn right (west) 1 mile to four way stop, turn left (south) 1/2 mile to plot.

Project Title:	**Alternative Methods of Weed Control in Corn**	*Time Span:*	February 89 to February 91
Principal Investigator:	Sister Esther Nickel	*Tel:*	507-847-5498
Address	Route 3, Box 79 Jackson, MN 56143	*County:*	Jackson
Cooperators:	Dr. Jeffrey Gunsolus - Extension Specialist Dr. Harlen Ford - Southwest Exp. Station Rod Hamer - Jackson County Agent	*Enter-prise*	corn, soybeans

Project Description

This two-year on-farm demonstration study evaluated the effectiveness of alternative methods of weed control for row cropped corn. Treatments include: banded herbicide and no herbicide , rotary hoeing, 0, 1, or 2 cultivations, or using an intercrop between rows to provide a 'living mulch'.

A comparison was also made of yields harvested from small plots (yd^2), from rows (2 rows x 50 ft), and from field size plots via combining.

Project Results

Soil testing was completed in fall of 1989 and the field was fertilized for a yield goal of 110 bu/A. The study was planted in a randomized complete block experimental design on May 4, 1990. A mustard intercrop was planted with a target population of 11 lb/A. Lasso II was banded in all of the mustard plots to test for effects only due to mustard intercrop plants. The mustard plants emerged on 5/9, the corn emerged on 5/19. Rotary hoe was used on 5/18 and on 5/28. The weeds were at the white stage at both rotary hoeings. We had 13" of rain during May through September. Small plot (yd^2) harvest began the first week in October. Harvest of 2 rows x 50 ft followed. Large plot via combine was delayed until October 29.

The summary of the data is as follows:
1. A herbicide band improved yield over no herbicide band.
2. In general, the rotary hoe improved weed control and enhanced yield.
3. Number of cultivations (one or two) did not make a difference.
4. There was a wide variation between small plot, row, and large plot sampling methods.
5. Mustard intercrop decreased yield, but seems viable with further study.

Key for the following table:
check = no weed control methods used;
Costs calculated using Lasso II band 12.5 lb/Acre at $10.50/acre; rotary hoe at $3.50/acre; cultivations at $2.50/acre; and corn price of $2.10/bu

Data for following table based on average corn yields and weed control costs from two years, 1989-90.

Cost/Profit Analysis of Alternative Weed Control for 1989-1990

Rotary Hoe	Culti-vation	Herbi-cide	Cost of treatment ($/Acre)	Yield over check (bu/acre)	Profit/A over check ($/Acre)
yes	0	yes	14.00	27	42.70
yes	0	no	3.50	13	23.80
yes	1	yes	16.50	40	67.50
yes	1	no	6.00	28	52.80
yes	2	yes	19.00	45	75.50
yes	2	no	8.50	32	58.70
no	0	yes	10.50	12	14.70
no	0	no	0.00	check	check
no	1	yes	13.00	35	60.50
no	1	no	2.50	18	35.50
no	2	yes	15.50	37	62.20
no	2	no	5.00	22	41.20

1989 Results:
In all treatments the use of the rotary hoe raised the crop yield compared to the non-rotary hoed counter parts. The second cultivation did increase yields, but the first cultivation increased yields dramatically by 10-30 bushels per acre and reduced weeds by 66 %. Use of the banded herbicide increased yields and profits consistently.
The living mulch alfalfa plot yielded low this year because it used some of the moisture needed for the corn crop in this dry year. The integration of several weed control methods into a system seemed to be of most value. Alfalfa as a living mulch failed to establish quickly and reduce weed pressure, and was a competitor with corn for moisture. The Gandy was very effective for seeding of the living mulch as an inter-crop.

Management Tips

1. Use rotary hoe as one option (tool) for weed control.
2. Make a weed map of field to get control of perennials and have a knowledge base for problem areas with annuals.
3. The Land Stewardship Project has made a valuable video "The Rotary Hoe", which may give helpful ideas.
4. Intercropping needs further research.

Location of Project

Take interstate 90 to Jackson exit, and go south. The first street to the right is Springfield Ave. Take it at least 4 miles until you come to a Y in the road with Scott's Body Shop, bear right. Go 1 mile north of the interstate overpass. Take first gravel to the left and go 1 mile to Sisters of Mercy mailbox.

Project Title:	**Herbicide Ban? Could You Adapt on a Budget?**	*Time Span:*	Fall 88 to Fall 91
Principal Investigator:	David Michaelson	*Tel:*	612-769-4683
Address	Route 2, Box 158 Dawson, M N 56232-9574	*County:*	Lac Qui Parle
Cooperators:	Jon Olson - L.Q.P. County Extension Agent John Moncrief - U of M, Soils, Tillage Audrey Arner - Land Stewardship Project	*Enterprise*	soybean, corn, soybean (3 year rotation)

Project Description

Many farmers already own the equipment necessary to realize an indirect energy savings by using an alternative to herbicides. The economic and yield impact of raising soybean and corn on reduced fertilizer and herbicides will be examined in this project. The yields, input costs, test weight, and moisture of soybean and corn will be measured and compared under the following regimes:

a) High Fertility + Mechanical Weed Control
b) High Fertility + Chemical Weed Control
c) Low Fertility + Mechanical Weed Control
d) Low Fertility + Chemical Weed Control

High Fertility = Least-cost-per-unit based on private lab tests and recommendations of a local fertilizer dealer.

Low Fertility = Reduced cost approach, eliminating anhydrous ammonia, 0-0-61, and any other fertilizer detrimental to biological activity of the soil; will not exceed 50% of that applied on High Fertility treatments.

Chemical Weed Control = Cultivator plus Dual, Banvel, Blazer, Basagran, Poast, Pursuit, Bladex, and Round-up; whatever is necessary to eliminate weeds post-emergence.

Mechanical Weed Control = Dragging, rotary hoeing, extra cultivation, and hand-weeding.

All of the above treatments will be conducted on a ridge tillage system, which reduces erosion and saves soil moisture compared to our previous tillage system.

Project Results

Yields and Net Returns of Corn and Soybeans Under Different Fertility and Weed Control Treatments

Fertility	Weed Control	Corn 1990	Soybean 1989	Total Returns
High	Mechanical	127.6 bu	45.88 bu	
High	Chemical	131.5 bu	45.34 bu	
Low	Mechanical	113.3 bu	49.32 bu	
Low	Chemical	118.4 bu	45.49 bu	
High	Mechanical	$191.83	$216.54	$408.37
High	Chemical	$189.26	$223.64	$412.90
Low	Mechanical	$186.20	$251.36	$437.56
Low	Chemical	$185.94	$240.83	$426.77

Costs of Treatments under Different Fertility and Weed Control Regimes

	Fertility		Weed Control	
	High	Low	Mechanical	Chemical
Corn	$41.60	$20.00	$9.00	$19.00
Soybean	$16.38	$0.00	$13.00	$3.00

The mechanical weed control which was very successful in 1989, was effective in 1990 through June. It was not until July and August, when extra rains germinated more weeds, that mechanical control was less effective than the chemical weed control. Compost which was intended for the low fertility plots got incorporated into the high fertility plots. Corn is more difficult to produce under organic production methods because of its high nitrogen needs. Comparing end results of 1989 and 1990 shows the value of not making decisions based on one year's findings. Low fertility and mechanical weed control is least effective based on 1990 results, but is still the best system when the results of two years are added together. Results of all four treatments remain unchanged when analyzed based on both years.

Management Tips

I am still sold on the use of the rotary hoe and a good cultivator for mechanical weed control. If you have never used a rotary hoe for weed control, be sure to do some studying of techniques and timing. A good cultivator will be capable of throwing soil up around the crop to help control weeds that cannot be cut off with the sweep.

Location of Project

1-1/4 miles east of Dawson along Hwy 212 on north side of road. Look for sign.

Project Title:	**Benefits of Weeder Geese and Composted Manures in Commercial Strawberry Production**	*Time Span:*	April 89 to November 91
Principal Investigator:	Joan Weyandt-Fulton	*Tel:*	218-624-3971
Address	3680 Sandberg Road Duluth, MN 55810	*County:*	St. Louis
Cooperators:	Dell Christianson - Detroit Lakes AVTI Frank Skaff - Detroit Lakes AVTI Bob Olin - St. Louis County Extension Agent	*Enterprise*	strawberries, geese

Project Description

Geese have great potential in fitting into a strawberry farm as biological weed control agents because they feed on a wide variety of weeds without disturbing strawberry plants. They provide an ideal and economical alternative to pre-emergent herbicides since the cost of rearing the geese can be recovered at the end of the season when they are dressed and sold for meat and for down feathers.

This project explores the impact of geese in keeping a strawberry farm clean of weeds and demonstrates the benefits of using composted manure blends as the basic foundation for a well-balanced fertility program. A geese-weeded/compost-fertilized field will be compared to a conventionally-farmed field in a side-by-side demonstration.

Project Results

Geese Experiment:

Forty (40) goslings were brooded in 1990 and 35 in 1989 to weed 1-1/2 acre of strawberries. The geese were very successful in controlling the weeds and reduced the amount of labor required for handweeding by about 30%. In 1990, the cost of each goose was $9.73, and sold for $10.00 each at the end of the strawberry season, leaving a profit of $0.27/goose. The net cost of the geese in 1990, in the table below, is only a reflection of the cost of fencing.

The advantage of using weeder geese is especially noticeable in newly planted fields. The geese greatly reduce the amount of labor required for weeding new strawberry fields compared to applying herbicides, which damage young strawberry plants.

Comparison of Herbicide and Geese Weed Control on Strawberry Farm 1989 and 1990 (1.5 acres)

	Herbicide	Geese
Labor Hours Weeding Strawberries[a]		
1990	112	50
1989	135	90
Net Costs		
1990	$162[b]	$135[c]
1989	$229	$171

[a]Includes mechanical cultivation, handweeding, spraying
[b]Costs of herbicides
[c]Depreciation cost of fencing

Cost Advantage for Weeder Geese (labor @ $4/hr) Compared to Herbicide in Strawberries

1990	$270/A for new plantings $184/A for established fields
1989	$159/A

List of Weed Species Consumed by Geese

Common Name	Eat	Common Name	Eat
annual grasses	yes	canada thistle	slight
carpetweed	?	clover	yes
common chickweed	yes	dandelion	yes
knotweed	no	ladysthumb smart	yes
lambsquarter	yes	orange hawkweed	no
prostrate pigweed	some	quack grass	yes
red sorrel	slight	redroot pigweed	yes
vol. oat/wheat	yes	white cockle	no
wild buckwheat	no	wild mustard	yes
yellow rocket	slight	yellow wood sorrl	no

Compost Experiment:

Compost made by combining chicken and horse manure was run through a manure spreader 4 times for aeration. Resulted in a very friable, odorless, and nutrient-rich compost. Analysis showed 9 lb nitrogen, 26 lb P_2O_5, and 9 lb K_2O per ton. Plant tissue tests comparing commercial fertilizer with compost showed very little difference. There was no difference in yield. Soil tests showed 0.2% higher organic matter content in composted soils compared to commercially fertilized soils.

Management Tips

1. Success of weeder geese depends mainly on the commitment of the farmer. Desire and ability to work with the animals is of utmost importance. A tolerance for a small amount of weed pressure is a necessary and often difficult attitude to develop.

2. Erecting good sensible fencing is very time-consuming and a costly investment, but can make or break your success with weeder geese. Recognize the unique fencing needs of your farm. Have the fence in place before you get any geese.

Weyandt-Fulton continued on page 53

Project Title:	**Minnesota Integrated Pest Management Apple Project**	*Time Span:*	January 89 to December 91
Principal Investigator:	John Jacobson & Bill Kidd	*Tel:*	612-429-8026
Address	Pine Tree Apple Orchard 450 Apple Orchard Road White Bear Lake, MN 55110	*County:*	Dakota
Cooperators:	Bill Kidd - Horticulturist Carpenter Nature Ctr. Dr Emily Hoover - Extension Specialist	*Enterprise*	apples

Project Description

Apple production is the leading fruit production industry in Minnesota. Apple Scab (*Venturia inaequalis*) is the most serious fungal disease affecting apple production both in Minnesota and across the United States. Present control measures involve the spraying of fungicides at 5-7 day intervals as protectant sprays during the primary infections stage. This frequency is reduced to 10-14 day intervals later in the season. Growers are forced to use this rigid spray schedule, which is probably excessive, because there is a lack of information available on determining the least amount of spray necessary for optimal control. Using techniques to predict scab infection periods can reduce or totally eliminate the need for fungicide application.

We will establish baseline information, gathered from apple orchards throughout the apple growing regions of Minnesota, on apple scab sporulation and infection.

Information on the conditions which are ideal for infection would be made available weekly or biweekly to help growers decide whether or not fungicide application is necessary. If this project is successful, a similar system could be researched and established for other disease and insect problems. This project would be not only economically beneficial for all Minnesota apple growers, but also environmentally beneficial for all Minnesotans since agri-chemical use could be greatly reduced.

Seven growers cooperated on this project by maintaining 10 trees for the project and preparing leaf samples from their orchards for analysis in St. Paul where the sample was analyzed for apple scab spore maturity. IPM plots were only to be sprayed when spore maturity reached 5%, and when temperature, moisture and duration of wetness of leaves indicated that the apples were most vulnerable to spore damage. Growers were then instructed to spray on a calendar basis.

Project Results

Ascospores which cause apple scab were abundant on leaf samples from April 11-June 21, 1990. Participating growers were instructed to apply fungicides on test blocks based on spore maturity and rainfall duration. Some growers experienced a significant savings in pesticide costs based on the 'dosage equivalent' unit - which standardizes the amount of pesticide used.

1. Primary spore released occurred later than expected, indicating that growers may be able to withhold early season scab sprays if this trend continues.
2. At least two growers used half the pesticides in the test block compared to the control block with no increase in the incidence of scab damage at harvest.
3. Results for 1990 confirm those of 1989, although weather conditions were markedly different for both years (drought in 1989; above-average moisture in 1990).
4. Amount of fungicide applied was greater in the calendar based spray system as opposed to the scab-monitoring system, but was less effective in controlling scab based on results of two years of study.

Average Percentage of Scab-Damaged Apples and Amount of Fungicide Applied for Seven Orchards

Year	IPM		Conventional	
	%	D.E.*	%	D.E.
1990	1.30	5.56	1.34	7.10
1989	3.24	2.99	3.97	4.51
1989-90	2.3	4.2	2.7	5.6

*D.E.=dosage equivalent of fungicide used

Management Tips

Preliminary data suggests that apple scab should be monitored to reduce the amount of excessive fungicide applied.

Location of Project

From Hastings on the north side of the Mississippi River, take Highway 10 southeast about 3 miles. On the Minnesota side of the bridge into Wisconsin, turn left (north) on St. Croix Trail (Co. Rd. 21). Go about 3 miles to John Leadholm's Croix Farm Orchard
12971 St. Croix Trail South on the east side (the St. Croix River side) of the road. At 12:00 noon, the tour will continue at the Carpenter Nature Center at 12805 St. Croix Trail South.

Project Title:	**Strip-Cropping Legumes with Specialty Crops for Low-Cost Mulching and Reduced Fertilizer/Herbicide Inputs**	*Time Span:*	April 89 to November 90
Principal Investigator:	Mark Zumwinkle	*Tel:*	612-625-8114
Address	Department of Soil Science University of Minnesota St. Paul, MN 55108	*County:*	Hennepin
Cooperators:	Dr. Carl Rosen - Department of Soil Science	*Enterprise*	peppers, broccoli, alfalfa

Project Description

Living mulches interplanted with crops have the potential to control soil erosion, smoother weeds, aid in pest control, and in the case of legumes, fix nitrogen. In this project, a living mulch of alfalfa strip cropped between ridges of a specialty crop (peppers, broccoli), was evaluated for its ability to reduce fertilizer and perticide requirements. The alfalfa was cut 3 times with a sickle mower and delivered with a V-plow into the base of the ridge containing the cash crop. Two methods of mulch utilization was investigated. One treatment allowed the mulch to remain on the surface to slowly decompose. The second treatment incorporated the mulch into the surface soil by disking the base of the ridge and "hilling" soil over the mulch. Strips of alfalfa measured 27 inches Cash crop ridges measured 27 inches. Ridges were planted with single rows of peppers and broccoli.

The above cut living mulch plots were compared to plots with standard application rates of nitrogen fertilizer and herbicide, and to plots receiving no nitrogen fertilizer. All plots were irrigated.

Project Results

Living mulch provides some nitrogen in the first year but not enough to equal fertilizer nitrogen inputs for heavy feeding crops.

Broccoli in the mulch plus nitrogen treatment (160 lb/A) yielded the same as the plus nitrogen treatment without mulch, suggesting that competitive effects between the alfalfa and broccoli were minimal. The lack of competition suggests that if the alfalfa mulch system eventually raises soil nitrogen levels equal to those obtained by the fertilizer nitrogen, then equally high yields can be obtained.

Peppers did not show a positive response to the living mulch system. Pepper yields in the mulch were approximately equal to those in the no nitrogen control. Nitrogen-treated plots (120 lb/A) produced greater yields. This was true for both the number of fruits per plant and the average weight per fruit.

Pepper yields in the alfalfa mulch were severely depressed in early harvests but then increased beyond the no nitrogen treatment late in the season, indicating a delayed maturity due to the living mulch.

Alfalfa was harvested three times producing a mulch dry weight of 0.21 lb/broccoli plant and 0.63 lb/pepper plant.

Estimated Amount of Nitrogen Supplied to Plants

	Alfalfa	Ammonium Nitrate
	--- lb Nitrogen per plant ---	
Broccoli	0.005	0.10
Pepper	0.016	0.11

*assumes alfalfa contains 0.025 lb N/lb dry matter

Soil temperature was lower in the alfalfa mulch treatments than in the bare soil treatments.

Comparison of Broccoli Yield (lb/head) Under Several Nitrogen (N) Treatments

Year		Alfalfa Mulch	160 lb N	Mulch + 160 lb N	No N Control
1990	Spring	0.32	0.45		0.26
	Fall	0.77	0.81	0.84	0.65
1989		0.66			

Benefits from the living mulch include a reduction of the following: runoff, erosion, fertilizer inputs, deep percolation of nitrogen and herbicides, and herbicide use. Rill erosion was evident in clean soil plots and not in living mulch plots. The yield response was greater than would have been expected by the amount of nitrogen added which indicate more efficient use of alfalfa residue compared to ammonium nitrate. These crops require 100-160 lb/A nitrogen, which can be supplied completely by alfalfa in the second year. Treflan for weed control can be replaced by spot spraying alfalfa with poast herbicide. Suppression of weeds by mulches replaces cultivation.

Management Tips

Sidedressing with N will be necessary in the first year if soil N pool is low. Poast herbicide can be spot sprayed to reduce grasses in early spring before the cash crop goes in.

Location of Project

3.5 miles north of Rockford on Hennepin County Hwy 10, on the Crow River.

Project Title:	**Common Harvest Vegetable Farm**	*Time Span:*	January 90 to November 91
Principal Investigator:	Dan Guenthner	*Tel:*	612-729-8695
Address	2406 31st Ave. So. Minneapolis, MN 55406	*County:*	Hennepin
Cooperators:		*Enterprise*	organic vegetables

Project Description

Fresh-market organic vegetables will be raised on six acres of suburban agricultural land. This demonstration project will emphasize the importance of a localized food system and the need for urban food production.

Part of our program will involve "subscription farming" building long-lasting sales relationships with groups of people interested in buying directly from the producer. Farm sales records for the season will show the consistency of these contracts and the volume and related costs involved. The potential for opening new markets is high, and we hope to demonstrate that a personal connection between the farmer and the buyer will offer more stability and a better profit margin for smaller operations. We also hope that this relationship will allow an ongoing dialogue, making the farmer more responsive to the consumers' interests, and the consumer in turn more aware of rural issues and more certain of the quality of their produce.

We intend to evaluate a catch crop strategy for grasshopper control by planting a border of small grains, or other crops, around the vegetables to be "sacrificed" to the insects - thereby protecting the vegetables.

We also will develop a network for charitable distribution of surplus or "seconds".

Project Results

The 60 mile distance to our markets proved to be a large obstacle for fresh market distribution. However, the Subscription network proved to be a viable marketing option for Minnesota Grown produce. Approximately 28% ($2628.50) of our sales was through a distribution network of four neighborhood based buying groups. In all over 100 people participated in this experimental form of food supply. For the 1991 season, the subscriber base has grown to over 200 people and will possibly account for over 50% of the farm income.

The grasshopper project, under the assistance of Univ. of Minnesota entomologist Dave Noetzel, changed with the arrival of above average rain fall. The spring hatch was not as significant as predicted, so the numbers were not available to monitor. However, the densely planted small grain border did provide a catch for the grasshoppers, but with a larger hatch these results may have proven otherwise. We found the Cucurbit family would provide as much of a trap as a small grain and it would not reduce farm income lost to the reduced yield of the border.

The Gleaning portion of the project never did get off the ground as planned. For the 1991 season I have made a contact with a large St. Paul food shelf that is willing to come right to the farm to pick up the seconds.

Management Tips

For creative marketing
- Start Early! The previous fall begin to draft printed material explaining Subscription Farming.
-Gather Interested People
-Be creative in finding groups-don't rule out any group.
-Encourage subscribers to participate on the farm
-Keep the project centralized
-Diversify your markets and your crops
-Draw up a business plan
-Work with other growers and existing organizations to help generate ideas and to plug into the network.

Location of Project

Watertown Road and Willow Drive
Long Lake, MN

Project Title:	**Alternative Mulch Systems for Intensive Specialty Crop Production**	*Time Span:*	April 89 to October 91
Principal Investigator:	Lindentree Farm/Ron Roller	*Tel:*	218-495-3235
Address	Route 2, Box 133 Underwood, MN 56586	*County:*	Ottertail
Cooperators:	Del Christianson - Spec. Crops Detroit Lakes AVTI Ken Rose - Extension Agent Ottertail County Patrick Moore - Land Stewardship Project	*Enterprise*	everlasting flowers, tomatoes, kale, squash/pumpkin

Project Description

Conventional weed management methods in specialty crop production generally involve 1) no-mulch, cultivation, and herbicide, or 2) plastic mulch and herbicide. Both of these systems create a number of environmental and production problems, including soil erosion, and pollution from plastic and herbicide residue.

Alternative systems such as live legume mulch, straw mulch, and overwintered rye mulch would help reduce the need for herbicides and plastics as well as decrease soil loss, increase soil organic matter, conserve soil moisture, and reduce fungal disease and soil contact - the latter two resulting in higher grade crops. Fertilizer needs are also potentially lower due to nutrient credits from legume mulches. These mulch systems are evaluated on everlasting flowers, tomatoes, kale, and pumpkin/squash.

The following treatments were tested:
Plot A: tomatoes, kale, flowers
1. PL/BG: plastic mulch with bare ground between rows.
2. PL/LM: plastic mulch with live mulch between rows.
3. ST/LM: straw mulch with live mulch between rows.

Plot B: pumpkin/squash
1. BG: bare ground
2. ST/LM: straw mulch with live mulch between rows
3. Inter-seeded LM (rye + barley)

Project Results

1. Both PL and ST dramatically conserved more water than BG. The ST/LM seemed best for erosion control since LM absorbed rainfall, and water flow was slowed by ST/LM. The PL do not absorb water, thus all rain was directed out between the rows, causing more erosion/wash problems, even in the PL/LM treatments.
2. Plastic removal/disposal was approximately $240/A, not including long term environmental effects of the plastic after disposal.
3. Herbicide usage was lower in PL/LM & ST/LM treatments.
4. Fungicide usage was also lower in PL/LM & ST/LM treatments due to less crop/soil contact, especially in wet period.

Plot A (see above):
All mulch treatments resulted in increased value compared to bare ground. PL/BG was most profitable, followed by ST/LM. Tomatoes do not grow well in close proximity to vigorous grain rye crop, presumably due to allelopathy.
Plot B: (see above)
ST/LM was most effective, followed by BG. Inter-seeded LM (rye/barley) was less successful, but may work with some modifications, such as keeping the LM out of the crop's root zone, or seeding the LM after the crop has been well established.

Crop Value ($) Comparison Under Different Mulching Systems - 1990 Season (area size of treatments all equal)

	BG	ST/LM	PL/LM	PL/BG
Crop				
Flowers	1660.00	2409.50	2125.90	3277.50
Tomato	309.00	645.00	304.00	448.00
Kale	400.00	510.00	360.00	440.00
Total Value	2369.00	3564.50	2789.90	4165.50
Production Cost*	286.00	321.00	339.00	343.00
Net Value	2083.00	3243.50	2450.90	3822.50

BG=bare ground; ST/LM=straw/live mulch;
PL/LM=plastic/live mulch; PL/BG=plastic mulch/bare ground
*Does not include cost of harvest labor

Comparison of Different Mulching Treatments in Pumpkin Production - 1990 Season

	BG	ST/LM	LM Inter-seed
Yield (# of pumpkin)	5000	5600	2800
Value ($)	750.00	990.00	420.00
Production Cost ($)*	70.00	155.00	96.00
Net Value ($)	680.00	835.00	324.00

BG=bare ground; ST/LM=straw/live mulch; live mulch inter-seed
*Does not include cost of harvest labor

Results for 1989

Drought conditions in 1989 obscured results for evaluating mulching systems. Although the rye production in 1989 was poor, it was still adequate for weed control. Weather conditions, and thus crop growth, in 1990 were more typical for the region compared to conditions in 1989.

Roller continued on page 53

Project Title:	**Mechanical Mulching of Tree Seedlings**	*Time Span:*	April 89 to October 91
Principal Investigator:	Timothy and Susan Gossman	*Tel:*	507-867-3129
Address	Route 1, Box 110 A Chatfield, MN 55923	*County:*	Fillmore
Cooperators:	Fillmore County Forestry Association Tammy Keith-Wellstone - Land Stewardship Proj.	*Enterprise*	Trees

Project Description

The first three years following the planting of trees are critical in determining whether the tree seedlings will survive. Weed competition is a major obstacle for young trees, and herbicides are commonly used to counter the problem. The environmental hazards of using herbicides on tree farms are especially pronounced since trees are frequently planted on marginal lands which are often highly erodible, shallow, or close to streams. It has been shown that herbicide applications in forested areas often exceed those used on agricultural crops. This may be harmful to wildlife and to people using these areas for recreation.

Vegetation surrounding the trees can be chopped and used for mulching the tree seedlings as an alternative to chemical weed control. Mulching may provide additional benefits, such as soil conservation and increasing soil microbial and earthworm activity, which are important to the survivability of the tree seedlings.

In this project, we will evaluate the use of a PTO Flail Mower and grain swather modified for use as a mechanical mulcher compared to a system where trees are planted in sod with no additional site preparation.

Project Results

When our second season of the project began in April 1990, we intended to compare three treatments: 1) Trees planted in sod that was not mowed (500 count); 2) Trees planted in mowed areas to be mulched later (500 count); and 3) Trees planted in mowed areas to be treated with herbicide (100 count). However, we discovered that the area sprayed with herbicide in 1989 to kill the existing grass had provided a good site for Musk Thistle seeds to germinate. Musk Thistles are a serious problem in our area. We have found that competition from grass helps to control them. Because we did not feel that we could continue a practice that will worsen our problem with Musk Thistles, we made the decision not to apply herbicide in 1990 or in the future. From this point on, our study will compare only the mulched trees to trees planted in sod.

In April 1990, we made a new count of surviving trees planted in 1989. This count showed that we had undercounted the surviving trees in October 1989 due to difficulty in finding the trees amidst the tall grass. Spring count was more accurate because grass had turned brown and had been flattened by the snow. The next survival count will be made in Spring of 1991.

Data from 1989 (first year) indicate that mulched trees have a slight survival advantage over trees that were not mulched. Trees had high survival rates under both treatments in 1990 due to plentiful moisture throughout the growing season.

Percentage (%) of Trees Surviving First Year After Planting Under Different Weed Management Strategies

Tree Type	Sod	Chemical*	Mulch
White pine	48	11	45
Scotch pine	85	37	79
Norway pine	85	57	84
White spruce	51	29	70
Norway spruce	71	45	72
Average	68	36	70

*Data gathered from first year of study. This treatment will not be repeated in subsequent years.

Equipment costs for mulching and mowing 500 trees amounted to $97. This system resulted in 10 more surviving trees ($20) compared to non-mowed sod treatment, causing a net loss of $77. This may change as we continue to look at survivability over the long term. Also, using the machinery on a large scale would reduce the cost per tree, so it would take a smaller increase in survival rate to make it profitable.

Management Tips

We are still perfecting the mulching system and learning how to use it effectively. It is important to do the initial mulching relatively soon after planting. This depends on the season and how fast the grass is growing. We have not used the mulcher on deciduous trees, but it seems that this might work better due to the fact that the seedlings are usually taller than conifers and the leaves may make them easier to distinguish from the grass.

Location of Project

Southwest of Chatfield on the east side of Fillmore County Road 101, 1.5 miles south of Fillmore County Road 2.

Project Title:	**Modified Ridge Till System for Sugar Beet Production**	*Time Span:*	September 88 to December 91
Principal Investigator:	Alan Brutlag	*Tel:*	218-458-2112
Address	Route 1, Box 41 Wendell, MN 56590	*County:*	Grant
Cooperators:	Dr Gerald Smith - Private Consultant Randy Larson - Private Consultant Dr Alan Cattanach - Ext. Sugar beet Specialist Marv Jensen - Grant County Extension Agent	*Enterprise*	sugar beets, wheat, soybeans, corn

Project Description

Sugar beet production in Minnesota typically entails three (3) tillage passes in the fall: 1)moldboard plowing or heavy disking, 2)chisel plowing, 3)and field cultivation to level the field. In a sense, part of spring tillage would be done in the fall. Under this system, only 5-10% of crop residue is left on the soil over winter. Spring tillage is usually accomplished by intensive multiple passes, creating a garden-like seedbed. The justification for such intensive tillage practices is that sugar beets do not germinate and emerge as readily as other crops such as wheat, corn, or soybeans; however, the soil under these practices become very prone to wind and water erosion.

Using a fall cover crop and modified ridge till system would provide an ideal seedbed for sugarbeets while reducing erosion and reducing inputs of fertilizer, pesticides, and fuel. The ridges have potential to benefit sugar beet production in several ways: 1) increase rate and uniformity of emergence - a condition necessary for a high tonage crop with high sugar content; 2) increase available moisture for early emergence and seedling vigor; 3) increase internal drainage - moving excessive water from high part of ridge to lower valleys; 4) avoid conventional seed bed preparation in wet years; 5) reduce soil compaction and improve soil texture. The ridges would be built, and cover crop planted, in the fall on small grain stubble. In the following spring, de-ridging and leaving a high level of fall cover crop residue would provide a good seed environment without aggressively working the soil. The cover crop residue would reduce spring erosion while aiding and protecting the growing sugarbeets.

In addition to investigating the cover crop/modified ridge till system, we will compare nitrogen applied in season when it is most needed by the crop to nitrogen applied in the fall.

Project Results

1) Modified ridge till reduced fuel usage from 6.74 gal/A to 3.91 gal/A (42%), or 2.8 gal/A which amounts to $2.26/A; and reduced labor from 0.5 hrs/A to 0.41 hrs/A (18%) in both 1989 and 1990 compared to conventional tillage.
2) Ridge tilling provided a crop residue on the soil surface of 67% compared to 41.5% on conventional tillage.
3) Yield differences not as pronounced in 1990 compared to 1989 may be due to adequate rainfall in 1990.
4) Red Root Pigweed population was reduced by 51.1%/A under the modified ridge till system. Sustainable weed control practices reduced amount of herbicide (active ingredients) needed by 81%. Our total weed control costs were $47/A, or 50% lower than the average $72.17/A for my growing area (based on data from "Sugar Beet Production Costs in the Red River Valley for 1989" as published in the *1989 Sugar Beet Research and Extension Reports*, p. 171), for a net savings of $25.17/A.
5) Increased erosion control, reduced soil compaction because we made 2 or 3 fewer trips across the field with ridge tillage.
6) Total savings in reduced inputs of $27.43/A, and increases in profit from higher yield was $54.00/A, resulted in an increased net profit of $81.43/A. Machinery costs have not been calculated in these costs because they could vary from extremely low for the individual willing to build some of his equipment to $9/A for the individual purchasing his equipment.

Plot A: Ridge till vs. Conventional till - No fall application of nitrogen
Plot B: Ridge till w/o added nitrogen vs. Conventional till with 60 lb/A anhydrous ammonia applied in the fall.

Sugar Beet Production Under Conventional Tillage (*C*) and Modified Ridge Tillage (*R*) for 1989 and 1990

	1990[a]				1989[b]	
	Plot A		Plot B			
	C	R	C	R	C	R
Yield Ton/A	13.21	12.97	14.58	14.81	16.44	17.58 **
% Sugar	17.41	17.08	16.71	17.44 **	16.22	16.71 *
Plants per Ac	24360	26021	30981	32120	17638	21019 **
Return per Ac $	575	555	602	656 *	627	701 **

[a]6 replications - 12 rows wide-length of field
[b]8 replications - 12 rows wide-length of field
*,**Significant at 0.05 and 0.01, respectively

Brutlag continued on page 53

Project Title:	**Demonstration of Land Stewardship Techniques in the Red River Valley**	*Time Span:*	April 89 to January 92
Principal Investigator:	Donald H. Ogaard	*Tel:*	218-784-7183
Address	11 East 5th Avenue Ada, MN 56510	*County:*	Norman
Cooperators:	Kenneth J. Pazdernik - Norman County Agent Dr John F. Moncrief - Extension Soil Scientist	*Enterprise*	sugar beets, soybeans, spring wheat

Project Description

Conventional sugar beet production requires several tillage operations to incorporate herbicides and to prepare a suitable seedbed. Sugar beet fields account for much of the wind erosion in northwestern Minnesota and northeastern North Dakota. We will evaluate sugar beets, pinto beans and wheat under conventional and reduced input systems.

Project Results

Treatments tested:
Pinto Beans - Weed control trials:
Conventional, post-emergence, no herbicide/rotary hoe
Wheat - Herbicide + Fungicide trials:
Standard herbicide rate (60%, 80%, 100%) +/- Fungicide
Sugar beets - Fertilizer trials:
Conventional fertilizer rates (0%, 50%, 75%,100%)

Pinto Beans: The rotary hoe/no herbicide plot out-yielded both the post- and pre-plant chemical treatments both for 1989 and 1990. The average difference this year was small.

Pinto Beans Yields and Returns under Different Weed Management Systems for 1990

	Yield (lb/A)	Net Income/A
Rotary hoe	1571	$101.30
Conventional (PPI)	1511	$87.25
Post-emergence	1495	$81.05

We observed that the pre-plant chemical plots were free of weeds at harvest, whereas the no-chemical/rotary hoe plots had weeds that matured and seeded. The post chemical plots had almost as much late season weed growth as the no-chemical plots. Half of the pinto bean field received no tillage with no observed difference in plant growth.

Wheat: Seeded directly into '89 sugar beet and pinto bean ground after fertilizer was applied to standardize soil fertility levels. Fungicide was applied to half of each plot at the flag leaf stage.

Wheat Yields (bu/A) under Varying Herbicide and Fungicide Treatments Planted into Fields Previously Growing Sugar Beet or Pinto Bean

Herbicide Rates	'89 Sugar Beets Fungicide		'89 Pinto Beans Fungicide	
	Yes	No	Yes	No
100%	67.8	65.9	70.1	77.5
80%	68.8	72.3	73.7	76.1
60%	68.1	72.3	76.2	77.9

1. The fungicide-treated plots yielded 2.88 bu/A more than no fungicide plots, with no advantage in cash returns because application costs equalled value of increased yield.
2. Yields are more affected by crop history than by herbicides.
3. Herbicide at 60% did not provide enough control to prevent weeds from seeding.
4. Herbicide at 80% gave equal control to 100% under ideal application conditions (70°F/70% humidity).
5. All plots received minimum tillage with heavy residue on the surface before and after planting. Minimum tillage resulted in greater average yields for all crops. In 1990, fields received 10" of precipitation (including snow melt).

Sugar beets: Recommended rates of fertilizer (with fall tillage) was compared to reduced rates applied by under-row application with minimum tillage. Early season growth of the fertilized plots appeared more vigorous and developed more leaves compared to unfertilized plots. By harvest, all plots were visually equal.

Sugar Beet Yields under Different Fertilizer Rates

Rate	Yield (ton/A)	% Sugar	($) Ave. price/ton	Net Income/A
100%*	18.26	19.5	47.50	522.84
75%	15.56	19.1	45.50	373.06
50%	14.81	19.0	45.00	341.05
None	12.31	19.9	49.50	284.06

*% of Conventional rate

Minimum tillage methods show exceptional promise for erosion control and the advantages far outweigh the negative effects of excessive tillage.

Results for 1989 - Brief Summary

No-herbicide/rotary hoe Pinto beans yields were as high as pinto beans treated with conventional herbicides. Rotary hoe treatment netted $67/A compared to reduced herbicide of $46/A and conventional herbicide of $-0.96/A.
In wheat, reducing herbicide applications by 20 to 40% did not change yields much when very high management was used.
In sugar beets, herbicide and fumigant treatments resulted in highest yields, but return/acre was about equal to no-chemical input.
Minimum-tillage system with standing stubble between rows reduced wind erosion.

Location of Project

4 miles west of Ada on Hwy. 200, 2 miles south on Co. Rd. (no county road number).

Project Title:	**Improving Groundwater Quality and Agricultural Profitability in East Central Minnesota**	*Time Span:*	April 89 to November 91
Principal Investigator:	Rod Elmstrand, Chisago County Extension	*Tel:*	612-674-4417
Address	6 Sunshine Boulevard North Branch, MN 55056	*County:*	Chisago
Cooperators:	Dr George Rehm - Extension Soil Scientist Dr Michael Schmidt - Extension Soil Scientist	*Enterprise*	corn

Project Description

The Chisago/Isanti County Cluster is located in the Anoka Sand Plain area, one of the two major regions in Minnesota where nitrate-nitrogen (NO_3-N) in the groundwater is a major concern because this material can easily move through the root zone and into the water table. We propose to research the Hach field nitrate testing kit for farmers to do an "on-the-spot" analysis of their nitrogen (N) need, therefore, eliminating excessive nitrogen use and maximizing economic inputs.

The demonstration plots will include four different locations in the two-county area. Each demonstration plot will contain four (4) replications of seven (7) different nitrogen rates. The individual replications will be 15 feet X 40 feet.

The four replications are necessary to provide enough measurements for a statistical analysis by University of Minnesota personnel. Soil samples will be collected at five (5) different times of corn growth: two weeks before planting, after planting but prior to emergence, the 2-3 leaf growth stage before side dressed N application, the 6-7 leaf growth stage, and after harvest. This sample will also be taken from six (6) different depths. From this we can determine the best time to sample and determine where the various forms of nitrogen are coming from.

Plant samples will be analyzed at the 5-6 leaf growth state for NO_3-N. Individual soil and plant analysis of combinations of measurements will be related to the fate of nitrogen that produces the most profitable yield.

Project Results

1990 Results:

This year, our objective was focused on whether a 1' nitrogen soil test (either lab analysis or the on-the-spot Hach field test kit) would be an indication of yield response. On the two sites in which this study was conducted, one showed a correlation between NO_3-N from the soil test, whereas the other site did not show a correlation. On the Isanti site, no N response was found so every pound of N applied was a liability.

Result of NO_3-N Soil Test and Corn Yields in Isanti

Crop Stage	Depth of Sample (ft) 0-1	1-2	Yield Response N rate (lb/A)	Yield (bu/A)
pre	12.1	23.6	0	136
V2	8.3	10.3	90	174
V5	8.7	7.8	180	145

No yield response from 0-180 lb of N applied

On the Chisago site, the test results showed some correlation with yield response.

Result of NO_3-N Soil Test and Corn Yields in Chisago (Hach Test at 0-1' showed 3.5 ppm)

Crop Stage	Depth of Sample (ft) 0-1	1-2	Yield Response N rate (lb/A)	Yield (bu/A)
pre	3.8	1.85	0	41.2
V2	3.75	1.95	60	89.9
V5	2.7	1.95	90	96.7
			120	102.1
			150	106.9

The Hach test did provide adequate information for this field which was to apply the full nitrogen rate for these soils.

Management Tips

Nitrate tests may provide farmers with the appropriate information to cut nitrogen rates in the future. The guidelines for the Hach test may need some refining for Minnesota.

Researcher in this project suggests:
For farmers contemplating the 1 foot, presidedress nitrate test, I would not encourage use of this test at this time due to lack of strong correlations. I would recommend that N fertilizer rates be based on yield goals, N credits, and organic matter. More testing is needed for presidedress N test.

Location of Project

60 miles north on I35 from St. Paul to Rush City. Exit at Rush City and go east into downtown Rush City. At intersection of Co. Rd. 30 take a right and go south about 1 3/4 miles, take a right go west 1/2 mile, plot is on left side of road.

Project Title:	**Nitrogen Utilization from Legume Residues in Western Minnesota**	*Time Span:*	April 90 to November 92
Principal Investigator:	Arvid Johnson	*Tel:*	612-677-2450
Address	Route 1 Herman, MN 56248	*County:*	Grant
Cooperators:	Robert Peters - Consultant, Land O Lakes Marvin Jensen - Grant County Extension Agent	*Enter-prise*	wheat, corn, soybeans, navy beans, alfalfa

Project Description

Western Minnesota has less rainfall than other parts of Minnesota. The farms in Western Minnesota typically have larger cash grain operations with more acres in small grain production than farms in other parts of the state. The objectives of this project are to examine forage legumes as sources of nitrogen for subsequent crops in western Minnesota. Specifically we would examine 1) annual alfalfa as a forage and nitrogen source, and 2) wheat followed by under-seeded alfalfa and rye/vetch/oats.

"Nitro" alfalfa would be seeded early in the spring with a preplant herbicide. Two cuttings of alfalfa would be harvested through the summer. The alfalfa would be allowed to grow in the fall and would be incorporated into the soil, following a killing frost, either by chisel plowing or mold-board plowing.

Corn will be grown the following year with treatments of 0, 40, 80 lbs. of nitrogen plus forage incorporation vs. conventional corn production following wheat or soybeans to evaluate amount of N recovered from the alfalfa forage and crowns. This project would be done twice over a three year period.

An early maturity HRS spring wheat would be seeded followed by a) an under-seeded conventional alfalfa, b) late July planting of rye/hairy vetch/oats, c) mid-August planting of rye/hairy vetch/oats. The forages would be allowed to grow through the fall and early spring. A decision would be made to either incorporate the residues with tillage or to kill the forages with a herbicide.

Project Results

Annual Alfalfa as Forage and Nitrogen Source
Variety: Nitro
Seeding Rate: 13 lbs/A alfalfa + 1 bu/A oats
Forage Harvested: 1.92 ton/A
Stand establishment was not a problem and yield was good considering the dry conditions. Oats should be killed after establishing alfalfa as it can be a strong competitor with the alfalfa.

Legume Forages in a Wheat-Corn Production System
Variety: Hy N Brand
Seeding Rate: 10 lbs/A
Forage Harvested: 0.55 ton/A

Fall-seeded Hairy Vetch
Seeding Date: August 31
Seeding Rate: 20 lbs/A
Stand Count: 5/ft ^{2} 5 leaf stage

Fall-seeded Red Clover
Seeding Date: August 31
Seeding Rate: 10 lb/A
Stand Count: 17/ft^2 2-3 trifoliates

After harvesting wheat there was good growth from the under-seeded alfalfa. It grew tall enough for harvest due to a late killing frost. It would have made a good plowdown if frost were earlier.

It was difficult to determine proper seeding date for fall-seeded hairy vetch and red clover. An adequate rainfall for a moist seed bed did not occur until late August.

Management Tip

Weed control in under-seeded wheat-alfalfa needs special attention.

Location of Project

1 mile north and 1 mile west of Herman.

Project Title:	**NITRO Alfalfa, Hog Manure, and Urea as Nitrogen Sources in a Small Grain, Corn, Soybean Crop Rotation**	*Time Span:*	March 90 to December 92
Principal Investigator:	Carmen M. Fernholz	*Tel:*	612-598-3010
Address	Route 2, Box 9A Madison, MN 56256	*County:*	Lac Qui Parle
Cooperators:	Jim Tjepkema - Rodale Research Coordinator Audrey Arner - Land Stewardship Project Craig Sheaffer - Professor, U of M	*Enterprise*	grain, hogs

Project Description

Soil fertility for a corn crop is usually maintained with NPK fertilizer application based on soil test recommendations. With fuel costs increasing, the use of commercial fertilizer may become too expensive. Additionally, nitrogen fertilizer that is not immediately taken up by plants is prone to leaching which contributes to groundwater contamination.

NITRO is a nondormant alfalfa developed to supply nitrogen in crop rotations in Upper Midwestern United States. A crop rotation of small grain interseeded with NITRO to supply nitrogen followed by corn in the next year and soybeans in the third year would be compared to the same rotation with NITRO left out and either hog manure or urea used to supply nitrogen. Soil moisture, soil compaction, pest populations, and crop yields would be measured and nitrogen levels in the crops and the soil would be monitored. Economic analysis and public education would be included in the project.

The total plot area is 713 ft long and 540 ft wide with 6 replications of each of the three (NITRO, urea, hog manure) treatments. Each treatment strip is 30 ft wide.

Project Results

Soil tests were made to determine initial fertility prior to the nitrogen treatments.

Soil Tests Results

Nitrate-Nitrogen	45.6 lb/A
Phosphorus (Bray-Olson)	9.88/18.11 lb/A
Potassium	340.5 lb/A
Zn (ppm)	0.65
pH	7.02
Organic Matter	2.57%

To begin the study, the NITRO and Urea plots were fertilized with 37-15-0 at 125 lbs/A, and the NITRO was planted at a rate of 15 lbs/A. Oats were planted at 2 bu/A. Hog slurry was applied at 4,000 gal/A two (2) times - during Spring before planting, and after harvest of oats. Manure analysis showed the following nutrient levels:

N	32 lbs/1000 gallons
P	21 lbs/1000 gallons
K	9 lbs/1000 gallons

The oat yields for the three treatments were very close.

Analysis of Oats Under Different Fertilizer Regimes (averages)

	Yield (Bu/A)	% Moisture	% Protein
Manure	53.7	12.46	13.58
Urea	56.3	12.37	13.85
NITRO	55.7	12.95	14.84

Plant Tissue Analysis of Oats (at boot stage)

Treatment	Nitrogen	Phosphorus	Potassium
	%	%	%
Manure	2.75	0.34	4.17
Urea	3.25	0.27	3.94
NITRO	3.00	0.25	4.00

Spring soil nitrate tests will be made in 1991 to determine the nitrate levels under each treatment.

Management Tips

First year's results are inconclusive.
We have determined a liquid manuring rate of about 4000 gallons/acre. Because we are analyzing the manures, we are able to determine our fertilizer rates.

Location of Project

2-1/2 miles east of Madison, MN on Highway 40.

Project Title:	**Demonstration of Tillage Effects on Utilization of Dairy and Hog Manure in Southeastern Minnesota**	*Time Span:*	April 89 to January 91
Principal Investigator:	John Moncrief	*Tel:*	612-625-3737
Address	Soil Science Department University of Minnesota St. Paul, MN 55108	*County:*	Goodhue
Cooperators:	Brian Schreiber - Goodhue County Ext. Agent Ken Ostlie - Extension Entomologist Dave Andow - Entomologist	*Enterprise*	hog, dairy, corn

Project Description

Typically, when animal manures are used for fertilizing soils, neither the rates of manure application nor the nitrogen concentration and form are known. In some cases, high rates of manure are applied close to the barn and intensive tillage is used for incorporation. These practices cause leaching losses of manure nitrogen into groundwater and erosion on vulnerable soils. In this project, hog and dairy manure were compared to commercial nitrogen fertilizer evaluated under two forms of conservation tillage (chisel plow and no tillage) for corn production. The response of the crop during the year of application and the following two years were evaluated. By determining the effects of residual nitrogen, the amount of nitrogen available to the crop from manure can be credited. This will reduce over-application of supplemental commercial nitrogen and thereby reduce contamination of the fractured limestone aquifer in this area of Minnesota.

Project Results

Dairy Manure Results - Flueger Farm:

Liquid dairy manure was injected either annually, biennially, or triennially on chisel-plowed soil; and annually or biennially on no-till treatment to provide nitrogen at recommended rates. The results of 1989-90 are summarized as follows:

1. Liquid dairy manure at about 8500 gallons per acre supplied 220 lbs of total N, of which 52% was in the mineral form. The total available N in the year of application from both organic and inorganic (mineral) fractions met the recommended rate of 170 lb/A nitrogen for corn.

Corn Yields (bu/A) under Different Conservation Tillage and Potassium Fertilizer Levels

	K_2O	No-Till		Chisel	
	lb/A	89	90	89	90
Manure	0	151	128	136	129
(yr after)	200	136	146	133	156
Manure	0	141	146	155	155
(yr of)	200	160	142	145	151
Manure	0	160	166	159	171
(annual)	200	178	175	167	162
Anhydrous Ammonia					
	200	163	164	167	153

2. Nitrogen applied as liquid dairy manure and anhydrous ammonia at equivalent rates resulted in similar yields.
3. Nitrogen applied at the same rate as liquid dairy manure but every other year (effectively one half the rate) resulted in yields that were 6 and 22 bushels per acre less than annual applications in the year of application and succeeding year, respectively.
4. Anhydrous ammonia application resulted in greater nitrogen movement in the soil compared to manure applied annually and manure applied every other year. Soil nitrogen in top 5 feet from anhydrous ammonia was 125 lb/A higher than nitrogen from annual manure application, and 170 lb/A higher than nitrogen from every other year application.
5. Soil water nitrate concentrations at 5 feet followed a similar trend. Concentrations were about 70, 50, and 15 mg/l for the anhydrous ammonia, annual manure, and every other year manure treatments, respectively.
6. The cost of tillage was $24.71 and 19.51 per acre for the chisel plowing and no-till systems, respectively.
7. Manure provided $28.73 per acre worth of N.

Swine Manure Results - Nord Farm:

Liquid swine manure was injected every other year. In 1987-88, manure from an anaerobic pit receiving manure from farrowing house was applied at 12,000 and 7,300 gal/A on ridge and chisel till treatments.

8. Anhydrous ammonia, liquid pig manure from an anaerobic pit and from a lagoon was applied at 170, 160, and 143 lb/A, respectively. Grain yields were 20 bu/A less with manure sources of N.
9. Soil mineral nitrogen increased from the spring of 1989 to the spring of 1990 by 135 and 39 lb/A for the anhydrous and anaerobic pit sources of N.
10. Soil water nitrate at 5 feet deep followed a similar trend and was 10 and 50 mg/l for the manure and anhydrous sources, respectively.

In summary, there were large increases in mineral nitrogen in soil and soil water with the anhydrous source of nitrogen over the manure sources at both sites. The N rates as manure or fertilizer were similar at the Flueger farm but slightly higher with fertilizer at the Nord farm.

Moncrief continued on page 53

Project Title:	**Transition Soil Building and Maintenance**	*Time Span:*	January 89 to December 91
Principal Investigator:	Larry H. Olson	*Tel:*	612-564-2571
Address	Route 1, Box 136 Granite Falls, MN 56241	*County:*	Yellow Medicine
Cooperators:	Richard Kuols - Y.M. County Extension Agent Don Hovland - Soil Conservation Service Roger Larson - Chippewa County Agent Audrey Arner - Land Stewardship Project	*Enterprise*	corn, soybeans, small grain, green manures

Project Description

Farmers who wish to make the transition away from using fuel-intensive chemical fertilizers and herbicides for soil fertility and weed control have options including the use of raw manures, compost and legumes for maintaining soil fertility, and rotary hoeing for weed control. Two legume systems and two livestock manure systems will be compared to a check for the following: 1) soil fertility, 2) weed development and control, 3) environmental benefits and 4) yield effects and cost effectiveness. We will use three 25 acre plots divided into five 5 acre sub plots. We will use soil testing and observation to track the fertility and environmental effects of each system.

Project Results

Livestock manure when applied at 3 ton/A (120-80-100) compared to equivalent rates of chemical fertilizer (120-80-100) made a noticeable difference in the residual P and K available for the following crop. At this rate of application, the livestock manure resulted in a savings of $28.72/acre compared to the chemical fertilizer.

Difference in 1989 & 1990 Spring Soil Test and Yields

	Chemical Fertilizer (120-80-100)	Livestock Manure (120-80-100) 3 ton/A
Nitrogen	-16.8	-31.2
Phosphorus	+9.6	+22.5
Potassium	+11	+83
89 Corn Yield	98.4 bu/A	94.5 bu/A
90 Soybean Yield	44.6 bu/A	47.7 bu/A

The organic production system (rotary hoe & manure) outyielded the conventional system (herbicide & chemical fertilizer) and was more cost effective.

Organic Vs. Conventional Soybean and Corn

	Soybean 1990		Corn 1990	
	Organic	Chemical	Organic	Chemical
Yield (bu/A)	47.7	44.6	133.1	130.3
Rotary hoe	$6.00/A	- 0 -	$6.00/A	- 0 -
Herbicide	- 0 -	$23.84	- 0 -	$28.84
Fertilizer	- 0 -	- 0 -	$40.00/A	$68.72/A
Cost Benefit	$38.67/A		$44.94/A	

Weed populations were compared for 3 different fertilizers (compost, manure, chemical) in corn production, the two year results show the total weeds were similar, but the compost treatment appears to show a slight advantage.

Number of Weeds Per Row for Three Different Fertilizers

	Compost	Manure	Fertilizer
1989	2.8	3.0	4.5
1990	8.3	12.0	11.5

Herbicides were compared to rotary hoe/walking as weed control options. In 1989, there were 2.6 weeds/row with herbicides and 4.8 weeds/row with the rotary hoe. In 1990, under wetter conditions, the herbicide treatment averaged 31.8 weeds compared to 45.4 weeds with the rotary hoe. The increased weed population did not affect crop yields.

In order to investigate the potential of including a cash crop legume into a rotation, cash alfalfa was compared to cash corn in 1990. The average yield of corn was 152.7 bu/A which sold for $1.97/bu. The average yield of alfalfa was 6.4 ton/A and sold for $56.59/ton. The net income after direct costs was $165.27/A for corn and $245.89/A for alfalfa, resulting in an average advantage of $80.62/A for alfalfa when compared to corn.

Management Tips

Begin with a farm resource inventory. Then test the soil. Remember all living things need to be fed, including the soil. Walk the land to know how it lays. Tillage affects the life of the soil. Choose carefully your tillage system. Since the soil is alive be sure to cover it from elements that will destroy it. If you ridge till leave the stalks and stubble through the winter to catch snow and cover the ridge. They chop better when weathered by winter elements. Learn about the nutrients necessary for the germination of the different crops on your farm and consider that in establishing a rotation. If you rotary hoe for weeds look for white hairs, and if there is a crust use it to your benefit. Rotary hoe twice on the same field in the same day in different directions for better coverage.

Location of Project

Go northwest of Granite Falls on Hwy. 212 pass "Lee-Mar" Ranch to a Y in the road and turn left on Co. Rd. 34, go 5 1/2 miles (last mile is gravel) turn right and go 1/3 mile. Farm is on the left side of the road.

Project Title:	**Cooperative Manure Composting Demonstration and Experiment**	*Time Span:*	June 90 to November 93
Principal Investigator:	Rich Vander Ziel	*Tel:*	507-879-3541
Address	Route 1, Box 133 Chandler, MN 56122	*County:*	Murray
Cooperators:	Robert Koeler, Murray County Agent People For A Responsible Agriculture Members	*Enterprise*	livestock, crops

Project Description

Compost improves moisture retention and pore volume of soil. Composted soils have a relatively stable structure and are more resistant to erosion. Beneficial microorganisms create compost or humus by digesting raw materials. To do so, these organisms require both a nitrogen source - either from manure or nitrogen fertilizer - and a carbon source (e.g. straw, bedding materials, corn stalks, crop residues, yard wastes, etc.). A carbon to nitrogen ratio (C:N) of 20-30:1 is ideal. The C:N ratio of straight manures is generally 10-12:1; thus additional carbon material is needed to compost manures. The compost pile must have air in order to select for the right kinds of microorganisms. To provide aeration to the microorganisms, the compost pile needs to be turned - in this project with a flail-type turner. The aeration is monitored by taking the temperature of the compost pile. True composting occurs within a temperature range of 130 to 160°F. A moisture content of 40 to 60% is optimum.

Demonstration-research plots have been set up to determine the value of on-farm composting of animal manures. Treatments will include compost, liquid and raw manure. Information obtained from these farms include soil fertility, weed levels, yields, profitability and nitrate movement.

Project Results

We have been able to produce compost with only 5-6 turnings. We turn the material when the average temperature has dropped to 125°F. The temperature of the compost pile is often up in the range of 150-160°F. Making one windrow of compost requires about 8 hours of labor, 4 hours of tractor time, and 12 gallons of fuel. (In this case, one windrow was about 100 tons, although the size of the windrow does not noticeably change the amount of energy and time required to make the compost.) The estimated cost of making compost is 1$ per ton, not including labor, repairs or capital investment (machinery). Compost analyses show an average of 44 lbs of N, 30 lbs of P, and 50 lbs of K per ton dry matter.

Vander Ziel Farm:
Observed 10% greater yield under the compost treatment compared to raw manure.

The fields with compost had only 56% as much grass weeds as the fields with raw manure.

Vander Ziel Farm - Comparison of Compost with Manure After First Year of Application 1990

	Raw Manure	Compost
Oat Yield (bu/A)	83.6	91.8
Grass weeds*	30.8	17.3
Broadleaf weeds*	8.5	7.2
Analysis of Fertility	357 lbs N 183 lbs P_2O_5 469 lbs K_2O	155 lbs N 104 lbs P_2O_5 271 lbs K_2O
Amount Applied	25.5 ton/A	12.7 ton/A

*Number per 4 ft^2

Gleis Farm - Comparison of Compost with Liquid Manure After First Year of Application 1990

	Liquid Manure	Compost
Barley Yield	50.4 bu/A	50.4 bu/A
Grass weeds[a]	87	105.8
Broadleaf weeds[b]	16.5	23.5
Analysis of Fertility	63.8 lbs N 22 lbs P_2O_5 52.8 lbs K_2O	56.7 lbs N 39.6 lbs P_2O_5 74.6 lbs K_2O
Amount Applied	2200 gal/A	3.3 ton/A

[a]Number per 1 ft^2; [b]Number per 4 ft^2

Management Tips

1. "Soft" manures may be piled with a loader and easily turned. More compacted and heavily bedded manures will be turned more easily if they are windrowed with a spreader.

2. Select a site to compost that will not become a mudhole or be subject to run-off. The soil should be compacted somewhat before manure is applied to help prevent leaching of nutrients. This can be done by driving a tractor over the area several times while the soil is somewhat wet.

Vander Ziel continued on page 53

Project Title:	**Economically and Environmentally Sound Management of Livestock Waste**	*Time Span:*	February 90 to February 92
Principal Investigator:	Fred G. Bergsrud	*Tel:*	612-625-4756
Address	University of Minnesota Extension Service 209 Ag Eng., 1390 Eckles Avenue St. Paul, MN 55108	*County:*	Ramsey
Cooperators:	Mike Schmitt - Extension Soil Scientist, Fertility Tim Wagar - Extension Agent, crops and soils Chuck Clanton - Asst. Professor, Ag Engineering	*Enter-prise*	corn, dairy, hogs

Project Description

Livestock wastes vary substantially in their nutrient content. Some of the factors that affect nutrient content are: animal species, type of manure handling system, livestock housing and bedding system, diet, temperature, moisture, soil and miscellaneous contamination. Tables of average nutrient concentration exist but the use of these tables for soil fertilization assumes "average" manure which is not accurate enough to get optimum benefit. In addition the application amount may not be accurately known and the manure not applied uniformly either within a field or between fields. The combination of these factors results in a very poor utilization of the resources and an increased potential for ground and/or surface water pollution. The project will demonstrate to producers how to make accurate estimates of the nutrients available; how to determine accurately the amount and uniformity of application; and how to minimize pollution potential while maximizing the use of these on-farm produced nutrients and resultant profitability.

Project Results

Liquid manure from dairy and hog operations were analyzed before and after agitating for nutrient content. The results of the analyses were as follows:

Analysis of Dairy Manure Before Agitating

Site	Total Solids		N	P	K	Na
1	7.2%	576*	14.6*	3.1*	15.1*	1.7*
2	16.0%	1280	31.2	8.3	29.0	31.9
3	0.8%	64	3.8	0.2	4.5	1.5
	7.2%	576	23.3	4.8	23.2	5.2
4	9.8%	784	20.5	7.0	24.1	2.8

*lbs/1000 gallons

Analysis of Dairy Manure After Agitating

Site	Total Solids		N	P	K	Na
1	9.7%	776*	33.2*	5.0*	27.5*	3.8*
2	10.8%	864	42.1	7.3	18.5	1.9
3	9.9%	792	35.8	5.4	23.8	4.3

*lbs/1000 gallons

Analysis of Hog Manure Before Agitating

Site	Total Solids		N	P	K	Na
5	18.0%	1440*	63.8*	36.6*	25.9*	5.0*
	9.1%	728	64.6	17.9	19.9	4.4
6	9.8%	784	20.5	7.0	24.1	2.8

*lbs/1000 gallons

Analysis of Hog Manure After Agitating

Site	Total Solids		N	P	K	Na
5	15.4%	1232*	69.6*	23.4*	21.2*	4.1*
6	did not spring agitate or apply					

*lbs/1000 gallons

Based on the results of the manure analyses, recommendations were made for rate of application of the manure for a 170 bu/A corn crop following corn. Univ. of Minnesota suggestions for nutrients in SE Minnesota with high to very high P + K soil tests are: N (170 lbs/A), P_2O_5 (15 lbs/A), K_2O (15 lbs/A).

Nutrients Applied with Manure - Spring 1990*

Site	Gall/A	Total N	P_2O_5	K_2O
		----------lbs/A----------		
1 Dairy	6,000	199	68	199
3 Dairy	5,000	179	61	143
5 Hog	4,000	278	213	102

*Manure applied based on farmers' past experiences. About 1/2-2/3 of total N is utilized by the crop during the season. Much of the remaining N is organic N which will be mineralized in subsequent years. It is recommended at site #5 to reduce application rate to 3,000 gals/A.

Starter Fertilizer Applied with Manure and Potential Savings in Fertilizer Costs

Site	Total N	P_2O_5	K_2O	Cost/ Acre	Acres Appl	Save/ Farm
	--------lbs/A--------			--$--		--$--
1	9	23	30	7.00	200	1,400
3	13.5	34.5	45	10.50	100	1,050
5	0	0	0	0	100	0

Location of Project

Various farms throughout the southeast part of Minnesota

Project Title:	**Research and Demonstration of Rotational Grazing Techniques for Dairy Farmers in Central, Minn.**	*Time Span:*	January 90 to December 92
Principal Investigator:	Francis Januschka	*Tel:*	612-255-6169
Address	Stearns County Extension Office 2700 First St. North #205 St. Cloud, MN 56301	*County:*	Stearns Benton Wright Sherburn
Cooperators:	Ken McNamara- Univ. of Minn., Sustainable Ag. Prog. Dr Craig Scheaffer - Forage Researcher Dr James Linn - Dairy Scientist	*Enterprise*	dairy, pasture, forages

Project Description:
The conventional method of producing forage is to fertilize with P & K and lime at the time of establishment and topdress annually according to harvest yield. Herbicides are commonly used at time of establishment and often yearly for grasses and other weeds. With rotational grazing, all of these inputs can be reduced. Cattle will control many of the weeds and do much of the fertilizing. By increasing the stocking rate, cattle are forced to eat the forage that is available. That, in combination with putting animals into paddocks where the forage is still at a young stage, the animals will eat almost any weed. Some initial means of controlling an existing high population of Canada thistle may need to be done. As for fertilization, the animals provide the nutrients. During the time they are confined in a small area, their excrements are uniformly spread throughout the paddock. The other input that will be reduced is energy input. The gas needed to harvest, transport and store feed and haul manure, can be reduced by approximately one half. Electricity used to feed animals should also be reduced. Animals will provide much of the energy to do those chores.

This project demonstrates and provides research data on rotational grazing systems for dairy farmers in Central Minnesota.

Project Results
Three dairy farmers participated in this first year of the project. Fences were purchased, layout designed, and installed on two farms.

Molitor Farm:
The Molitors put 90 heifers onto some existing pasture/hay land for rotational grazing, after designing a good rotational scheme. They fed the heifers 24 lbs of corn silage and 1.5 lbs of concentrated feed in addition to the grazing. The heifers gained 1.85 lbs/day for the 150 days on pasture.

Comparison of Rotational Grazing (RG) with Conventional Management (CM) of Dairy Heifers on Molitor Farm 1990 Season (90 Heifers)

	CM	RG	Cost Benefit of RG
Labor	1350 hrs	990 hrs	450 hrs/yr
Feed Costs	$30,780	$19,890	$10,890
Livestock Supplies	$6,750	$5,580	$1,170
Manure Hauling	$400	-0-	$400
Profit	$696	$13,156	$12,460

Kerfeld Farm:
Grazed lactating cows on oats in September. Haylage and corn silage supplemented the diet. Milk production was maintained, but butterfat dropped because of the lush, high moisture content in the diet.

Klassen Farm:
Seeded a former ridge-till field with oats, alfalfa, orchard grass, and trefoil. The oats smothered out the seeding and at harvest time, humidity was high causing a lot of windrow damage. The field was reseeded July 27 with a press drill and currently has 90% to 100% stand.

Forage Value of Pasture Hay 1990 (Dry Matter)

Farm	Date Tested	Crude Protein (%)	Relative Feed Value
Molitor	8/17/90	21.8	116.5
Kerfeld	9/7/90	23.3	111.5

Management Tips
Start grazing early; right after April 15th. Good fence is essential. Recommend alfalfa/grass mixture. Lactating cows should be kept close to barn; not more than half mile away. Adequate, firm seedbed preparation is essential for new seeding.

Location of Project
Joe Molitor's Farm. 2 1/2 miles west of Rockville on County Road 47.

Project Title:	**Intensive Rotational Grazing in Sheep Production**	*Time Span:*	April 89 to December 91
Principal Investigator:	James M. Robertson	*Tel:*	218-631-4618
Address	Route 3, Box 182 Wadena, MN 56482	*County:*	Wadena
Cooperators:	Bill Blaha - Instructor, Wadena AVTI Neal Martin - Forage Extension Specialist	*Enterprise*	sheep, pasture

Project Description

Switching to an intensive rotational grazing system from a conventional cool season low-intensity grazing system requires an investment in time and capital. This project will show what environmental benefits can be expected, what energy and production cost savings can be realized by a reduced dependence on harvested forages, what production levels can be obtained with lambs in an intensive grazing system utilizing a variety of forage species, and whether the necessary investment in time and capital can be justified by the actual return on investment.

Project Results

Changes made to project in 1990 compared to 1989:
Ewes were added to the project in addition to lambs to evaluate the ewe and lambs as a coherent whole rather than lambs alone as in 1989. This year lambs were fed no concentrates. April-born lambs remained with the ewes over an extended period and were not weaned until Sept. 9. All gains reported were made on milk and grass alone. Lamb growth and ewe maintenance were monitored from first day of grazing on May 6, 1990 - last year, lamb growth was monitored only in the period following weaning.

In period from birth to weaning lambs gained an average of 65.5 lbs to attain a total average weaning weight of 75.4 lbs. Condition of ewes scored (on 1-5 system) averaged 2.7 on May 4, 1990, and 2.92 at end of grazing system on Nov. 1, 1990.
Parasite infestation of lambs was a serious problem.

Changing to an intensive rotational grazing system from a conventional grazing system resulted in a net savings $2065 for this 100 ewe operation. The breakdown in costs is as follows:
Added Costs: Management/labor $1600; Fencing depreciation $140;
Reduced Return: 2nd hay cutting $2700
Total Decrease of Income: $4470
Reduced Costs: 2nd hay cutting $1350; no purchase hay for ewes $2650; hay for lambs $1380; Concentrated feed $1125
Total Increase of Income: $6505
Net Increase From Rotational Grazing : $2065

Costs, including feed, veterinary, land, and depreciation was $77 per ewe. At a market price of $0.50/lb, value of lambs weaned was $77.30/mature ewe; and $49.75/ewe for all ewes including yearlings. Value of wool per ewe was $28 (excluding wool incentive) at an average value of $3.50/lbs for wool (retail to handspinners) on a clip averaging 8 lbs of clean wool per ewe.

Results of Intensive Rotational Grazing of Lambs

	1990	1989
lbs of lamb weaned per ewe exposed	99.5	*
lbs of lamb weaned per mature ewe exposed	154.6	*
Change in condition score of ewes from first day of grazing on Nov. 1	+0.18	*
Length in days of grazing season	126	105
Lamb weight gain per day of grazing	0.35	0.46**

*These items are not comparable or not available. In 1989 information on lamb growth is post-weaning and therefore not comparable with this year's data which goes from birth to late weaning in September. Ewes were not conditioned scored in 1989.
**Includes concentrate supplement

1989 Grazing Results:
$12.20 per lamb was saved on feed cost to market weight. Lambs on pasture for 107 days and fed 1 lb of concentrate a day gained .46 lb/lamb/day. Cost/lb of gain for concentrates was 12.7 cents. Pasture cover was maintained which reduced potential erosion problems.

Management Tips

1. Using at least 10 paddocks allows clear observations of grass as a crop. One can observe clearly how long it takes a pasture to recover from a grazing period. The farmer is allowed an opportunity to decide when these crops should be harvested, considering the crop species and stage of maturity.
2. Grazing lambs and ewes together over a long season presented a serious problem to me this year in the form of tapeworm infestation of lambs which certainly reduced lamb gains.

Location of Project

From Wadena, take U.S. Hwy. 71 north approximately 7 miles to Wadena Co. Rd. 6. Turn west and go 2 miles to stop sign. At stop, turn north and go 1 mile. Turn west and go 0.2 mile. Farm is the first place on the south side of the road.

Project Title:	**A Comparison Study of Intensive Rotational Grazing vs Dry-Lot Feeding of Sheep**	*Time Span:*	April 90 to December 92
Principal Investigator:	R & K SHEPHERDS	*Tel:*	612-587-6094
Address	Route 3, Box 141 Hutchinson, MN 55350	*County:*	Meeker
Cooperators:	Doug Rathke Connie Karstens	*Enterprise*	pasture, forage, sheep

Project Description

We have incorporated the Voisin system of grazing management that controls what and when livestock eat by dividing a 12 acre pasture into 16 smaller paddocks and rotating sheep through them.

Our selected pasture mixture included (per acre):

birdsfoot trefoil	6 lb
white clover	2 lb
brome	2 lb
timothy	2 lb
orchard grass	2 lb
oats (cover crop)	1 bushel

Project Results

There are numerous environmental benefits from the rotational grazing system. Our system reduces the contamination of ground water by using no insecticides or herbicides and makes use of the sheep manure as a natural fertilizer. Wind and water soil erosion was reduced because the pasture is carefully managed, and soil is always covered. Earthworm population is increased, which helps produce rich top soil. Fuel usage was reduced under this system.

1. Increased profit by decreasing feed costs by $14.95 per ewe, which was especially noteworthy since this was a seeding year. While grazing, the ewes' body condition improved from a score of 3.0 to 4.0-4.5 (on a 1-5 scale) at the end of the grazing period.
2. Labor was reduced under rotational grazing compared to dry lot feeding. Managing sheep on dry lot required 9 times more labor compared to pasture feeding, which does not include the time and labor required for hay production and barn cleaning.
3. Rotational grazing extended our grazing time well beyond the traditional pasture season in this area.
4. Increased capacity of the pasture to graze a higher number of sheep per acre.

Management Tips

1. Due to the extensive rainfall this season, white clover grew so profusely that it could have inhibited other forages, such as birdsfoot trefoil. We would consider reducing white clover planting from 2 lb to 1/2 lb/A.
2. After grazing a paddock, mowing the weeds will help reestablish the desirable forages.
3. We highly recommend that the rotation of the paddocks be planned so that the paddocks located furthest from the shelter source would be used during periods of favorable weather. In this case, the paddocks closest to the barn were used when the weather became colder and the snowfall began.

Location of Project

Highway 7 west of Hutchinson 8 miles to Cedar Mills. First farm west of Cedar Mills on Highway 7 (approximately 3/4 miles). Farm located on south side of road past bridge.

Project Title:	**A Demonstration of an Intensive Rotational Grazing System for Dairy Cattle**	*Time Span:*	April 89 to November 91
Principal Investigator:	Ken Tschumper	*Tel:*	507-894-4248
Address	Route 1, Box 194 LaCrescent, MN 55947	*County:*	Houston
Cooperators:	Dan Patenaude - Dairy Farmer Jim Tjepkema - Rodale Institute	*Enterprise*	dairy, pasture

Project Description

In this project, I will demonstrate my transition from a year-round stored feeding system to one using intensive rotational grazing (IRG). IRG is a system whereby livestock graze a small area of pasture (paddock) until all the forage is removed. They are then rotated into a new paddock. The animals are rotated in such a way that the forages have enough time to fully recover. Research has found that one can greatly improve both animal and pasture productivity with the system. This project will demonstrate the following: 1) How the pastures will be divided up into paddocks. We will use two different pasture areas, 13 acres for cows and 13 acres for heifers. The paddocks, (approximately 13 for each area) will be arranged so that cows are close to the barn and heifers can easily be viewed. 2) Latest fencing technology. What makes IRG a viable option for today's farmer is innovative fencing materials. An important part of the project will be to demonstrate to farmers how these materials make it possible to: a) put up or move temporary fence in minutes, b) build permanent fence without the use of barrier type materials, c) charge fence for the whole farm with little electricity use and no shorting out by weed growth, and d) various other aspects of high tech fences which make building, moving and maintaining them less labor intensive. 3) A low cost method of pasture renovation. We will demonstrate how one can increase the legume content of permanent pasture by over seeding different species at early spring when the ground is still frozen (frost seeding).

Project Results

1990 Season

1. Milk cows received virtually all of their forage from grazing for 6 weeks starting May 1st. The herd was moved 3 times/day on alfalfa strips. Cows milked well and feed costs were very low. After six weeks, milking cows were fed haylage until early afternoon, then grazed until evening milking. This stimulated and increased intake, especially in hot weather.
2. Small heifers (7-10 months) were also grazed for 203 days, from May 7 to Nov. 26; they gained 1.32 lb/day. This is double the number of days on pasture compared to previous years when intensive rotational grazing system was not used.
3. Grazing cows full time in the spring saved the harvesting costs of the forage with equal milk production..
4. Frost seeding made it possible to dramatically improve pasture productivity without using any fuels and without any tillage on steep slopes.

1989 Season

Intensive rotational grazing doubled the number of days on pasture in a dry year and still produced a respectable gain of 1.5 lbs/day for the young stock. In addition, this system lessened the need for growing row crops in a region prone to erosion.

Management Tips

1. Lightweight portable fencing is the key to making it possible to do all the paddock fencing that is required. The low-impedence fencers, fiberglass posts and multi-strain wire are being produced domestically as well as abroad and prices should be compared.
2. Nothing will make a pasture system fall into place more easily than the use of plastic underground water pipe and rubber tanks. They are highly movable; the pipe is left on top of the ground and freezing will not damage it. The cost is low, and it allows for complete flexibility for laying out paddocks.
3. Frost seeding is very effective. It is low cost and excludes the need for mechanical renovation on steep slopes. I used red clover, although other grasses could also be used.

Location of Project

County Highway 25 west from LaCrescent for 3 miles to Channel 19 TV tower. Turn left on Tschumper Road, 1 mile on Tschumper Road.

Project Title:	**Intensive Rotational Grazing**	*Time Span:*	April 90 to October 92
Principal Investigator:	Chad Hasbargen	*Tel:*	612-563-8066
Address	Route 2, Box 101 Wheaton, MN 56296	*County:*	Traverse
Cooperators:	Randy Anderson - Stevens County Agent Lee Johnston - Animal Scientist, West Central Exp. Station, U of M Ken Nichols - Traverse County Agent	*Enterprise*	sheep, beef

Project Description

This project explores the benefits of rotational grazing 40 cow/calf pairs and 500 ewes on 160 acres of marginal farmland. The field was divided into twenty-two 6 acre paddocks, and an 18 acre control plot. The cow/calf pairs were to graze for 18 hours (noon-6 AM) each day and the ewes to graze 6 hours (6 AM - noon). The polywire fence would then be moved to a new paddock. The beef were controlled with one strand of polywire, and the sheep with three strands.

Project Results

The sheep were no longer grazed after 67 days because the polywire did not contain them on a 6 hour grazing schedule. Labor required to move 3 strands of wire was an additional constraint. The paddock size was increased from 2 to 6 acres for the cows, and the grazing time was increased to 3-5 days/paddock. The change from a daily rotation to a 3-5 day rotation schedule did not seem to make much difference. The accumulated rainfall for the 1990 season was 16.67".

Results of this grazing project were as follows:
1. An increase in profit of $2468, or $16.20/A under the rotational grazing system.
2. Rotational grazing increased the animal unit days to 148% of conventional stocking rates.
3. Calves, which were from first-calf heifers, gained 2.15 lb/day for 177 days of grazing.
4. Cows gained 0.52 lbs for 177 days, and condition score improved from 4.2 to 5.5 (Optimum condition for cows is 5; for heifers is 6) by the end of the season.
5. Ewes gained 0.22 lb/day for 67 days.
6. Pasture forage quality contained up to 26.1% protein, with a relative feed value of 173.3.
7. Ewes were moved to paddocks to eliminate brush problems.
8. Overall herd health improved under the rotational grazing system compared to dry lot feeding of the previous year.
9. Economic benefits should be much greater next year as we learn more about how to manage intensive grazing.

Management Tips

1. Grazing must begin at least 2 weeks earlier in the spring under the rotational season compared to the conventional system in order to keep grasses from flowering. Once grasses flower, they stop growing.
2. In general, begin grazing when grass is 8-12" tall and remove stock when grass has been grazed down to 3-4".
3. Consider using permanent paddocks made of high tensile wire if large numbers of sheep (350+ head) are run together.
4. Construct alleys wide enough (minimum of 24 feet for 350 sheep or more) if alleys are used.

Location of Project

5 miles north of Wheaton on Highway #75, turn right at Monson Town Hall, 1/2 mile on left hand side of road.

Project Title:	**Using Sheep and Goats for Brush Control in a Pasture**	*Time Span:*	April 89 to November 91
Principal Investigator:	Alan and Janice Ringer	*Tel:*	218-848-2475
Address	1765 Pequaywan Lake Road Brimson, MN 55602	*County:*	St. Louis
Cooperators:	Kendall Dykhuis - St. Louis County Ext. Agent Russ Boe - Resource Consultant	*Enter-prise*	livestock, pasture, high-tensile fencing

Project Description

The emergence of brush, or browse species which invade or become overabundant in a clear-cut field, is an obstacle in converting woodland into pasture. Sheep and goats are potential biological controls for suppressing woody brush growth as alternatives to herbicides. This would be especially advantageous in the sandy high permeability soil of this area which is prone to groundwater contamination. In this project, we will examine: 1)the feasibility of using sheep and goats for brush control without herbicides, 2) the effectiveness of high tensile fencing to control predators, and 3) the productiveness of a pasture system for raising lambs as compared to the more costly feed-based plan.

Our ultimate goal is to suppress woody vegetation so we can prepare a seedbed and seed selected pasture grasses and legumes. The paddock system will be retained for intensive management for optimum forage production. We expect that the weight gains in the lambs will be even more substantial with the improved pasture. We intend to develop a permanent pasture which does not need to be reestablished every 4 to 5 years.

Project Results

We have a 30 acre plot that we have subdivided into 12 paddocks and are grazing 125 animals: 51 ewes, 64 lambs, and 10 angora goats. The estimated annual growth of brush was 7357 lbs/A. The grazing sheep and goats effectively defoliated about 85-90% of the brush. In some of the paddocks the brush reached a height too high for the animals to graze, so a brush cutter was used to trim the excess growth. We put the animals in a paddock for approximately 2-4 days then rotated them to another area when all of the edible forage had been consumed. In our second grazing season we found that the sheep and goats were successful in controlling the brush in the pasture to such an extent that we did not need to apply any herbicides.

In the 6 years that we have used high tensile electric fence, we have not lost one animal to a predator, despite the presence of coyotes and bears. Our animals live out in the pasture from May 10 to October 20th.

Lambs gained an average of 0.48 lbs/day on pasture. This compares favorably to the grain-fed weight gain of 0.75-1.0 lbs/day when considering that a pasture system has much lower out-of-pocket expenses.

Rate of Weight Gain in Lambs* On Pasture in 1990

Lamb #	Rate of gain for last 30 days
155	0.52 lbs/day
162	0.54 lbs/day
168	0.48 lbs/day
169	0.52 lbs/day
198	0.68 lbs/day

*No grain fed to these lambs

Results of Grazing for 1990 and 1989:

Year	Number of Days Grazed	Number of animals	Animal Unit Days
1990	125	51 ewes 67 lambs 10 goats	1962
1989	153	52 ewes 12 goats	1609

An additional benefit of this grazing system is that the animals spread their manure over a large area (30 acres) while out on the pasture instead of accumulating it in a drylot situation. This may result in reduced contamination of groundwater.

Estimated Savings of Rotational Grazing for Brush Control and Feed in Pasture Reclamation from Woodland

Year	Input Reduction	Savings
1990	Herbicide	$1650.00 for 30 Acres
1989-90	Grain Feed	$1232.13 for 67 animals

Management Tips

-Use good quality fencing
-Have an easy and dependable watering system
-Stockpile some forage in the form of fall pastures or hay in case the grazing season is cut short.

Location of Project

1 1/2 miles s.w. of Hellmans store on Co. Rd. 44.

Project Title:	**Controlled Grazing of Ewes on Improved Pastures, and Lambs on Birdsfoot Trefoil**	*Time Span:*	April 90 to October 92
Principal Investigator:	Leatrice McEvilly	*Tel:*	507-724-2505
Address	P.O. Box 67 Caledonia, MN 55921	*County:*	Houston
Cooperators:	Richard Ness - Land Stewardship Project Russell Krech - County Ext. Director	*Enterprise*	alfalfa, birdsfoot trefoil, sheep

Project Description

This project will demonstrate the feasibility of intensive rotational grazing on extremely fragile hilly ground in southeast Minnesota. Sheep will be put on pasture for 6 to 7 months in an intensively managed operation. Part of this project will include improving these pastures with birdsfoot trefoil.

Project Results

This productive ewe flock of 65 heads (203% lambs weaned/ewe lambing) was put onto a rotational grazed legume/grass pasture on April 28th with the young lambs. The lambs were weaned on June 7th averaging 45 lbs. At that time, the lambs went to a 4 acre birdsfoot trefoil interseeded bluegrass pasture.

Results of the Lamb Production on Rotational Pastures:

1. Fertilizer and seed costs were $49.00 for 4 acres.
2. Lambs were grazed from June 7-November 16.
3. Actual income on pasture alone was $825/A from breeding stock sales.
4. Lambs gained 3402 lbs on 4 acres (850.5 lbs/A). At an average lamb price of $0.65/lb of lamb, they earned $552.82/acre.
5. Cost of a pound of gain just on pasture was $0.16 per pound.
6. Cost of a pound of gain on pasture plus supplements was $0.23 per pound. The supplemental feed costs were inflated because the lambs were pulled off pasture for two weeks due to a coccidiosis outbreak, and were fed entirely on hay and supplements.
7. High-tensile fencing cost for 8 acres plus a mobile lane was $1115. Only 4 acres was used for lamb pasturing.
8. Average daily gain on pasture was 0.49 lbs/day.

Results of Ewe Production:

1. Sixty-two (62) ewes were rotational grazed on 17 acres for 234 days (from April 28 to December 17).
2. Ewes started with 3.0 condition score, dropped to a 2.5 score at weaning and then went to a 4.0 score by breeding time.
3. Spent one hour per day moving fence for sheep.
4. Stockpiled birdsfoot trefoil was still grazed on December 17 from that pasture.
5. Sixteen (16) tons of hay was also harvested from pasture.

Other findings:

1. No-Till seeding worked very well without the use of herbicides.
2. Fly problems were minimal.
3. Coccidia management is important in pastures.
4. No erosion on hilly fields.
5. Very little synthetic fertilizers or chemicals used.

Management Tips

1. Plan carefully before you do any actual fencing. Make easy access from one pasture to another a priority.
2. Buy the best energizer you can afford.
3. If planning to graze sheep, put up more of a barrier type fence than you need for cattle.
4. Train the sheep to the fence when they are in short fleece.
5. Add legumes to your grass pastures; I am very partial to birdsfoot trefoil because of its longevity and non-bloating qualities.
6. Start grazing as early in the year as possible.
7. Graze grasses before legume/grasses because grasses grow more quickly, and some are inhibited by hot weather. Sheep prefer eating legumes so they may not graze the grasses thoroughly if given a choice between grasses and legumes.
8. Brome-, orchard-, and timothy-grasses are adapted to warmer climates and grow well through the summer. Alfalfa, birdsfoot trefoil, red clover, and white clovers (alsike, white dutch, ladino) mix well with grasses and are good summer forages.
9. We keep sheep in the paddock until the forage is about 3" tall. Trefoil can be grazed lower, but other forages need some green remaining in order to regrow.
10. Small paddocks which can be rotated after one day of grazing helps keep manure spread over a large area.
11. Generally, we allow each paddock to be grazed 3-4 times/summer.

Location of Project

2-1/2 miles northwest of Caledonia on State Highway #76; farm is located on west side of Highway, mid-way between County Trunk 10 and County Trunk 20. Look for the only farm with a long driveway.

Project Title:	**Improving Permanent Pastures for Beef Production in Southwest Minnesota**	*Time Span:*	February 90 to December 92
Principal Investigator:	David Larson Southwestern Technical College Pipestone Campus	*Tel:*	507-825-5471
Address	Box 250 Pipestone, MN 56164	*County:*	Pipestone
Cooperators:	Glenn Eikmeier Dr. Ed Twidwell, South Dakota State University	*Enterprise*	beef feeders, beef cow/calf, native prairie pasture

Project Description

Rotational grazing offers a number of environmental and economic benefits. It allows for a higher stocking rate per acre which may increase profits. More attentive management of animals in this system allows grasses to grow more evenly without being grazed off, thus reducing fertilizer needs and soil erosion. Native grasses can be maintained rather than eliminated. Weed control is improved because the animals are forced to eat more of the plants available, which cuts herbicide usage. By decreasing fertilizer and herbicide needs, groundwater contamination can be minimized. Portable fences in rotational grazing systems are less expensive than traditional barbed wire or woven fences. They can be moved to different fields which can benefit farmers who rent land. Rotational grazing requires a greater initial purchase of fencing, and requires more intensive management than continuous grazing, but the improved productivity in animal and forage offsets the added costs.

Project Results

Four farms cooperated in this project and achieved varying degrees of success. Buschena farm with a beef cow/calf operation grazed from May 28-Oct. 1, 1990. In addition to grazing, they baled 16 tons of grass hay from rotational pastures. Calves gained 307 lbs/A, which compares favorably to corn/soybean feed.

*ADG = Average Daily Gain (lbs)

Results of Buschena Beef Cow/Calf Grazing 1990

	Rotational	Continuous
Calf ADG*	2.611	2.438
lbs/Acre	49	-0.6
# of Cows	15	5
# of Acres	20	5
Increased Profit	$1059.93	

Ebbinga beef cow/calf operation grazed from June 10-Oct. 22, 1990. Also harvested 8 large round bales of hay from rotational pastures. Observed that the cows were in better condition, cattle were easier to handle, and different grass species were growing.

Results of Ebbinga Beef Cow/Calf Grazing 1990

	Rotational	Continuous
Calf ADG	1.563	1.525
lbs/Acre	38.9	17.3
# of Cows	38	12
# of Acres	60	13
Increased Profit		$301.34

Burke beef cow/calf operation grazed from June 8-Oct. 29, 1990.

Results of Burke Beef Cow/Calf Grazing 1990

	Rotational	Continuous
Calf ADG	2.429	2.224
lbs/Acre	33.3	-11.9
# of Cows	45	15
# of Acres	84.5	19
Increased Profit	$1802.69	

Smeins dairy calf operation harvested 9 round bales of grass in rotational pastures. Weekly tests for pasture quality showed an average of 16% protein, and was as high as 23% protein.

Results of Smeins Dairy Calf Grazing 1990

	Rotate Group#1	Rotate Group#2	Continuous
Calf ADG	1.083	0.977	0.816
lbs/Acre	237.31	78.40	179.16
# of Calves	28	18	21
# of Acres	17.5	17.5	13.1
Increased Profit	$217.72		

Location of Project

Meet at the Southwest Technical College which is 1 mile north of Pipestone on Hiawatha St.

Weyandt-Fulton
(continued from page 30)

3. Preparing for the goslings and caring for them the first three weeks pays off with healthy young birds that need very little attention once feathered and able to forage.

4. Availability of manure is concern for composting. Good front end loader and dependable manure spreader are necessities.

Location of Project
Highway 2 west out of Proctor to Midway Rd. Go south on Midway Rd. to Morris-Thomas Rd. (#56). Go west on Morris-Thomas Rd. 1.5 miles to Sandberg Road. Go north half mile on Sandberg Rd to farm.

Roller (continued from page 34)

Comparison of Different Mulching Systems to Bare Ground System (1989-90) - Net Increase in Crop Value

	LM/ST	PL/LM	PL/BG
1989 ($)	577.60	604.20	654.90
1990 ($)	1160.50	367.90	1739.50

Comparison of Net Value of Pumpkin Under Different Mulching Systems (1989-90)

	BG	LM/ST	LM Inter-seed
1989 ($)	510.00	247.50	322.50
1990 ($)	680.00	835.00	324.00

Management Tips
1. In this project, we use drip irrigation and provide moisture only to the target crop. Producers often use overhead irrigation on most crops, but plastic mulches will keep overhead water from reaching the crop, especially at early stage of root development. But, overhead irrigation supplemental to drip system will increase growth of LM crop if necessary.
2. Producers may consider growing their own straw, or using a chopped forage like sudax or even alfalfa as an alternative to straw. We have been told that almost any non-seeded forage will work.
3. Soil temperature must be warm enough before applying any type of organic mulch, unless the host crop needs cooler temperatures. The straw mulch delays any increase in soil temperature.
4. Soil moisture must be adequate before seeding LM to insure a quick start ahead of potential weed growth.
5. Consider using a grain/legume combination to lengthen the lifetime of the LM.

Location of Project
18 miles northeast of Fergus Falls, 9 miles north of Underwood on County Road 35.

Brutlag (continued from page 36)

Management Tips
-Build ridges in small grain stubble or on set aside ground
-Build ridges only 4" high in small grain stubble, 5 1/2" high in set aside that is somewhat free of residue.
Planting cover crop is a must on set aside fields, if properly maintained.
-De-ridge at least one day ahead of planting to let soil dry.
-Eliminate as many fall tillage passes as possible; try to leave 75% residue.
-Spray Quackgrass with Roundup 4-7 days before de-ridging.

Location of Project
1-1/2 miles south of Wendell (18 miles south of Fergus Falls) on County Road 11.

Moncrief (continued from page 41)

Grain yields were similar between nitrogen sources at the Flueger site but 20 bu/A lower with the manure sources at the Nord site. This was most likely due to a lower effective N rate with manure at this site.

Location of Project
Take Hwy 61 down to Red Wing downtown. Turn right on Hwy 58. Drive past Red Wing Tech. Institute and Casey's. Turn left on Hwy 45. Stay on Hwy 45 four (4) to six (6) miles. Tillage plots on right side of road. Dale Flueger farm on left side of road.
(Note: on Hwy 45, you will reach a point where the road forks. Be sure to take the road on the right and continue on Hwy 45 until you reach the farm.)

Vander Ziel (continued from page 43)

3. Most of the time involved in the turning process is spent in setting up, hooking up, and cleaning the machine. So select a site which will allow you to collect all your manure in one area.

4. Although cold weather slows the process, composting during the off-season will work. In many cases, this is the best option for spreading out the work schedule.

5. Use the compost to fertilize those fields which are most difficult to get to. With a 50% reduction in volume and weight, it becomes more feasible to transport the compost.

Location of Project
2-1/2 miles northwest of Chandler, located on the north side of County Highway #5.

Special Projects

In order to explore a broader range of sustainable agriculture issues, the Energy and Sustainable Agriculture Program has conducted or contributed to some additional projects. One project is an economic analysis of five Minnesota certified organic farms conducted by ESAP staff. The other two projects received partial funding from ESAP: a University of Minnesota research project on winter rye cover crop; and a Steele-Waseca Cooperative Electric study on grain drying. The information gathered from these projects are presented in the following section.

Analysis of Certified Organic[1] Farms in Minnesota

Many people have wondered whether an organic production system in Minnesota can be economically profitable. In an effort to address this question, the Energy and Sustainable Agriculture Program staff selected five long-term organic farms and did a year-end financial analysis (FinAnX or Farm Management System Analysis) on each to determine actual returns on these select organic systems. We made no attempt in this study to compare these organic farms to conventional farms in their respective areas. A methodology is being developed to make these comparisons.

The size of the selected farms ranged from a 104 acre (dairy) farm to a 1500 plus acre (cash grain) operation. Two of these farms are dairy operations, one is a hog farm, and two are cash grain farms. These farms are scattered throughout the state. We are reporting the return to overhead[2] for crops which do not account for their fixed costs per acre. Two of the 5 farms received premiums for some of their organic crops. The remaining farms did not receive premiums; none of the livestock operations received premiums. All figures reported are for the 1989 calendar year.

Livestock Production

The two dairy operations received an average of $1033.01 return over direct cost for their herds. The one hog producer had a $318.99 return over direct costs per litter.

Crop Production

Four out of the 5 farms produced corn. The average return to overhead was $188.59 per acre, ranging from $136.27 to $216.07.

Listed below are some of the crops that are grown on the organic farms and the average "return to overhead". These figures do not account for the fixed costs of production.

Crop	Farms	Return to Overhead per acre
Soybean	1 & 4	$203.44
Alfalfa hay	2 & 3	$354.34
Oats	2 & 4	$104.40
Wheat	3 & 5	$94.38
Dry Bean	5	>$300.00

These figures should not be used to judge whether one crop is more successful under an organic system than another, since the crops were raised in different areas of the state by different farmers.

Profitability of Organic Production

The profitability of the five organic farms in this study is listed in the following table:

Farm	Enterprise	Size (acres)	Return to Labor and Management[3]
A	42 cow	104	$55,269
B	153 cow	541	$128,277
C	24 sows	191	$57,203
D	cash grain	198	$20,403
E	cash grain	1500+	$214,770

Although these farms were not randomly selected to participate in the study, they do provide some insight on whether a sustainable system is economical; and whether an organic production system can be profitable.

[1] "Certified Organic" is defined briefly as food that is grown or raised without the use of synthetic fertilizers, pesticides, hormones, antibiotics, growth stimulants, and arsenicals. Soils on organic farms must have been free of those synthetics for at least three years.

[2] Return to Overhead = Gross Returns minus Total Direct Costs.

[3] "Return to Labor and Management" indicates the absolute level of earnings for the past year.

Winter Rye Cover Crop Study

DRAFT OF ABSTRACT
To be presented at the National Conference, "Cover Crops for Clean Water" held April 9-11, 1991, Jackson, TN

EFFECTS OF A WINTER RYE COVER CROP SYSTEM AND AVAILABLE SOIL WATER ON WEED CONTROL AND YIELD IN SOYBEANS

D.D. Warnes, J.H. Ford, C.V. Eberlein, and W.E. Lueschen

INTRODUCTION

Concerns about soil erosion, water quality, and the use of synthetic agricultural chemicals have increased interest in the development of more sustainable cultural systems for soybean (*Glycine max* (L.) Merr.) production. The use of winter rye (*Secale cereale* L.) as a cover crop could help reduce erosion, improve physical condition of soil, increase water penetration[1] (Benoit *et al.*, 1962), and help control weeds through competition and allelopathic effects[2] (Putnam and DeFrank 1983). A limitation of a winter rye cover crop system in Minnesota may be the lack of adequate soil water to support growth of both the cover and the soybean crop. Therefore, the objective of this research was to determine the effects of a fall or spring planted winter rye cover crop on weed control, soybean yield, and available soil water.

METHODS AND MATERIALS

Field studies were conducted from 1985 to 1990 at Morris, Lamberton, and Waseca, MN to evaluate the use of a winter rye cover crop system for weed control in soybeans. Each fall, winter rye was planted no-till into small grain stubble or a seedbed was prepared by fall plowing and cultivation. The following spring, the winter rye was killed with glyphosate (0.5 lb/A) two days prior to planting soybeans no-till into the rye residue. Spring-planted winter rye was allowed to grow for 6 weeks and was killed with glyphosate (0.5 lb/A) two days prior to planting soybeans no-till (10 or 30 inch spacing) into the rye residue. No further cultivation was performed. Percent weed control was evaluated visually. Grass and broadleaf weeds were harvested from a 2 by 2 ft area, separated, dried and converted to pounds per acre of weed dry matter. Soybeans were harvested with a small plot combine and seed yield measured. Weed control and yield data were analyzed using analysis of variance, and means were compared using Fishers LSD at α=0.05. The studies conducted at Morris were on Doland-Tara silt loam (4-5% O.M.), at Lamberton on Clarion-Webster silt loam (5% O.M.), and at Waseca on Webster clay loam (7% O.M.).

Available soil water in the top 5 feet of the soil profile was determined by gravimetric soil sampling in the fall prior to establishing these experiments. During the growing season, available soil water was determined by using a neutron soil probe. Official U.S. National Weather Service records from each location were used for precipitation data.

RESULTS AND DISCUSSION

Field studies conducted from 1985 to 1989 indicated that soybeans had tolerance to the winter rye cover crop system when available soil water was adequate (Table 1). The fall planted winter rye system resulted in soybean yields equal to the handweeded check at Morris in 1985 and 1986, when precipitation was above average. However, slightly lower to significantly lower yields were obtained with the rye system at Morris in 1987, 1989, and 1990, and at Waseca in 1989 when conditions were dry. In 1988,.yields ranged from zero to four bu/A soybean yield because of severe drought at Morris and Lamberton. The spring planted winter rye system produced soybean yields nearly equal to the handweeded check at Morris in 1986 and 1987, but resulted in significantly lower yields than handweeded check in 1985 and 1989.

The winter rye cover crop controlled weeds for a period of time after the winter rye had been killed by the glyphosate treatment. Weed control by winter rye, which was the result of both allelopathy and competition, ranged from 50 to 90% (Table 1). The fall planted rye provided a greater reduction in the weed dry matter yield than the spring planted rye at Morris in 1985, 987, and 1989 (Table 1). In heavy weed infestation plots at Waseca in 1988 and 1989, soybean yields were significantly reduced in the winter rye system due to lack of adequate weed control.

Neutron probe readings for available soil water showed that in June the fall and spring planted winter rye system had 2.2 and 0.9 inches, respectively, less soil water than the handweeded check. The early fall and late fall planted winter rye in 1990 had 3.3 and 1.1 inches, respectively, less available soil water than the handweeded check (Table 3).

The relative soybean yield was calculated as yield from the fall rye treatment divided by yield of the handweeded check and was compared to available soil water levels. Available soil water status was calculated by adding fall soil moisture plus

precipitation from April 1 to June 30. Locations eliminated from this comparison were the Waseca 1988 and 1989 sites because of heavy weed infestations, and the Morris 1987 site because fall available soil water was not determined. Approximately 15 inches of available water were needed to produce soybean yields in the winter rye system equal to the handweeded check. Soybean yields were severely reduced when available soil water was less than 10 inches. In years with over 20 inches available water, the fall planted winter rye cover crop system may be beneficial because it removes excess soil moisture.

Variable precipitation and high weed pressure are the major risks associated with using a winter rye cover crop system for soybean production. Minimizing moisture stress in the soybean crop 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 soybean, there will be a greater reliance on postemergence herbicides and cultivation for weed control. Additional cover crops should be evaluated for their potential to reduce wind and water erosion, to control weeds, and to produce minimal stress on the soybean crop.

This research was partially funded by grants from the Minnesota Soybean Research and Promotion council, Minnesota Department of Agriculture, and the Greater Minnesota Corporation.

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2. Putnam, A.R., and Joseph DeFrank. 1983. Use of phytotoxic plant residues for selective weed control. Crop Protect. 2:173-181.

D.D. Warnes, West Central Experiment Station, Morris, Minnesota, J.H. Ford, Southwest Experiment Station, Lamberton, Minnesota, C.V. Eberlein, Aberdeen Experiment Station, Waseca, Minnesota. Contribution from the Minnesota Agric. Exp. Stn. Sci. J. Series Paper No. 18,655. Corresponding Author (612) 589-1711.

Table 1. Effect of fall or spring planted winter rye cover crop on weed and soybean yield at Morris, MN 1985-89.

Treatment	85	86	87	88	89	85	86	87	88	89
	Weed Yield					Soybean Yield				
	----------lb dry matter/A----------					----------bu/A----------				
A	150	697	814	0	510	54	40	25	0	39
B	430	449	965	0	738	39	32	33	2	36
Weedy Check	1103	2699	9329	8976	3888	27	2	8	0	17
Handweed Check	57	136	22	0	6	51	36	36	17	45
LSD α = (0.05)						5	11	5	4	7

Treatment A = Fall planted rye, glyphosate 2 days before no-till planting soybeans;
Treatment B = Spring planted rye, allowed to grow six weeks, glyphosate 2 days before planting soybeans

Table 2. Effect of fall planted winter rye cover crop system on soybean yield at Morris, Waseca, and Lamberton, MN 1988-90.

				Waseca Weed Infestation					
	------Morris------			--Heavy--		--Light--		--Lamberton--	
Treatment	88	89	90	88	89	88	89	88	89
	----------bu/acre----------								
A	0	23	27	10	17	38	42	4	25
B	0	18	24	7	12	37	46	6	39
C	2	10	32	9	33	32	46	9	34
Weedy Check	0	11	18	6	1	31	29	0	21
Handweeded Check	14	29	32	25	41	45	48	15	47
LSD α = (0.05)	3	9	5	9	9	15	8	5	16

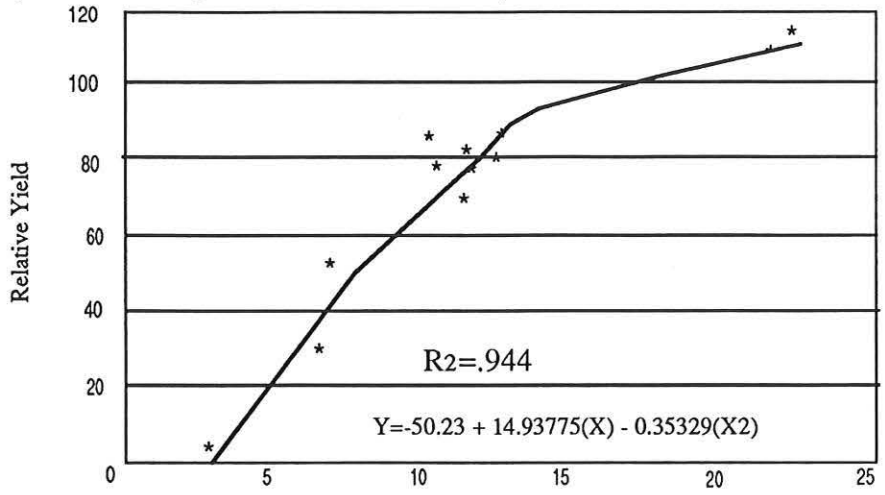
Treatment A = Fall planted rye, glyphosate 2 days before no-till planting soybeans
Treatment B = No winter rye, glyphosate 2 days before no-till planting soybeans
Treatment C = Herbicide check with no rye, alachlor (3 lb/A) + metribuzin (0.25 lb/A)

Table 3. Available soil water in winter rye cover crop-soybean system at Morris, MN on June 29,1989 and June 7, 1990 in top 0 to 5 ft of soil profile

Treatment	Available Soil Water	
	-----inches-----	
	1989	1990
A	2.0	
B	3.3	
C		4.1
D		6.3
Handweeded check	4.2	7.4

Treatment A = Fall planted winter rye, glyphosate 2 days before planting
Treatment B = Spring planted winter rye, grown for 6 weeks, glyphosate 2 days
Treatment C = Early fall (9/1) planted rye, glyphosate 2 days before planting
Treatment D = Late fall (10/15) planted rye, glyphosate 2 days before planting

Figure 1. Effect of available water in inches (fall soil + spring precipitation) on relative soybean yield (fall rye treatment as a percent of handweeded check)



Combination High-Speed, Natural Air Corn Drying Project

Energy usage in conventional grain drying can account for as much as 10-15% of a farmer's out-of-pocket expenses for producing corn. By increasing the efficiency of the grain drying process, farmers can reduce their energy usage, become less dependent on off-farm energy inputs, and increase their net income. In recognizing the potential for improvement in this phase of a farming operation, the Energy and Sustainable Agriculture Program committed itself to funding a combination high-speed, natural-air drying project for three years.

In conventional grain drying, the entire drying process takes place in a dryer. In combination drying, the grain is partially dried in a heated-air dryer and then "dumped hot" or moved into grain bins and cooled in natural air circulated with electric fans to complete the drying cycle.

How This Study was Done

Roger Wrase of Blooming Prairie, MN, Steele-Waseca Cooperative Electric, Steele County Extension Service, and the University of Minnesota cooperated in conducting this study on the Wrase Farm. Data on costs of drying, percent moisture of corn, amount of energy usage, etc. has been collected since 1984 on the Wrase Farm.

Summary

The advantages to the combination drying system are numerous:

1. Reduced Energy Use. The amount of time required to dry the grain is reduced since the grain is only partially dried (to about 20% moisture) in the high-speed dryer, instead of fully dried (to 14-16% moisture) as in the conventional system. Thus, the amount of LP gas required to operate the dryer is reduced.

2. Handling a Larger Volume. A larger volume of grain can be dried in combination drying since the dryer does not need to be tied up through the entire drying cycle. Instead of heating and cooling only one batch of grain in a high-speed dryer - as in the conventional system - the dryer can be used to heat a second batch of grain while the first batch is cooled in grain bins with unheated air. On the Wrase Farm, the output of the grain dryer has been doubled due to more efficient management.

3. Increase Speed of Drying Grain. Since a larger volume of grain can be dried, the amount of time to required to dry grain from a harvested field is reduced. This frees up the farmer to tend to other needs in his/her operation.

4. Avoiding Peak Energy Periods. Combination drying allows energy usage during off-peak hours. After the initial heating in the dryer, the grain is slowly cooled. Farmers using combination drying can take advantage of lower energy rates during periods of the day when the demand for energy is less. Energy cooperatives are severely fined when they exceed energy usage during peak energy periods. These increased costs are passed on to the farmer - who can avoid these costs by delaying their grain drying until energy is cheaper.

5. Reduced Costs. Grain drying costs can be reduced by 25% using the combination drying system compared to conventional drying.

6. Improve Grain Quality. Under the combination drying system, the grain is allowed to slowly cool. This reduces the occurrence of stress cracks compared to the rapidly cooled conventionally dried grain.

The ultimate goal in this project is to rely completely on natural air drying and eliminate the need for LP gas entirely. The Wrase Farm is currently looking at ways to expand on the natural air drying system. This system can be developed with advances in drying equipment and augmented with corn hybrids which have faster dry down.

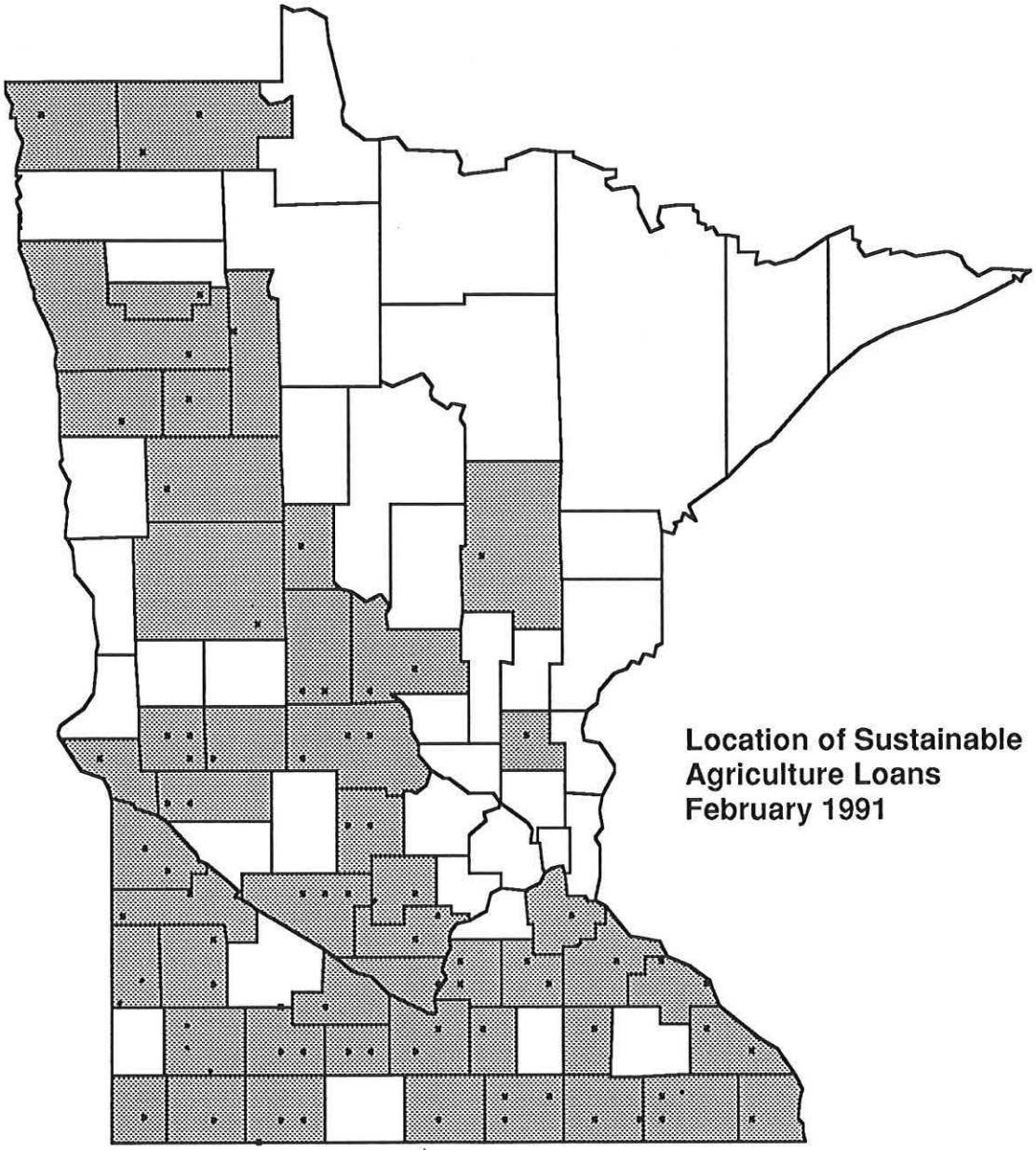
Loan Program

Making a transition in today's modern farm operation can be very capital intensive. For example, a different method of planting a crop to conserve soil can involve the replacement or modification of numerous individual pieces of equipment. There are few quick and inexpensive solutions to implementing farming practices that meet the goals of environmental conservation, while still providing a level of profit to sustain the operation. Even practices that have the potential to increase profits will have risks due to the management changes necessary for implementation. This added risk may discourage the farmer from implementing the practice on his farm. The Sustainable Agriculture Loan Program is intended to ease the financial burden and help tilt the scale in favor of adopting these best management practices.

The Loan Program provides low-interest financing to farmers to assist them in adopting management practices that are environmentally sound, conserve soil, and reduce energy consumption. The State of Minnesota appropriated $1 million to be set up as a revolving loan fund for this purpose. Loans up to $15,000 per farmer are made at a fixed 6% interest rate for a term of up to 7 years. The revolving concept allows repayment from the outstanding loans to be pooled and redistributed to farmers in the form of new loans. Many farmers will have the opportunity to benefit from this continuing program with no additional cost to the State of Minnesota.

Presently, a total of $946,000 has been loaned to 95 farmers. Loans continue to be added to the original accounts approved in 1989. To date the program has not experienced a single delinquency or default. The Loan Program has the potential to reach as many as 500 Minnesota farmers. Many of the operators receiving loans are leaders in their area of the state. As they implement farm systems to control soil loss, become more prudent with their use of agri-chemicals, conserve energy, and produce efficiently, they serve as models to their neighbors. These farmers may be catalysts to help speed the adoption of sustainable farming practices by setting the example of profitable and environmentally sound agriculture.

To illustrate the types of equipment purchased and costs involved in making a system change, we have provided examples in the following pages.



Location of Sustainable Agriculture Loans February 1991

Example of Equipment Financed by the Sustainable Agriculture Loan Program

County: Lyon
Items Purchased: Ridge till attachment for planter, banding sprayer, rotary hoe
Project cost: $22,157
Loan Amount: $15,000

Project description: Borrowers are in a transition to ridge till on their 1200 acre corn and soybean farm. They hope to reduce both water and wind erosion as well as cutting their fertilizer cost. Chemical costs will be cut in half by banding and the timely use of the rotary hoe in the spring.

Equipment needed to convert to ridge till as requested in the application:

Item	*Cost*
12 row ridge till attachment for IHC 800 Planter	$9,384
Rear stabilizer discs for planter	$470
Banding kit and parts for the planter	$845
Tractor saddle tanks for chemicals	$1,778
12 row Yetter rotary hoe	$6,120
Bestway banding sprayer	$3,560
Total cost	**$22,157**

Other items needed in this transition:

Item	*Estimated cost*
12 row ridge till cultivator	$12,000
Guidance system for cultivator (optional)	$4,500
Duels and spacers for combine (trade wheels)	$2,500
Total estimated cost	**$19,000**

Items of equipment that probably will be traded or sold in the transition:

Item	*Estimated Salvage value*
Primary tillage equipment	$10,000
Total salvage value	**$10,000**

Net cost of the transition to ridge till	**$31,157**

Example of equipment financed by the Sustainable Agriculture Loan Program

County: Red Lake
Items Purchased: Conversion of existing grain storage (26,400 bu.) to a full floor natural air drying system.
Project cost: $15,975
Loan Amount: $11,932

Project description: Existing grain storage bins will be modified by adding a full floor, vents and larger fans. Valuable time will be saved by not having to wait for the batch dryer during harvest. Advantages of the conversion include a substantial reduction in fuel and labor, and higher quality grain by drying at lower temperatures.

Equipment needed to convert the grain bins as requested in the application:

Item	*Cost*
2 Hi-Flow Blowers with 5 h.p. motors	$2,160
"No Fines" full floors	$5,130
Inlet assemblies	$504
Transition connectors	$504
Snap on supports	$2,073
Roof vents	$750
Other, connectors, bolts, etc.	$811
Labor	$2,000
Augers, unload tubes, etc.	$2,043
Total cost	**$15,975**

Items of equipment that probably will be traded or sold in the transition:

Item	*Estimated Salvage value*
Portable batch dryer	$2,500
Total salvage value	**$2,500**

Net cost of the transition	**$13,475**

Example of equipment financed by the Sustainable Agriculture Loan Program

County: LeSueur
Items Purchased: 15 Ft. No Till Drill
Project cost: $17,500
Loan Amount: $15,000

Project description: Borrowers plan is to reduce wind and water erosion on his highly erodible land and maintain more acres undisturbed after harvest for wildlife. No tilling his acres will reduce field passes and conserve soil moisture in his light soil. Incorporated pre-emergent herbicides can be avoided and input costs reduced by only spraying post emergent herbicides when necessary.

Equipment needed for no till drilling as requested in the application:

Item	*Cost*
Great Plains No Till Drill	$17,500
Total cost	**$17,500**

Items of equipment that probably will be traded or sold in the transition:

Item	*Estimated Salvage value*
Equipment assets sold	$2,000
Total salvage value	**$2,000**

Net cost of the transition	**$15,500**

The following is a partial listing of loans approved with brief descriptions.

Listed alphabetical by county.

County: Big Stone
Items purchased: Banding and side-dressing equipment installed on existing planter and cultivator.
Project cost: $3,500
Loan amount: $3,500
Project description: Borrower converted both his planter and cultivator to allow banding of fertilizer. He can now tailor his fertilizer use according to weather. He hopes to achieve maximum profit per acre and reduce chances of over-application. By utilizing his farm shop and used equipment he was able to accomplish the conversion for approximately half the cost of new equipment.

County: Cottonwood
Items purchased: Hiniker 12 row high residue cultivator, 60' three point sprayer for banding
Project cost: $17,914
Loan amount: $15,000
Project description: Borrower purchased a cultivator that is better able to handle residue tillage situations. He also purchased a sprayer to band chemicals, reducing both cost and amount of chemical applied.

County: Dodge
Items purchased: Hiniker ridge till cultivator with nitrogen side-dress attachment.
Project cost: $9,120
Loan amount: $9,120
Project description: Borrower was looking for an alternative to broadcasting chemicals. He chose to start banding which would allow him to cut the amount of chemical applied in half. To accomplish adequate weed control with this new system a cultivator was needed. The cultivator was also adapted to side-dress anhydrous ammonia. Previously anhydrous had been applied in the fall.

County: Fillmore
Items purchased: Minimum till planter with banding equipment, saddle tanks for tractor, cultivator.
Project cost: $13,700
Loan amount: $13,700
Project description: Borrower is updating from his current planter to a planter with minimum to no till capabilities and banding equipment. The spray tanks will be mounted on the tractor. A cultivator will be necessary to control weeds between the rows.

County: Goodhue
Items purchased: Spray equipment for banding herbicide, conservation style cultivator.
Project cost: $9,500
Loan amount: $9,500
Project description: Unsatisfactory herbicide performance and concern for the environment have been the major factors influencing this borrowers decision to farm lower input. Both the planter and the cultivator will be adapted to band herbicide. The conservation cultivator will be used to control weeds as well as side-dress nitrogen when necessary.

County: Houston
Items purchased: Kewanee conservation cultivator.
Project cost: $4,900
Loan amount: $4,900
Project description: Borrower has been reducing herbicide and insecticide rates, and experimenting with alternative crop rotations since 1986. Higher residue field conditions and a greater dependence on mechanical weed control made the purchase of an aggressive conservation cultivator a requirement.

County: Jackson
Items purchased: Chisel plow, rotary hoe, band sprayer.
Project cost: $8,750
Loan amount: $8,750
Project description: The band sprayer will allow chemical usage to be cut in half and still adequately control weeds with help from the rotary hoe. Borrower also intends to practice conservation tillage.

County: Jackson
Items purchased: High residue field cultivator, chisel plow, rotary hoe.
Project cost: $23,000
Loan amount: $11,500
Project description: Chisel plowing corn stalks in the fall will leave adequate crop residue on the field to reduce the rapid loss of soil due to wind erosion. The high residue field cultivator is needed to prepare the field in the spring. Borrower is also attempting to reduce herbicide rates by mechanically controlling the weeds with the rotary hoe.

County: LeSueur
Items purchased: Manure containment and storage facility for farrow to finish hog operation.
Project cost: $7,500
Loan amount: $7,500
Project description: Borrowers plan to expand their operation by constructing a new building and a manure containment and storage facility. They wish to improve their waste handling methods and reduce the need to purchase commercial fertilizer. Through testing and proper management waste products will be utilized in a manner more beneficial to the farm operation and the environment.

County: Lyon
Items purchased: Hiniker ridge till cultivator with navigator guidance system.
Project cost: $17,350
Loan amount: $15,000
Project description: Borrower farms with the above operator. The cultivator will provide the weed control needed. They project substantial savings to come from reduced use of herbicides, fertilizer and fuel. With less equipment needed replacement purchases will decrease as well as machinery repair costs.

County: Meeker
Items purchased: Fencing for rotational grazing, 2 way plow, truck.
Project cost: $14,284
Loan amount: $14,284
Project description: Fencing will allow access to 56 acres of permanent pasture and 200 acres of tillable land. A total of 3.8 miles of permanent fence and 1.5 mile temporary fence will be installed. The two way plow will be used on contour strips to plow uphill and eliminate dead furrows. The used truck with hoist will be used to haul and stockpile poultry manure to be used as fertilizer.

County: Meeker
Items purchased: Ridge pre-plant conditioner, ridge cultivator.
Project cost: $18,825
Loan amount: $15,000
Project description: Borrower experimented for a year then chose to convert to ridge till for corn and soybeans. He was interested in lowering his investment in machinery and lowering his cost of production. Fewer field passes and reduced herbicide rates contributed most to the savings.

County: Morrison
Items purchased: Rotary Hoe
Project cost: $3,000
Loan amount: $3,000
Project description: Borrowers major objective is to cut back on chemical rates. He calculates a savings due to reduced chemical rates and environmental benefits as well.

County: Murray
Items purchased: Ridge till planter
Project cost: $13,600
Loan amount: $8,500
Project description: Borrower is switching over to ridge till. Herbicides will be banded instead of broadcast. He feels his efficiency and profitability will increase due to reduced fuel, labor and herbicide cost. The soil will be less susceptible to wind and water erosion.

County: Murray
Items purchased: Band-equipped sprayer, cultivator, rotary hoe.
Project cost: $20,000
Loan amount: $15,000
Project description: Borrower cites the following key practices as objectives in moving toward a more environmentally sound and economically viable farm. Early rotary hoeing of row crops, post emergence herbicide band applied and precision cultivation with a late model cultivator.

County: Nicollet
Items purchased: Mulch tiller and stalk cutter.
Project cost: $24,000
Loan amount: $15,000
Project description: Fall soil and residue management is a top priority for this borrower. The mulch tiller will tack down residue to prevent wind and water erosion. The stalk cutter is used to even out plant debris and prepare a field for a crop that is to be drilled.

County: Norman
Items purchased: Chisel plow and harrow
Project cost: $4,400
Loan amount: $4,400
Project description: Borrower is concerned about the continued erosion of soil by the wind. He plans to chisel more and moldboard plow less this fall. He cites fuel and labor savings as direct cost savings.

County: Red Lake
Items purchased: Conversion of existing grain storage (26,400 bu.) to a full floor natural air drying system.
Project cost: $15,975
Loan amount: $11,932
Project description: Existing grain storage bins will be modified by adding a full floor, vents and larger fans. Valuable time will be saved by not having to wait for the batch dryer during harvest. Advantages of the conversion include a substantial reduction in fuel and labor, and less damaged grain by drying at lower temperatures.

County: Renville
Items purchased: 12 row hooded band sprayer.
Project cost: $3,875
Loan amount: $3,875
Project description: Borrower is now broadcast spraying. He plans on constructing a band sprayer, thereby reducing chemical usage by one half. He plans on keeping costs down by purchasing as many used components as possible for the construction of this sprayer.

County: Rice
Items purchased: Disc chisel plow, high residue field cultivator, minimum till/no till planter.
Project cost: $30,000
Loan amount: $15,000
Project description: Borrower is converting his tillage system to a combination of minimum tillage and no tillage to avoid wind and water erosion on his farm. Efficiency will increase due to fewer trips across the field. A combination of mechanical and chemical weed control will continue to be used.

County: Rock
Items purchased: Minimum tillage cultivator, rotary hoe.
Project cost: $7,364
Loan amount: $4,750
Project description: Borrower discontinued moldboard plowing in order to conserve soil moisture and avoid erosion from wind and water. With increased crop residue on the soil surface, it was necessary to use a cultivator and rotary hoe designed for these conditions to work the field. Borrower will use these devices for weed control along with limited herbicides.

County: Roseau
Items purchased: 10,000 bushel bin with natural air drying.
Project cost: $10,600
Loan amount: $9,000
Project description: Borrower is a grain and legume seed producer. Higher quality crops sold at a premium price will be the primary benefit of this system over the present high temperature system. Areas of cost savings include fuel, both LP and diesel, and labor hours.

County: Sibley
Items purchased: 15' Yetter rotary hoe, fencing for rotational grazing.
Project cost: $7,500
Loan amount: $6,500
Project description: Borrower wishes to purchase a used rotary hoe instead of continuing to lease. He has been using mechanical weed control successfully in corn and soybeans. Because he has no herbicide carryover he is able to sow an aftermath crop to provide short term pasture for lambs. A 5-wire permanent, perimeter fence will be built with temporary fencing used to divide paddocks for grazing.

County: Stearns
Items purchased: Manure storage area and animal feedlot.
Project cost: $31,800
Loan amount: $7,952
Project description: This borrower was concerned about his animal waste runoff problem and plans to better utilize manure as an on farm fertilizer resource. The project was specifically designed to eliminate or permanently reduce runoff of animal waste into the nearby river.

County: Stearns
Items purchased: Rotary hoe
Project cost: $5,000
Loan amount: $4,600
Project description: Borrower is conservation-minded and has been practicing minimum tillage since 1972. He is purchasing a used rotary hoe. He wants to reduce his herbicide costs.

County: Stevens
Items purchased: GT VersaDrill model 1006.
Project cost: $14,000
Loan amount: $14,000
Project description: Borrower intends to purchase the VersaDrill and lease it out to other farmers through the local SWCD office. The drill will be used to renovate pastures, seed alfalfa and other legumes, and to seed small grains and soybeans into no-till or reduced tillage high residue conditions.

County: Stevens
Items purchased: Hiniker ridge till cultivator with guidance system, equipment to adopt sprayer for wide banding.
Project cost: $18,060
Loan amount: $15,000
Project description: Borrower is steering his operation toward less tillage, better utilization and placement of fertilizer and targeting specific areas for weed control. Profitability will be most affected by the reduced levels of fertilizer and chemicals. Fuel and labor will also be affected due to fewer trips across the field.

County: Swift
Items purchased: Corn planter with no-till capabilities.
Project cost: $13,500
Loan amount: $4,000
Project description: Borrower purchased a planter and used the loan funds to set it up with no-till capabilities in order to plant corn directly into soybean stubble and soybean into wheat stubble. This will eliminate tillage trip, reducing the cost of production and soil loss due to erosion.

County: Todd
Items purchased: Manure handling and storage system.
Project cost: $25,800
Loan amount: $15,000
Project description: Borrower's barnyard has a severe water runoff problem. With technical and financial assistance from his county ASCS and SCS offices, a manure handling system was designed to minimize further pollution of nearby designated wetlands. This system will also allow for better management of manure, thus reducing dependence on commercial fertilizer.

County: Wadena
Items purchased: Central wood hot water heating system.
Project cost: $18,223
Loan amount: $15,000
Project description: This outdoor system heats water by burning wood. The hot water will heat two dwellings, the milk house, calf barn, machine shop and all the hot water consumed on the farm. Borrower has over 100 acres of wooded land on his farm to be used for fuel. He expects to recapture his investment in less than 4 years.

County: Winona
Items purchased: Minimum till planter, nitrogen side-dress equipment for cultivator, used rotary hoe.
Project cost: $18,500
Loan amount: $15,000
Project description: This equipment will assist borrowers in moving toward their goal of using less chemicals and commercial fertilizers on their farm. The planter will allow planting in fields with more crop residue. The rotary hoe will be used to control early emerging weeds. The side-dress equipment will allow nitrogen to be applied timely at the appropriate rate.

County: Yellow Medicine
Items purchased: 30' minimum till rotary hoe.
Project cost: $9,000
Loan amount: $4,500
Project description: Borrowers are ridge till operators and have been banding pre-emergent herbicides. They will attempt to eliminate herbicides by using the rotary hoe twice before cultivating. If necessary they will band spray post-emergence herbicide on only the fields that have weed pressure.

The following case study was prepared to demonstrate how the equipment purchased through the Sustainable Agriculture Loan Program is assisting the farmer in the transition from conventional to more sustainable farming practices. The figures cited were provided by the farmer. These figures are estimates and no field trials were run to verify them. The case study presented is not intended to promote any one farming concept but merely to provide information on how the Sustainable Agriculture Loans can be used.

Sustainable Agriculture Loan Program
Actual Case

Address: Roseau, MN. 56751 *County:* Roseau

Purpose of loan: Natural air drying bin for grain, 10,000 bushel capacity

Projected cost of the project: $10,600
Size of loan requested and received: $9,000

Terms: Semi-annual installments of $800 payable May 1 & November 1 each year for 7 years. Collateralized loan at 6% simple interest. No penalty for early repayment.

Projected savings to the borrower by participating in the Sustainable Agriculture Loan Program vs. a conventional loan at 12% interest. The difference between a 6% interest rate loan through the Sustainable Agriculture Loan Program and a 12% interest rate conventional loan with the same terms would save the borrower $1,812 in *present value dollars.

**assuming an 8% opportunity cost interest rate*

Operation: This farm is located in rural Roseau, Roseau County in northwestern Minnesota. This producer farms 1127 tillable acres of which 920 acres are owned and 207acres rented. The primary crops are spring wheat, barley, clover, oats and corn. There are no livestock raised on this farm. The clover is sold as seed and much of the barley is sold for malting. This farmer is in the process of purchasing the real estate and farm machinery from his father. He supplements his income by working off season as a part-time township assessor. His wife works as a school teacher in a nearby town.

Project description:

The loan through the Sustainable Agriculture Loan Program was used to finance the construction of a 10,000 bushel capacity natural air grain drying system. This producer wanted to replace the use of a high temperature recirculating system with the natural air grain drying system on part of his crop. He anticipates drying about 5,000 bushels of barley in the bin then transferring it out for storage. The bin will then be filled to capacity with wheat at time of harvest. The wheat can then be dried and stored in this drying bin until sold. Grain quality is usually better when dried in a lower temperature system. The system was designed following the recommendations of Dr. Harold Cloud of the University of Minnesota.

Benefit due to the project: The below partial budget worksheet is used to estimate the monetary savings due to the implementation of this natural air grain drying project. The major areas of improvement are in savings of labor hours, better quality grain and reduced energy cost.

Partial Budget Worksheet

** Of the 5,000 bushels of barley dried in this drying bin 2,500 bushels are expected to be sold as malting barley at a premium price.

Added costs

Item	*Dollars*
electric fan on bin 15 HP motor, 145 hours drying time for barley and 200 hours on the wheat 345 x x.044=	170
interest cost $9,000 x 6% =	540
depreciation cost $10,600 / 10 years =	1,060
Total added costs	*$1,770*

Added returns

Item	*Dollars*
premium price for malting barley ** 2,500 bushels x $.20 per bushel =	500
Total added returns	*$500*

Reduced returns

Item	*Dollars*
none	
Total reduced returns	*$0*

Reduced costs

Item	*Dollars*
LP fuel that will not have to be used on the 15000 bushels of grain. 1500 gal.x $1.00 =	1,500
50 tractor hours not needed 50 hours x $7 per hour =	350
50 man hours not need to run the dryer 50 x $5 per hour =	250
Total reduced costs	*$2,100*

Income decreasing	**$1,770**
Income Increasing	**$2,600**

Net Annual Change $830

What makes this a Sustainable system?

Conservative cost figures indicate that this grain drying system has a beneficial effect on profitability while reducing overall input expenditures. As LP fuel prices rise this less energy intensive system becomes increasingly attractive. This farmer cites time savings and better quality grain as factors influencing his decision. As additional markets open up in the future for quality grain, farms like this will be in a position to market accordingly.

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Grant Technical Review Panel 1988-90

Mr. Bob Olson, Dakota County Extension agent; **Mr. Mark Ackland**, Freeborn County farmer; **Dr. Richard Goodrich**, animal scientist, University of Minnesota; **Mr. Steven Schwen**, Wabasha County farmer; **Mr. Richard Ness**, On-Farm Practices coordinator, Land Stewardship Project; **Dr. David Andow**, entomologist, University of Minnesota; **Mr. Craig Murphy**, Stevens County farmer; **Dr. Steven Simmons**, agronomist, University of Minnesota; **Mr. Craig Cramer**, consultant and contributing editor of New Farm magazine; **Dr. Richard Cates**, On-Farm Research coordinator, Wisconsin Sustainable Agriculture Program; **Mr. Ken McNamara**, manager of Farmland Stewardship Center, Wilder Forest Foundation; **Mr. Wayne Monsen**, Watonwan County farmer; **Mr. David Granatstein**, formerly of Land Stewardship Project; **Dr. John Moncrief**, soil scientist, University of Minnesota; **Dr. Dennis Johnson**, dairy scientist, University of Minnesota.

Loan Technical Review Panel 1989-90

Mr. Dell Christianson, specialty crop management instructor, Detroit Lakes Technical College; **Mr. Randy Krzmarzick**, Brown County farmer; **Mr. Craig Cramer**, consultant and contributing editor of New Farm magazine; **Mr. Jim Kusilek**, Senior Product Officer, First Bank of Wilmar; **Mr. Tim Gossman**, vice-president, Root River State Bank in Chatfield; **Dr. Ian Moore**, agricultural engineering professor, University of Minnesota; **Mr. Wayne Monsen**, Watonwan County farmer; **Mr. Arlen Messerli**, Sibley County farmer; **Mr. Romeo Cyr**, farm management instructor, Red Wing Technical College.

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